BER BUSINESS AND ECONOMICS RESEARCH JOURNAL
www.berjournal.com
ISSN: 2619-9491

Business and Economics Research Journal Vol. 9, No. 4, 2018, pp. 735-747 doi: 10.20409/berj.2018.135

The Validity of Purchasing Power Parity Hypothesis in E-7 Countries: Panel Data Analysis

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Abstract: *The exchange rates are one of the most important macroeconomic variables influencing the economic activities of any country such as foreign trade, money and capital markets. From this aspect, examining the changes in exchange rates, which are considered as one of the indicators of economic stability, is of significant importance. The aim of this study is to test the purchasing power parity (PPP) hypothesis for E-7 countries between 1994 and 2017. Within the scope of this analysis, firstly the dependence between the cross-sections was examined. Then, the validity of PPP hypothesis was tested using SURADF (Seemingly Unrelated Augmented Dickey Fuller) panel unit root test developed by Breuer et al. (2001) and Carrion-i-Silvestre et al. (2005) panel unit root test (PANKPSS), which takes the structural breaks into consideration. According to the results of SURADF test, it was determined that the PPP is holds only in Russia and Turkey, but not in the other countries. According to the results of PANKPSS unit root test considering the structural breaks, however, it was found that PPP is holds in all the countries.*

Keywords: Purchasing Power Parity, Real Exchange Rate, E-7 Countries, Panel Unit Root Test, Structural Breaks

JEL: C01, F31

Received : 16 July 2018
Revised : 11 September 2018
Accepted : 21 September 2018

Type : Research

1. Introduction

The SAGP theory is the basis for macroeconomic models in open economies. It also plays an important role in predicting long-run exchange rate movements, in comparing the national income levels of the countries in the international arena, and in making long-term policies for the exchange rate movements by central banks, international companies and other foreign exchange market participants. According to PPP theory, the exchange rate equals to the ratio of countries overall price level. Given that the purchasing power of any country's currency is determined based on the overall price level in that country, PPP projects that, depending on the increase in domestic price level, the national currency should lose in value when the purchasing power of national currency decreases (Krugman & Obstfeld, 2003: 390). The first versions of PPP date back to the Salamanca School of Spain in 16th century and the studies carried out by Gerrad de Malynes in England in 1601. In second half of 18th century and early 19th century, the Swedish, French, and English followers of Bullionism carried out studies on PPP theory. Throughout the 19th century, the classical economists including Ricardo, Mill, Goschen, and Marshall introduced new opinions on PPP. Even though the PPP theory has built on a solid ground until World War I, it has been re-shaped by the Swedish economist Gustav Cassel in the following period and become much stronger (Dornbusch, 1985: 6-7).

Cite this article as: Altiner, A., & Bozkurt, E. (2018). The validity of purchasing power parity hypothesis in E-7 countries: Panel data analysis. *Business and Economics Research Journal,* 9(4), 735-747.

The current issue and archive of this Journal is available at: ***www.berjournal.com***

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The aim of this study is to empirically analyze whether the SAGP hypothesis, which has great importance with regard to disclosure of exchange rates changes and policy making, is valid for the E-7 countries. Although many studies have been carried out in literature in order to test the validity of PPP hypothesis, there are few studies taking into account the structural breaks emerging as a result of the sudden capital movements, the financial crises and consequently the changing interest rates, the changes in the exchange rate system, devaluation, the unexpected increase in the inflation rate, the speculative attacks, the central bank's intervention in the foreign exchange market and the changes in the customs system (Bozoklu & Yılancı, 2010: 601). From this aspect, this study is expected to contribute to the literature since it both uses relatively newer econometric methods and the unit root test considering the structural breaks in order to test the validity of PPP. The following sections of this study are organized as follows. In the Section 2, theoretical framework and related literature are presented. The section 3 is allocated for the dataset and econometric method. In Section 4, the empirical analysis results are presented, and the results and discussion are presented in final section.

2. Theoretical Framework and Related Literature

The starting point of traditional PPP theory is the Law of One Price. Accordingly, in a world consisting of two countries and in case of no boundary against the international trade such as transportation costs and tariffs, the goods manufactured similarly would be sold at similar prices in both countries. The Law of One Price is expressed as follows:

$$P_t^i = S_t P_t^{i*} \tag{1}$$

Here, P^i refers to the domestic price of good *i*, and *S* refers to the foreign exchange rate (national currency unit per foreign currency unit), and P^{i*} refers to the foreign price of good i. The mechanism laying the foundation of Law of One Price is the arbitrage. If the domestic price level is higher than the foreign price level of good, then it would be reasonable to buy the goods from other country. Since the demand to domestic goods will decrease and the demand to foreign goods will increase in this process, the domestic price will decrease, the foreign price will increase and the "Law of One Price" will work. Assuming that each country produces *n* goods, the overall price level is calculated as follows:

$$P_t = \sum_{i=1}^{n} \propto^i P_t^i \quad \text{and} \quad P_t^* = \sum_{i=1}^{n} \propto^i P_t^{i*} \tag{2}$$

Here, α refers to the weight of good i in the basket prepared in order to accumulate the individual prices, and it is assumed to be same in all countries. By using these price levels, the condition of absolute PPP can be achieved:

$$S_t = \frac{P_t}{P_t^*} \tag{3}$$

According to the absolute PPP, the nominal exchange rate of a country is determined based on the proportion of the overall domestic price level to the overall foreign price level. In this case, the country having higher overall price level than its opponent has would have so depreciated national currency when compared to its opponent. Equation 3 can be showed as follows in logarithmic form:

$$s_t = p_t - p_t^* \tag{4}$$

The absolute PPP can be stated as follows from the aspect of real exchange rate (Q):

$$Q_t = \frac{S_t P_t^*}{P_t} = 1 \tag{5}$$

According to the Equation 5, the hypothesis of absolute PPP is holds when the real exchange rate equals to unity. As an alternative, as seen below, the hypothesis is also valid when the log of real exchange rate equals to zero (MacDonald, 2007: 41-42):

$$q_t = s_t - p_t + p_t^* = 0 \qquad (6)$$

In fact, it is not possible to hold the absolute PPP hypothesis because of the trade-disturbing effects of transportation costs, imperfect information, tariffs, and non-tariff barriers. However, it was projected that the weaker form of PPP, which is known as relative PPP, can be holded even in presence of various trade-disturbing effects. According to the relative PPP, the exchange rate is determined based on the differences between inflation rates of two countries. This is expressed as follows:

$$\%\Delta S = \%\Delta P - \%\Delta P^* \qquad (7)$$

In this equation, $\%\Delta S$ refers to the percentage of change in exchange rate, $\%\Delta P$ refers to the domestic inflation rate, and $\%\Delta P^*$ refers to the foreign inflation rate. Accordingly, the currencies of countries having higher inflation rates would depreciate against the currencies of their trade partners. In conclusion, when compared to the absolute PPP, the relative PPP is considered as a more realistic approach (Pilbeam, 2006: 127; MacDonald, 2007: 43).

The main problem with PPP theory is that the PPP hypothesis is rarely valid in any country. There are certain reasons for not holding the PPP. The main point here is about the parameters used in presenting the domestic price level (P) and the foreign prices level (P^*). In empirical studies focusing on PPP, the price indices are used in representing these parameters since the series of domestic and foreign prices cannot be easily obtained. At this point, the primary problem is that the domestic and foreign price indices are not based on the same good basket. The other problem is that the price indices cover generally the tradable and non-tradable goods and services. Since the non-tradable goods and services are determined by the domestic factors, the international arbitrage conditions are not valid. For this reason, the differences emerge between domestic and foreign prices. Besides that, the reasons such as the presence of transportation costs, trade barriers, and imperfect competition conditions cause deviations from PPP (Alves et al., 2001: 1175-1176; Ridzuan & Ahmed, 2011: 43; Rogoff, 1996: 653-654).

The early studies on PPP have been based on the simple regression analyses testing the absolute and relative PPP hypothesis. In the first studies, the traditional econometric techniques such as the ordinary least squares (OLS) method and the instrumental variable estimation have been applied. However, the modern statistical methods showed that the stationarity tests and cointegration analysis should be applied in order to test the established model. For instance; if the nominal exchange rate and relative prices have non-stationary structure, then the spurious regression problem will be seen in the model to be estimated (Taylor, 2006: 4; Granger & Newbold, 1974: 116-117). But, taking the first difference of series would cause the loss of long-term relationship between the original series of variables by preventing obtaining the robust results (Engle & Granger, 1987). From this aspect, the next step in testing the validity of PPP was to consider the non-stationary conditions of real exchange rate. Together with the development of time series techniques for non-stationary series, the rejection of the short-term validity of PPP encouraged the use of real exchange rate and unit root and cointegration analysis in testing the long-term validity of PPP. As shown in equation 6, in order for the purchasing power parity to be valid, the real exchange rate must equal to zero. From this point, it can be stated that the difference of real exchange rate from zero indicates the deviation from PPP. By using time series characteristics of real exchange rate, it is examined if the nominal exchange rate and relative domestic prices are settle down together at level consistent with PPP in long-term. Accordingly, the condition for the long-term PPP to be hold is that the real exchange rate must return to its average value, in other words, it must be stationary (Taylor, 2006: 4).

There are many studies in the literature testing the validity of PPP and some of them are presented below. In literature review, it was determined that there is no consensus on the short- and long-term validity of PPP. However, it was also observed that the majority of studies reported that PPP is holds. Some of these studies are as follows: Kugler and Lenz (1993), Coakley and Fuertes (1997), Sarno (2000), Erlat (2003), Narayan (2005), Hoarau (2007), Kargbo (2009), Güloğlu et al. (2011), Özcan (2012), Ağayev (2013), Yılancı and Eriş. (2013), Li et al. (2015), Yalçınkaya (2016), and Aliyeva and Hüseynov (2017). On the other hand, some other studies reported the results indicating that PPP is not holds. Some of these studies are listed below: Bahmani-Oskooee (1995), Bahmani-Oskooee (1998), Zumaquero and Urrea (1998), Telatar and Kazdağlı (1998), Baum et al. (1999), Bjørnland and Hungnes (2002), Yıldırım (2003), Alba and Park (2005), Aslan and Kabur (2007), Gil-Alana and Jiang (2013), Tiwari and Shahbaz (2014), and Cevıs and Ceylan (2015).

3. Data and Econometric Methodology

3.1. Data

In this study, the monthly real effective exchange rates covering the period between 1994:01 and 2017:12 were used in order to test the validity of PPP hypothesis in E7[1] countries. The concept of E-7 (emerging 7) was first used by Hawksworth, head of macroeconomics of the US research and inspection firm PWC, in the report titled "World in 2050". In this report, E-7 economies with high growth performance over the past 20 years have exceeded G7 economies in terms of economic size depending on some variables such as population growth rate, human and physical capital trends, technological catch-up speed and real exchange rate trends (Hawksworth, 2006: 12-46). Therefore, it is important to examine the validity of the PPP hypothesis as one of the indicators of economic stability in these 7 countries which have recently achieved high economic growth rates.

The series of real effective exchange rates used in this study were obtained from *bruegel.org*. The Real Effective Exchange Rate (REER) is calculated as follows:

$$REER_t = \frac{NEER_t \times CPI_t}{CPI_t^*}, \tag{8}$$

In Equation 8, $REER_t$ refers to the real effective exchange rate index of country against a basket of currencies of its trading partners, $NEER_t = \prod_{i=1}^{N} S(i)_t^{w^{(i)}}$ refers to the nominal effective exchange rate of the country that is the $(S(i))$ geometrically weighted nominal exchange rate expressed as the foreign currency unit per domestic currency unit, CPI_t refers to the domestic consumer price index, $CPI_t^* = \prod_{i=1}^{N} CPI(i)_t^{w^{(i)}}$ refers to the geometrically weighted average of consumer price indices of trading partners, $CPI(i)$ and $w^{(i)}$ refer to consumer price index and weight of trading partner *i*, and *N* refers to the number of trading partners (Darvas, 2012:2). According to Equation 8, the increase in REER means that the national currency of a country appreciates against the currencies of trading partner countries.

3.2. Econometric Methodology

In this study, firstly, it was aimed to determine the dependence between the cross-sections of panel by using REER series. For this purpose, the Langrange Multiplier $(CDLM_1)$ test developed by Breusch and Pagan (1980), $CDLM_2$ test developed by Pesaran (2004), and $(CDLM_{adj})$ test developed by Pesaran et al. (2008) were utilized. Under the light of results obtained, SURADF, which is one of the second-generation unit root tests considering the cross-section dependence, and the structural breaks panel KPSS (PANKPSS) unit root test were used in order to examine stationary of the series.

3.2.1. Cross-Section Dependence Test

In today's globalizing world, many countries have economic relationship with each other, and a shock experienced by any country is experienced also by the other countries at different levels. Thus, it can be stated that there may be the dependence between these countries based on this relationship. From this aspect, the results to be obtained from analyses, which will be performed without investigating the cross-section dependence between the series, would be biased and inconsistent (Tatoğlu, 2013: 9; Mercan, 2014:

35). For this reason, the cross-section dependence will be tested at first, and then the other analyses will be performed.

The LM statistics developed by Breusch and Pagan (1980) in order to test the presence of cross-section dependence,

$$CDLM_1 = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij,}^2 \quad (9)$$

$\hat{\rho}_{ij}$, is the estimation of pair-wise correlation of residuals,

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{T} e_{it}e_{jt}}{\left(\sum_{t=1}^{T} e_{it}^2\right)^{1/2}\left(\sum_{t=1}^{T} e_{jt}^2\right)^{1/2}} \quad (10)$$

is the estimation of $e_{it} = y_{it} - \hat{\beta}_i' x_{it}$ and u_{it} by using OLS. LM test does not have a specific requirement for the cross-section units, and it can be used when T> N. But, this test has been developed, and the *CDLM₂* test can be used in testing the cross-section dependence when cross-section and time dimensions are larger was obtained:

$$CDLM_2 = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{\rho}_{ij}^2 - 1) \quad (11)$$

According to this rest, when $T \to \infty$ and $N \to \infty$, it is accepted that there is no cross-section dependence (regarding the null hypothesis) (Pesaran, 2004: 6-7). Moreover, Pesaran et al. (2008) made a correction in LM statistics and they developed a new test that can be used when N>T;

$$CDLM_{adj} = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left[\hat{\rho}_{ij}^2\left(\frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{v_{Tij}}\right)\right] \sim N(0,1)(12) \quad (12)$$

In this equation, μ_{Tij} refers to the mean value, whereas v_{Tij} refers to the variance. This test called the bias-adjusted CDLM ($CDLM_{adj}$) test is capable of determining the cross-section dependence without any deviation when N>T and T>N. The hypothesis tests are as follows;

H_0: For each i unit, u_{it} error term is independent with zero means and constant variance. In other words, there is no cross-section dependence.

H_α: There is the cross-section dependence (Pesaran et al. 2008: 1-4).

In this study, the $CDLM_1$, $CDLM_2$ and $CDLM_{adj}$ tests were used in testing the cross-section dependence.

3.2.2. SURADF Panel Unit Root Test

Developed by Breuer et al. (2001), SURADF test is presented by the Equation 5 below;

$$\begin{aligned}
\Delta y_{1,t} &= \alpha_1 + (\rho_1 - 1)y_{1,t-1} + \sum_{i=1}\delta_i \Delta y_{1,t-i} + u_{1,t} \\
\Delta y_{2,t} &= \alpha_2 + (\rho_2 - 1)y_{2,,t-1} + \sum_{i=1}\delta_i \Delta y_{2,t-i} + u_{2,t} \\
&\;\;\vdots \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (13)\\
\Delta y_{N,t} &= \alpha_N + (\rho_N - 1)y_{N,t-1} + \sum_{i=1}\delta_i \Delta y_{N,t-i} + u_{N,t}
\end{aligned}$$

In this Equation, ρ_i refers to the autoregressive coefficient for the series i. This system is estimated by using SUR method, and the significance of each $(\rho_i - 1)$ is tested against the critical values by using the simulation. The specification of this model has some advantages over the panel unit root test developed by Levin and Lin. First, because SUR estimation take account of the cross sectional correlation of error terms, it provides more information when compared to the single-equation ADF and Levin and Lin (1992,1993) tests. Second, Equation 5 assumes that the lag structure between the cross-sections constituting the panel are heterogeneous. Assuming the presence of unit-specific lag structures eliminates misspesification problem and makes each of error terms to be white-noise. Determining an identical lag structure for the cross-sections constituting the panel would cause biased test statistics. However, in SURADF method, one lag length is enough for eliminating the serial correlation problem in each cross-sections. In sum, the specification allows the different auto-regression coefficients among the units. In this method, by removing the limitation of $(\rho_1 - 1) = (\rho_2 - 1) = \cdots = (\rho_N - 1)$, the null hypothesis that all the series have unit root and the alternative hypothesis that all the series are the stationary with the same coefficient avoided. In other words, within the frame of SUR, this test enables calculating the null and alternative hypotheses for each cross-sections constituting the panel.

The null and alternative hypotheses for N number of cross-sections:

$$H_0^1 : \beta_1 = 0;\ H_A^1 : \beta_1 < 0$$

$$H_0^2 : \beta_2 = 0;\ H_A^2 : \beta_2 < 0$$

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$$H_0^N : \beta_N = 0;\ H_A^N : \beta_2 < 0$$

SURADF test statistics lower than the critical value indicates that the series is stationary (Breuer et al., 2001: 487; Breuer et al., 2002: 531).

3.2.3. PANKPSS Unit Root Test

The structural breaks are possible in the series that are very sensitive to change in economic conditions such as exchange rates. As stated by Perron (1989), the null hypothesis can be accepted at an extreme if the series include structural breaks. This situation may lead to incorrect results that show that a stationary series has unit roots. In this respect, the unit root test which takes the structural breaks into consideration has also been applied (Özcan, 2012: 145). Developed by Carrion-i-Silvestre (2005) and Carrion-i-Silvestre et al. (2005), panel KPSS (PANKPSS) unit root test is the panel data version of KPSS test developed by Hadri (2000). PANKPSS test considers the cross-section dependence of series and it is a stationarity test applied in case of multiple structural break in the series. This method can provide the structural break of each cross-sections of panel at different times and different numbers. The model allowing the presence of multiple structural break and defined in order to test the stationarity hypothesis is as follows:

$$y_{i,t} = \propto_{i,t} + \beta_i\, t + \varepsilon_{i,t} \quad (14)$$

Here,

$$\propto_{i,t} = \sum_{k=1}^{m_i} \theta_{i,k} D\left(T_{b,k}^{i}\right)_t + \sum_{k=1}^{m_i} \gamma_{i,k} DU_{i,k,t} + \alpha_{i,t-1} + \upsilon_{i,t} \quad (15)$$

$\upsilon_{i,t} \sim i.i.d.(0, \sigma^2_{\upsilon,i})$ and $\propto_{i,0} = \propto_i$ and it is constant. The dummy variables in this equation are defined as specified below:

$D(T^i_{b,k})_t = 1, \quad t = T^i_{b,k} + 1$ and 0 in other cases,

$DU_{i,k,t} = 1, \quad t > T^i_{b,k}$ and 0 in other cases.

$T^i_{b,k}$ refers to the date of k[th] break ($k = 1, \ldots, m_i, m_i \geq 1$) for *i*th unit. Moreover, it is assumed that the error terms in Equations 14 and 15 are distributed independently from each other. As a result of this, the null hypothesis of a stationary panel is $\sigma^2_{\upsilon,i} = 0, \ \ \forall i = 1, \ldots, N$ and it indicates the stationarity of the series. Based on this hypothesis, Equations 6 and 7 can be written as follows:

$$y_{,t} = \propto_i + \sum_{k=1}^{m_i} \theta_{i,k} DU_{i,k,t} + \beta_i t + \sum_{k=1}^{m_i} \gamma_{i,k} DT^*_{i,k,t} + \varepsilon_{i,t} \tag{16}$$

In Equation 16, the dummy variable $DT^*_{i,k,t} = t - T^i_{b,k}$ when $t > T^i_{b,k}$, and it equals to 0 in other cases. The equation includes the individual structural break effect indicating the changes in the mean caused from structural break -the temporary effects- in case of $\beta_i \neq 0$ and -the temporal structural break effects- in case of $\gamma_{i,k} \neq 0$ referring to the changes in individual time trends.

The specification in Equation 16 allows taking three characteristics into account; (i) the structural breaks may have different effects on each time series and the effects are measured using $\theta_{i,k}$ and $\gamma_{i,k}$, (ii) since the break dates are not limited in order to satisfy the $T^i_{b,k} = T_{b,k}$ and $\forall i = 1, \ldots, N$ criteria, the structural breaks might have occurred on different dates for each series, and (iii) each of the units may have different numbers of structural breaks. The general statement of test statistics is showed below:

$$LM(\lambda) = N^{-1} \sum_{i=1}^{N} \left(\widehat{\omega}_i^{-2} T^{-2} \sum_{t=1}^{T} \hat{S}^2_{i,t} \right) \tag{17}$$

In Equation 17, $\hat{S}_{i,t} = \sum_{j=1}^{t} \hat{\varepsilon}_{i,j}$ and $\omega_i^2 = lim_{T\to\infty} T^{-1} E\left(S^2_{i,T}\right), i = 1, \ldots, N$ and $\hat{S}_{i,t}$ is the process of partial sum process obtained using estimated OLS residuals of Equation 8 together with $\widehat{\omega}_i^2$ that is the consistent predictor of long-term variance of $\varepsilon_{i,t}$. The test in Equation 9 can be calculated by assuming that the long-term variance between the individuals is homogenous. If the long-term variance is allowed to vary for each unit, then the following equation can be utilized;

$$LM(\lambda) = N^{-1} \sum\nolimits_{i=1}^{N} \left(\widehat{\omega}^{-2} T^{-2} \sum\nolimits_{t=1}^{T} \hat{S}^2_{i,t} \right) \tag{18}$$

In Equation 18, $\widehat{\omega}^2 = N^{-1} \sum_{i=1}^{N} \widehat{\omega}_i^2$. λ indicates that the test is dependent on the structural break dates. For each unit, λ_i vector is defined as follows;

$$\lambda_i = (\lambda_{i,1}, \ldots, \lambda_{i,m_i})' = (T^i_{b,1}/T, \ldots, T^i_{b,m_i}/T)' \tag{19}$$

on the entire time periods, T, refers to the relative position of break dates (Carrion-i Silvestre et al., 2005: 160-162).

The dates and numbers of structural breaks are obtained using the Bai and Perron (1998) process calculating the global minimization of error sum of squares. Bai and Perron (1998) use two different processes for this purpose. The first process is dependent on the Bayesian information criteria developed by Liu et al. (1997) and the modified Schwarz information criteria. The second process is dependent upon the sequential computation of F statistics for determining the number of structural breaks. Finally, then estimating the number of structural breaks in PANKPSS test, the regression model with trend was used in first process, whereas the regression model without trend was used in second process (Carrion-i-Silvestre, 2005: 845). Furthermore, the cross-section dependence problem is removed by the bootstrap distribution specified in Maddala and Wu (1999) (Carrion-i Silvestre et al., 2005: 170). The PANKPSS test statistics lower than the critical threshold calculated using bootstrap indicate that the series is stationary.

4. Empirical Results

Firstly, the results of cross-section dependence are presented in Table 1 below.

Table 1. Results of Cross-Section Dependence

	Model with Constant		Model with Constant+Trend	
	Statistics	Probability	Statistics	Probability
$CDLM_1$	203.865***	0.000	204.358***	0.000
$CDLM_2$	28.217***	0.000	28.293***	0.000
$CDLM_{adj}$	67.521***	0.000	71.243***	0.000

Note: ***, **, and * refer stationarity at the statistical significance of 1%, 5%, and 10%, respectively.

Based on the results of *CDLM₁, CDLM₂,* and *CDLMadj* tests presented in Table 1, the null hypothesis indicating the cross-section independence of REER variable in both of the model with constant and the model with constant/trend was rejected at the significance level of 1%. Based on this result, it was determined that there is a cross-section dependence between the cross-sections of the series, and it was found that the use of second-generation panel unit root tests is necessary while investigating the stationarity of series. The results of SURADF unit root test among the second-generation panel unit root test used in examining the stationarity of REER series are presented in Table 2.

Table 2. Results of SURADF Panel Unit Root Test

Models with Constant and with Constant+Trend				
		Critical Values		
Countries	$SURADF_{test}$	**10%**	**5%**	**1%**
Brazil	-1.957	-2.495	-2.919	-3.631
China	-1.661	-2.456	-2.782	-3.505
India	-2.572	-3.151	-3.487	-4.233
Indonesia	-2.722	-2.730	-3.049	-3.660
Mexico	-1.910	-2.716	-3.071	-3.712
Russia	-2.750*	-2.374	-2.800	-3.576
Turkey	-3.100*	-2.664	-3.101	-4.023

Note: ***, **, and * refer stationarity at the statistical significance of 1%, 5%, and 10%, respectively. Critical values were obtained from the Monte Carlo simulation with 10,000 cycles.

According to the results obtained from SURADF panel unit root test and presented in Table 2, it was determined that the test statistics calculated for REER series are statistically significantly lower that the critical values only for Russia and Turkey at the significance level of 10%. But, in the other countries, the test statistics were found to be higher than the critical values. Thus, it was determined within the scope of model with constant and with constant/trend that the REER series was stationary in Russia and Turkey and it includes unit root in other 5 countries. Under the light of these findings obtained from the results of SURADF test, it was found that PPP is holds only for Russia and Turkey among the E-7 countries but not in the other countries.

In order to be able to make a comparison with the findings obtained from SURADF unit root test, the PANKPSS unit root test, which takes the structural breakages into consideration, with constant and with constant-trend are presented in Table 3 and 4.

Table 3. PANKPSS Test Results (Model with Constant)

PANEL A: Structural Break Dates and Individual KPSS Test Results										
			Structural Break Dates					Critical Values		
Countries	**KPSS**	**m**	$T_{b,1}$	$T_{b,2}$	$T_{b,3}$	$T_{b,4}$	$T_{b,5}$	**0.90**	**0.95**	**0.99**
Brazil	0.029	4	12-1998	06-2005	07-2009	05-2013	-	0.057	0.066	0.085
China	0.028	4	07-1997	02-2003	07-2008	01-2013	-	0.057	0.066	0.076
India	0.015	2	03-2005	05-2014	-	-	-	0.056	0.064	0.082
Indonesia	0.028	5	09-1997	01-2002	10-2005	11-2009	07-2013	0.063	0.073	0.106
Mexico	0.027	4	03-1999	01-2003	09-2008	05-2014	-	0.057	0.064	0.082
Russia	0.060	5	08-1998	03-2002	10-2005	02-2010	05-2014	0.062	0.077	0.105
Turkey	0.035	4	09-1997	05-2003	12-2006	08-2013	-	0.058	0.069	0.087

PANEL B: KPSS Test Results for Entire Panel (%)				
	Test Statistics	**0.90**	**0.95**	**0.99**
LM(λ)(hom)	-0.150	1.532	2.066	3.349
LM(λ)(het)	-0.701	1.292	1.794	2.804

Note: Critical values for Panel KPSS test statistics were obtained from the Monte Carlo simulation with 10,000 cycles. M refers to the number of structural breaks in REER series. T_b refers to the dates of structural breaks.

According to the PANKPSS unit root test results presented in Table 3, since the individual panel KPSS test statistics found for each country in Panel A were lower than the bootstrap critical values at the significance level of 1%, it was determined that REER series has a stationary structure for all the countries in the panel. According to these results, it can be stated that the short-term shocks observed in the real effective exchange rates in E-7 countries for the period being examined were not permanent, and that the series returned to its mean values in the long-term. Since the LM statistics calculated were lower than the bootstrap critical values at the significance level of 1%, it was determined according to the KPSS test results presented in Panel B that the series were stationary for the entire panel.

According to the results of individual panel KPSS taking the structural break into account for the model with constant and trend showed in Panel A of Table 4, it was determined that REER series has a stationary structure for all of the countries since the individual test statistics calculated for each of the countries were lower than the bootstrap critical values at the significance level of 1%. These results indicate that the shocks observed in short-term in real effective exchange rates in E-7 countries are not permanent, and that the series returned to its average values in the long-term. According to the KPSS test results showed in Panel B, it was determined that the series has a stationary structure for the panel since the LM test statistics were lower than the bootstrap critical values at the significance level of 5%.

Table 4. PANKPSS Test Results (Model with Constant+Trend)

PANEL A: Structural Break Dates and Individual KPSS Test Results

			Structural Break Dates					Critical Values		
Countries	**KPSS**	**m**	$T_{b,1}$	$T_{b,2}$	$T_{b,3}$	$T_{b,4}$	$T_{b,5}$	**0.90**	**0.95**	**0.99**
Brazil	0.013	4	12-1998	07-2002	08-2008	03-2012	-	0.030	0.033	0.044
China	0.012	5	09-1998	05-2005	12-2005	07-2009	05-2014	0.031	0.036	0.044
India	0.009	4	02-2000	08-2006	03-2010	04-2014	-	0.041	0.049	0.062
Indonesia	0.014	3	11-1997	03-2002	08-2013	-	-	0.037	0.044	0.057
Mexico	0.015	3	07-1997	05-2002	12-2012	-	-	0.034	0.039	0.050
Russia	0.028	3	08-1998	12-2008	05-2014	-	-	0.034	0.038	0.051
Turkey	0.024	2	02-2001	09-2007	-	-	-	0.026	0.029	0.034

PANEL B: KPSS Test Results for Entire Panel (%)

	Test Statistics	**0.90**	**0.95**	**0.99**
LM(λ)(hom)	1.808	8.934	10.171	13.212
LM(λ)(het)	2.045	9.064	10.227	12.468

Note: Critical values for Panel KPSS test statistics were obtained from the Monte Carlo simulation with 10,000 cycles. M refers to the number of structural breaks in REER series. T_b refers to the dates of structural breaks.

According to the results of individual panel KPSS taking the structural break into account for the model with constant and trend showed in Panel A of Table 4, it was determined that REER series has a stationary structure for all of the countries since the individual test statistics calculated for each of the countries were lower than the bootstrap critical values at the significance level of 1%. These results indicate that the shocks observed in short-term in real effective exchange rates in E-7 countries are not permanent, and that the series returned to its average values in the long-term. According to the KPSS test results showed in Panel B, it was determined that the series has a stationary structure for the panel since the LM test statistics were lower than the bootstrap critical values at the significance level of 5%.

5. Concluding Remarks

In order for PPP, which is defined as the relationship between the nominal exchange rates and price levels of two countries, to be hold, the short-term deviations in real exchange rates should return their average values in long-term. Even though many studies have been carried out on testing the validity of PPP hypothesis in the literature, no consensus could be achieved in terms of the validity of hypothesis.

In the present study, the validity of purchase power parity in E-7 countries was examined using the monthly data of period 1994:01-2017:12. For this purpose, the stationarity of real exchange rate was tested for each of the countries by using SURADF test and PANKPSS test, which are the second-generation panel unit root tests that consider and do not consider the structural breaks, respectively. These tests yield more reliable results than the other unit root tests do because they take the cross section dependence.

According to the results of SURADF unit root test, it was determined that the real effective exchange rate series was stationary only for Russia and Turkey among the E-7 countries. Consequently, it was found that PPP is holds only in Russia and Turkey but not in other E-7 countries. According to the results of PANKPSS unit root test that is accepted to be a more robust unit root test since it considers the structural breaks in comparison to the SURADF test, REER series has a stationary structure for all the countries constituting the panel, and thus the PPP is holds for all the E-7 countries. According to the results for the entire panel, it was determined that the PPP hypothesis is valid in all set of countries examined. In sum, it can be stated that the deviations from the real effective exchange rates are not permanent in any of the countries, and that the nominal exchange rates occurred in the way eliminating the price differences. These results indicate that the exchange rate policies applied in relevant countries are effective on the economic activities and ensuring the stability. In sum, it can be stated that the deviations from the real effective exchange rates are not permanent in any of the countries, and that the exchange rate series has returned to its average values in the long-term to remove the price differences between the countries. These results indicate that the exchange rate policies applied in relevant countries are effective on the economic activities and ensuring the stability. It can also be said that this theory should be used in long term equilibrium exchange rates estimations and international development comparisons.

End Notes

1. *E7 Countries: Brazil, China, India, Indonesia, Mexico, Russia and Turkey*

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