PURCHASING POWER PARITY IN THE SAARC REGION: EVIDENCE FROM UNIT ROOT TEST WITH CROSS-SECTIONAL DEPENDENCE

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ABSTRACT

Mixed results on the validity of Purchasing Power Parity (PPP) relationship in South Asian countries motivates this paper to make further investigation. Existing studies lack appropriate treatment of cross-country dependence in the testing procedure. In this paper we employ Pesaran (2004, 2007) to identify the degree of cross-sectional dependence (CSD) and apply panel unit root test accommodating this dependence on the real exchange rate series of five South Asian countries in the South Asian Association of Regional Cooperation (SAARC), namely, Bangladesh, India, Pakistan, Sri Lanka and Nepal. We find evidence of strong cross-country dependence, cross-country correlation being 0.735. Our panel unit test results support the validity of long-run PPP in the sample countries. This result is in contrast to the previous studies in similar countries, which did not accommodate CSD in their estimation. This finding implies that real shocks do not have any permanent effect on the real exchange rate and other things remaining the same, no active policy intervention is warranted for the sustainability of external balance.

JEL Classification: F31, F32, F41

Key words: Purchasing power parity, real exchange rate, unit root, cross-sectional dependence

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INTRODUCTION

Purchasing power parity (PPP) is one of the most extensively researched, yet unresolved, topics in international finance literature. PPP, in its absolute form states that the nominal exchange rate between two currencies should equal the ratio of the respective price levels. If it is not the case then arbitrage activity will take place and finally restore this relationship. However, this definition of PPP requires identical price ratios in the respective countries, which is a strong assumption hardly satisfied (Pakko and Pollard, 2003). Absolute form of PPP is thus not useful for practical purpose. Instead, economists use the relative form of PPP which states that “exchange rate should bear a constant proportionate relationship to the ratio of national price levels” (Isard, 1995, p. 58). Implication of this definition is that the real exchange should be stationary or mean reverting in order to hold the PPP in the long run. Stationarity of the real exchange rate has significant implication for the international competitiveness of an economy. If the real exchange rate contains unit root, a current shock to it is permanent, which has significant consequences for the balance of payment, such as, an appreciation of the real exchange rate will cause permanent deficit in the current account (MacDonald, 1996).

There are two alternative ways to test the PPP hypothesis, testing unit root in the real exchange rate and testing cointegration between the nominal exchange rate and the ratio of price levels between the respective countries; however, testing cointegration requires imposing equal and opposite coefficients on relative prices. Therefore, for the ease of estimation, huge number of studies have employed unit root testing in the real exchange rate to test the PPP hypothesis. There has been an extensive body of literature on the validity of the PPP hypothesis both in developed and developing countries; however, in this paper, we mainly focus on studies on Asian, particularly South Asian countries. The detail discussion on this research area these can be seen in the following literature: Taylor and Sarno (1998), Sarno and Taylor (2002), Taylor and Taylor (2004), and Taylor (2005).

Traditional unit root test (such as ADF or PP) fail to accommodate structural break or nonlinearity in data. Micheal et al. (1997), Sarantis (1999), Baum et al. (2001) and Taylor et al. (2001) examined the nonlinear properties of real exchange rates. Taylor et al. (2001) found that transaction costs, shipping costs, tariffs and taxes are the possible factors that contribute to nonlinearity in real exchange rates. A few studies extended their
research in the line of the nonlinearity real exchange rates of Asian countries. Liew et al. (2003, 2004) and Liew (2004) conducted a series of studies in the Asian region, however, South Asian countries were excluded in these studies. Narayan (2006) employed unit root test with structural break on India’s real exchange rate and found evidence of mean reversion. Chowdhury (2007) found strong support for nonlinear mean reversion in Bangladesh taka real exchange rate. Wu and Lee (2008) employed nonlinear unit root test to the real exchange rate series in G11 and Asian countries and find mixed results of mean reversion. Ahmad and Rashid (2008) examined the stationarity of real exchange rate for Bangladesh, India, Pakistan, Sri Lanka and China and conclude that nonlinear unit root tests provide more evidence in favour of stationary real exchange rates than linear unit root tests, such as ADF or KPSS. Noman and Rahman (2010) do not find any evidence of nonlinear mean reversion of real exchange rates for India, Pakistan and Sri Lanka; however, their tests results are not conclusive for Bangladesh. Baharumshah and Soon (2012) applied one and two structural break unit root test to Malaysian real exchange rate and find weaker support for the long run PPP. They conclude that 1997 currency crisis weakens the evidence of PPP in Malaysia. Recently Hoque and Banerjee (2014) applied unit root test with structural break to the real exchange rate of Bangladesh, India, Pakistan and Sri Lanka. They arrived at finding similar to Noman and Rahman (2010) and conclude that long-run PPP does hold for these countries.

Unit root tests on univariate real exchange rate series fail to reject the null of unit root (for example, Meese and Rogoff, 1988, Mark, 1990, Edison and Pauls, 1993). This failure is attributed to the fact that individual time series are not long enough to capture the mean reversion necessary to reject the null of unit root (MacDonald, 1996). To overcome this problem panel unit root is proposed in the literature. By pooling time series data from several cross-section units, this method provides significant improvement in the statistical power of the test. Baharumshah et al (2007) employed panel unit root and find that East Asian real exchange rates show mean reversion after the Asian crisis; however, before the crisis they do not find any evidence of mean reversion. Hooi and Smyth (2007) find evidence of real exchange rate mean reversion in 15 Asian countries. It is, therefore, seen that the studies on Asian real exchange rates, both on individual series and panel, do not achieve a consensus on the mean reversion property of the real exchange rates in Asian region. Particularly studies on the countries in the South Asian Association of Regional Cooperation (SAARC) provide contrasting evidence, such as, Narayan (2006), Noman and Rahman (2010) and Hoque and Banerjee (2014). Panel studies also do not provide any strong support for stationarity of the real exchange rates in Asian countries. One possible source of this inconclusive finding is cross-sectional dependence. Countries are related to each other through trade and investments. Any major global shock that is transmitted through these trade and investment channel affects macroeconomic variables of countries in a region, more or less, in similar fashion. For example, in 1997 almost all Asian countries were affected by the currency crisis. Unit root test on real exchange rate series in isolation cannot capture this interdependence and hence the results from univariate unit root test lack reliability. Even panel unit root tests that do not accommodate this cross-sectional dependence (CSD) may also give misleading results. The objective of the present paper is to address this issue. We apply panel unit root test proposed by Pesaran (2007) that explicitly allow for CSD to the real exchange rate series of the countries in the SAARC region, namely Bangladesh, India, Pakistan, Sri Lanka and Nepal.

This paper makes three major contributions to the literature. First, as far our knowledge, no study has been done on SAARC region using panel unit root approach with CSD. Second, the paper explicitly quantify the extent of CSD and find that the cross-country correlation is very high, which justifies the use of panel unit root test with cross-sectional dependence. Third, it uses long time series data, more than 57 years’ monthly data for India, Pakistan and Sri Lanka, for Nepal data is for more than 50 years and for Bangladesh it is nearly 21 years’ of monthly data. The remainder of this paper is organized as follows: Section 2 discusses the data used in this study and develops the research methodology; Section 3 reports and interprets the results of the empirical analysis; finally, Section 4 concludes the paper.

METHODOLOGY AND DATA

Real exchange rate between foreign country $i$ and home country, $Q_{i,t}$, is constructed as the nominal exchange rate, $S_{i,t}$, adjusted by the ratio of foreign price level, $P^*_i$, and domestic price level, $P_t$, that is:

$$Q_{i,t} = S_{i,t} \times \frac{P^*_i}{P_t}$$  \hspace{1cm} (1)

Eq (1) can be expressed in logarithmic form as follows:

$$q_{i,t} = s_{i,t} + p^*_i - p_t$$  \hspace{1cm} (2)

where lower case letters are the logarithmic forms of their upper case counterparts in Eq (1).
In this study we construct the real exchange rate of all sample countries against the US dollar. We use Consumer Price Index (CPI) of the USA and individual countries to proxy foreign and domestic price levels respectively. Monthly data on nominal exchange rate and CPIs are collected from Datastream.

An unbalanced panel of five countries in the SAARC, namely Bangladesh, India, Pakistan, Sri Lanka and Nepal, is used in this study. Maldives and Bhutan are not included in the sample due to insignificant data. Table 1 describes the data range for individual countries.

### TABLE 1: DATA DESCRIPTION

<table>
<thead>
<tr>
<th>Country</th>
<th>From</th>
<th>To</th>
<th>Months (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>1993:07</td>
<td>2014:03</td>
<td>249 (20.75)</td>
</tr>
<tr>
<td>India</td>
<td>1957:01</td>
<td>2014:03</td>
<td>687 (57.25)</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1957:01</td>
<td>2014:03</td>
<td>687 (57.25)</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>1957:01</td>
<td>2014:03</td>
<td>687 (57.25)</td>
</tr>
<tr>
<td>Nepal</td>
<td>1963:07</td>
<td>2013:10</td>
<td>604 (50.33)</td>
</tr>
</tbody>
</table>

Before testing the panel for unit root, we first examine if there is any unobserved common factor that affect the sample countries giving rise to CSD in the panel. If there is CSD in the panel, then this must be accounted for, otherwise the unit root test results will not be reliable. To detect CSD we employ test proposed by Pesaran (2004). Under the null hypothesis of no CSD the error term \( (u_{it}) \) in standard panel regression model is assumed to be identically and independently distributed. However, under the alternative hypothesis the error term is allowed to be correlated across cross-section units. Therefore, the null and alternative hypotheses can be specified as follows:

\[
H_0: \rho_i = \rho_j = \text{Corr}(u_{it}, u_{jt}) = 0 \quad \text{for } i \neq j \\
H_a: \rho_i \neq \rho_j = \text{Corr}(u_{it}, u_{jt}) \neq 0 \quad \text{for } i \neq j
\]

where \( \rho_{ij} \) is the product-moment correlation coefficient between the error terms of two different cross section units. To test the above hypotheses Pesaran (2004) has proposed the following CD (cross-section dependence) test statistics:

\[
CD = \frac{2T}{N(N-1)} \left( \sum_{i=1}^{N} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right)
\]

For unbalanced panel the above CD test statistic formula is slightly modified as follows:

\[
CD = \frac{2T}{N(N-1)} \left( \sum_{i=1}^{N} \sum_{j=i+1}^{N} T \hat{\rho}_{ij} \right)
\]

Next we conduct panel unit root test. The motivation to employ panel unit root test comes from the low power of univariate unit root tests like ADF or PP tests. Panel unit root tests are more powerful because of increased sample size. By using panel data set one can exploit the extra information contained in pooled cross-section time series data. Besides, the asymptotic distribution of panel unit root test is standard normal which is in contrast to univariate time series unit root tests that have non-standard asymptotic distribution (Baltagi et al., 2007). Several methods have been proposed to test stationarity in panel data among which three methods are widely used: Pesaran and Shin (2003) [hereafter IPS], Levin, Lin and Chu (2002) [hereafter LLC] and Maddala and Wu (1999) [hereafter MW]. All these tests have their own limitations, such as LLC is applicable for homogeneous panel, where the autoregressive (AR) coefficients for unit roots are assumed to be the same across cross-sections. Although IPS allows heterogeneous panels, a major criticism of both LLC and IPS tests is that they both require cross-sectional independence. Although MW test also requires cross-sectional independence, Maddala and Wu (1999) find that MW test is more robust than LLC and IPS tests to the violation of this assumption. Moreover, they find that in a variety of situations the MW test is more powerful than IPS test, which, in turn, is more powerful than the LLC test. Pesaran (2007) proposed a panel unit root test that explicitly incorporates cross-sectional dependence among the panel members. Previously proposed panel unit root tests with cross-section dependence had their own limitations, such as, Chang (2002) is valid for panel with fixed \( N \) as \( T \to \infty \); Choi (2002) is restrictive in the context of heterogeneous panel; Breitung and Das (2005) is applicable if \( T \geq N \). Pesaran’s (2007) test has some attractive features that make it applicable to a variety of cases, such as, high cross-section dependence and serial correlation. The power of the test is satisfactory even for a very
small sample sizes. In this test the standard ADF regression is augmented with cross-section averages of lagged levels and first differences of the individual series to filter out the effect of unobserved common factor following Pesaran’s (2006) reasoning that unobserved common factor can be proxied by the cross-section mean of the series. The test begins by specifying a dynamic linear heterogeneous panel regression as follows:

\[ y_{it} = (1 - \phi_1)\mu_i + \phi y_{it-1} + u_{it}, \quad i=1,\ldots,N, \quad t=1,\ldots,T \]  (5)

The error term is assumed to have single-factor structure as follows:

\[ u_{it} = \gamma_i f_t + \epsilon_{it}, \]

where \( f_t \) is the unobserved single common factor and \( \epsilon_{it} \) is the idiosyncratic error. Now Eq (5) can be written as:

\[ \Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \gamma_i f_t + \epsilon_{it} \]  (6)

where \( \alpha_i = (1 - \phi_1)\mu_i; \quad \beta_i = (1 - \phi_1); \quad \Delta y_{it} = y_{it} - y_{it-1} \)

The unit root hypothesis of interest is \( H_0: \beta_i = 0 \) for all \( i \) against the alternative hypothesis \( H_1: \beta_i < 0, \quad i = 1,2,\ldots,N_i, \quad \beta_i = 0, \quad i = N_i + 1, N_i + 2,\ldots,N \), where \( N_i \) is number of individual processes that are stationary.

The effects of unobserved single common factor \( f_t \) in Eq (6) is filtered out by taking the cross-section mean of \( y_{it} \) and its lagged values. With this correction the unit root test above is based on the significance of the OLS estimate of \( \beta_i \) in the following cross-sectionally augmented ADF regression:

\[ \Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \gamma_i f_t + \epsilon_{it} + d\Delta y_{it-1} + e_{it} \]  (7)

Statistical significance of \( \beta_i \) can be tested either by \( t \) or \( z \) statistic. For balanced panel both \( t \) and \( z \) statistics are available; however, in case of unbalanced panel only \( z \) statistics is available.

**EMPIRICAL ANALYSIS**

The results of CSD test reported in Table 2 indicate that there is high degree of dependence among the log of real exchange rate series (Inner) of the cross-section units. Null hypothesis of CSD is rejected at a very high significance level. Also the correlation among the cross-section units is very high (0.735).

**TABLE 2: CROSS-SECTIONAL DEPENDENCE (CSD) TEST**

<table>
<thead>
<tr>
<th>Variable</th>
<th>CSD test statistic</th>
<th>P-value</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner</td>
<td>52.30</td>
<td>0.000</td>
<td>0.735</td>
</tr>
</tbody>
</table>

These results indicate that panel unit root tests that do not account for cross-section dependence are not able to capture the true time series property of the underlying series. Accordingly we employ Pesaran’s (2007) panel unit root test described above. We also report results of panel unit root test proposed by Maddala and Wu (1999). Unlike Pesaran (2007) this test requires cross-sectional independence. The motive to report this test result is to show how the conclusion on stationarity of the underlying time series depends on whether the test in question accommodates CSD.

Next, the Maddala and Wu (1999) panel unit root test results are given in Table 3. This test assumes that the cross-section units in the panel are not correlated. With this CSD assumption, the test results show that the real exchange rate in the SAARC region is nonstationary at level, but stationary at first difference. This indicates that PPP does not hold in these countries in the long run. However, the results dramatically change when we give due consideration to the CSD by using Pesaran (2007) test.

**TABLE 3: MADDALA AND WU (1999) PANEL UNIT ROOT TEST**

<table>
<thead>
<tr>
<th>Lags</th>
<th>Test statistic at level</th>
<th>Test statistic at first difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without trend</td>
<td>With trend</td>
</tr>
<tr>
<td>1</td>
<td>10.5901</td>
<td>6.4297</td>
</tr>
<tr>
<td></td>
<td>(0.3903)</td>
<td>(0.7780)</td>
</tr>
<tr>
<td>6</td>
<td>11.3054</td>
<td>5.4455</td>
</tr>
</tbody>
</table>
Finally, Pesaran (2007) panel unit root test results in Table 4 show that the real exchange rate in the SAARC region is mean reverting. In both specifications, with and without trend, null of unit root in the panel is strongly rejected. As monthly data are used, we consider 1, 6 and 12 lags and find that the conclusion invariably remains the same. That is, in the SAARC region PPP holds in the long run. This finding is in sharp contrast to the studies that employ univariate unit root tests, such as, Noman and Rahman (2010) and Hoque and Banerjee (2014), who conclude that PPP does not seem to hold in the long in the South Asian region.

**TABLE 4: PESARAN (2007) PANEL UNIT TEST**

<table>
<thead>
<tr>
<th>Lags</th>
<th>Without trend (p-value)</th>
<th>With trend (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-3.118 (0.001)</td>
<td>-2.387 (0.008)</td>
</tr>
<tr>
<td>6</td>
<td>-2.629 (0.004)</td>
<td>-1.776 (0.038)</td>
</tr>
<tr>
<td>12</td>
<td>-2.838 (0.002)</td>
<td>-2.107 (0.018)</td>
</tr>
</tbody>
</table>

**CONCLUSION**

In this paper we provide strong evidence of the validity of the long-run PPP hypothesis for five South Asian countries in the SAARC region, namely Bangladesh, India, Pakistan, Sri Lanka and Nepal. We find that there is high degree of dependence among the real exchange rate series in these countries. Correlation among the real exchange rate series is found to be 0.735. This high cross-sectional dependence validates the use of Pesaran (2007) panel unit root test with cross-sectional dependence. Using various lags (1,6&12) we find that the test strongly rejects the null of unit root both with and without trend assumption, that is, in the long run PPP holds in these countries. We also report Maddala and Wu (1999) panel unit root test without cross-sectional dependence to show how the assumption of cross-sectional dependence significantly alter the results. According to Maddala and Wu (1999) test the real exchange rate series is I(1), whereas according to Pesaran (2007) test, it is I(0).

Our results are sharp contrast to those of Noman and Rahman (2010) and Hoque and Banerjee (2014), who conclude that real exchange rate is I(1) and hence PPP does not hold for Bangladesh, India, Pakistan and Sri Lanka. We argue that this difference in result is attributable to the assumption of cross-sectional dependence.

Our result has significant policy implication. Stationarity of real exchange rate indicates that any real shock, such as, consumption preference, tariff or terms of trade shock, is short-lived. These will not have any lasting impact on the external balance. Other thing remaining the same, no active policy intervention is need for external balance as real exchange rate will not have any permanent effect on current account.

**REFERENCES**


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