



Purchasing Power Parity for Developing Countries: Evidence from Panel Unit Root Tests

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Abstract

The current study focuses on examining the robustness of the PPP theory for a sample of 40 developing economies categorised on the basis of geographical location. For this purpose, all the data series of real exchange rates of selected economies have been checked for stationarity by employing three different methods of panel unit root tests namely Levin, Lin and Chu, ADF-Fisher Chi-square and PP-Fisher Chi-square test. The findings support the existence of strong PPP for the groups of South Asian, South-East Asian and Latin American countries. On the contrary, the group of African and Middle Eastern nations fail to exhibit stationarity in real exchange rate and thus do not support the validity of PPP for these group of nations. This implies that external balance of an economy where PPP holds will not be influenced by long-run or short-run shocks but for the nations where the validity of PPP is rejected the internal economic shocks pose a challenge for the external economic balance of home currency exchange rate.

Introduction

Academicians and experts from all around the globe are engaged in an ongoing and vigorous debate regarding purchasing power parity (PPP) and the sustainability of real exchange rates over the past three decades, particularly after the demise of the Bretton Woods fixed exchange rate system (Taylor 2006). PPP theory is one of the sound theories for analysing the long-run fluctuations in exchange rates. This theory holds the opinion that exchange rates and prices have an impulse-response relationship (Chortareas & Kapetanios, 2013). In other words, it can be said that exchange rate and price levels are interconnected through purchasing power parity. It implies sale of similar goods at the same price at the same time in two different nations. According to PPP, disparities in price levels among two countries can be used to determine the relative exchange rate fluctuations among those countries. (Hoque & Banerjee, 2014).

Variations in currency's exchange rates is a major issue for the emerging open economies such as India. In an emerging economy, the foreign exchange rate has a significant and comprehensive impact on businesses, investment and consumer price

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determinations. A steady exchange rate and reliable currencies are necessary for foreign tourists, business transactions and international portfolios. In short, numerous macroeconomic activities depend upon exchange rate in one way or another. Therefore, forecasting the exchange rate is one of the most significant aspects for the participants engaged directly or indirectly in the international finance activities.

Purchasing Power Parity (PPP) is a key theory that assists in determination of exchange rate. It is the most feasible and efficient approach for analysts, entrepreneurs, investors, policymakers, bureaucrats and researchers to forecast exchange rate. In addition to exchange rate forecasting, PPP is frequently used as an initial step in cross-country comparisons with regards to real GDP and its components. PPP postulates that fluctuations in exchange rates should make it possible for a basket of commodities bought in two separate nations to have the same price when converted into a single currency. The theory asserts that mutual exchange rate of two currencies is in equilibrium if the purchasing power is same in both the countries and thus this theory holds 'the law of one price'. It signifies that similar products should have similar prices in the markets of two different countries and consequently the exchange rate between two countries should equate the ratio of the countries' price levels for a fixed basket of goods. According to the PPP theory, a nation experiences inflation when its domestic price level rises faster than other nations. In such a situation, that currency need to depreciate in order to revert back to PPP (Al-Gasaymeh & Kasem, 2016). There are two main version of PPP theory that is, the absolute and the relative version. According to the absolute PPP theory, the exchange rate between currencies of two countries should be equal to the ratio of the respective price levels upon the conversion of the prices of commodities of different nations into a common currency. Thus, absolute PPP theory holds that purchasing power should be same between the countries.

$$E = \frac{P}{P^*}(1)$$

Where E, P and P* are the nominal exchange rate, domestic price level and foreign price level respectively.

Relative PPP states that the percentage of exchange rate changes of a nation's currency is equal to the difference between price level change in home country and price level change in foreign country. It can be expressed by using following equation:

$$\frac{E_t - E_{t-1}}{E_{t-1}} = \frac{P_t - P_{t-1}}{P_{t-1}} - \frac{P^*_t - P^*_{t-1}}{P^*_{t-1}}(2)$$

According to the relative PPP theory, inflation rate differentials between two nations are offset by means of inverse changes in nominal exchange rate so as to make constant the purchasing power ratio between the two nations (Suranovic, 1999) and this constant parameter is denoted by k in the following equation:

$$E = k \left(\frac{P}{P^*} \right) (3)$$

Where k is a constant parameter. Therefore, relative PPP transforms absolute PPP from a statement about levels in price and exchange rate into one that addresses about change in price and exchange rate (Lafrance & Schembri, 2002).

Review of Literature

PPP has been discussed at length for the last few decades. Some of the relevant studies which focused PPP analysis are discussed as below in the chronological order:

Borsic & Beko (2006) examines the reliability of PPP hypothesis for Slovenian tolar and the Hungarian forint in comparison to currencies of France franc, Austrian schilling, Italian lira and German mark respectively spanning over January 1992 to December 2001. For this purpose, ADF unit root test and Johansenco-integration approach have been applied. Despite cointegration has been found among some selected nominal exchange rates and a few consumer price indices, the validity of PPP could not be detected entirely in this study.

Chowdhury (2007) by employing monthly data from January 1994 to December 2002 for Bangladesh and its four trading partners including the Euro area, India, Japan and US evaluate the theory of long-run purchasing power parity. The researcher does not apply conventional unit root test but more robust nonlinear model such as smooth transition autoregressive (STAR) model, logistic STAR (LSTAR) and exponential STAR (ESTAR) model. The results significantly support the validity of long-run PPP hypothesis.

Dimitriou and Simos (2013) in their study investigate both the weak (short-run) and strong (long-run) versions of the PPP hypothesis between the United States and Japan for time period from January 2000 to October 2012 employing structural breaks i.e., Tsunami in year 2011 and subprime crisis of US in 2008. To identify the potential structural breaks in data, Lee-Strazicich unit root tests, Gregory-Hansen and Hatemi cointegration approaches have been employed. Further to analyse the strong PPP, the dynamic ordinary least squares regression (DOLS) has been applied. The findings confirm the existence of weak form of PPP over the sample period. On the contrary, the strong PPP is existed only after the period of subprime crisis of US.

Considering both one and multiple structural breaks, Hoque & Banerjee (2014) seek to investigate the order of integration of the real exchange rates for four South Asian nations- India, Bangladesh, Sri Lanka and Pakistan. Two data sets of real exchange rates compressed by CPI and PPI respectively has been taken for more robust examination. The results of the standard ADF and PP unit root test observed mixed results whereas the findings of the Zivot-Andrews and the Clemente-Montañes-Reyes test clearly depict that real exchange rate is non-stationary at level. Overall, the findings of the study do not support the existence of PPP over the long run.

Al-Gasaymeh & Kasem (2015) in their study tested purchasing power parity (PPP) using two versions of PPP namely, the strong and the weak form of PPP among Jordan and its key trading partners nations over the period January 2000 to December 2012.

The findings demonstrate that the PPP fails to hold for all nations in the long run as each country's real exchange rate is nonstationary at level. Conversely, the results of the Johansen cointegration test confirm the existence of weak form of PPP as the long-run cointegrating relation has been found between exchange rates of both domestic and foreign price levels in case of all countries. Overall, this study supports only weak PPP.

Another study by Al-Zyoud (2015) refuted the existence of absolute purchasing power parity on the basis of ADF, PP unit root tests and Engle-Granger cointegration test on monthly data series of US and the Canadian dollar over the period 1995M01- 2008M08. The study observed no cointegration between the exchange rate and purchasing power parity rate. The study also does not provide evidence for the existence of relative PPP. However, the study maintains that the real exchange rate for both the countries can be significantly determined using the PPP rate.

The study by Al-Gasaymeh et al., (2015) seeks to go beyond the scope of developed and developing country and examine the influence of nation's characteristics on purchasing power parity. For this purpose, ADF unit root test has been employed to analyse the stationarity property of the real exchange rate for a group of nations, categorizing into three distinct groups where the first group has been classified on the basis of trading agreements, the second based on inflation and the third group comprised of nations located in same geographical area. The results exhibit that it is appropriate to analyse PPP across nations that share similar attributes but inappropriate when the nations differ with regard to attributes.

This study of Al-Gasaymeh & Kasem (2016) analyses the reliability of the purchasing power parity theory among Jordan and its trading partner nations which include Oman, Bahrain, Qatar, Kuwait, United Arab Emirates and Saudi Arabia. In addition to this, market integration among these countries has been explored. For the purpose of analysis, data spanning over 2005Q1–2012Q4 has been tested using ADF and KPSS unit root tests, Johansen cointegration test and VECM (vector error correction model). The findings revealed that the purchasing power parity model holds across the long-run.

Al-Gasaymeh et al., (2019) apply Johansen-Juselius co-integration technique to investigate the hypotheses of purchasing power parity to the intriguing scenarios of India and Pakistan on annual time series data over 2004 to 2014. The findings confirm the existence of cointegrating relationship among nominal exchange rate, domestic and international price levels which in turn validate the PPP theory in the context of both the nations. The results further reveal that the Pakistani and Indian economies are integrated.

The earlier studies on PPP have been mostly conducted for developed economies which generally fail to discover evidence of long-run PPP and mixed findings have been observed. However, research on examining PPP of developing nations has not been analysed elaborately. This research paper aims to fill this existing gap and broaden the investigation of PPP by employing panel unit root tests on developing economies divided on the basis of same geographic location.

Data Description

For the purpose of examining the validity of PPP theory, the quarterly data spanning over 2001:Q1-2020:Q4 across 40 nations is being considered. Since the majority of the countries considered in this study trade in US dollars, the US dollar has been selected as the common currency. The real exchange rate (r) has been constructed using the nominal exchange rate (end period spot rate) and consumer price index(CPI). The data on nominal exchange rate and CPI for each nation has been retrieved from the International Financial Statistics of IMF. Here, the nominal exchange rate is domestic currency per US dollar for each country considered. The real exchange rate i.e., r has been computed by using following equation:

$$\log(r) = \log(e) + \log(p^*) - \log(p) \quad (4)$$

Research Methodology

Analysing the stationarity properties of data series and assessing their degree of integration is the preliminary step in determining PPP. As per this theory, real exchange rate should revert back to mean implying that it must revert back to the level determined by PPP as a consequence of any shock or disturbance. This notion is relevant because it can be empirically tested. For this purpose, all the data series of real exchange rate have been checked for stationarity by employing three different methods of panel unit root tests namely, Levin, Lin and Chu's (2002), ADF-Fisher Chi-square and PP-Fisher Chi-square that incorporate cross-country and time-series fluctuations. The null hypothesis for all these tests is that each member of the panel has unit root whereas the alternative hypothesis is that each member is level stationary that is integrated of order zero $I(0)$. The basic autoregressive AR(1) model can be presented as follows:

$$y_{it} = \rho_i y_{it-1} + \alpha_i X_{it} + \mu_{it} \quad (5)$$

where $i=1, 2, \dots, N$ represent series of nations observed across time periods $t=1, 2, \dots, T$, ρ_i stands for the autoregressive coefficients, X_{it} stands for exogenous variable within the model including any individual trends or fixed effects and error μ_{it} is a stationary process. It is stated that y_{it} is weakly trend-stationary if $\rho_i < 1$. On the contrary, y_{it} contains a unit root if $\rho_i = 1$. The regression that has been run on univariate ADF tests is as per following equation:

$$\Delta r_t = \mu + \alpha r_{t-1} + \sum_{i=1}^k C_i \Delta r_{t-i} + \varepsilon_t \quad (6)$$

where k is the number of lagged first differences and Δr_t is the first difference of real exchange rate. Similarly, regression analysis that has been used to conduct the panel tests is presented as per the following equation:

$$\Delta r_{it} = \mu_j + \alpha r_{jt-1} + \sum_{i=1}^k C_{ji} \Delta r_{jt-i} + \varepsilon_{jt} \quad (7)$$

where, u_j stands for heterogeneous intercept and subscript j represent the nation index while k is the lag length and the coefficient C_{ji} are heterogeneous across nations. ADF test results have been applied to determine the values of k in equation (7) which is computed using a feasible GLS (SUR). The coefficients α are the same across all the nations. The constraint on α follows the panel unit root tests proposed by Levin et al. (2002). The test statistic is expressed using t-statistic on α . The null hypothesis is rejected if the coefficient of the lag of real exchange rate i.e., α is negative and significantly different from zero. The study focuses on five categories of developing nations which are grouped as below:

1. South Asia (Six countries: India, Pakistan, Bangladesh, Nepal, Sri Lanka and Bhutan).
2. South-East Asia (Seven countries: Indonesia, Malaysia, Philippines, Thailand, Myanmar, Singapore and Vietnam).
3. Africa (Ten countries: Burundi, Ghana, Botswana, Gambia, Niger, Malawi, Kenya, Tanzania, Uganda, Zambia).
4. Latin America (11 countries: Brazil, Bolivia, Colombia, Chile, Guatemala, Costa Rica, Honduras, Nicaragua, Mexico, Paraguay and the Dominican Republic).
5. Middle East and North Africa (MENA, Six countries: Egypt, Tunisia, Algeria, Jordan, Turkey, and Morocco).

Results and Discussion

In accordance with the PPP theory, the real exchange rate ought to remain constant. So, this study investigates the same by arranging countries into panel groups of equal size and grouping them according to geographical location. The literature suggests that robust findings can only be derived using panel data integration approaches when there is a certain level of homogeneity across the data sets. For this reason, the study considers 40 countries divided into homogeneous groups on the basis of geographical locations. The following tables display the findings for each group. Three different methods of panel unit root tests have been applied to investigate the stationarity characteristics of real exchange rate.

Table 1. Panel Unit Root Results of Considered South Asian Nations

Unit Root Method	Statistic	Prob. value	Cross sections	No. of Observation
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t^*	-3.12847*	0.0009	6	461
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	21.7385**	0.0406	6	461
PP - Fisher Chi-square	19.6236***	0.0746	6	474

*, ** and *** shows 1%, 5% and 10% level of significance respectively.

The lag length was selected automatically using the Akaike information criteria (AIC).

Table 1 depict the findings of panel unit root tests. The null hypothesis for the existence of unit root is strongly rejected at 1% level of significance using Levin, Lin and Chu test. Similarly, the results of ADF-Fisher Chi-square and PP-Fisher Chi-square reveal that again we can reject the null of existence of unit root at 5% and 10% level of significance respectively. It indicates that at levels, the real exchange rate is stationary which implies that after a shock or disturbance real exchange rate reverts toward mean value. Thus, the evidence of PPP has been found among this group of countries. Hence it is concluded that PPP holds in south Asian nations. Our findings are in line with Hassan et al. (2015) that provide strong evidence of PPP for south Asian nations. The results of the panel unit root tests for the seven south-east Asian countries have been presented in table 2. The findings of Levin, Lin and Chu test exhibit the rejection of null hypothesis of unit root existence at 1% level of significance. Similarly, at a 10% level of significance, the ADF and PP-Fisher Chi-square results demonstrate that we can reject the null of existence of unit root again. The results reveal that at levels, the real exchange rate is stationary and mean reverting which in turn highlighted that the findings support the validity of PPP also for the south-east Asian countries.

Table 2. Panel Unit Root Results of Considered South-East Asian Nations

Unit Root Method	Statistic	Prob.value	Cross sections	No. of Observation
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.07920*	0.0010	7	553
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	22.7808***	0.0639	7	553
PP - Fisher Chi-square	21.9501***	0.0796	7	553

*, ** and *** shows 1%, 5% and 10% level of significance respectively.

The lag length was selected automatically using the Akaike information criteria (AIC).

Table 3. Panel Unit Root Results of Considered African Countries

Method	Statistic	Prob.value	Cross sections	No. of Observation
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.23483	0.1084	10	772
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	20.2726	0.4410	10	772
PP - Fisher Chi-square	19.4188	0.4948	10	790

*, ** and *** shows 1%, 5% and 10% level of significance respectively.

The lag length was selected automatically using the Akaike information criteria (AIC).

Table 3 show the results of three panel unit root tests for the ten African countries. The findings of the Levin, Lin and Chu test, ADF and PP-Fisher Chi-square unit root tests

demonstrate that the null hypothesis for the existence of unit root cannot be rejected indicating that the real exchange rate is non stationary at levels. Thus, PPP does not hold in African nations. These findings are commensurate with Drine and Rault (2008) which also fails to support PPP for the African countries.

The panel unit root tests have been conducted for 11 Latin American countries for which the results are presented in Table 4. The findings clearly depict that for all the countries the null hypothesis of existence of unit root can be rejected at specified level of significance. In case of Levin, Lin and Chu test, the null hypothesis of unit root existence can be rejected at 1% level of significance. Similarly, in case of ADF and PP Fisher Chi-square tests the null hypothesis for the existence of unit root can be rejected at 5% level of significance.

Table 4. Panel Unit Root Results of Considered Latin American Nations

Unit Root Method	Statistic	Prob.value	Cross sections	No. of Observation
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.35746*	0.0092	11	836
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	36.4313**	0.0273	11	836
PP - Fisher Chi-square	34.0263**	0.0488	11	869

*, ** and *** shows 1%, 5% and 10% level of significance respectively.

The lag length was selected automatically using the Akaike information criteria (AIC).

Thus, it can be concluded that the real exchange rate is stationary and mean reverting which in turn confirm the validity of PPP for the Latin American countries. These results on Latin American nations are compatible with the study of Al-Gasaymeh & Kasem (2016).

Table 5. Panel Unit Root Results of Considered Middle East and North African (MENA Countries)

Unit Root Method	Statistic	Prob.value	Cross sections	No. of Observation
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	0.51846	0.6979	6	472
Null: Unit root (assumes individual unit root process)				
ADF - Fisher Chi-square	4.88484	0.9617	6	472
PP - Fisher Chi-square	4.78151	0.9649	6	474

*, ** and *** shows 1%, 5% and 10% level of significance respectively.

The lag length was selected automatically using the Akaike information criteria (AIC).

Table 5 depicts the results of three panel unit root tests that have been conducted to assess PPP validity for the six Middle East and North African countries. Considering the results of the Levin, Lin and Chu test, ADF-Fisher and PP-Fisher Chi-square unit root tests, the null hypothesis for the existence of unit root cannot be rejected. This indicates that the

real exchange rate is non-stationary at levels. These outcomes of the tests thus demonstrate that PPP does not hold for this particular group of nations. These findings of MENA countries are consistent with Al-Gasaymeh & Kasem (2016) and Drine and Rault (2008) which have failed to establish any evidence of PPP validity for the developing countries.

Conclusion

The present study focuses on investigating the validity of long-run purchasing power parity for panel groups of 40 developing nations classified geographically into five groups namely South Asia, South-East Asia, Africa, Latin America and Middle East & North Africa (MENA). For this purpose, stationarity of log of real exchange rate vis-à-vis the US dollar has been examined applying three types of panel unit root tests i.e., Levin, Lin and Chu test, ADF-Fisher and PP-Fisher Chi-square tests. This will provide an insight on the validity of PPP on the basis of geographical location while focusing only on developing nations.

The findings support the existence of strong PPP for the groups of South Asian, South-East Asian and Latin American countries. On the contrary, the group of African and Middle Eastern nations fail to exhibit stationarity in real exchange rate and thus do not support the PPP theory. Hence, this study reveals mixed results for the developing nations when categorised geographically.

Our findings have few important policy implications. The stationarity of real exchange rate for the groups of South Asian, South-East Asian and Latin American countries signifies that any economic shock caused by changes in consumption preferences, tariffs or terms of trade would disappear quickly in short span and revert to mean value. This implies that the external balance of an economy within these groups will not be influenced by disturbances in the long run. Since the real exchange rate does not have a long-term impact on the current account, no effective monetary policy action is needed to counter the currency fluctuations. These unit root tests signify the restrictive constraints of proportionality and symmetry criteria are fulfilled in PPP, which implies that nominal exchange rate and aggregate price ratios move in tandem in the long-run.

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