

Macroeconomic Variables and Validity of PPP Theorem: An Examination of Panel Unit Root Method

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The main purpose of this paper is to examine the validity of purchasing power parity between a group of countries based on macroeconomics variables namely, high/low income and the highest GDP per capita over the period 2005Q1-2015Q4. Four types of panel unit root methods, namely Levin, Lin and Chu (LLC), ADF-Fisher, PP-Fisher and Im, Pesaran and Shin (IPS) had been used to test the unit root in real exchange rates. The results of common unit root test LLC found evidence in favor of the validity of PPP. But the results of Im, Pesaran and Shin, ADF-Fisher and PP-Fisher unit root tests results failed to find evidence in the favor of validity of PPP for high/low income and GDP. Hence, this study fails to find evidence for both characteristics. Therefore, the debate of PPP remains elusive and the puzzle will continue.

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1. Introduction

Purchasing power parity (PPP) is a powerful tool that provides us a common lens by which to view the economic health and condition of different countries. Just as with any tool or device, we must be aware of the limitations and weakness of PPP and understand how we can control those limitations within a particular data set. The motivation of this study is that if we can control those limitations within a particular data set and PPP is valid, then we can use it in many circumstances. The concept of PPP maintains that the national price levels should be equal when expressed in the units of a common currency (Cassel, 1918). Translated into observables, it states that the real exchange rate (a ratio of price indexes in two countries expressed in terms of a single currency) should be constant. Although simple in theory, the real world is characterized by a number of complications such as differentiated products, tastes and wide range of costs, which created considerable problems for economists testing the theory empirically in the post-Bretton Woods era. With the move to flexible exchange rates in the early 1970s, it was generally assumed that the exchange rate would quickly adjust to changes in relative price levels. In determining the validity of PPP, the results from several empirical studies have been mixed. Few studies have found evidence for the theory in the short run; while the results on PPP in the long run have been more varied. For example, Adler and Lehmann (1983), Ballie and McMahon (1989), Cochran and DeFina (1995), Corbae and Ouliaris (1988), and Meese and Rogoff (1988) found little support for the hypothesis, while Abuaf and Jorion (1990), Glen (1992), Kim (1990), Pippenger (1993), Whitt (1992), and Razzaghipour *et al.* (2001) found some evidence of PPP.

The PPP theory has been tested for several countries using various statistical methods in different sample periods. Some empirical studies find evidence of a tendency toward PPP in the

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long run, while others reject the hypothesis that there exists a long run relationship between exchange rate and price ratio. The puzzle in PPP is that the empirical evidences showed that international price differences for individual goods (in the case of the law of one price) or baskets of goods (in the case of PPP) appear highly persistent or even non-stationary and fluctuations in the real exchange rate are very volatile and very persistent. An important and yet somewhat under-researched issue is what determines the validity of PPP? Does high level of income contribute towards the validity of PPP? Is low income important? Does GDP per capita matter? Therefore, this study tries to link these characteristics with the validity of PPP.

Small open economies in the developing world often face the problem of fluctuations in exchange rate. Foreign exchange rate is pervasive and singularly important price in an open economy, influencing consumer prices, business and investment decisions. Hence, exchange rate prediction is one of the most challenging and critical decisions for those who are involved in international finance. One of the major theories that explain exchange rate determination is Purchasing Power Parity. PPP is the simplest tool for global trader, investor, economist, policy makers and academicians to predict exchange rate. Besides exchange rate prediction, PPP is commonly used as a first step in making inter-country comparisons based in real terms of gross domestic product (GDP) and its component expenditures. PPP also can be used to examine whether or not the regional trade agreements has been satisfied. PPP had been a very useful tool and had been a component for many economic models; however, there are a number of issues surrounding PPP theory. In the literatures; Alba and Papell, 2007; Cheung and Lai 2000) put forward that trade barriers, transportation costs, non-tradable products, imperfect competition in the measure of average prices for goods and services or different commodity baskets and price rigidity might cause deviations from PPP. While significant, they are still not compelling enough for scholars to discard a theory that makes strong intuitive logic. Empirical study of PPP found mixed results may be due to heterogeneity among countries (Al-Gasaymeh and Kasem 2015). The results of this paper do not support the validity of PPP for the groups of countries which are in the same level of GDP. Therefore, this study fails to find evidence of PPP between all groups of countries and the debate of PPP remain elusive and the puzzle remain unsolved.

Given these theoretical explanations, this paper will contribute to the existing literature whether GDP and other disturbances outlined above have caused deviations from PPP. To our knowledge, few empirical studies have been done on this regards (Al-Gasaymeh and Kasem 2015). Due to the lack of studies tries to link the level of income and GDP per capita with the validity of PPP. Therefore, this study tries to study PPP in a framework that arranges countries according to similar characteristics.

The paper is organized as follows. Section 2 discusses the existing literature, and Section 3 discusses the methodology and data analyzed in this study. Section 4 reports the empirical results, and the last section provides the conclusion and overview of this study.

2. Literature Review

Looking at previous studies, they mostly focused on developed countries and using real exchange rate and ADF unit root test. The critic point of using real exchange rate. The unit-root tests of real exchange rates impose the proportional restriction among exchange rates and prices due to the lack power and one implication of unit root is that the restrictive conditions of proportionality and symmetry restrictions are satisfied in PPP that is nominal exchange rates and aggregate prices move together in a one-to-one fashion in the long run. Recently, there are some studies conducted beyond the developed/developing country dichotomy to investigate the role of individual country characteristics on PPP (Al-Gasaymeh and Kasem 2015) and (Al-

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Gasaymeh et al (2015) using panel unit root. For instances, Cheung and Lai (2000) investigated how the characteristics of Openness and Per capita GDP growth affect PPP; Holmes (2001) tested how the Inflation & Geographic region affect PPP; while Alba and Park (2003) tested on the Openness, Inflation and growth. Besides Openness, Inflation and Growth rate, Alba and Papell (2007) tested how the characteristics of distance and nominal exchange rate volatility affect PPP. The study of Drine and Rault (2008) examined the criteria of level of development and the geographic zone, type of exchange rate regime and inflation level. Al-Gasaymeh and Kasem (2015) examined the stationarity of real exchange rate by using 4 types of unit root tests for a group of countries classified into three groups; the first group is based on trade agreements, the second group is the top 55 inflation countries in the world and the last group is the same geographically located countries. The results do not support the validity of PPP for the first group based on trade agreement for the regions of the Greater Arab Free Trade Area (GAFTA), but evidence for Latin American countries shows that the result could support the validity of PPP based on trade agreements. The evidence of PPP is stronger for countries which have higher inflation. Geographic regions for Middle East countries failed to find evidence for the validity of PPP.

According to the literature shows that PPP works in a better way for countries with high inflation, and the best of all periods is at its hyper-inflation period. With the exception of this period, short-term studies have shown the acceptance of the assumption that the real exchange rates follow a random walk with no tendency to return to an equilibrium level. Most of the studies using long-term data have found evidence of the reversion towards PPP but in a very low rate: it takes between three and five years for half of the exemption is lifted. This generates what Rogoff (1996), called the "PPP puzzle" in the Post-Bretton Woods era. He states that during the nominal floating exchange rates, the real exchange rates have been extremely volatile in the short term and thus very slow to achieve equilibrium. The short-term deviations from PPP can be explained by the high volatility of the nominal exchange rate, which is presumably due to the volatility of the underlying financial factors, combined with nominal price stickiness. However, such short-term stickiness is difficult to reconcile due to the very slow pace of deviation in the PPP. Some recent studies suggest a number of explanations for the puzzle, including non-linear dynamics, which shows that return to PPP is rapid for large businesses but much less for small businesses due to the heterogeneity between the goods in their rates of convergence (Holmes 2001; Cheung and Lai 2000 and Alba and Park 2003).

However, there is a completely satisfactory explanation of the data, which remains elusive. According to Alba and Papell (2007), there are a number of reasons why PPP might vary systematically with the country's characteristics. PPP may hold better for countries which are more open to trade because trade barriers hinder international arbitrage and also among countries that are geographically closer because high transportation costs associated with greater distance could hinder trade and arbitrage. PPP may also hold better between countries with similar inflation rates because with differences in inflation, countries can prevent their nominal exchange rates from adjusting to parity. Balassa (1964) and Samuelson (1964) posit that countries with high productivity growth in traded goods will have appreciating real exchange rates. In that case, PPP will not hold between high-growth and low-growth countries. PPP is expected to hold between trading partners because of many reasons, such as "free trade movements", "avoiding double taxation", and high volume of trade", "removing barriers and promotion of trade". Normally special trade agreement between countries existed for trading partners. Removing trade barriers and tax exemption encourage trade. When the trade volume between countries is high, the transportation cost per unit is lower. Thus, the price differences will be smaller. It is expected that the PPP will hold when there is high trade. What could cause much stronger evidence of PPP for some regions than in others? Level of income, GDP and

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trading partners appear to be important factors. Therefore, this paper will focus on macroeconomics determinants factors which could influence the validity of PPP.

There are some recent studies conducted beyond the developed/developing country dichotomy to investigate the role of individual country characteristics on PPP. Al-Gasaymeh and Kasem (2015) test two forms of purchasing power parity, specifically the strong and the weak form of PPP between Jordan and its major trading partners. The results show that the real exchange rate in each country is nonstationary. This implied that the long-run PPP fails to hold for all countries. The results of cointegration tests showed that there exists a cointegrating relationship for all the countries between exchange rate, domestic and foreign price levels. They conclude that the evidence of weak PPP is found between Jordan and its major trading partners. The unit-root tests of real exchange rates imposed proportionality and symmetry restrictions that nominal exchange rates and aggregate prices move together in a one-to-one fashion. The weak form of the PPP states that the nominal exchange rate and aggregate price ratios may move together in equilibrium, but the relationship need not necessarily be one-to-one. This paper found evidence for weak PPP but not for strong PPP, hence, the conditions of proportionality and symmetry restrictions may be one of the reasons that PPP not hold when being tested empirically. Given the above discussion, this paper provides a notable contribution by filling the gap for the validity of PPP based on the level of income and GDP and due to lack of studies on developing countries exists on this regards.

3. The Methodology and Model

In this paper, we employ quarterly data from 2005-2015:Q4. The data of nominal exchange rate and consumer price for all 45 countries² are obtained from IMF's International Financial Statistics. The real exchange rates are grouped to different panels based on three characteristics. The choice of countries is based on the similarity for each characteristic such as similar high GDP per capita and the income level and we choose 15 countries for each group. A common test of long run PPP is to examine if the real exchange rate has a unit root. The real exchange rates should be mean-reverting. That is, in response to any shock or disturbance, the real exchange rate must eventually return to its PPP-defined level. The empirically testable form for real exchange rates involves testing for unit roots in real exchange rates. Rejection of the unit root hypothesis indicates mean reversion in real exchange rates. Moreover, this study will employ various panel unit root tests to test the unit roots in real exchange rates. As discussed in the literature review, this study is not the first to investigate the purchasing power parity using panel unit root tests (Al-Gasaymeh and Kasem 2016).

The real exchange rate is calculated as follows:

$$q = e + p^* - p \quad (1)$$

Where q is the real exchange rate, e is the nominal US dollar exchange rate; p is the domestic price index and p^* is the price index of the United States. q , e , p and p^* are in logarithms.

The panel tests are conducted by running regressions on the following equation:

$$\Delta q_{it} = \mu_j + \alpha q_{jt-1} + \sum_{i=1}^k C_{ji} \Delta q_{jt-1} + \varepsilon_{jt} \quad (2)$$

² Countries are listed in appendix

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Where Δq_t the first difference of the real exchange rate and k is the number of lagged first differences, where μ_j represents heterogeneous intercept and the subscript j is the country index. The lag length k and the coefficient C_{ji} are heterogeneous across countries. This unit root test is performed on the level of variables. At first, the model without trend is adopted in the empirical analysis because an inclusion of linear time trend would be theoretically inconsistent with long run PPP proposition and, as suggested by most empirical studies, time trend in real exchange rate is not consistent with the PPP hypothesis. Recent literature suggests that panel-based unit root tests have higher power than unit root tests based on individual time series. In this study we use four types of panel unit root tests by Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003), Fisher-PP and Fisher-ADF.

4. The Findings

Table 1 shows the results of panel unit root tests for the high income countries that had been employed in this paper. From the results obtained by using Levin, Lin and Chu's (LLC) test, we can reject the unit root hypothesis at 10% level of significance, which means real exchange rate is stationary at level. Thus the result of LLC test does support the evidence of PPP. The results obtained from the Im, Pesaran and Shin W-stat, ADF-Fisher Chi-square and PP-Fisher Chi-square unit root tests, show that we cannot reject the unit root which means that real exchange rate is non stationary at level. Thus, the results of the tests indicate that we cannot support the validity of PPP for this group of countries.

Table 1: Panel Unit Root of High Income Countries

Country group	No. of Countries	Intercept	
		t-statistic	P-Value
Levin, Lin and Chu (LLC)	15	-1.43806	0.0752
Im, Pesaran and Shin W-stat	15	-1.10599	0.1344
ADF-Fisher Chi-square	15	63.9429	0.1238
PP-Fisher Chi-square	15	41.9192	0.8399

Note: The null hypothesis for all the tests is unit root.

The lag length was chosen by Akaike information criteria (AIC) auto selection.

Table 2 shows the results for the group of countries based on the low level of income is conducted. The result from the Levin, Lin and Chu's (LLC) test shows that we can reject the unit root hypothesis at 10% level of significance, which means that the real exchange rate is mean reverting or stationary at level. Hence, thus the result of the LLC test does support evidence of PPP. The results from the Im, Pesaran and Shin W-stat, ADF-Fisher Chi-square and PP-Fisher Chi-square unit root tests, indicate that we cannot reject the unit root which means real exchange rate is non-stationary at level. Thus, the results of these tests show that we cannot support the validity of PPP for this group of countries.

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Table 2: Panel Unit Root of Low Income Countries

Country group	No. of Countries	Intercept	
		t-statistic	P-Value
Levin, Lin and Chu (LLC)	15	-1.55207	0.0603
Im, Pesaran and Shin W-stat	15	-0.56185	0.2871
ADF-Fisher Chi-square	15	16.0807	0.4473
PP-Fisher Chi-square	15	17.3946	0.3605

Note: The null hypothesis for all the tests is unit root.

The lag length was chosen by Akaike information criteria (AIC) auto selection.

Table 3 shows the results of four types of panel unit root tests for similar GDP for a group of countries that had been employed. From the result of Levin, Lin and Chu's (LLC) test, we can reject the unit root hypothesis at 5% level of significance which means that the real exchange rate is mean reverting or stationary at level. Thus, the result of LLC test does support the evidence of PPP. The results of Im, Pesaran and Shin W-stat, ADF-Fisher Chi-square and PP-Fisher Chi-square unit root tests, show that we cannot reject the unit root which means real exchange rate is non-stationary at level. Hence, the results of the tests show that we cannot support the validity of PPP for countries that are in the low income level.

Table 3: Panel Unit Root Tests for the GDP Per Capita

Country group	No. of Countries	Intercept	
		t-statistic	P-Value
Levin, Lin and Chu (LLC)	15	-3.03	0.01
Im, Pesaran and Shin W-stat	15	-1.06	0.33
ADF-Fisher Chi-square	15	24.15	0.23
PP-Fisher Chi-square	15	12.41	0.92

Note: The null hypothesis for all the tests is unit root.

The lag length was chosen by Akaike information criteria (AIC) auto selection.

These results are compatible with Al-Gasaymeh and Kasem (2015), who fails to find evidence for the validity of PPP for number of country characteristics. Hence, the results of the tests show that we cannot support the validity of PPP for countries that are in the same level GDP. Moreover, the results are different from the previous studies based on the macroeconomic variable which has been taken in this study.

5. Summary and Conclusions

The main aim of this paper is to examine the validity of PPP between a group of countries based on macroeconomics variables namely, high/low income and GDP per capita over the period 2005Q1-2015Q4. Four types of panel unit root methods, namely Levin, Lin and Chu (LLC), ADF-Fisher, PP-Fisher and Im, Pesaran and Shin (IPS) had been used to test the unit root in real exchange rates. This paper examined the stationarity of real exchange rate for a group of 45 countries classified into three groups; the first group is based high level of income, the second group is based on the low level of and last group is based on the similarity of GDP per capita. The results obtained from the Im, Pesaran and Shin W-stat, ADF-Fisher Chi-square and PP-Fisher Chi-square unit root tests, show that we cannot reject the unit root which means that real exchange rate is non stationary at level. Thus, the results of the tests indicate that we cannot support the validity of PPP for all group of countries. In summary, the result of the common unit root using Levin, Lin and Chu's (LLC) test for high level of income could only find

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weak evidence at 10% level. But the results of Im, Pesaran and Shin W-stat, ADF-Fisher and Chi-square PP-Fisher Chi-square unit root tests results fail to find evidence in the favour of validity of PPP for this group of countries. The common unit root test, Levin, Lin and Chu (LLC) found evidence of PPP, but the results of Im, Pesaran and Shin W-stat, ADF-Fisher and Chi-square PP-Fisher Chi-square unit root tests fail to find evidence in the favour of validity of PPP for countries in the favour of GDP. Hence, the results do not support the validity of PPP for the groups of countries which are in the same level of GDP. Therefore, this study fails to find evidence of PPP between all groups of countries and the debate of PPP remain elusive and the puzzle remain unsolved.

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Appendix

List of Countries included

No	High Income	No.	Low Income	No.	GDP Per Capita
1	United State	1	Afghanistan	1	Luxembourg
2	Japan	2	Burundi	2	Norway
3	Germany	3	Mali	3	Qatar
4	United Kingdom	4	Malawi	4	Macao SAR, China
5	Italy	5	Mozambique	5	Switzerland
6	France	6	Nepal	6	Australia
7	Ireland	7	Niger	7	Denmark
8	New Zealand	8	Rwanda	8	Sweden
9	Sweden	9	Chad	9	Singapore
10	Switzerland	10	Haiti	10	United States
11	Norway	11	Ethiopia	11	Ireland
12	Saudi Arabia	12	Cambodia	12	Netherlands
13	Qatar	13	South Sudan	13	Iceland
14	Kuwait	14	Somalia	14	Austria
15	United Arab of Emirates	15	Zimbabwe	15	Canada