Validity of Purchasing Power Parity in BRICS under a DFA Approach

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Abstract: This study tests the validity of the purchasing power parity (PPP) theory in Brazil, Russia, India, Macao-China and South Africa. We examine real exchange rates of these countries for mean reversion. The Hurst exponent is our mean reversion measure which is evaluated by the Detrended Fluctuation Analysis (DFA) in a rolling window to determine the validity of the PPP theory amongst these countries through time. Our results show persistence in real exchange rates; an indication not supporting the PPP theory in the five countries. The study contributes to the extant literature of the PPP theory in BRICS using the DFA approach in a rolling window through time.

Keywords: Real Exchange rates; Hurst exponent; DFA; Rolling window

JEL Classification: F31; C22

1. Introduction

The Purchasing Power parity (PPP) which is based on the law of one price states that goods in the same basket should be of the same price in two trading countries. This means that if PPP is valid, a unit of currency in one country will have the same value and purchasing power of the other country (Taylor & Taylor, 2004).

In this study, we test the validity of the PPP of 5 countries; Brazil, Russia, India, China and South Africa. These 5 countries known as BRICS are members of the G20 who came together in 2001 with South Africa joining in 2010 to trade amongst themselves. Their trading relationship is based on mutual gains and equality hence the need to test whether a currency in one country is of the same value and of the same purchasing power in another country to avoid unbounded gain from arbitrage in traded goods (Chang et al., 2012). The validity or otherwise of PPP within BRICS has implication for the equilibrium exchange rate and also helps to monitor currency manipulation to gain unfair trade advantage.

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The PPP has been tested for many countries over time. The literature reports of methods such as cointegration tests by Frenkel (1978), Krugman (1978), Telatar & Kazdagli (1998), Doganlar (2006), Nayaran et al. (2009), Liew et al. (2010) etc. Also, researchers such as Adler & Lehman (1983), Edison (1987), Erlat (2004), Alba & Park (2005), Sollis (2005), Tastan (2005), Nayaran & Nayaran (2007), Aslan & Korap (2009), Yildirim et al. (2013), Yilanci et al (2013), Zhou & Kutan (2014) used linear and nonlinear unit root tests to investigate the validity of the PPP.

On the BRICS countries, the PPP has been tested by Chang et al. (2010) who used the momentum threshold tests advanced by Enders & Siklos (2001). Chang et al. (2010) investigated if there were asymmetric adjustment discernible for BRICS. Their study reported that PPP holds for the BRICS countries in the long- run. Also, Chang et al. (2012) employed the Autoregressive Distributed Lag (ADL) test for threshold cointegration to test if the PPP of the BRICS countries is valid in the long-run. It was reported that the PPP holds in the BRICS countries except Brazil. Furthermore, Su et al. (2012) investigated the validity of the long-run Purchasing Power Parity (PPP) for the BRICS countries using linear and nonlinear unit root tests with stationary covariates. It was reported that the PPP is valid for all the BRICS countries.

In this work, the PPP will hold for all the BRICS countries if the real exchange rates (RER) are mean reverting. The Hurst estimate; Hurst (1951) will be used as our mean reversion measure which will be evaluated by the Detrended Fluctuation Analysis (DFA). The superiority of Hurst exponent in testing mean-reversion is acknowledged by Gogas, Papadimitriou and Sarantitis (2013). The Hurst estimates takes values between 0 and 1. That is $H \epsilon [0, 1]$. Values close to zero ($H<0.5$) indicate anti-persistent series meaning the series is mean-reverting; a situation validating PPP. If $H \geq 0.5$, it indicates either the series follows a random walk ($H=0.5$) or a persistent series ($H>0.5$), a situation providing evidence against PPP. The DFA is a method proposed by Peng et al. (1994) to detect long memory and stationarity of time series data over time. The DFA method was chosen for this study amongst other methods for evaluating the Hurst exponent such as the rescaled range analysis, local whittle estimator and the likes because the DFA is robust to stationary and non-stationary data according to Cannon et al. (1997) and Eke et al. (2002). The DFA method was first employed to estimate the Hurst exponent for the full sample data. Second, two rolling windows with different lengths were employed to observe the trends of the Hurst estimates through time.

The rest of the article is organized as follows. Section 2 describes the data and the methodology. Section 3 describes the empirical results and the conclusion is in section 4.

2. Data and Methodology

Monthly data on nominal exchange rates against the US dollar and consumer price indexes (CPI) of Brazil, Russia, India, Macao-China and South Africa were obtained for the period between 1993M01 to 2015M12. The data was obtained from International Financial Statistics (IFS) of the International Monetary Fund (IMF).

Real exchange rate is given as:

$$\mathrm{RER_t} = \ln(\mathrm{S_t}) - \ln(\mathrm{CPI_{US,t}}) + \ln(\mathrm{CPI_{i,t}}) \quad (1)$$

Where $\mathrm{S_t}$ is the nominal exchange rate expressed in US dollars per one unit of foreign currency, $\mathrm{CPI_{US,t}}$ is the consumer price index of US (domestic country) and $\mathrm{CPI_{i,t}}$, the consumer price index of a foreign country.

We construct real exchange rates of the five countries using equation 1 which gives us 276 observations for each country.

The Hurst exponent, our mean reversion measure is evaluated using the detrended fluctuation analysis (DFA) first for the full sample period and second through the rolling window method. We chose two windows of size 138 and 207 to observe the dynamics of the Hurst exponent through time.

Detrended Fluctuation Analysis (DFA)

The Detrended Fluctuation Analysis (DFA) is used in calculating the Hurst exponent, H of the real exchange rates (RER) in absolute form and through time in a rolling window approach.

We follow Peng et al. (1994) who proposed the DFA.

Suppose X(t) is a time series with t = 1,…, N. in this method, the time series is divided into blocks of the same length n.

The ordinary least squares method is used to estimate the trend in each block. In each block, the ordinary least square line is expressed as $X_n(t)$. The trend of the series is removed by subtracting $X_n(t)$ from the integrated series X(t) in each block.

This procedure is applied to each block and the fluctuated magnitude is defined as

$$\sigma_{DFA} = \sqrt{\frac{1}{N} \setminus \sum_{t=1}^{N} (X(t) - X_n(t))^2} \quad (2)$$

This step is repeated for every step n and to estimate Hurst exponent, the following scaling relationship is defined:

$$\sigma_{DFA} \alpha n^H \quad (3)$$

Equation (3), can be written as:

$$\log(\sigma_{DFA}) \alpha H \log(n) \quad (4)$$

This linear relationship between σ_{DFA} and n on a log – log plot support the presence of a power law (fractal) scaling which indicate there is self – similarity in the series. This means the fluctuation over small time scale are related to fluctuations over larger time scales. The slope of the linear relationship estimates the Hurst exponent. The Hurst exponent H ∈ [0, 1] where H = 0.5 means the series follows a random walk, H < 0.5 indicates mean-reversion and H > 0.5 indicates persistence.

3. Empirical Results

Table 1. Hurst Exponent for full sample

Country	Hurst Exponent
Brazil	0.792
Russia	0.899
India	0.685
Macao-China	0.767
South Africa	0.664

Table 1 shows the Hurst results for the full sample for the five countries. Figures 1-3 are the graphical representations of the Hurst exponents of the countries under consideration. The Hurst exponents are greater than 0.5 indicating persistence; a condition giving evidence against purchasing power parity.

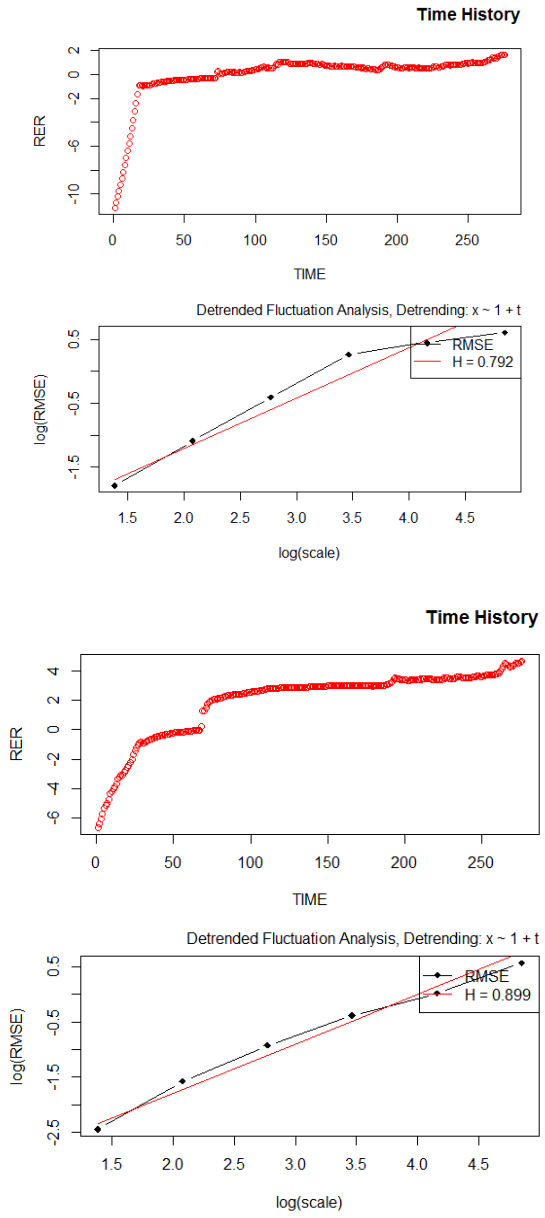

Figure 1. EDA plots of Brazil and Russia

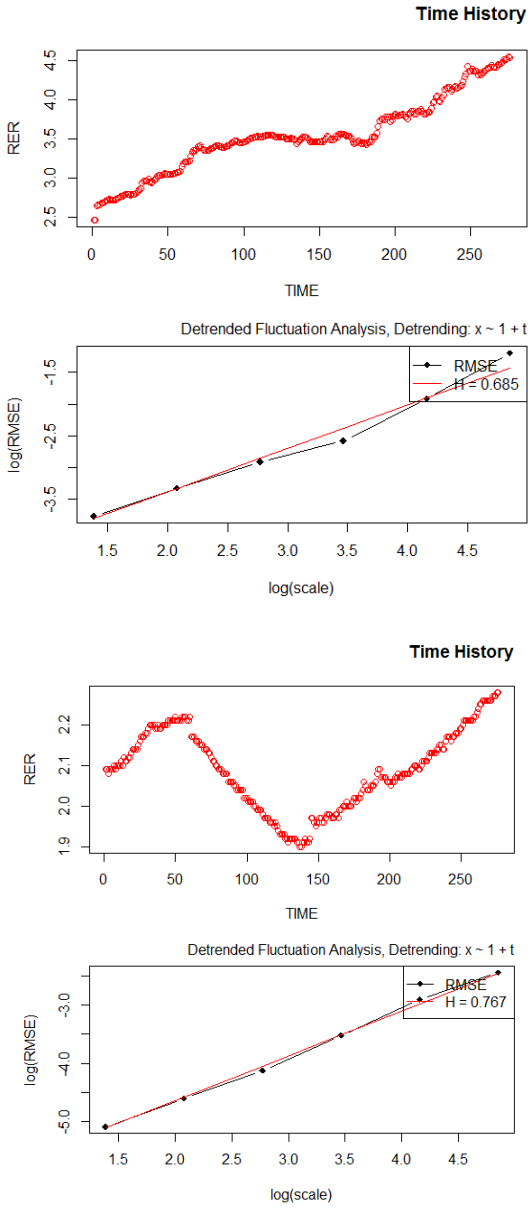

Figure 2. EDA plots of India and Macao-China

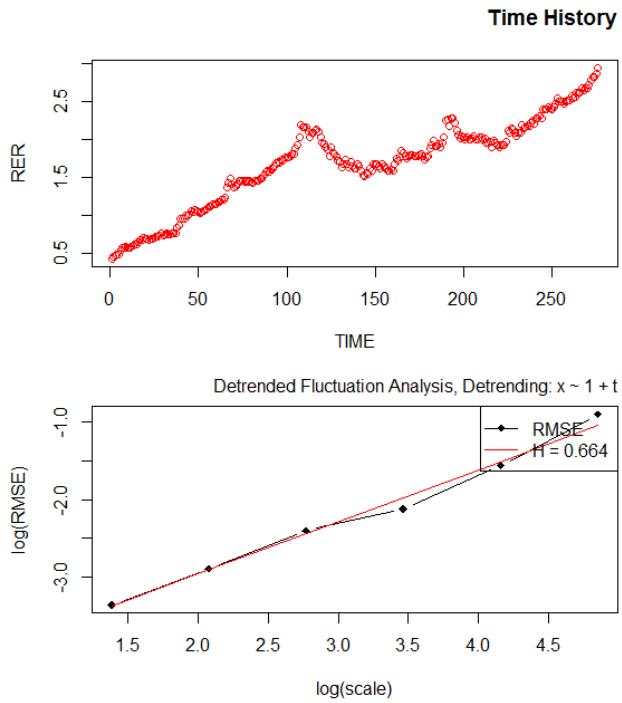

Figure 3. EDA plots of South Africa

Next, we compute Hurst exponents using the rolling window method. We chose two window lengths; 138 and 207 because of the length of our data. These window lengths produced 139 and 70 Hurst exponents respectively. The Hurst exponents computed using the rolling window method are graphically represented in Figures 4-8. It is observed from Figures 4-8 that the Hurst exponents are mostly high (>0.5) for all the countries with values ranging from 0.2 – 0.9 for Brazil, India, Macao-China and South Africa. In Figure 5, Russia had values as high as 1.1 which is out of the range of H. This situation is attributed to small sample size according to Cannon et al. (1997) and Delignieres et al. (2006), who posit that the DFA performs poorly with biased results when sample size is less than 256 observations. The results obtained shows that the real exchange rates of the BRICS countries are mostly persistent with few periods of anti-persistence through time. This means the PPP is mostly violated through time.

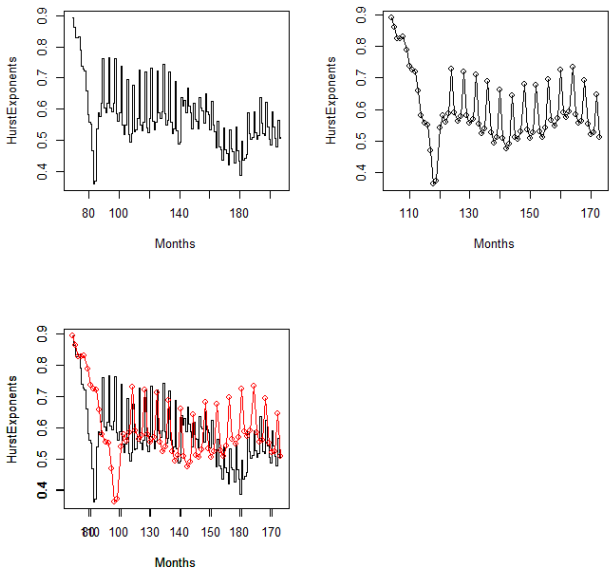

Figure 4. Hurst Exponent Estimates of Brazil for the two rolling window lengths

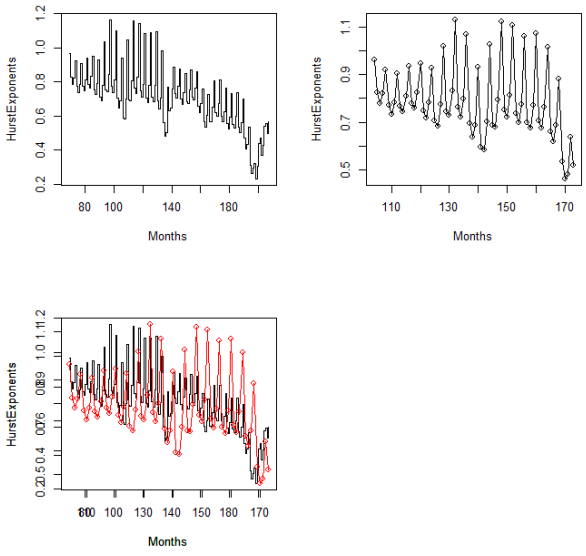

Figure 5. Hurst Exponent Estimates of Russia for the two rolling window lengths

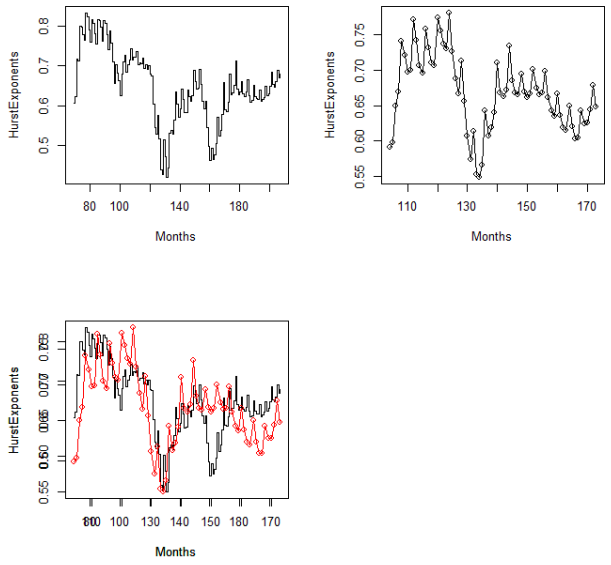

Figure 6. Hurst Exponent Estimates of India for the two rolling window lengths

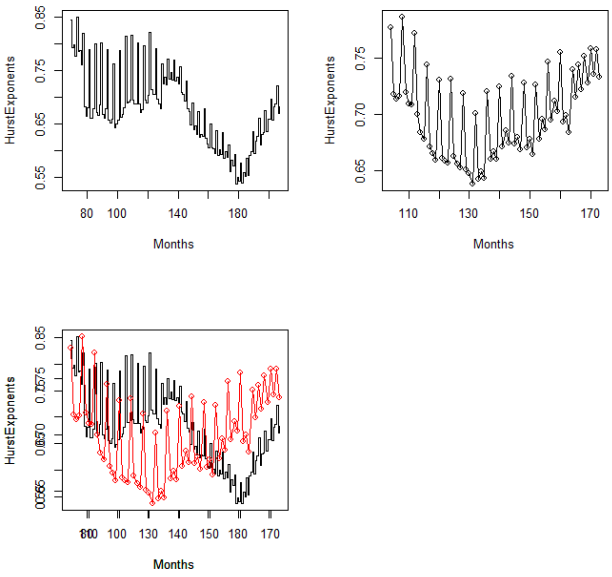

Figure 7. Hurst Exponent Estimates of Macao-China for the two rolling window lengths

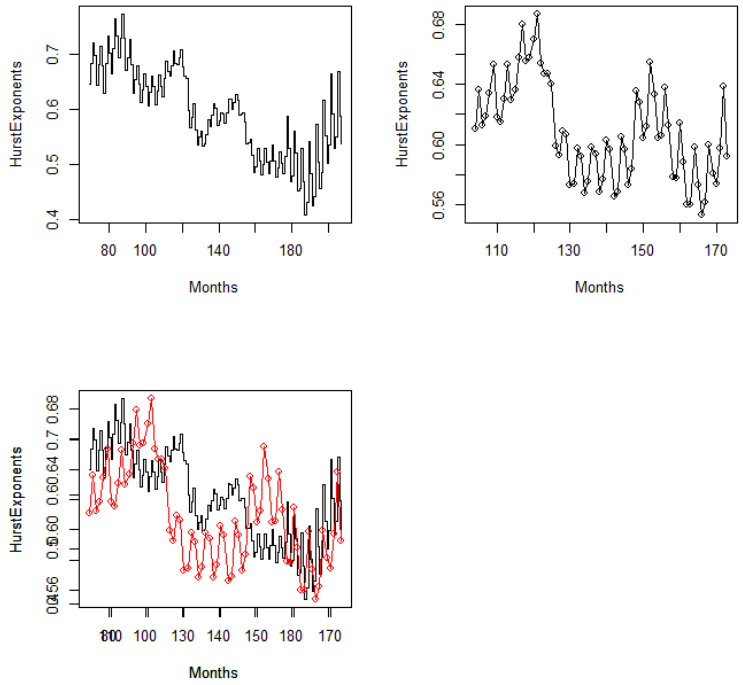

Figure 8. Hurst Exponent Estimates of South Africa for the two rolling window lengths

4. Conclusion

We tested the validity of the PPP theory in BRICS; five countries made up of Brazil, Russia, India, China and South Africa. The Hurst exponent was employed as a measure of mean reversion in real exchange rates which was evaluated by the Detrended Fluctuation Analysis (DFA) in absolute form and in a rolling window approach through time. The Hurst exponents obtained for the full sample and the rolling window samples were mostly greater than 0.5. This means persistence in the real exchange rates; a condition which provides evidence against the PPP theory in the real exchange rates of the five countries. Our findings contradicts the findings of the PPP theory by Chang et al. (2010), Chang et al. (2012) and Su et al. (2012). Our contradictory findings is because of the use of the rolling window approach employed in our analysis and the time span. The rolling window approach helps us tract the trends of the Hurst estimates through time.

We therefore conclude that a major policy implication from our findings is that, in most times, the PPP cannot be used to determine the equilibrium exchange rates for the five BRICS countries. This means that abnormal gains can be made from arbitrage in traded goods.

5. References

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