

**TESTING THE VALIDITY OF PURCHASING POWER PARITY
FOR BRICS COUNTRIES
USING NON-LINEAR UNIT ROOT TEST**

**SATIN ALMA GÜCÜ PARİTESİNİN BRICS ÜLKELERİ İÇİN
DOĞRUSAL OLMAYAN BİRİM KÖK TESTİ İLE SINANMASI**

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ABSTRACT

The main aim of this paper is to investigate the validity of the purchasing power parity (PPP) hypothesis for BRICS countries, by using both Kapetanios et al. (KSS) and rolling KSS unit root tests. By adopting the rolling unit root test, the study aims to determine episodic characteristics of the real exchange rates. The results of the KSS unit root test show that the PPP hypothesis is not valid for the entire countries. On the other hand, the study has found evidence of the validity of PPP for only short time of periods by using rolling KSS.

Keywords: Purchasing power parity, non-linear time series, KSS unit root test.

ÖZ

Bu çalışmanın amacı satın alma gücü paritesini (SGP) BRICS ülkeleri için hem KSS hem de yuvarlanan KSS yöntemlerini kullanarak test etmektir. Çalışmada yuvarlanan KSS birim kök testini kullanarak, reel döviz kurunun dönemsel karakteristiklerini tespit etmeyi amaçlıyoruz. KSS birim kök testinin sonucunda SGP hipotezinin bütün BRICS ülkeleri için geçersiz olduğu tespit edilmiştir. Diğer taraftan, yuvarlanan KSS birim kök testi ile kısa zaman aralıklarında ülkelerde SGP'nin geçerli olduğu tespit edilmiştir.

Anahtar Kelimeler: Satın alma gücü paritesi, doğrusal olmayan zaman serileri, KSS birim kök testi.

1. INTRODUCTION

Purchasing Power Parity (hereafter, PPP) is a cornerstone of many theoretical models in international finance. PPP states that the exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries. This means that the exchange rate between any two countries should equal the ratio of two currencies' price level of a fixed basket of goods and services.

$$q_t = \frac{s_t p_t^*}{p_t} \quad (1)$$

Where q_t is the real exchange rate, s_t is the nominal exchange rate (one unit of foreign currency in terms of local currency), and p_t^* and p_t are respectively the foreign and domestic price indices. The basic idea behind the PPP hypothesis is that since any international goods market arbitrage should be traded away over time, we should expect the Real Exchange Rate (RER) to return to a constant equilibrium value. Studies on this issue are critical not only for empirical researchers but also for policymakers. In particular, a nonstationary RER indicates that there is no long run relationship between nominal exchange rate and domestic and foreign prices, thereby invalidating the PPP.

There are several reasons why we should question if the real exchange rate has a unit root. First, we should look at the degree of persistence in the real exchange rate can be used to infer what the principal impulses driving exchange rate movements are. Second, from a theoretical perspective, nonstationarity of the real exchange rate implies that PPP is not valid long run international parity condition (Sarno, Taylor; 2001: 20-21).

The empirical analyses of PPP has reached different stages of what depending on the evolution of the econometric techniques available. Early literature aimed to regress the nominal exchange rate on the price indices by simple OLS and instrumental variables methods, tests of random walk hypothesis for the real exchange rate, cointegration studies long span studies, panel data studies, while recent advances in econometrics have provided more accurate tools with which to analyse PPP fulfilment empirically, such as non-linear techniques.

As mentioned earlier, the more recent contributions to the analyses of PPP focus on the application of techniques that take into account the existence of non-linearities. The use of these techniques is justified by at least three main reasons. The first one is related to the fact that the existence of trade barriers and, therefore, absence of arbitrage within a threshold of exchange rate values, yields to a non-linear behaviour in the path of the variable. Additionally, Taylor (2004) claims that interventions in the foreign currency markets might generate a non-linear behaviour in the RER path, where the RER is a unit root process for central values within a threshold, but stationary when it is outside of the

threshold. Finally the existence of structural changes in the RER might imply broken deterministic time trends.

The presence of these two types of non-linearities has implications for the power of the technique applied to analyse the order of integration of the variables. In both cases traditional unit root tests suffer from important power distortions, like tendency to accept a false unit root null hypothesis (Cuestas, 2007: 3).

Unlike the linear approaches, the non-linear approach considers the presence of market frictions that restrict the possibility of arbitrage, causing the real exchange rate to adjust towards the long run equilibrium through a non-linear process. For this reason, the studies, that tested the validity of PPP by using linear unit root tests such as ADF, KPSS, etc., can obtain wrong statistical values because of these linearities. Due to this situation, we employ a non-linear unit root test to identify the validity of PPP.

As pointed out by Bahmani-Oskooee et.al (2009) the standard ADF or DF-GLS test assumes the adjustment of a time series variable such as a real exchange rate is in a linear fashion. The writers' results could be best summarized by saying that using non-linear unit root test, they are able to support PPP in 16 out of 19 cases, on the other hand ADF test results support just 8 out of 19 cases.

Freixo et. Al (2004) apply the smooth transition autoregressive non-linear model (STAR) to the Brazilian real exchange rate, aiming to test the validity of the PPP for Brazil. The results indicate that consumer price index based RER reveals non-linear behaviour, being stationary when distant from the equilibrium and with an explosive tendency when close to parity.

Chang et al. (2012) apply the Threshold Autoregressive (TAR) model to test the validity of long run PPP of nine East Asian countries over the period January 1986 to October 2009. The empirical results indicated that PPP holds true for more than half of these nine East Asian countries under study and the adjustment towards PPP is found to be non-linear.

Tiwari et.al. (2014) examines the PPP hypothesis in case of India for her five major trading partners over the period of 1991:M1-2009M2. The study used the DF-GLS unit root test and TAR model as well as momentum TAR (M-TAR) models for empirical analysis. Their empirical exercise reveals that PPP hypothesis does not exist for all major trading partners in case of India.

2. DATA, METHODOLOGY AND EMPIRICAL RESULTS

The study utilize the tests developed by Kapetanios, Shin and Snell (2003) (KSS) to incorporate non-linearity in time series movement in testing for the stationary of real exchange rates. KSS (2003) have expanded the standard ADF test by keeping the null hypothesis as nonstationarity in a time series variable against the alternative of a non-linear but globally stationary process. Their test is based on the following exponential smooth transition

autoregressive (ESTAR) specification. The ESTAR function allows for a symmetric adjustment of the real exchange rate for deviations greater or less than the equilibrium level.

$$\Delta y_t = \gamma y_{t-1} [1 - \exp(-\theta y_{t-1}^2)] + \varepsilon_t \quad (2)$$

Where y_t is the raw, de-meant or de-trended data, ε_t is an i.i.d error with zero mean and constant variance, and $1 - \exp(-\theta y_{t-1}^2)$ is the exponential transition function adopted in the test to present non-linear adjustment. The null hypothesis of a unit root in y_t implies that $\theta = 0$, thus $[1 - \exp(-\theta y_{t-1}^2)] = 0$. If θ is positive, it effectively determines the speed of mean reversion.

The null hypothesis of non-stationary with the KSS test procedure is $H_0: \theta = 0$ against the mean reverting non-linear alternative hypothesis $H_1: \theta > 0$. Because γ in (2) is not identified under the null, we cannot directly test $H_0: \theta = 0$. To deal with the issue, KSS suggest to reparameterize (2) by computing a first order Taylor series approximation to specification (2) to obtain the auxiliary regression expressed by (3) below:

$$\Delta y_t = \delta y_{t-1}^3 + error \quad (3)$$

This suggests that we could obtain t-statistic for $\delta = 0$ against $\delta < 0$ as

$$t_{KSS} = \hat{\delta} / s.e(\hat{\delta}) \quad (4)$$

Where $\hat{\delta}$ is the OLS estimate of δ and $s.e(\hat{\delta})$ is the standard error of $\hat{\delta}$. KSS tabulated the asymptotic critical values for the t_{KSS} in their paper.

In the rolling-KSS unit root test, the study employ a fixed length window as Yılancı (2012) and compute the t_{KSS} by estimating equation (3), moving this window forward by one observation. It is clear that this procedure will be continued until the last observation is used to test the null hypothesis. For convenience of interpretation, we scale the test statistics by 1% critical value (-2.82).

The study's empirical analysis covers a sample of five countries: Brazil, Russia, India, China and lastly South Africa. These five countries are called BRICS countries. In order to test PPP for these countries, I use the series of monthly nominal exchange rates (NER). Datas are obtained from OECD. The time period is 2000:1 to 2014:9. U.S. dollar is used for the base money in the

study because fewer than the member of the I.M.F countries use the U.S. dollar as the dominant exchange rate.

The real exchange rate can be calculated using the following equation:

$$y_t = NER_t \frac{P_t^f}{P_t^d} \quad (5)$$

Where y_t is the real exchange rate and NER_t is the nominal exchange rate, P_t^f and P_t^d show the foreign (United States) and domestic consumer price indices, respectively. This equation can be redescribed in logarithmic terms as below:

$$\log y_t = \log NER_t + \log P_t^f - \log P_t^d \quad (6)$$

With this equation, we can calculate the real exchange rates (RER) for BRICS countries. KSS statistics computed for the whole analysis period are pointed out in table 1.

Table 1: KSS Unit Root Test Results

Country	KSS Statistic
Brazil	-1.1879
Russia	-2.5028
India	-1.1580
China	-1.4447
South Africa	-0.3270

Source: Author's calculation (Critical value for statistical significance at the 1% level)

Table1 shows that we cannot reject the null hypothesis (which is unit root hypothesis) so PPP is not valid for all BRICS countries. These results showed that all series have unit root for the whole sample, but the results can change (non-linear or non-stationary) for short time periods. Due to this property, we now identify this episodic characteristic of the series, using the KSS unit root to the rolling windows.

Figure 1: Rolling KSS Test Results for Brazil.

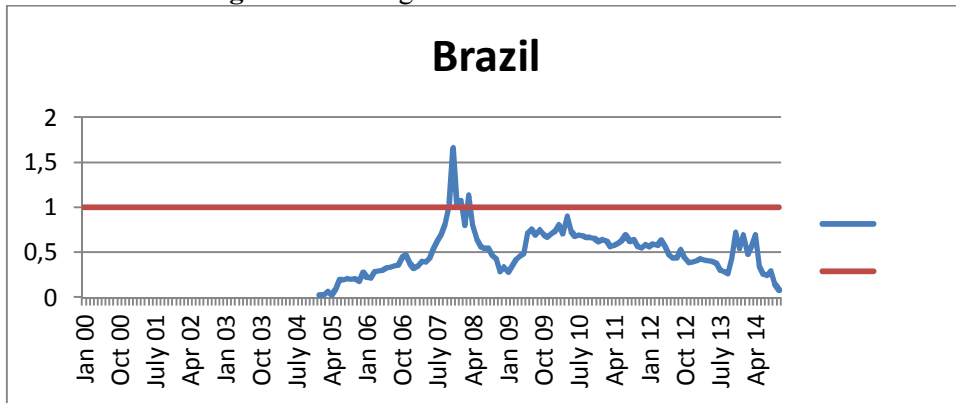


Figure 2: Rolling KSS Test Results for Russia.



Figure 3: Rolling KSS Test Results for India.

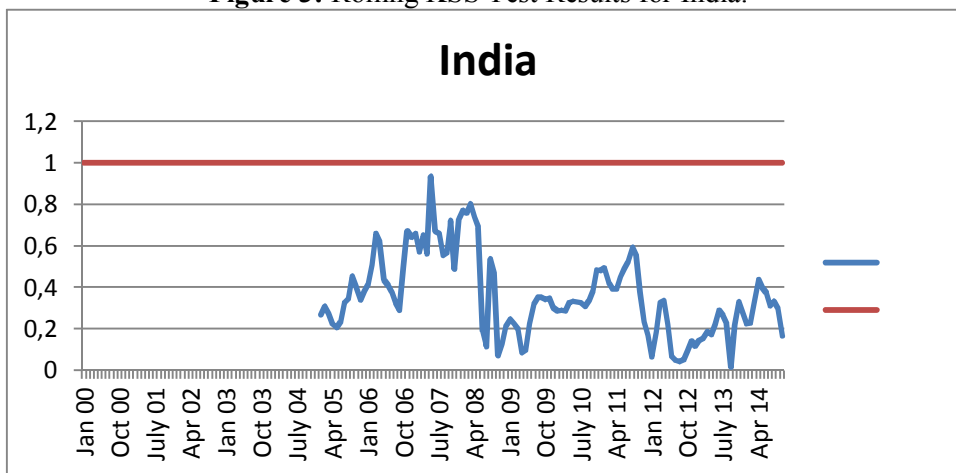


Figure 4: Rolling KSS Test Results for China.

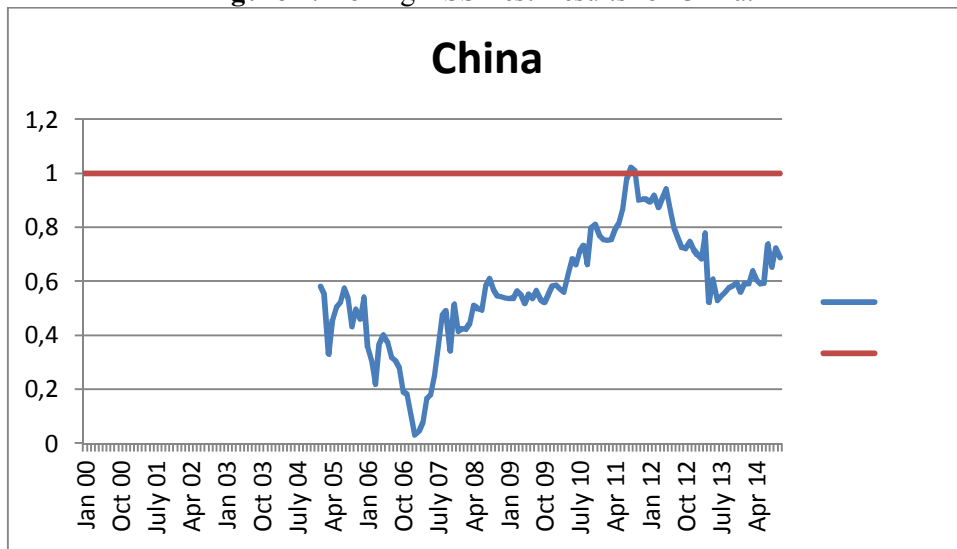
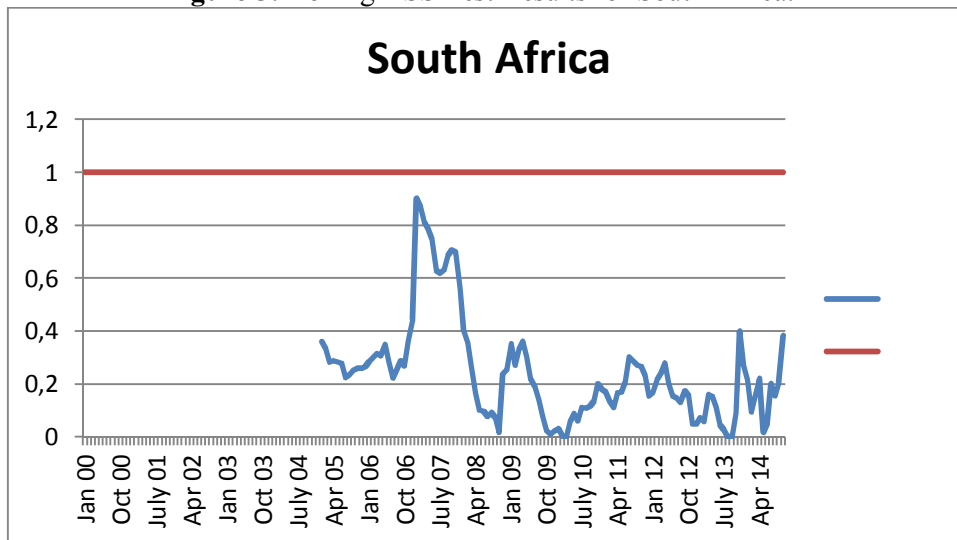


Figure 5: Rolling KSS Test Results for South Africa.



Figures that showed above are the rolling KSS test results. For each country, we set the window size 60 observations which is equal to five years. It means that with first KSS statistic is calculated with the first 60 observations. The scaled test statistic above the line demonstrate that the series in that time period are non-linear, so the PPP is valid in this period for that country. Increased volatility of PPP after 2008 is because of renewed increase in financial volatility. This financial volatility highlights the challenges for emerging market economies (such as BRICS countries) posed by the changing

external environment. Countries with relative weaknesses such as higher inflation, or wider current account deficits were generally more affected. Although, such weaknesses are not new, prospects of improved returns in advanced economies have made investor sentiment less favorable toward emerging market risks (IMF AREAER 2014: 2).

When we analyse these figures one by one, first country is Brazil. PPP for Brazil between September 2007-March 2008 is valid and after April 2014 the line that represents RER moves downward. This movement is the consequence of Brazil's precautions. In 2014 Brazil takes precautions for the financial risks and moves that aims for a macroprudential liquidity buffer against potential financial shocks from foreign exchange short positions within the banking system.

The second figure represents Russia's PPP. Russia's RER line is upwarding after July 2013. This upward moving is the consequence of the changed Russia's exchange market intervention policy. Russia eliminated its targeted foreign exchange interventions and widened its nonintervention band while reducing the cumulative level of interventions necessary to move the exchange rate corridor, increasing the flexibility of the ruble.

The third figure represents India's PPP. India's RER line is highly volatile and has a downward moving after April 2014. Due to the desire to reduce foreign exchange market pressures, India shortened the repatriation period of export proceeds and most other tightening measure applied to export quotas, tax and bans on specific products or to specific countries for national security reasons. As global liquidity conditions tightened India experienced significant portfolio debt outflows; pressure on its currency, equity and bond markets; and widening of the current account deficit. In response, India took measures to attract additional portfolio inflows.

The fourth figure represents China's PPP. China's RER line is highly volatile and has an upward behaviour after August 2007. The volatility of RER is still continued after August 2007, but path of RER line is changed downward until April 2014. After April 2014, owing to Chinese government precautions which are taken March 2014, the line is moving upward. China changed the floating band of the renminbi's (RMB) trading prices against the U.S. dollar in the interbank foreign exchange market was widened from 1% to 2%. That is, on each business day, the trading prices RMB against the U.S. dollar in the market may fluctate within a band of $\pm 2\%$ around the central parity released that day by the China Foreign Exchange Trade System.

And lastly fourth figure is South Africa's PPP. South Africa's RER line is highly volatile after May 2008 like others'. It's RER line has an upward sloping after May 2014 because government of South Africa tries to reduce the intervention to markets. Due to this aim government permitted certain unlisted companies to list overseas or to raise foreign loans, capital and borrowings.

CONCLUSION

The purpose of this research is to investigate the PPP in BRICS countries because the results of the previous empirical studies inconsistent. Also PPP has been a great important factor that to understand the behaviour of exchange rates for policy makers.

The standard ADF based unit root tests assumes adjustment of a time series variable is in a linear fashion. But real exchange rates behaviours follow a non-linear path. Due to this situation, we have to use non-linear unit root tests for testing the validity of PPP.

This study investigates the validity of the PPP hypothesis in the long run by using KSS (2003) and rolling KSS unit root tests which the latter one distinguish episodic non-linearity and nonstationarity for BRICS countries.

The results of the KSS unit root test show that PPP hypothesis is not valid for the entire countries. On the other hand, when we analyse the non-linearity characteristics by using rolling KSS, we find the real exchange rates show episodic non-linearities (which means PPP is valid at that interval).

When we analyzed KSS and rolling KSS unit root test results, it can be seen that real exchange rate of Russia is characterized by nonlinearity over greater periods of time than other countries, which shows that PPP is valid in Russia for relatively longer periods than other countries. On the other hand, the real exchange rates of India and South Africa are nonstationary in all subsamples, which indicates that PPP is not valid in the analysis period for both countries. The real exchange rates of Brazil and China are characterized by nonlinearity in short time periods.

These results show the importance of testing the real exchange rates via the rolling KSS unit root test because the real exchange rates of Brazil and Russia, which were found to be nonlinear in the full sample, but PPP is valid between, October 2007 and March 2008 in Brazil; February 2007 and January 2009 in Russia. The main policy implication of our findings is that BRICS countries RER lines are generally more volatile after 2008 global crises and episodic behaviours can be appeared. So, the politicians should be take into account these movements.

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