THE VALIDITY OF PURCHASING POWER PARITY IN THE BRICS COUNTRIES

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Abstract

It is observed that purchasing power parity (PPP) as one of the controversial and most interesting topics of international macroeconomics literature is tested by using different econometric methods for certain countries and/or country groups by many researchers. The validity of PPP is important in terms of being a common exchange rate used in international comparison. In this context, the validity of relative purchasing power parities in the BRICS countries (Brazil, Russia, India, China and South Africa) were analysed for the January 1993–March 2015 period. Non-linear stationarity analysis was used in the study. According to the findings of the analysis, it was concluded that all of the BRICS countries have a non-linear structure; the PPP approach was valid for Brazil and South Africa, but not valid for Russia, India and China in the relevant period.

Keywords: purchasing power parity, BRICS countries, Fourier stationary test, nonlinearity
JEL Classification: C22, F31

1. Introduction

The exchange rates that have an important place in the economic structure of countries and the different approaches to exchange rates have drawn an attention of many researchers and policy makers. A common approach in literature to currency exchange rates is the analysis of the validity of purchasing power parity. The importance of the purchasing power parity (PPP) first introduced by the Swedish economist Gustav Cassel (1918) has started to increase after the collapse of the Bretton Woods system and the fluctuation of the exchange rates.

PPP has been one of the controversial issues of international economics especially since the 1970s. PPP as one of the indicators used in the comparison of the levels of development between countries is the equation between the increase in the rate of foreign currency and the difference in inflation between the domestic and foreign country. Of course, high inflation rates reduce the value of the currency of the country (Enders and Falk, 1998). If expressed in a common currency, PPP offers the necessary adjustments to market exchange rates in order for the price of an item to be identical as in two countries (Majumder, Ray and Sinha, 2011).

PPP can be defined under two subtitles as absolute and relative purchasing power parity. Absolute PPP refers to the fact that purchasing power of the domestic currency is the same in foreign countries. Relative PPP means a proportional change of nominal exchange rates corresponding to relevant currencies against changes in national price levels (Coakley *et al*., 2005). Due to the complex structure of the economy and differences between nations, it is seen that relative PPP is more commonly used in studies.

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It is observed that there is a wide range of literature related to the PPP theory that is examined and still being explored by many researchers for countries or country groups. Some of the prominent studies in the literature are Roll (1979), Adler and Lehmann (1983), Dornbush (1985), Rogoff (1996), Papell (1997), Sarno and Taylor (1998), Culver and Papell (1999), Lothian and Taylor (2000), Cheung and Lai (2001), Kapetanios, Shin, Snell (2003), Taylor and Taylor (2004), Taylor (2006), Cerrato and Sarantis (2007), Lothian and Taylor (2008), Bahmani-Oskooee, Hegerty and Ku (2009), Zhou and Ku (2011), Bahmani-Oskooee, Chang and Hung (2013), the Bahmani-Oskooee, Chang and Wu (2015).

In their study, Froot and Rogoff (1994) stressed that there are three different stages in the analysis of the validity of PPP: (i) old tests showing the validity of PPP under basic hypothesis; (ii) PPP completely permanent under basic hypothesis with newer methods and time series tests; (iii) the linear combination of the exchange rate and the price permanent under basic hypothesis with much newer techniques such as co-integration tests.

The validity of PPP refers to the fact that real exchange rates are permanent in the long term by having a mean reversion. If the changes that occur in the price levels do not change the nominal exchange rate at the same rate, the real exchange rates will not tend to gravitate to the value of the equilibrium in the end. PPP validity depends on several phenomena; PPP model does not take into account the transportation cost and tariffs; the sticky prices do not allow efficient market hypothesis and use of different goods baskets for the index calculation. There are different techniques for the exploration of mean reversion in real exchange rate. The most common of these techniques are the unit root tests testing the stability of real exchange rates. It is observed in literature that the validity of PPP is examined by using linear, structural breaks, non-linear and panel unit root tests in accordance with the structure of the classified series.

The method frequently used to test PPP empirically is the use of unit root tests. If the realexchange rate is stationary, the shocks will have a temporal effect. If the real exchange rate contains a unit root, then the shocks will have a permanent effect. This means that the purchasing power parity is invalid (Cuestas and Regis, 2013). The validity of PPP for the BRICS (Brazil, Russia, India, China and South Africa) countries was analysed by using Becker, Enders and Lee (2006) nonlinear stationary test. Becker, Enders and Lee (2006) suggested a KPSS type nonlinear stationary test, and they used trigonometric terms to capture unknown nonlinearities with the Fourier approximation. The reason for preferring these tests is that the transition between regimes considered to be more appropriate for the economic structure is smooth and has a better power than previous tests. According to our knowledge, there are no other studies that examine the validity of the purchasing power parity in the BRICS countries by using this method.

The BRICS countries have an important place among country groups and the world economy. The BRICS countries have approximately 26% of the world land area. However, this country group with a young and dynamic population has nearly 40% of the world's population. According to 2014 data, combined nominal GDP of these five countries is equivalent to 20% of world GDP. Another important feature of the BRICS is their projection of building a new Development Bank with $ 100 billion reserve as a competitor to the World Bank. For this purpose, empirical studies about the PPP of the BRICS countries will be examined after giving

information about the PPP. After that, the econometric method that will be used in the analysis of the validity of PPP for the BRICS countries will be introduced and its importance will be highlighted. Finally, the findings of the econometric study will be evaluated.

2. Literature Review

The validity of PPP theory is analysed for different countries and/or country groups by using econometrics and time-series methods. It is observed that different results are obtained in empirical studies. The main reasons for this are that the period under review is different, the econometric method used in the review and the tests of this method differ from each other, the types of price indexes are different from each other, *etc*. Table 1 shows the empirical studies regarding the validity of PPP in the BRICS countries. When the table related to literature review is examined, it is observed that there is no common decision about the validity of PPP.

Table 1 | Literature about the BRICS Countries

Author	Countries	Data Range	Method	Finding
Su, Horng and Wu (2008)	BRIC	June 1992-December 2006	Linear and Nonlinear Cointegration test	PPP is not valid in Linear Cointegration, PPP is only valid for China in Nonliear Cointegration
Bahmani-Oskooee Hegerty and Kutan (2009)	52 Country	January 1994-June 2007	Unit root test	PPP is only valid for China and India
Chang, Su, Zhu, and Liu (2010)	BRIC	July 1992-December 2006	Linear and Nonlinear Cointegration test	PPP is not valid for China, PPP is valid for others countries
Chang, Lee and Hung (2012)	BRIC	January 1996-July 2010	Nonlinear Cointegration test	PPP is not valid for Brazil, PPP is valid for others
Su, Chang, Chang and Lee (2012)	BRIC	January 1996-July 2010	Nonlinear unit root test	PPP is valid for all countries
Bahmani-Oskooee Chang and Lee (2014)	BRIC	January 1994-June 2012	Linear, Nonlinear and Panel unit root tests	Mixed results
Baghestani (1997)	India	1973-1991	Linear Cointegration test	PPP is valid
Bahmani-Oskooee and Barry (1997)	Russia	May 1991-March 1995	Linear Cointegration tests	PPP is valid
Guimaraes-Filho (1999)	Brazil	1855-1990	Unit root tests	PPP is valid
Alves, Cati and Fava (2001)	Brazil	1855-1996	Cointegration test	PPP is not valid
Caporale and Gil-Alana (2010)	South Africa	1990-2008 Daily, Weekly, Monthly data	Unit root test	PPP is not valid
Gregory and Shelley (2011)	China	January 1986-September 2006	Unit root tests	PPP is not valid

Source: Authors.

3. Data and Methodology

The validity of PPP for the BRICS (Brazil, Russia, India, China and South Africa) countries was analysed by using the new time series methods. The relevant series in the study are monthly data covering the January 1993–March 2015 period and the KPSS stationarity test developed by Kwiatkowski *et al.* (1992) and the Fourier stationarity test developed by Beckers, Enders, and Lee (2006) were used. The data that are used in the analysis have been obtained from the OECD data and all series are used in logarithmic form. The real exchange rates series for the validity of PPP are obtained from the Equation 1.

$$y_{i,t} = s_{i,t} + p_{us,t} - p_{i,t} \tag{1}$$

Here $y_{i,t}$ represents the logarithmic real exchange rates, $s_{i,t}$ represents the logarithmic nominal exchange rate (units of domestic currency *per* U.S. dollar), $p_{us,t}$ represents the logarithmic price index (US), and $p_{i,t}$ represents the *i* country's logarithmic price index.

The method frequently used to test PPP empirically is the use of unit root tests. Unit root test or stationary test is a crucial issue in time series analysis for an empirical study. The basic problem experienced in unit root tests is that the correct model specification cannot be determined. Enders and Granger (1998) demonstrate that the standard tests for unit root and cointegration all have lower power in the presence of misspecified dynamics. Perron (1989) showed that when the existing structural break ignored the conventional unit root tests, it will be biased towards not rejecting a false null of a unit root. A similar phenomenon occurs in nonlinear models. If the data are nonlinear, then the linear unit root tests will face the problem of power. These test results will be the non-rejection of the null hypothesis and biased (Cuestas and Garrant, 2011).

A lot of unit root tests have been developed for nonlinear time series analysis (*e.g.* Enders and Granger (1998), Leybourne, Newbold and Vougas (1998), Caner and Hansen (2001), Kapetanios, Shin and Snell (2003) and Park and Shintani (2005)). Becker, Enders and Lee (2006) developed a nonlinear stationary test with the Fourier function. They suggested a KPSS type nonlinear stationary test, and they used trigonometric terms to capture unknown nonlinearities with the Fourier approximation.

Following the Becker, Enders and Lee (2006) study, the data generating process (DGP) is

$$\begin{aligned} y_t &= X_t'\beta + Z_t'\gamma + r_t + \varepsilon_t \\ r_t &= r_{t-1} + u_t \end{aligned} \tag{2}$$

where ε_t and denotes respectively, stationary errors and iid with variance σ_u^2. They suggested $Z_t = \left[\sin(2\pi kt/T), \cos(2\pi kt/T)\right]'$ to capture a break in the deterministic term. Here, *k* represents the number of frequencies and *T* is sample size. Following the Becker, Enders and Lee (2006), we consider the following Fourier series;

$$\alpha(t) = \alpha_0 + \sum_{k=1}^{n} \alpha_k \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^{n} b_k \cos\left(\frac{2\pi kt}{T}\right); \qquad n < \frac{T}{2} \tag{3}$$

where n shows the number of frequencies contained in the approximation (Becker, Enders and Lee, 2006). They suggest the two following regressions and where $\tilde{e}_t$ denote residuals;

$$y_t = \alpha + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + e_t \tag{4}$$

$$y_t = \alpha + \beta_t + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + e_t \tag{5}$$

While Equation 4 tests the null of level stationary, Equation 5 tests the null of trend stationary (Chang, 2011). The Fourier stationary test statistics $\tau_\mu(k)$ or $\tau_\tau(k)$ for Equation 4 and Equation 5;

$$\tau_\mu(k) \text{ or } \tau_\tau(k) = \frac{1}{T^2} \frac{\sum_{t=1}^{T} \tilde{S}_t(k)^2}{\hat{\sigma}^2} \tag{6}$$

where $\tilde{S}_t(k) = \sum_j^t \tilde{e}_j$ and $\tilde{e}_j$ represents OLS residuals from the Equation 4 and Equation 5, respectively. They suggest that a nonparametric estimate of as in KPSS;

$$\tilde{\sigma}^2 = \tilde{\gamma}_0 + 2\sum w_j \tilde{\gamma}_j \tag{7}$$

where $\tilde{\gamma}_j$ is the j-th sample autocovariance of residual from Equation 4 and Equation 5, respectively (Becker, Enders and Lee, 2006). They obtained a critical value for their stationary test with the aid of Monte Carlo simulations, which is k between 1, …, 5 and sample size (T) of 100, 500 and 1000 observations. They tabulated the critical values of the linearity test and stationary test in their study.

In the case where there is no non-linear trend, a standard KPSS test will be stronger. For this reason, the lack of a non-linear trend must be tested. Becker, Enders and Lee (2006) suggest the following F-test statistics calculated against the alternative nonlinear trend with a given frequency k

$$F_i(k) = \frac{\left(SSR_0 - SSR_1(k)\right)/2}{SSR_1(k)/(T-q)} \qquad i = \mu, \tau \tag{8}$$

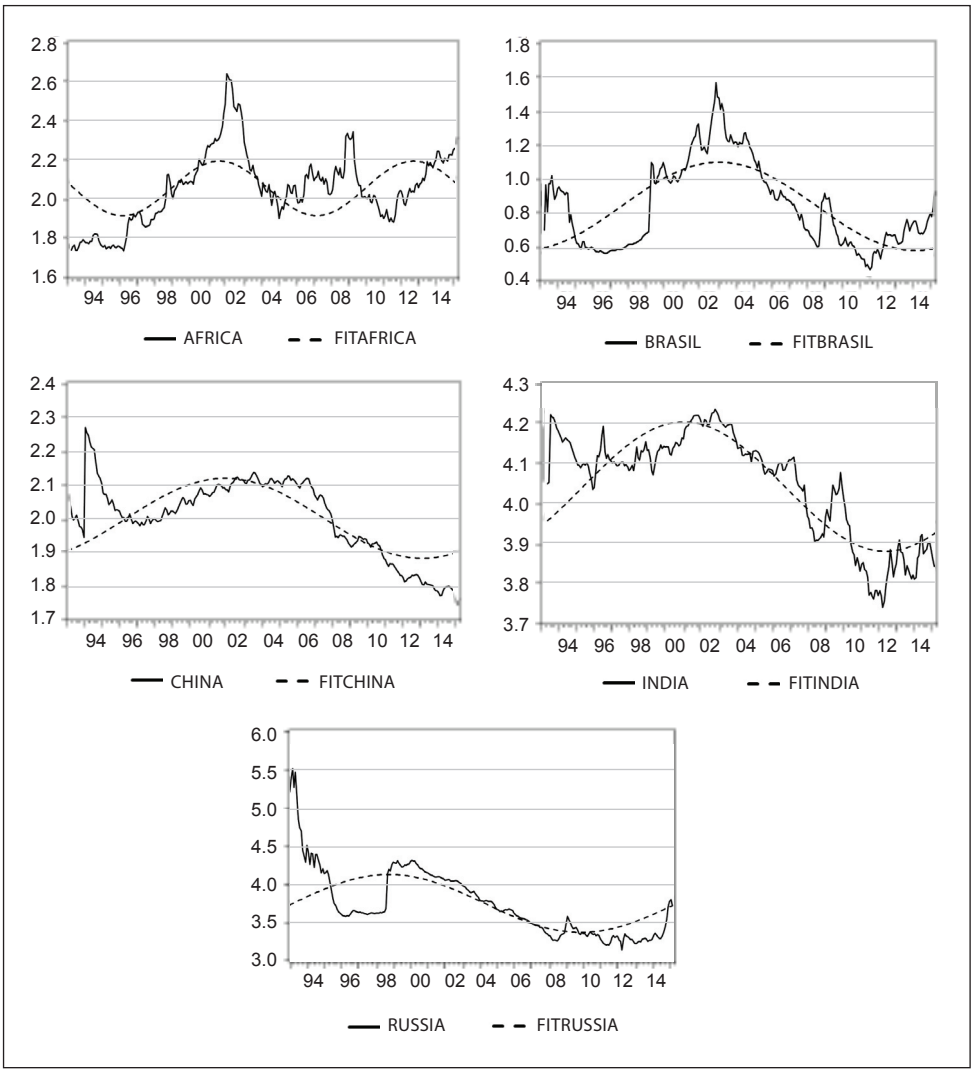
where SSR_0 denotes the SSR from regression without the trigonometric terms, SSR_1 (k) denotes the SSR from Equation 2 or 3 and q is the number of regressors. The distribution of F test is non standard when the null of stationary is rejected. From this viewpoint, the critical values to be used were tabulated in the study of Becker, Enders and Lee (2006).

4. Empirical Results

The validity of PPP shows that real exchange rates tend to have a mean reversion. The most common techniques that can be used whether real exchange rate had a mean reversion are the unit root tests for the exploration of the stability of real exchange rates.

As discussed in the econometric methodology section, the Fourier stationary test developed by Becker, Enders and Lee (2006) is used for testing the validity of PPP in BRICS countries. The standard KPSS test and the Fourier stationarity test results are shown in Table 2.

Figure 1 | Plots of Real Exchange Rates and Fitted Nonlinearities



Source: Author´s calculations.

$F_{\mu}(\hat{k})$ test statistics are reported in Table 2 showing that the null hypothesis of linearity is rejected in all series. Given these findings, the null hypothesis of stationarity can be tested using the Fourier stationarity test. According to the results in Table 2, $\tau_{\mu}(\hat{k})$ the test statistics indicate that the null hypothesis of stationarity is accepted for Brazil and South Africa, while it is rejected for China, India and Russia. Additionally, as can be seen in Figure 1, the Fourier approximations can fit well. The empirical results imply that PPP holds true for Brazil and South Africa but not for China, India and Russia.

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Table 2 | Tests for Stationarity in BRICS Countries

	$KPSS(\tau_{KPSS})$	k	$F_{\mu}(\hat{k})$	$\tau_{\mu}(\hat{k})$
Brazil	0.567332(8)	1	154.75415[a]	0.15492[*]
China	1.71587(8)	1	156.02515[a]	0.84503
India	2.23465(8)	1	330.77571[a]	0.67549
Russia	1.93752(8)	1	76.60438[a]	0.45296
South Africa	0.783312(8)	2	50.00598[a]	0.5211[*]

Note: (τ_{KPSS}) is the value of standard KPSS test for the null hypothesis of stationary. The figures in parentheses are optimal lag length. The critical values for KPSS test are 0.739, 0.463, 0.345 at 1%, 5%, 10% significance level, respectively. [a, b, c] denotes the null hypothesis of linearity are rejected at 1%, 5%, 10% significance level, respectively. [*, **, ***] denotes that PPP are supported at significance level, respectively.

Source: Author´s calculations.

5. Conclusions

In this study, the intention was to test the validity of PPP in the BRICS countries that have an important place in the world economy. The validity of PPP as a frequent subject of empirical studies was tested using the Fourier stationarity tests. According to the findings, there is a non-linear structure for all countries. The results obtained in this context show that PPP is valid for Brazil and South Africa and not valid for China, India and Russia. It can be argued that deviations from the real exchange rate are permanent in countries where there is no validity of PPP. The exchange rate policies implemented in these countries will not have an effect on national economy, exchange rate changes will not be stable and therefore economic stability will be affected in a negative way.

The factors that have an impact on the invalidity of PPP could be listed as follows: differences in price indexes, use of different goods baskets for the index calculation, the transport costs that have an impact on the price levels of two countries, customs taxes, administrative regulations and tariffs. In addition to these, the growth and efficiency differences between the BRICS countries and the USA are also important factors. Therefore, the policymakers of China, India and Russia should take these characteristics into consideration and develop policies accordingly. This conclusion implies that deviation from PPP is permanent. The policymakers of Brazil and South Africa will be able to implement monetary policies to preserve the value of their national currencies by developing foreign trade strategies based on PPP and by deciding on the optimum level of foreign exchange currency. The countries follow these policies as long as PPP will be valid in future.

In addition to the abovementioned factors, the economic and political conditions of the BRICS countries specific to the country in question have an effect on the results testing the validity of PPP. Contrary to the situation in Brazil and South Africa, using the exchange rate policies in India and China as a more active foreign trade tool, especially

during the 2009 economic crisis and later, had an effect on the validity of PPP. On the other hand, the volatility of natural resources, which are the most important foreign exchange resource for Russia, might have had an effect on the validity of PPP. However, detailed analysis of the economic and political conditions of these countries is beyond the purpose and scope of this paper.

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