Validity of Purchasing Power Parity in Fragile Five Countries:
The Bayesian Unit Root Analysis

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The Purchasing Power Parity (PPP) is one of the most debated issues in international economy. The purchasing power validity of the Fragile Five countries (Brazil, Indonesia, South Africa, India and Turkey) for the period 1990:Q1 – 2016: Q2 period was tested using the ADF and Sims (1988) Bayesian unit root test in this study. The analysis showed that the PPP is valid only for India.

Keywords: Bayesian Unit Root Tests, Stationarity, Purchasing Power Parity, Fragile Five Countries

Introduction

The Purchasing Power Parity (PPP) theory was first introduced to the literature by the Swedish economist Gustav Cassel in 1918, but the idea underlying the PPP dates back to the academic writings of scientists at Salamanca University in the 15th and 16th centuries. The Purchasing Power Parity theory, which is one of the most important and most debated topics of international economy, is based on the Single Price Law. The Purchasing Power Parity is a version of the Single Price Law applied to international markets. The Single Price Law argues that in an environment where transportation costs, trade barriers and taxes do not exist, the prices of similar goods traded in different countries must be equal when expressed in the same currency.

The meaning of PPP is clear where the Single Price Law is applicable. The theoretical and practical content of PPP is not clear in an environment where there are relative price changes, different consumer preferences among countries, goods not subject to trade and where there is uncertainty (Shapiro, 1983, p.295).

Although PPP is sometimes referred to as a "theory" of exchange rate behavior, a more appropriate interpretation of the PPP is seen as a long-term equilibrium relationship among the internal variables. According to this interpretation, despite the possibility of deviation from the PPP value in the short run, the exchange rate will return to a level consistent with the PPP in the long run (Mahdavi and Zhou, 1994, p.403). PPP is usually a default equilibrium

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situation in both theoretical and practical economic analysis. This equilibrium equals the prices of the goods of the two different countries that are subject to trade.

PPP is handled in two different ways, namely absolute and relative. Absolute PPP extends the single price law to the general price level (Hakkio, 1992, p. 38). In absolute terms, PPP means that the exchange rate between the domestic and foreign currencies is the same as the ratio between the domestic and foreign price levels. The relative version of the PPP indicates that the proportional changes in domestic and foreign prices will be equal to the proportional exchange rate exchange between domestic and foreign currencies (Shapiro, 1983, p.295).

A common approach to test the validity of the PPP theory is to test the stationarity of real exchange rates. The non-stationarity of the real exchange rate series indicates that there is no long-term relationship between the nominal exchange rate and the domestic and international price levels, ie, the PPP theory is invalid.

Emerging market economies are more vulnerable to economic crises as their economic systems are not at a sufficient level of development and as they have political and monetary policy risks. The shocks caused by the crises can cause the economies of these countries to become fragile. The concept of fragility has been used by the American investment bank Morgan Stanley to define the countries most vulnerable to global capital flows based on the current account deficit/GDP ratio (Karakurt, Şentürk and Ela, 2015, p. 284). The economy report prepared by James K. Lord and published by the investment bank Morgan Stanley on August 1, 2013 refers to Brazil, Indonesia, South Africa, India and Turkey as the Fragile Five countries. After the announcement by the Federal Reserve (FED) that it will reduce bond purchases, these five countries were the countries among the emerging market economies with the greatest loss of value of currency leading to the emergence of the Fragile Five Group. The common reasons for the inclusion of these countries within this group are as follows: current account deficit, inflation rate, high unemployment rates, decline in the growth rate, continuous depreciation of the currencies of these countries against the US dollar, political instabilities of the countries due to the elections at that time, their dependence on foreign financing and the fact that they are in the middle income trap.

In this study, it was aimed to investigate the validity of the purchasing power parity for the fragile five countries among the emerging market economies. The study consists of five parts. In the second section of the study that reference will be made to relevant literature. Information about the data set and the econometric methodology used will be given in the third section. The results obtained from the analysis will be shared in the fourth section, while the results obtained will be interpreted in the fifth and last section. The study contributes to literature by analyzing the purchasing power validity of fragile five countries within the framework of Bayesian unit root tests that provide the possibility of incorporating prior knowledge into the analysis and by revealing that more reliable results can be obtained compared to the classical unit root test.

**Literature**

There are many studies in literature that investigate the validity of the purchasing power parity with classical, structural, panel, nonlinear unit root tests and cointegration tests and deal
with various country or country groups. In this part of the study, some of the applied studies including fragile five countries are given.

Holmes (2001) investigates the stationarity of the quarterly series of real exchange rates of 30 underdeveloped countries for the period 1973-1999. It is concluded in the subgroup-based analysis that the PPP does not apply for the majority of underdeveloped countries. Bahmani-Oskooee, Hegerty and Kutan (2009) investigate the validity of PPP using non-linear unit root tests for the data period 1994:04-2007:06 for 88 underdeveloped and developing countries. According to the results of the study, PPP applies for China and India but not for any other countries.

Bozkulu and Yılançı (2010) investigate the stationarity of the real exchange rates of E7 countries using unit root tests with structural breaks for the period 1995:01-2009:12 and conclude that PPP applies for the consumer price index but not for the producer price index.

Büberkökü (2014) investigates the validity of the PPP for the period of 2003: 01-2012: 12 for 21 emerging market economies. As a result of panel cointegration tests, the weak form of the PPP compared to the first generation tests and the PPP relative to the second generation tests are not valid.

Lee and Chou (2013) investigate the real exchange rate stationarity of G20 countries using 1994: 01-2014: 04 monthly data. Analysis made using the panel unit root tests show that the real exchange rates for the panel are stationary in the G20 countries and that the PPP applies for them.

Alper (2015) investigates the PPP validity of the BRICS (Brazil, Russia, India, China and South Africa) countries with the KSS unit root test and the rounded off KSS unit root test for the period 2001: 01-2014:09. In the KSS unit root test, the PPP does not apply for any of the countries, while when the KSS unit root test is rounded off, the PPP is valid in short time intervals.

Sağlam and Sönmez (2017) investigate the PPP validity with multiple structural break tests for the BRICT (Brazil, Russia, India, China and Turkey) countries. According to the results obtained, PPP theory does not apply in the BRICT countries.

Gürüş and Turaşoğlu (2017) investigate the purchasing power parity validity of the BRICS (Brazil, Russia, India, China and South Africa) countries by applying linear and nonlinear unit root tests using the monthly data of 1993: 01-2015:03. As a result of the study, it is seen that the real exchange rate series of the BRICS countries have a non-linear structure and that the PPP applies only to Brazil and South Africa.

Gürüş et al. (2017) applies the Lee and Strazicich (2003) test for linear series and the Sollis test (2009) for nonlinear series in the linearity tests of E7 countries for the period of 2000: 01-2016:10 to investigate the PPP validity. As a result of the analysis, it concludes that the PPP applies only for the linear series that allow for intercept and trend breaks in the Brazilian and Indian models, whereas the PPP applies only for China in the average neutralized model in nonlinear series.
Since the introduction of the concept of fragile five, more and more applied studies have been conducted exploring the validity of the PPP theory for fragile five countries. Çeviş and Ceylan (2015) investigate the validity of the PPP theory in fragile five countries with the help of cointegration test for the period 2003: 1-2013: 8. According to the analysis results, there is a long-term relationship between nominal exchange rate, domestic consumer price index and the consumer price index of the US with Brazil, India, South Africa and Turkey. In other words, PPP applies for these countries.

Atasoy (2016) investigates the validity of the purchasing power parity for the Fragile Five countries using the 1996: 05-2013:12 data and the ADF unit root test. The study concludes that the PPP does not apply for Brazil, India, South Africa and Turkey whereas it applies only for Indonesia.

Umit (2016) investigates the stationarity of real exchange rates of the Fragile Five countries for the period 2003:01 – 2015:10 using the ADF, Phillips-Perron, Zivot-Andrews, Lee-Strazicich and Carrion-i-Silvestre tests. The PPP does not apply for all Fragile Five countries in the ADF and Phillips-Perron tests, the PPP only applies for Brazil and India in the Zivot-Andrews test and only for India in the Lee-Strazicich test whereas it applies for Brazil, Indonesia and Turkey in the Carrion-i-Silvestre test.

Some studies examining the validity of the PPP for Turkey include Akgül (1995), Civcir (2003), Sayyan (2005), Çağlayan and Saçaklı (2006), Gülöğlu and Ispir (2009), Yavuz (2009), Tişaloğlu (2014) and Gürüş et al. (2016). It seems that there is no common conclusion regarding the validity of the PPP theory based on the applied studies carried out over different data periods for different countries/country groups. The main reasons for failure to arrive at a common conclusion include the econometric methods used, the data period covered, country groups, price indices, and different currencies of the countries taken as the basis. The interest shown in the investigation of the validity of theory continues since a common conclusion cannot be derived as a result of research.

**Dataset**

The purpose of the study is to investigate the validity of the PPP by testing the stationarity of the real exchange rates of the Fragile Five countries (Brazil, Indonesia, South Africa, India and Turkey) for the period 1990: Q1 – 2016:Q2.

In order to test the validity of the PPP theory, the real exchange rates of the Fragile Five countries are calculated using the following equation:

$$RER_t = \frac{P_{t, foreign}}{P_{t, domestic}} \cdot NER_t$$

The real exchange rates in natural algorithmic form are obtained using the following equation:

$$\ln(RER_t) = \ln(NER_t) + \ln(P_{t, foreign}) - \ln(P_{t, domestic}).$$
\( R_{ER,t} \) indicates the real exchange rate in the time \( t \), \( N_{ER,t} \) indicates the nominal exchange rate in the time \( t \), \( P_{t}^{\text{foreign}} \) and \( P_{t}^{\text{domestic}} \) indicate the price levels of the foreign country and the domestic country in question in time \( t \).

For the Fragile Five countries, the nominal exchange rates of the currencies of each country in US Dollars (US Dollars) and the consumer price indices of 2010 = 100 base years are taken into account. The data used in the study were obtained from the International Monetary Fund's International Financial Statistics (IFS) database.

The long-term validity of the PPP theory depends on the real exchange rate going back to the average. Stability tests can be used to analyze whether real exchange rates have gone back to the average.

**Methodology**

The AR(1) equation is estimated first in the Sims (1988) Bayesyen unit root test based on the Bayesian a posteriori odds ratio;

\[
Y_t = \rho Y_{t-1} + \varepsilon_t.
\]

Here the null hypothesis is expressed as \( \rho = 1 \) and the alternative hypothesis is expressed as \( \rho < 1 \).

Sims (1988) offers a priori distribution with uniform distribution for the interval of \( 0 < \alpha < 1 \) for the coefficient of \( \rho \) with a probability of \( \alpha \) and for the unit root (\( \rho = 1 \)), the \( (1 - \alpha) \) probability is given (Sims, 1988, s. 470). The similarity function has a normal reverse-gamma shape based on the initial observations. The marginal similarity rate for \( \rho \) has got \( t \) distribution with \( T-1 \) degree of freedom. This distribution is very close to the normal distribution for large \( T \) values \( N(\hat{\rho}, \sigma_p^2) \).

The Sims statistics (Sims, 1988, p. 470-471) is expressed using the following equation:

\[
\gamma = 2\log\left(\frac{1-\alpha}{\alpha}\right) - \log(\sigma_p^2) + 2\log\left(1 - 2^{-1/S}\right) - 2\log[\Phi(\tau)] - \log(2\pi) - \tau^2
\]

The \( s \) shows the number of periods in a year (for ex. for data with quarters, this value is 4). In the (3.14) equation, the part except \( \tau^2 \) is the Schwarz criterion. The Schwarz criterion has got an asymptotic Bayesyen logic and is accepted as the asymptotic Bayesyen critical value (Mishra, Quattara and Parhi, 2011, p. 1877). Sims (1988) claims that the \( 2\log[\Phi(\tau)] \) term in the (3.14) equation can be overlooked. Since \( \rho < 1 \) is the case, it is probable that this term is small and asymptotic. Sims (1988) also leaves out the term \( \log(2\pi) \) out of the equation (Moosa and Bhatti, 1996, p. 181).

Whether or not there is a unit root in the series is determined according to the "\( t^2 \)" test statistics or Marginal \( \alpha \) values. In the series where the \( t^2 \) test statistics is greater than the Schwarz limit, the unit root null hypothesis is rejected. Small marginal \( \alpha \) values also provide
strong evidence against the unit root hypothesis, but there is no specific level at which marginal $\alpha$ should be included.

**Empirical Findings**

Table 1 summarizes the results of the Augmented Dickey Fuller (ADF) test, in which both intercept and intercept and trends are taken into account for the real exchange rate series of the Fragile Five countries for the period 1990: Q1 - 2016: Q2.

In the ADF unit root test, the maximum lag length is calculated according to the Schwert criterion and is taken as 12. According to the results of the ADF test, which is a classical unit root test, the unit root null hypothesis cannot be rejected for all the countries in the intercept model whereas the unit root null hypothesis cannot be rejected for countries other than India in the intercept and trend model. In the intercept and trend model, the unit root null hypothesis for the Indian real exchange rate series is rejected with a significance level of 10%. According to the intercept and trend ADF test result, the real exchange rate series in India is stationary and the PPP theory applies. The real exchange rates of Brazil, Indonesia, South Africa and Turkey exchange rate series are not stationary, in other words, the shocks to these series are permanent.

**Table 1**

*ADF Unit Root Test Results*

<table>
<thead>
<tr>
<th>Countries</th>
<th>Intercept</th>
<th></th>
<th>Intercept + Trend</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test Statistics</td>
<td>Prob</td>
<td>Test Statistics</td>
<td>Prob</td>
</tr>
<tr>
<td>Brazil</td>
<td>-2.044</td>
<td>0.268</td>
<td>-2.056</td>
<td>0.564</td>
</tr>
<tr>
<td>Indonesia</td>
<td>-2.055</td>
<td>0.264</td>
<td>-2.022</td>
<td>0.582</td>
</tr>
<tr>
<td>South Africa</td>
<td>-1.546</td>
<td>0.506</td>
<td>-2.043</td>
<td>0.571</td>
</tr>
<tr>
<td>India</td>
<td>-1.832</td>
<td>0.363</td>
<td>-3.254</td>
<td>0.080***</td>
</tr>
<tr>
<td>Turkey</td>
<td>-1.547</td>
<td>0.506</td>
<td>-2.448</td>
<td>0.353</td>
</tr>
</tbody>
</table>

Note: The Schwarz Information Criterion is used to determine the optimal lag length. *, ** and *** indicate the levels of significance of 1%, 5% and 10% respectively.

The second test used to investigate the stationarity of the real exchange rate series of Fragile Five countries is the Sims (1988) unit root test based on the Bayesian approach. The Sims (1988) Bayesian unit root test results are given in Table 2 for the model with and without trend.
Table 2
Sims (1988) Bayesian Unit Root Test Results

<table>
<thead>
<tr>
<th>Countries</th>
<th>k</th>
<th>( t^2 )</th>
<th>Schwarz Limit</th>
<th>Small Sample Limit</th>
<th>Marginal ( \alpha )</th>
<th>k</th>
<th>( t^2 )</th>
<th>Schwarz Limit</th>
<th>Small Sample Limit</th>
<th>Marginal ( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>2</td>
<td>4.178</td>
<td>7.112</td>
<td>-1.164</td>
<td>0.217</td>
<td>2</td>
<td>4.225</td>
<td>7.097</td>
<td>-1.179</td>
<td>0.212</td>
</tr>
<tr>
<td>Indonesia</td>
<td>4</td>
<td>4.222</td>
<td>6.522</td>
<td>-1.753</td>
<td>0.168</td>
<td>4</td>
<td>4.087</td>
<td>6.505</td>
<td>-1.770</td>
<td>0.176</td>
</tr>
<tr>
<td>South Africa</td>
<td>1</td>
<td>1.085</td>
<td>7.144</td>
<td>-1.132</td>
<td>0.569</td>
<td>2</td>
<td>4.174</td>
<td>6.841</td>
<td>-1.435</td>
<td>0.195</td>
</tr>
<tr>
<td>India</td>
<td>2</td>
<td>3.356</td>
<td>7.407</td>
<td>-0.868</td>
<td>0.326</td>
<td>2</td>
<td>10.590</td>
<td>7.117</td>
<td>-1.159</td>
<td>0.011</td>
</tr>
<tr>
<td>Turkey</td>
<td>1</td>
<td>2.394</td>
<td>7.146</td>
<td>-1.130</td>
<td>0.407</td>
<td>2</td>
<td>5.995</td>
<td>6.440</td>
<td>-1.835</td>
<td>0.074</td>
</tr>
</tbody>
</table>

Note: The table shows the "\( t^2 \)" test statistics, the "Schwarz Limit" shows the asymptotic critical values for test statistics and the "Small Sample Limit" shows the Bayesian critical values for final samples. "Marginal \( \alpha \)" is a criterion showing how strong the rejection of the unit root null hypothesis is.

In the Sims (1988) test, the \( \alpha \) value (as suggested by Sims), which indicates the a priori likelihood of the autoregressive coefficient over the stationary values, is taken as 0.8. According to the no trend test results in Table 2, the \( t^2 \) test statistics for real exchange rate series of five countries is smaller than the Schwarz limit and the unit root null hypothesis cannot be rejected. According to the test results in which the trend is included, the \( t^2 \) test statistics for the real exchange rate series of India is bigger than the Schwarz limit and the unit root null hypothesis is rejected. The PPP theory applies for India. For Brazil, Indonesia, South Africa and Turkey, the \( t^2 \) test statistics is less than the Schwarz limit and the unit root null hypothesis is not rejected. The real exchange rates of these four countries are not stationary, in other words the PPP theory does not apply for these countries.

In contrast to the results of ADF classical unit root tests, India's real exchange rates are stationary and the PPP theory applies for India according to the Sims (1988) test.

Conclusion

The purpose of this study is to analyze whether the theory of purchasing power parity is valid in the fragile five of the most discussed theories of international economics. To this end, the stationarity of the real exchange rate series of the Fragile Five countries for the data period 1990: Q1 - 2016: Q2 is analyzed using the ADF and Sims (1988) Bayesian unit root test. Classical and Bayesian unit root test results support each other. According to the results obtained, in the ADF test and Sims test, where intercept and trend are taken into consideration, the real exchange rate series in four countries except India are not stationary. PPP does not apply for Brazil, Indonesia, South Africa and Turkey for the period in question. The PPP applies for India based on the intercept and trend ADF classical unit root test and the Sims Bayesian unit root test results.

There could be several reasons why the real exchange rates for Brazil, Indonesia, South Africa and Turkey do not go back to the average value in the long term so there could be several reasons why the PPP theory is not valid. Factors such as the impact of shocks on relative exchange rates and consumer price indexes, the existence of policies preventing
foreign trade, the different product baskets that make up consumer price indices and the cost of transport are some of the reasons why PPP is not valid. Making income comparisons based on PPP or taking policy decisions may lead to erroneous results in these countries. In order for these countries to use the PPP in determining the exchange rate equilibrium value, it would be appropriate to remove the factors that create financial fragility and to identify the obstacles that prevent the validity of the PPP and take required measures.

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