

**PURCHASING POWER PARITY TESTING UNIT ROOT TESTS
WITH STRUCTURAL BREAK IN TURKEY**

Büyükantarcı Tolgay SELMA¹, Kula FERİT²

^{1,2}*Erciyes University, Turkey*

Abstract

In this study, PPP, which has been the most important of many studies over the years as the exchange rate determination method in the literature, between 2003 January and 2017 August was tested for its validity in Turkey. The PPP was analyzed by ADF - PP and Lee-Strazicich fracture unit root tests in the study. Results of the study, the real exchange rate was not stable in the classical unit root tests. Three break-up dates were determined by Lee-Strazicich fracture root tests and it was determined that PPP was valid in case of structural breaks.

Keywords Exchange Rate; Purchasing Power Parity; ADF, PP, Unit Root Tests; Lee-Strazicich Structural Unit Root Tests

JEL classification: E41, C33, F31

1. Introduction

The purchasing power parity theory was mentioned by the Swedish economist Gustav Cassel, who first used it in 1918 (Gerek; Karabacak, 2017, p. 3). Cassel tried to develop this theory during the First World War in an environment of inflation that countries had fallen into. According to him, the starting point of this theory, the determinant of the rate of change between the two countries is the difference between the national purchasing power and the money of each country.

Although inflation during the war has reduced this purchasing power, the rate of change has shifted proportionally due to the inflation in each country. Regular movement of goods between the two countries and, as long as free trade occurs, exchange rates do not deviate from the determined purchasing power parity, even if there are trade constraints (Cassel, 1918, p. 413-415).

¹Ph.D., Erciyes University, e-mail: sbtolgay@erciyes.edu.tr

²Professor, Ph.D., Erciyes University, Faculty of Economics and Administrative Sciences, Department of Economics, e-mail: kulaf@erciyes.edu.tr

The purchasing power parity is the most commonly spoken exchange rate determination method. This theory states that the nominal exchange rate ratio between the two countries' currencies is equal to the ratio of total price levels between these countries and the nominal exchange rate is used to reveal the real exchange rate by multiplying the ratio of the internal and external price levels.

As such, purchasing power parity theory is similar to the Single Price Act.

$$P_{i,t} = E_t P^*_{i,t} \quad i= 1, 2, \dots, N \quad \text{Equation (1)}$$

$P_{i,t}$: in local currency price at time t

$P^*_{i,t}$: goods in foreign currency price at time t

E_t : T is the nominal exchange rate shown as the domestic price of the foreign currency at time t .

According to Equation (1), the absolute version of the single-price law fundamentally accepts that the same goods must have the same price between countries if the prices are expressed in the same currency.

The basic inference of the single-price law is often based on the idea of frictionless goods arbitrage (Sarno; Taylor, 2003, p. 52).

In this study, unlike other studies on *the* exchange rate and purchasing power parity, non-traditional monetary policies applied in extraordinary periods and the validity of purchasing power parity were examined when traditional monetary policies were applied.

The aim of the study is to determine the differences between the decisions taken by the countries with the global mortgage crisis that started at the end of 2008, and the developments in the exchange rate, the decisions taken in the current foreign exchange crisis and the changes in the exchange rate and purchasing power parity.

The source of our data is *the* IMF International Financial Statistic CD. The longest period, which includes 176 months of observation from January 2003 to August 2017 from the data source, was selected as the period. Data used; real exchange rate, domestic price level (CPI) and foreign country price level (CPI). The real exchange rate series used in the test was created using seasonally adjusted monthly data.

In the application part of the study, firstly, the stability of the real exchange rate was investigated by using Dickey-Fuller (Augmented Dickey-

Fuller: ADF) and Phillip-Perron (PP) unit root tests. Secondly, since the classical unit root tests did not show the effects of changes such as economic crises policy changes, the validity of the purchasing power parity was tested by Lee-Strazicich (LS) (2003) structural fracture unit root tests, which analyzed the existence of the unit root taking into account the structural breaks in the time series.

The rest of the paper is organized as follows: The next section is devoted to describe the literature. Section 3 presents the basic model and data. Section 4 describes the Dickey-Fuller (Augmented Dickey-Fuller: ADF), Phillip-Perron (PP) and the LM unit root methodology and section 5 presents the conclusion of the paper.

2. Literature Review

Hakkio (1982) investigated the causes of *the* poor performance of the SGP in the 1970s. To do this using the price and exchange rate data for the period 1921: 1-1924: 4 of the countries of England, France, Italy, Switzerland and Japan; 1973: 6 - 1979: 12 period is examined. According to the aim of the article, single-equation model estimates found that SGP was more successful in the 1920s but did not provide the expected achievement in the 1970s. In the 1970s, it was found that the SGP relationship was not provided in multiple estimates using monthly data. It is argued that the difference between these two periods results from the fact that countries in the world economy are becoming more dependent. Taylor (1988) presented an empirical analysis of long-term purchasing power parity for the five major exchange rates using econometric techniques in the cointegration of economic time series. June 1973-December 1985 period; USD-based exchange rates of West Germany, UK, France, Canada and Japan currencies and calculated relative prices of PPI type have been used in this study. The results of the study illustrated that the PPP hypothesis did not meet the long-term equilibrium requirement. Telatar and Kazdağlı (1998), with long-term cointegration analysis of PPP in Turkey 1980: 10-1993: 10 period was tested. Two sets of data was used concerning with the France, Germany, England and ABD which are the most important trading partner of Turkey. These are nominal US binary exchange rates (Turkish Lira Currency) and Consumer Price Indices (CPI). According to the results of the cointegration analysis, the two exchange rates and the CPI were not clearly defined. As a result, it is seen that long-term SGP hypothesis is not valid in countries. Aslan and Kula (2011) examined the Purchasing Power Parity for Eastern European countries such as Bulgaria, Czech Republic,

Hungary, Poland, Romania and Russia. For the real exchange rates in six Eastern European countries, one and two structural fractured univariate and panel applied Lagrange Multiplier (LM) unit root tests. The analysis showed that PPP is a valid hypothesis for Bulgaria, the Czech Republic, Hungary, Poland, Romania and Russia. Arize, Malindretos and Ghosh (2015) examined the cointegration of exchange rates and prices by using techniques of limited interest in a few studies on the validity of the Purchasing Power Parity hypothesis. The 1971-2011 period was used in the study. In the study, the symmetry and the proportionality conditions in PPP were investigated. As a result of the co-integration test, long-term PPP was found to be valid. Yalçinkaya (2016), examined the stagnation of real exchange rate through panel unit root tests and structural breakdown unit root tests in order to test the long-term validity of Purchasing Power Parity theory. For this purpose, 1994: Q1-2015: Q4 period in G-20 countries. As a result of the analysis, by taking into account the effects of the structural breaks occurring in the period examined, it was found that the SGP theory was valid in all G-20 countries. Jabeen (2018) examined the power of the condition of purchasing power parity in the long term. In this context, the empirical relationship between Pakistan-United Arab Emirates exchange rate and the relative price level were examined. The proposal power parity recommendation was tested by using the Engle Granger (EG) cointegration test. In this study, data for the period of 1981-2014 were used. According to the test of cointegration test, the long-term relationship between the Pakistan-UAE exchange rate and the domestic and foreign price levels were determined. However, it has been detected that the Purchasing Power Parity is not valid in the long term.

3. Basic Model And Data

In most studies, investigating whether Purchasing Power Parity is valid, unit root tests were used primarily. The theory of purchasing power parity is basically put forward as the long-term equilibrium real exchange rate theory. Accordingly, if the unit root tests show that the real exchange rate series is stationary, it is concluded that the SGP is valid and if the real exchange rate series is not stable according to the unit root test results, it is concluded that the PPP is invalid. Widely used unit root tests in the literature Dickey and Fuller (1979), (DF), Augmented Dickey Fuller (1981), (ADF); Phillips and Perron (1988), (PP) tests. However, in these tests, it was observed that there was no dimension breakage problem and structural breaks occurred in the tests. Therefore, tests that examine structural breaks were produced. The tests

produced by considering structural breaks are defined in two ways as single break tests that allow for internal breaks and double breakage tests. As single-break tests, Zivot and Andrews (1992) break root unit tests and Lee and Strazicich (2003-2004) fracture unit root tests can be mentioned. Double break tests can be seen in long-term series. Lumsdaine and Papell (1997) found double-break tests (Yıldırım, Yıldırım, 2012, pp. 230-231).

When testing the validity of PPP, only looking at the classical unit roots and paying not sufficient attention to structural breaks can lead to erroneous results by causing the statistical problems (Tıraşoğlu, 2014, p. 72).

Therefore, the test of the validity of PPP in Turkey, this study uses conventional unit root tests with structural break unit root tests. Between January 2003 and August 2017 in Turkey, IMF Financial Statistical validity of purchasing power parity using monthly data obtained from the CD Rom was tested. The data used are real exchange rate, domestic price level (CPI) and the foreign country price level (CPI). The most important reason for choosing CPI as price index in this study is that this index is able to measure the average changes in the price of a conventional consumption basket in a country and it can be found more easily than other indices.

The real exchange rate series used in the test was created using seasonally adjusted monthly data. The data includes 176 months of observation between January 2003 and December 2017.

4. Results

Expanded Dickey-Fuller to consider structural breaks primarily for Turkey analysis (Augmented Dickey Fuller: ADF), Phillip-Perron (PP) unit root tests with real exchange rate constant, Constants of-trend, including and first aware separately according to different lag length selection criteria and tested whether it is stationary or not. In addition, Lee-Strazicich (LS) (2003) and Carrion-i-Silvestre et al. (2009) tests and the stability of the real exchange rate series were examined.

Firstly, ADF and PP unit root tests as well as standard unit root test results are given in Table 1 for the real exchange rate.

Table 1. Standard unit root test results for real exchange rate

Level				First Difference			
ADF		PP		ADF		PP	
Constant and trend	Constant	Constant and trend	Constant	Constant and trend	Constant	Constant and trend	Constant
- 2,646(2) ^a (0,260) ^b	-2,525 (2) ^a (0,110) ^b	-2,580 (3) ^c (0,289) ^b	- 2,572(2) ^c (0,100) ^b	- 9,596(1) ^a (0,000) ^b	- 9,179(1) ^a (0,000) ^b	-9,138 (8) ^c (0,000) ^b	- 9,011(6) ^c (0,000) ^b

Notes: ^a shows the delay value selected according to the SIC criteria. ^b MacKinnon (1996) shows the p-value. ^c It shows the selected bandwidth value according to the Newey-West criteria.

To determine the appropriate delay for the ADF test, the selected delay value according to the SIC criterion is determined as two. For the PP test, the selected delay value according to the Newey West criteria is fixed and the trend is determined as two in three constants. The ADF and PP fixed and p-values at the level of Table 1 are respectively 0.260 and 0.289. In the steady state, the values of 0,110 and 0,100 respectively are less than 5% and they are not stationary in series level values and there is a unit root. The non-stationary series indicates that they are not normally distributed and have autocorrelation. In this case, the policies applied are not valid.

In order to stabilize a non-stationary series, the difference between each observation is defined as the change-over method (Sevüktekin and Nargeleşkenler, 2010, p. 237). The alternative situations in which we take the first difference of the real exchange rate are shown in detail on the right side of Table 1. When the first difference is taken, p- values are significant at 1%.

Contrary to the previous cases, the first difference of the series was taken, the hypothesis of the series containing the unit root was rejected according to the results of the ADF and PP tests. In this case, there is no unit root and the series is the first aware station.

In general, in Table 1, standard unit root tests (ADF and PP) demonstrate that the real exchange rate is not static, i.e. it contains a unit root. Therefore, purchasing power parity is not valid for the relevant period. However, in the case of structural breaks, standard unit root tests may give misleading results.

The hypothesis of the study was made safer tests to prove it is valid for the purchasing power parity in Turkey.

In order to obtain more reliable results in the study, the results are shown in Table 2 by applying LM unit root tests in which the structural breaks proposed by Lee and Strazicich (2003) are determined internally. The most general model was used, which allowed up to three breaks at the level of the series and the trend. According to the LM principle, a unit root test statistic is obtained from the regression (Kula, 2014, p. 162):

$$\Delta Y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum_{i=1}^k \gamma_i \Delta \tilde{S}_{t-i} + \mathcal{E}_t \quad \text{Equation (2)}$$

Where \tilde{S}_t de-trended series that $\tilde{S}_t = Y_t - \tilde{\psi}'x - Z_t \tilde{\delta}$, for $t = 2, \dots, T$. $\tilde{\delta}$ is a vector of coefficients estimated from the regression of ΔY_t on ΔZ_t and $\tilde{\psi}'x = Y_1 - Z_1 \tilde{\delta}$, where Y_1 and Z_1 are initial observations Y_t and Z_t , respectively. Z_t is a vector of exogenous variables defined by the data generation process of the series. The model includes three breaks in level and trend and is described by $Z_t = [1, t, D_{1t}, D_{2t}, D_{3t}, DT_{1t}, DT_{2t}, DT_{3t}]$, where $DT_{jt} = 1$ for $t \geq T_{bj} + 1$, $j = 1, 2, 3$; and zero otherwise.

The minimum LM unit root t-statistic determines the endogenous location of three breaks. ($\gamma_j = T_{bj} / T$, $J = 1, 2, 3$). The LM unit root test can endogenously determine the two breaks by utilizing a grid search as:

$$LM_t = \inf_{\gamma} \tilde{\tau}(\gamma). \quad \text{Equation (3)}$$

Breaking times in LM unit root tests that allow fracture in the level and slope were determined intrinsically. The rejection of the basic hypothesis in LM unit root tests indicates that the real exchange rate series is stationary and that the purchasing power parity is valid.

The hypotheses for the model in which there are three breaks are as follows;

$$H_0: Y_{i,t} = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + d_3 B_{3t} + d_4 D_{1t} + d_5 D_{2t} + d_6 D_{3t} + Y_{i,t-1} + v_{1t}$$

$$H_1: Y_{i,t} = \mu_1 + \gamma_1 + d_1 D_{1t} + d_2 D_{2t} + d_3 D_{3t} + DT_{1t} + DT_{2t} + DT_{3t} + v_{2t}$$

In Table 2, it is statistically significant in the three breaks that are predicted as a result of the three shear unit root tests, both in the fixed and in the trend or in the stationary or in the trend. A closer look at the fractures is

not statistically significant in the January-2005 break, although the same fracture period is statistically significant for the trend. July 2007 and September 2013 fractures are statistically significant for both trend and constant. Therefore, it is not necessary to repeat the unit root test with less break and can be interpreted as such.

Table 2: Three Structural Breaks LM Unit Root Test Results for Real Exchange Rate (Lee and Strazicich)

Breaks	D_{Ocak-2005}	D_{Temmuz-2007}	D_{Eylül-2013}	T_{Ocak-2005}	T_{Temmuz-2007}	T_{Eylül-2013}	LM
Ocak - 2005 Temmuz-2007 Eylül-2013	-0,022 (-0,833) ^b	0,065 (2,375) ^b	-0,067 (-2,471) ^b	0,046 (4,204) ^b	-0,036 (-4,009) ^b	0,029 (4,719) ^b	- 0,353(8) ^a (-5,989) ^c

Notes: ^a indicates the delay value. ^b It shows the t values of the variables. ^c The calculated LM test shows the statistical value. LM test critical values were considered to be 4,545 (1%), 3,542 (5%) and 3,504 (10%).

The hypothesis that the real exchange rate contains unit root is rejected at 1% level. According to this result, the real exchange rate series is stationary. That is, purchasing power parity applies. In order to determine whether the fractures are meaningful, statistics are compared with the absolute values of 1%, 5% and 10%. At the 5% significance level, the LM test has a critical value of 3,542 and is therefore rejected at this level. The parameters are significant and the real exchange rate is stable.

In the LM test, the calculated test statistic (-5,989) will be compared with the 1 per cent significance level (4,545), 5 percent significance level (3,542) and 10 per cent significance level (3,504). H_0 hypothesis is considered when the value is greater than the critical value (without considering the absolute value) and it is decided that the series is the root of the unit if there are structural breaks. According to LM unit root test results; Turkey's exchange rate series comprise units with fixed and root model with a significance level of 1%, while the constant and trend model that does not contain a stationary unit root. These results differ from ADF and PP test statistics. That is, purchasing power parity for Turkey is valid for a fixed and trendy model.

5. Conclusion

Purchasing power parity is one of the cornerstones of international macroeconomics. The PPP argues that the nominal and exchange rate should be determined by the differences between foreign and domestic inflation rates. PPP states that prices in two different countries should be equal to each other when expressed in the same currency. PPP is the long-term theory of the equilibrium exchange rate, therefore, there may be deviations from the PPP in the short term. However, in the long run, there should be forces to return the exchange rate to the PPP.

The validity of the PPP has great importance for the monetary and fiscal policies of the countries. The existence of unit root in the examination of the PPP hypothesis indicates that the series are not stable in the long term. In case of structural breaks in the series of countries, the unit root has been rejected and the real exchange rate has been observed and thus the PPP has been valid. Monetary policy decisions to be administered to be valid PPP in Turkey retrieving, if the PPP means utilized will give accurate results.

Stabilization of the exchange rate is important in order to steer the markets and reduce inflation. As a result of time series analysis of purchasing power parity in 2003 January - 2017 December, the exchange rate policy implemented in Turkey has demonstrated that it is successful and active on economic activity. In the analysed period, Turkey has had a very serious crisis period, they are also buying unconventional monetary policies that circumvented by application of force it is seen by the fact that the current parity.

The stabilization of the exchange rate significant to steer the markets and reduce inflation. These were also seen with the validity of purchasing power parity in which non-traditional monetary policies were overcome.

As in previous studies, the validity of purchasing power parity changes with the variances in the analyzes. SGP parity was found to be invalid in the classical unit root tests and it was found to be valid when the same test was tested with the unit root test.

6. References

- Arize, A. C., Malindretos, J., & Ghosh, D. (2015) Purchasing power parity-symmetry and proportionality: Evidence from 116 countries. *International Review of Economics & Finance*, 37, 69-85.
- Aslan, A. ve Kula, F. (2011) Purchasing Power Parity in Eastern European Countries: Further Evidence from Black Market Exchange Rates. *Amfiteatru Economic*, 13(29), 287-294.

- Cassel, G., (1918) Abnormal Deviations in International Exchanges, *The Economic Journal*, 28(112):413-415
- Gerek, S. ve Karabacak, M. (2017) Satın Alma Gücü Paritesi Yaklaşımı ile Türkiye’de Reel Döviz Kuru Yanlış Dengelenmesinin Belirlenmesi: Yapısal Kırılmalı ve Doğrusal Olmayan Birim Kök Testleri İle Bir Analiz. *Journal of Life Economics*, 4(1), 1-24.
- Hakkio, C. S. (1982) A Reexamination of Purchasing Power Parity: A Multi-Country and Multi-Period Study. NBER Working Paper, No. 865, March.
- Jabeen A. (2018) Exchange Rate Determination in the Long Run for Pakistan: A Purchasing Power Parity Approach. *RJ Economics, Marketing and Management*, 1(1):1-8
- Kula, F. (2014) Is Per Capita Electricity Consumption Non-stationary? A Long-span Study for Turkey. *Energy Sources, Part B: Economics, Planning, and Policy*, 9(2), 161-164.
- Lee, J., Strazicich M. C., (2004) Minimum LM Unit Root Test with One Structural Break, *Appalachian State University, Working Papers No.04-17*, p.1.
- Sarno L. and Mark P. Taylor (2002) *The Economics of Exchange Rates*. Cambridge University Press
- Sevüktekin, M., & Nargeleşkenler, M. (2010) *Ekonometrik Zaman Serileri Analizi, Genişletilmiş 3. Baskı*, Ankara: Nobel Kitabevi.
- Taylor, Mark P. (1988). An Empirical Examination of Long-Run Purchasing Power Parity Using Cointegration Techniques, *Applied Economics*, 20:1369-1381.
- Telatar, E. ve Kazdağlı, H. (1998). Re-Examine The Long Run Purchasing Power Parity Hypothesis for A High Inflation Country: The Case of Turkey 1980-93, *Applied Economics Letters*, 5:51-53.
- Tıraşoğlu, B. Y. (2014) Yapısal Kırılmalı Birim Kök Testleri İle Oecd Ülkelerinde Satın Alma Gücü Paritesi Geçerliliğinin Testi. *Ekonometri ve İstatistik e-Dergisi*, (20), 68-87.
- Yalçınkaya, Ömer. (2016) G-20 Ülkelerinde Satın Alma Gücü Paritesi Teorisinin Geçerliliği: Panel Birim Kök Testinden Kanıtlar (1994: Q1-2015: Q4). *Uluslararası Sosyal Bilimler Sempozyumu*, 145.
- Yıldırım S., Yıldırım Z., (2012) Reel Efektif Döviz Kuru Üzerinde Kırılmalı Birim Kök Testleri ile Türkiye İçin Satın Alma Gücü Paritesi Hipotezinin Geçerliliğinin Sınanması, *Marmara Üniversitesi İ.İ.B. Dergisi*, 33 (2): 221-238.