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Does PPP Hold? A Case for Singapore

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Abstract

The Purchasing Power Parity (PPP) is one of the hypotheses in economics that has been tested several times by various researchers due to its simplicity and intuitive appeal and its implications for international trade and capital flows. Just like other studies, in this study, we test the stationarity of the real exchange rate as a way to validate or refute the PPP hypothesis. But our study is different from others' in the sense that considering the increasing share in world gross domestic product of the BRICS (i.e. Brazil, Russia, India, China, and South Africa) countries, we chose the real exchange rate between Singapore dollar and five BRICS currencies to test the PPP hypothesis. Also, instead of using the direct exchange rates we use the cross exchange rate of Singapore dollar with these other currencies. We test the PPP hypothesis by testing the stationarity of the real exchange rates on a panel data instead of country-specific data. Our results fail to reject the null hypothesis that the real exchange rate series is non-stationary. Therefore, we conclude that the series of real exchange rates between Singapore dollar and BRICS currencies is non-stationary and that the PPP hypothesis is invalidated.

JEL Classification: F3
Key Words: purchasing power parity, real exchange rate, stationarity

I. Introduction

The purchasing power parity (PPP) is one of the hypotheses in economics that has been tested several times by various researchers due to its simplicity and intuitive appeal. It has also generated so much interest among researchers due to its implications for international trade and capital flows. Further, as the countries around the world are increasingly getting integrated financially and through international trade, its relevance has increased even further.

In its absolute form, the purchasing power parity hypothesis stipulates that the exchange rate between two currencies is equal to the price ratio in the two countries. In its relative form, the PPP hypothesis implies that the movement in the exchange rate between two currencies tends to equalize the price differential in the two countries. Among others, there are mainly two reasons why the hypothesis has generated so much interest among researchers – first, if the purchasing power parity holds, the exchange rate between two currencies tend to equalize the price levels across nations thereby eliminating comparative cost advantage in global trade. Second, the adjustments in exchange rates in response to a change in relative price (price ratio) are also an indication of a change in the real interest rates between two countries causing the capital flows from the country with a lower real interest rate to the one with a higher. Moreover, many macroeconomic theories are founded on the assumption that purchasing power parity holds. Therefore, the validity of those theories hinges on the validity of the PPP hypothesis.

The one-to-one correspondence of exchange rates with relative prices implied by the PPP hypothesis has prompted researchers to mostly use several variations of the unit root test on the real exchange rate (the relative-price-adjusted exchange rate) for the validity of the PPP

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hypothesis. Typically the null hypothesis is that the real exchange rate is nonstationary along with the alternative hypothesis that it is a stationary process. If the null hypothesis is rejected, the researchers would conclude that the real exchange rate series is stationary and, that the PPP holds in the long run. This long-run relation implies that even if the PPP does not hold in the short run due to the factors such as the presence of non-traded goods and transportation costs, any shock affecting currencies only has its effect in the short run and that the real exchange rate is mean reverting. So, the PPP hypothesis is only validated if the real exchange rate is a stationary process (Meese and Rogoff, 1988; Mark 1990; and Ardeni and Lubian, 1991). However, the argument that the misspecification of the deterministic component of the real exchange rate series may bias the result in favor of the null hypothesis (Perron and Phillips, 1987; and West, 1988) prompted many researchers (Darne and Hoarau, 2008; and others) to apply unit root tests with structural changes with the findings that invalidated the PPP hypothesis. Recently researchers have become increasingly interested in applying unit root test on panel data (Wu, 1996; Papell and Theodoridis, 2001; Papell, 2002). One group of researchers has used nonlinear specification of deterministic components in testing PPP and found evidence in its support (Cuestas and Regis, 2008; and Bahmani-Oskooee, Kutan, and Zhou 2007). Just like other studies, we test the stationarity of the real exchange rate as a way to validate or refute the PPP hypothesis. But our study is different from others' in the sense that considering the increasing share in world gross domestic product of the BRICS (i.e. Brazil, Russia, India, China, and South Africa) countries, we chose the real exchange rate between Singapore dollar and five BRICS currencies to test the PPP hypothesis, which has never been done before, to our knowledge. Also, instead of the using the direct exchange rates we use the cross exchange rate of Singapore dollar with these other currencies. We test the PPP hypothesis by testing the stationarity of the real exchange rates on a panel data instead of country-specific data.

We lay out our model in section 2, detail the methodology of this study in section 3, describe the data source in section 4, present our empirical findings in section 5, and finally conclude the study in section 6.

II. The Model

The purchasing power parity condition with no transportation costs, tariffs, and other trade restrictions can be laid as,

$$R = \frac{P}{P^*} \tag{1}$$

That is, the exchange rate between the currencies of any two countries is equal to the relative price level in the two countries. Here R is the exchange rate of the domestic currency (e.g. U.S. dollar) with a foreign currency – expressed as number of domestic currency units needed to purchase one unit of the foreign currency – P is the domestic price level, and $P^*$is the price level in the foreign country. Taking log of equation (1) yields,

$$logR = logP - logP^* \tag{2}$$

Taking total differential of equation (2) yields,

$$dlogR = dlogP - dlogP^* \quad \text{or}$$

$$\frac{dR}{R} = \frac{dP}{P} - \frac{dP^*}{P^*} \quad \text{or}$$

$$e = p - p^* \tag{3}$$

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That is, the percentage change in nominal exchange rate equals the difference in inflation rates between two countries, Here,

$e = \frac{dR}{R} = percentage\ change\ in\ exchange\ rate,$

$p = \frac{dP}{P} = percentage\ change\ in\ domestic\ price\ level = domestic\ inflation\ rate,$ and

$p^* = \frac{dP^*}{P^*} = percentage\ change\ in\ the\ foreign\ price\ level = foreign\ inflation\ rate.$

Economists in general agree that if PPP holds, or equivalently if the relationship shown in equation (3) holds, it only does so in the long run, which implies that the exchange rate can be higher or lower than the relative price in the short run. Suppose such deviation is represented by a variable, *d*. With this consideration, equation (3) can be rewritten as,

$$e = p - p^* + d \quad \text{or}$$
$$d = e - p + p^* \tag{4}$$

Researchers generally prefer to call the term *d* the real exchange rate and denote it by *r*, so that,

$$r = e - p + p^* \tag{5}$$

If absolute PPP is to hold, *r* must be zero. But empirical evidences fail to support this and the failure is attributed mainly to the presence of transportation costs and non-traded goods. The relative PPP hypothesis, on the other hand, stipulates that although the exchange rate may deviate from the relative price in the short run, the deviation itself remains stationary over time. Thus, testing whether purchasing power parity holds between any two countries is equivalent to testing whether the deviation factor – the real exchange rate, *r* – is stationary. Equation (5) with a time subscript can be written as,

$$r_t = e_t - p_t + p_t^* \tag{6}$$

III. Methodology

Most of the empirical research testing the purchasing power parity hypothesis (i.e. equation (6)) typically test the stationariy of the real exchange rate variable (r_t) by checking whether it has a unit root. For example, if the hypothesis of unit root for r_t, cannot be rejected, then purchasing power parity condition is satisfied. To test for unit root in r_t series, we will apply the ADF test with two different specifications – with constant and without constant. We will not apply the third specification – with constant and trend – as the testing of PPP does not allow the trend in the r_t series. The two models of ADF testing are given as following:

$$\Delta r_t = \alpha_0 + \beta r_{t-1} + \sum_{j=1}^{n} \delta_j \Delta r_{t-j} + u_t \tag{7}$$
$$\Delta r_t = \beta r_{t-1} + \sum_{j=1}^{n} \delta_j \Delta r_{t-j} + u_t \tag{8}$$

If the actual t-statistic associated with the ADF test turns out to be less than its critical value, then the null hypothesis of a unit root cannot be rejected and we will conclude that the real exchange rate, r_t, has a unit root and that the r_t series is non-stationary and, therefore, the PPP

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hypothesis is invalidated. On the contrary, the rejection of the null hypothesis will mean the absence of a unit root in r_t series and, therefore, the acceptance of the PPP hypothesis. Alternatively, if the null hypothesis of β=0 cannot be rejected in equation (7) and (8), then it implies that the r_t series has a unit root and that the PPP hypothesis is invalidated. Also, we will apply Akaike Information Criterion and SBC to determine the proper lag length for variable r_{t-j}.

IV. Data

We use a panel data on the official exchange rate between U. S. dollar and the currencies of Singapore plus five BRICS countries – Brazil, Russia, India, China, and South Africa – and the inflation rates in the U. S., Singapore, and in the BRICS countries for the years, 1996-2014. The data on exchange rates and inflation rates are obtained from the World Development Indicators, 2015. The cross official exchange rates of Singapore dollar with BRICS currencies are computed by dividing the official exchange rate of Singapore dollar with the U.S. dollar by the official exchange rate of BRICS currencies with the U.S. dollar. The real exchange rates of Singapore dollar with the BRICS currencies, then, are computed by subtracting the inflation rate in Singapore from and adding the inflation rate in BRICS countries to the cross official exchange rates of Singapore dollar with BRICS currencies.

V. Empirical Findings

We applied the ADF test to see if the real exchange rate series, r_t, contains a unit root. The detailed estimation outputs are given in the appendices, which shows that the t-statistics for Augmented Dickey-Fuller (ADF) test for models presented in equations (7) – (8) are -1.151488 and -0.903447 whereas their 5 percent critical values are -2.906923 and -1.945903 respectively. Since the actual t-statistics are less than their corresponding critical t-values, we cannot reject the null hypothesis that the real exchange rate series, r_t, has a unit root. The estimates of equation (7) and (8) are presented in equation (9) and (10) respectively as following:

$$\Delta r_t = \underset{(0.7301)}{0.0059} - \underset{(-1.1515)}{0.0278} r_{t-1} - \underset{(-0.7623)}{0.0909} \Delta r_{t-1} + \underset{(1.5177)}{0.0975} \Delta r_{t-2} + \underset{(1.9431)}{0.1026} \Delta r_{t-3} + \underset{(2.0262)}{0.0905} \Delta r_{t-4} + \underset{(1.8734)}{0.0083} \Delta r_{t-5} \quad (9)$$

$$\Delta r_t = \underset{(-0.9035)}{-0.0152} r_{t-1} - \underset{(-0.7640)}{0.0908} \Delta r_{t-1} + \underset{(1.4396)}{0.0913} \Delta r_{t-2} + \underset{(1.9224)}{0.1010} \Delta r_{t-3} + \underset{(2.0602)}{0.0916} \Delta r_{t-4} + \underset{(2.1369)}{0.0091} \Delta r_{t-5} \quad (10)$$

Alternatively, we tested the null hypothesis of β=0 in both of the above specifications. A low t-statistic associated with parameter β in both specifications does not reject the null hypothesis that β=0. This finding reconfirms that the r_t series has a unit root and that purchasing power parity does not hold between Singapore and five BRICS countries – Brazil, China, India, Russia, and South Africa.

VI. Summary and Conclusion

The purchasing power parity (PPP) hypothesis is one of the hypotheses in economics that has been tested several times by various researchers due to its simplicity and intuitive appeal. It has also generated so much interest among researchers due to its implications for international trade and capital flows. Further, as the countries around the world are increasingly getting integrated financially and through international trade, the relevance of the PPP hypothesis has increased even further. Just like other studies, we test the stationarity of the real exchange rate as a way to validate or refute the PPP hypothesis. But our study is different from others' in the sense that

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considering the increasing share in world gross domestic product of the BRICS (i.e. Brazil, Russia, India, China, and South Africa) countries, we chose the real exchange rate between Singapore dollar and five BRICS currencies to test the PPP hypothesis, which has never been done before, to our knowledge. Also, instead of using the direct exchange rates we use the cross exchange rate of Singapore dollar with these other currencies. We test the PPP hypothesis by testing the stationarity of the real exchange rates on a panel data instead of country-specific data for the years, 1996-2014. Our results fail to reject the null hypothesis that the real exchange rate series is non-stationary. Therefore, we conclude that the series of real exchange rates between Singapore dollar and BRICS currencies is non-stationary and that the PPP hypothesis is invalidated.

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Appendices

Appendix-A

Null Hypothesis: **R has a unit root**
Exogenous: **Constant**
Lag Length: 5 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**-1.151488**	**0.6902**
Test critical values:	1% level	-3.534868	
	5% level	**-2.906923**	
	10% level	-2.591006	

*MacKinnon (1996) one-sided p-values.

Appendix-B

Augmented Dickey-Fuller Test Equation
Dependent Variable: **D(R)**
Method: Least Squares
Date: 07/17/15 Time: 06:02
Sample (adjusted): 1996 2014
Included observations: 65 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
R(-1)	-0.027793	0.024136	**-1.151488**	**0.2543**
D(R(-1))	-0.090912	0.119258	-0.762318	0.4490
D(R(-2))	0.097502	0.064245	1.517651	0.1345
D(R(-3))	0.102556	0.052779	1.943138	0.0569
D(R(-4))	0.090512	0.044672	2.026149	0.0474
D(R(-5))	0.008319	0.004441	1.873411	0.0661
C	0.005935	0.008129	0.730136	0.4682

R-squared	0.319345	Mean dependent var	-0.009805
Adjusted R-squared	0.248932	S.D. dependent var	0.047875
S.E. of regression	0.041490	Akaike info criterion	-3.425280
Sum squared resid	0.099843	Schwarz criterion	-3.191115
Log likelihood	118.3216	Hannan-Quinn criter.	-3.332887
F-statistic	4.535333	Durbin-Watson stat	2.079014
Prob(F-statistic)	0.000780		

Appendix-C

Null Hypothesis: **R has a unit root**
Exogenous: **None**
Lag Length: 5 (Automatic - based on SIC, maxlag=11)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		**-0.903447**	**0.3212**
Test critical values:	1% level	-2.601024	
	5% level	**-1.945903**	
	10% level	-1.613543	

*MacKinnon (1996) one-sided p-values.

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Appendix-D

Augmented Dickey-Fuller Test Equation
Dependent Variable: **D(R)**
Method: Least Squares
Date: 07/17/15 Time: 06:04
Sample (adjusted): 1996 2014
Included observations: 65 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
R(-1)	-0.015223	0.016850	**-0.903447**	**0.3700**
D(R(-1))	-0.090753	0.118785	-0.764009	0.4479
D(R(-2))	0.091316	0.063432	1.439597	0.1553
D(R(-3))	0.100974	0.052525	1.922391	0.0594
D(R(-4))	0.091613	0.044470	2.060122	0.0438
D(R(-5))	0.009142	0.004278	2.136875	0.0368

R-squared	0.313089	Mean dependent var	-0.009805
Adjusted R-squared	0.254876	S.D. dependent var	0.047875
S.E. of regression	0.041326	Akaike info criterion	-3.446900
Sum squared resid	0.100761	Schwarz criterion	-3.246187
Log likelihood	118.0242	Hannan -Quinn criter.	-3.367706
Durbin-Watson stat	2.093526		