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Purchasing Power Parity Hypothesis in OIC Countries: Evidence from Panel Unit Root Tests with Heterogeneous Structural Breaks

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Abstract

Purchasing power parity hypothesis is viewed as one of the central doctrines in international economics. The hypothesis states an equilibrium condition equating the nominal exchange rate between two national currencies with the relative price of an identical basket of traded goods in each country. Empirical analysis has produced mixed results in testing for the PPP. This paper analyzes the empirical validity of PPP hypothesis in OIC countries. Hence, it examines the stationarity of real exchange rate by ADF unit root test and various panel unit root tests. Using univariate ADF unit-root test on single time series and also the conventional panel unit root tests namely, Im, Pesaran, and Shin (2003), Levin, Lin & Chu (2002), and Hadri (2000), it was found that the real exchange rate of all OIC countries and also panel series of real exchange rate have unit root. But when recently developed panel LM unit root test that allow for heterogeneous level shifts, are applied, the null unit roots isn't rejected in real exchange rates series. Our findings are generally supportive of the PPP hypothesis with the crises leading to shifts in long-run trends.

Keywords: Purchasing power parity, panel unit root test, Lagrange multiplier, Structural break

1- Introduction

The purchasing power parity (PPP) hypothesis is among the most popular research topics in the international macroeconomic literature that the empirical validity of PPP remains as controversial issue yet. The PPP

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suggest that the changes in exchange rates should balance the price of a basket of traded goods in a foreign country so that it roughly equals the price of the same basket in the United States, once the foreign prices are converted to American dollars at the exchange rate. This concept constitutes a major pillar of the economics of exchange rates.

In the PPP debate, the empirical literature distinguishes two concepts: the absolute version and the relative version. The idea behind the absolute version of PPP evolved from the law of one price, once converted to a common currency, the same good should sell for the same price in different countries. In other words, for any good i:

$$P_i^d = P_i^f E_i \qquad (1)$$

Where P_i^d is the domestic price for good i, P_i^f is the foreign price for good i, and E_i is the nominal exchange rate expressed as the domestic price of the foreign currency (Taylor, 2006, P: 3). If the same price were not to hold, then someone could make a quick profit by buying the good where it was cheaper and selling it where it was more expensive. The price of the good could be expected to rise in the place where it was cheaper and fall where it was more expensive, and the foreign exchange rate would also be expected to adjust to make goods in the cheaper country relatively more expensive. The PPP is the mechanism through which the exchange rate adjusts to the aggregated changes in the prices of tradable goods in two countries to reflect the law of one price (Craig, 2005, P: 1).

Although the idea of the law of one price seems reasonable enough, but as mentioned by Melvin (1992) and Rogoff (1996), it may not appear because transportation costs, barriers to trade, and the difference in the composition and weights used in the construction of official indices of the different countries. Hence, the relative version of PPP was introduced. It stipulates that the nominal exchange rate will adjust to offset inflation differentials between countries. The underlying intuition is the arbitrage across time rather across space.

According to different version of PPP doctrine, it is interpreted in different way[1]. One of them point out that the exchange rate move toward PPP in the long-run, but it might transitorily diverge from PPP by the obstacles that mentioned above. This definition of the PPP offers the possibility of testing the stationarity of the real exchange rate series. Hence The Purchasing Power Parity (PPP) hypothesis has been an active testing ground for successive advances in the econometric treatment of time series (Sabate et al, 2003, pp: 1-2). In empirical work, in order to examine this definition of PPP, three different directions have been taken: unit root tests, cointegration tests, and nonlinear stationary tests (Narayan and Prasad, 2005, pp: 135-136). Rejection of the unit roots in real exchange rate and/ or acceptance of cointegration between various measure of domestic price and nominal exchange rate-adjusted foreign prices indicates real exchange rate move toward PPP in the long run.

The earlier research on PPP used the conventional univariate unit root tests e.g. augmented Dickey and Fuller (ADF; 1979 and 1981) tests (see, Mark, 1990; Bahmani-Oskoee, 1993, and Flynn and Boucher, 1993). Whereas, ADF unit root tests have relatively low power to reject the null hypothesis of unit roots when the span of data is short or structural change have occurred in Data Generating Process, hence the earlier studies could not find crucial results in favor of the PPP. In order to solve the problems, subsequent studies have used three approaches, longer time horizon and panel unit root tests and univariate and panel unit root tests with structural breaks. As mentioned by Alba and Park (2003, pp: 2049), using long time horizon contains both fixed and flexible exchange rate regimes. On the other hand, recent studies (see Alba and Park, 2003; Lopez and Papell, 2007) have tested the PPP over flexible regime i.e. post-1973 by panel unit root tests. But as explained by Taylor and Samo (1998), and Taylor (2001), when we apply panel unit root tests for PPP hypothesis, there is possibility that when the unit root null hypothesis in the panel is rejected, some of the numbers may be stationary while others may be non-stationary. In order to overcome on above shortcoming, we can use panel unit root tests that allow for

1- See Papell and Proden (2006)

structural breaks, as non-stationary in panel series or some of the members may be due to failure to allow for structural break.

In this paper, we are going to examine the PPP hypothesis in the organization of Islamic Conference (OIC hereafter) countries over 1995-2008. To our knowledge, there isn't study so far in the PPP literature that has studied validity of PPP hypothesis on OIC data. On the other hand, in this paper, we apply various univariate and panel unit root tests namely ADF unit root test, Im, Pesaran, and Shin (2003), hereafter IPS, Levin, Lin & Chu (2002), hereafter LLC, and Hadri (2000) panel unit root tests. Moreover, we used the panel Lagrange Multiplier (LM) test proposed by Im et al (2005). It allows for the number of structural breaks to vary by country and allows for heterogeneous break points, which are endogenously determined for each country. The later test may solve both problem i.e. short span of data and structural change that have occurred in Data Generating Process.

The remainder of paper is set out as follows. Section 2 describes data and the econometric methodology used. The empirical results are discussed in the next section. Conclusion is presented in final section.

2- Data and Methodology

2-1- Data description

In this paper, we test the PPP hypothesis in 29 OIC countries namely, Albania, Algeria, Benin, Burkina Faso, Chad, Côte d'Ivoire, Egypt, Gabon, Guinea Bissau, Guyana, Indonesia, Iran, Jordan, Kazakhstan, Kuwait, Kyrgyz, Malaysia, Mali, Morocco, Mozambique, Niger, Nigeria, Oman, Pakistan, Saudi Arabia, Senegal, and Tunisia, Turkey and Uganda. The data used in the study are the quarterly observations from 1995.1 to 2008.4- the longest time period for which variables were available for the maximum number of countries under investigation and have taken from the IMF's international financial statistics. The Nominal exchange rates are the bilateral exchange rate of these countries against the US dollar, and the domestic and foreign prices are defined as each country's Consumer Price Indexes (CPI) and United States Consumer Price Index respectively. All series are expressed in logarithms.

2-2- Methodological Outline

As mentioned in section 1, in order to examine validity of the PPP hypothesis in OIC countries, we apply various univariate and panel unit root tests namely, ADF unit root test, IPS, LLC, and Hadri panel unit root tests and univariate and panel LM unit root tests. Whereas, the ADF, IPS, LLC, and Hadri tests use as customary in the empirical works, hence we explain only univariate and panel LM unit root tests.

The panel LM unit root test statistic is computed by averaging the optimal univariate LM unit root *t*-test statistics estimated for each country. The univariate LM test, following the work of Lee and Strazicich (2003), is based on the following model:

$$Ex_{it} = \gamma_i' \psi_{it} + \vartheta_{it}, \qquad i = 1,\dots,N \quad and \quad t = 1,\dots,T \tag{2}$$

$$\vartheta_{it} = \eta_i \vartheta_{it-1} + \epsilon_{it} \tag{3}$$

Where Ex_{it} is real exchange rate in country i and year t. ψ and γ are a vector of exogenous variables that takes the form $(1,t)$ and the corresponding parameter vector respectively. ϑ is the disturbance error component and ϵ is a zero-mean error term that allows for heterogeneous variance structure across cross-section units, but assumes no cross-correlations. Parameter η_i is used to test the unit root null hypothesis and allows for heterogeneous measures of persistence. As mentioned by Jewell et al (2005, p: 315), "when the data generating process follows Eq. (2), the resulting critical values of the panel unit root test will be invariant to γ_i. In order to allows for two structural breaks in level and slope of the *i-th* series, we define the vector of deterministic terms

$$\psi_{i,t} = [1, t, D(TB_1), D(TB_2), DT(TB_1), DT(TB_2)]'$$

where $D(TB_\kappa) = 1$ if $t \geq TB_\kappa + 1$ for $\kappa \in \{1,2\}$ and 0 otherwise. $DT(TB_\kappa) = t - TB_\kappa$ if $t \geq TB_\kappa + 1$ for $\kappa \in \{1,2\}$ and 0 otherwise.

The unit root test is based upon:

$$\Delta Ex_{it} = \gamma_i' \Delta\psi_{it} + \phi_i S_{it-1} + \sum_{j=1}^{p} \theta_{ij} \Delta S_{it-j} + v_{it} \tag{4}$$

Where $S_{it-1} = (Ex_{it} - Ex_{i1}) - \gamma_i'(\psi_{it} - \psi_{i1})$, with γ_i the estimated least square parameters vector in a regression of ΔEx_{it} on $\Delta\psi_{it}$. The unit root null hypothesis corresponds to $H_0: \emptyset_i = 0$ versus $H_1: \emptyset_i < 0$(implying no unit root and stationary) for each country.

The panel LM test statistic is derived from Eq. (3) and is defined as:

$$\overline{LM}_{NT} = \frac{1}{N}\sum_{i=1}^{N} LM_{iT} \qquad (5)$$

Where LM_{iT} is the individual t-statistic associated to $\emptyset_i$ with expected value $E(l_T)$ and variance $V(l_T)$. A standardized panel LM test statistic is constructed by $E(L_T)$ and $V(L_T)$ as follow (see Im et al 2005, p: 398):

$$\Gamma_{LM} = \frac{\sqrt{N}\,[\overline{LM}_{NT} - E(L_T)]}{\sqrt{V(L_T)}} \qquad (6)$$

Im et al (2005, pp: 399-401) provide numerical values for $E(L_T)$ and $V(L_T)$ for various combinations of T and p, via stochastic simulations using 500,000 replications.

As mentioned by Jewell et al (2003, PP: 317), "The panel LM unit root test has several attractive features. First, the distribution of the test statistic depends on "*N*" and "*T*" but does not depend on any other parameters under the null hypothesis. Second, similar to the Im et al. (2003) panel unit root test, the asymptotic distribution of the panel LM unit root test is standard normal. Most importantly, the distribution of the panel LM test is unaffected by the presence of break(s). This so called "invariance result" holds for any finite number of breaks. As such, it is unnecessary to simulate new critical

values for $E(L_T)$ and $V(L_T)$ as the number and location of breaks varies in each country[1].”

3- Empirical results

Table 1 presents the empirical results of univariate ADF unit root tests for real exchange rates series. As see, we can’t reject the null unit root in real exchange rate series. Thus, according to ADF unit root tests, the PPP hypothesis is rejected for all OIC countries.

Table 1: ADF Unit Root Tests

Countries	Coefficient	t-statistic	Countries	Coefficient	t-statistic
Albania	-0.24	-3.01	Kyrgyz Republic	-0.07	-1.68
Algeria	-0.06	-1.07	Malaysia	-0.09	-2.21
Benin	-0.14	-2.53	Mali	-0.09	-1.91
Burkina Faso	-0.05	-1.16	Morocco	-0.08	-1.96
Chad	-0.18	-2.35	Mozambique	-0.13	-1.91
Côte d'Ivoire	-0.08	-2.03	Niger	-0.05	-1.06
Egypt	-0.05	-1.31	Nigeria	-0.07	-1.28
Gabon	-0.09	-1.79	Oman	0.06	0.82
Guinea-Bissau	-0.11	-1.45	Pakistan	-0.07	-1.78
Guyana	-0.06	-1.03	Saudi Arabia	0.10	1.25
Indonesia	-0.16	-2.23	Senegal	-0.10	-1.82
Iran, I.R. of	-0.11	-2.04	Tunisia	-0.13	-1.90
Jordan	0.02	0.18	Turkey	-0.15	-2.36
Kazakhstan	-0.03	-0.94	Uganda	-0.03	-1.05
Kuwait	0.22	1.95			

1) The critical values for 1, 5, and 10 percent are -4.13, -3.49, and -3.18 respectively.
2) All ADF tests include both constant and trend, and the optimal number of lags is chosen according to t-statistic approach that used by Zivot and Andrews (1992).
3) The numbers in columns of coefficient and t-statistic are corresponded to coefficient and t-statistic of first lag of real exchange rates series.
4) Source: Authors’ findings.

1- the task of allowing for structural breaks in the existing panel unit root tests, such as those proposed by in et al. (2003) and Levin et al. (2002), would be quite difficult to implement. This is due to the fact that the distribution of these panel tests with structural breaks will critically depend on nuisance parameters indicating their location, as noted by Im et al. (2002). As such, it would be extremely difficult, if not impossible, to control for the numerous possible combinations of heterogeneous structural breaks that might occur when using these panel unit root tests.

The Results of conventional panel unit root tests i.e. LLC, IPS and Hadri tests present in table 2. LLC and IPS tests have a null hypothesis unit root in any of series while Hadri (1999) has null hypothesis of no unit root in any of series. Hadri (1999) and LLC tests assume common unit root process across cross-section but IPS assumes individual unit root process. As see in table 2, P-values of LLL, IPS and Hadri (1999) tests show, none of them can not reject the unit root hypothesis at the 10% for OIC countries.

The results were found using ADF and conventional panel unit root test is according to results of other studies that have examined the PPP hypothesis in development countries.

Table 2: Panel unit root tests

Method	statistic	P-value	Null hypothesis
Levine, Lin, and Chu (2002)	4.79	1.000	Null: unit root
Im, pesaran, and Shin (2003)	8.24	1.000	Null: unit root
Hadri-Z stat (1999)	16.08	0.000	Null: no unit root

1- Unit root test include individual effects and heterogeneous trend in data.
2- All tests assume asymptotic normality.
3- We use Schwarz criterion for the lag differences and Newey-West bandwidth selection method using Bartlett kernel.
4) Source: Authors' findings.

Results of panel LM unit root test for non break, one break, and two breaks have shown in table 3. As see, when we apply panel LM unit root test without structural breaks, such as conventional panel unit roots, we cannot reject the null unit root for all countries. These results are as conventional panel unit root tests. But when we apply the panel LM unit root tests with one and two structural breaks, we can reject the null hypothesis of unit root tests for all countries.

As regards break points in table 3, there are evidences that support the existence of structural change in the trend function of OIC real exchange rate due to the occurrence of large infrequent permanent shocks to the series. Because most OIC countries have low degree of diversification in production and export structures, hence their economics highly dependent on external conditions. There is clear-cut evidence supporting the presence of clustering patterns of the break dates based on external shocks such as booms and busts of primary commodity prices. Large terms of trade shocks in countries that produce minerals like the oil boom of 2004-2005 was caused the real exchange rate of most OIC countries experienced one break in the first half of 2000s. Financial crisis of the south East Asia led to one break in 1997 or 1998 for countries such as Malaysia, Indonesia, and Pakistan. Iranian real exchange rate experienced one break in 2001 because

the multi-tiered system was replaced by a unified, market-driven exchange rate.

Table 3: LM unit root tests for real exchange rate

country	LM unit root test without structural break		LM unit root test with one structural breaks			LM unit root test with two structural break			
	Univariate LM test statistic	Optimal lag length (p)	Univariate LM test statistic	Optimal lag length (p)	Break location	Univariate LM test statistic	Optimal lag length (p)	Break locations	
								first	second
Albania	-1.525	3	-3.368	2	Q4 1997	-5.517	7	Q4 1997	Q3 2003
Algeria	-3.813	8	-4.576	8	Q1 2004	-6.018	4	Q3 1997	Q4 1999
Benin	-1.397	0	-4.761	6	Q3 2002	-5.732	6	Q4 2001	Q1 2005
Burkina Faso	-1.617	0	-4.62	6	Q4 2002	-5.6	6	Q3 1999	Q4 2002
Chad	-1.68	2	-4.221	4	Q1 2002	-8.249	1	Q3 1999	Q4 2002
Côte d'Ivoire	-1.197	0	-3.964	1	Q3 2002	-6.35	8	Q1 2000	Q3 2005
Egypt	-2.271	6	-4.404	6	Q3 2002	-6.499	6	Q3 1998	Q4 2002
Gabon	-2.351	3	-4.521	6	Q4 2002	-6.908	6	Q4 2000	Q4 2004
Guinea-Bissau	-2.427	5	-4.659	8	Q2 2005	-5.96	8	Q3 2001	Q1 2005
Guyana	-2.509	1	-3.952	6	Q4 2002	-4.891	6	Q3 1999	Q2 2003
Indonesia	-1.93	3	-5.685	2	Q4 1998	-6.254	2	Q4 1998	Q3 2001
Iran	-1.615	3	-3.692	7	Q3 2001	-17.479	8	Q3 2001	Q3 2003
Jordan	-1.649	1	-2.835	1	Q1 2002	-4.982	5	Q4 1998	Q2 2004
Kazakhstan	-1.861	2	-4.547	1	Q1 1999	-8.106	7	Q4 1998	Q3 2001
Kuwait	-1.45	1	-2.554	6	Q1 2007	-4.715	7	Q3 1998	Q3 2005
Kyrgyz Republic	-2.206	8	-4.028	8	Q2 1998	-6.368	8	Q2 1998	Q2 2002
Malaysia	-2.826	3	-4.492	8	Q4 2001	-5.259	1	Q2 1998	Q2 2001
Mali	-2.587	3	-4.633	4	Q1 2002	-6.345	8	Q4 2000	Q2 2005
Morocco	-1.478	1	-4.114	4	Q2 2003	-5.88	8	Q3 1998	Q1 2005
Mozambique	-2.678	4	-3.82	8	Q3 2000	-6.104	8	Q3 2000	Q2 2004
Niger	-2.077	3	-3.544	3	Q2 2002	-6.742	8	Q1 2002	Q2 2005
Nigeria	-1.641	0	-4.478	8	Q4 1998	-15.349	8	Q3 1998	Q3 2000
Oman	-1.935	4	-2.522	0	Q1 2002	-4.001	0	Q1 1999	Q3 2002
Pakistan	-1.305	5	-4.006	1	Q4 2005	-4.747	1	Q4 1997	Q3 2005
Saudi Arabia	-1.608	1	-2.604	0	Q1 2002	-4.006	0	Q1 1999	Q3 2002
Senegal	-1.186	7	-4.632	7	Q2 2002	-6.56	6	Q4 1999	Q2 2003
Tunisia	-1.108	7	-4.836	8	Q2 2003	-6.155	6	Q1 2000	Q2 2004
Turkey	-3.01	1	-4.592	1	Q4 2002	-5.598	1	Q3 1999	Q3 2002
Uganda	-0.707	6	-4.764	4	Q2 2004	-5.654	4	Q3 2002	Q3 2005
Panel LM test statistic	0.088		-19.730			-41.92			

1) All tests allow for time fixed effects and all regressions include an intercept and time trend. The critical values for: 1% [*] 5% [**] 10% [***]

2) Lm unit root without structural break: −3.63 −3.06 −2.77

3) Lm unit root with one structural break: −4.239 −3.566 −3.211

4) Lm unit root with two structural breaks: −4.545 −3.842 −3.504

5) Q denotes quarter

6) Source: Authors' findings.

4- Conclusion

In this paper, we attempted to test the empirical validity of purchasing power parity as an equilibrium condition equating the nominal exchange rate between two national currencies with the relative price of an identical basket of traded goods in each country in a sample of twenty nine OIC countries over period of 1995q1-2008q4. For this purpose,we performed unit root tests of real exchange rates by using univariate ADF unit root test and various panel unit root tests namely, IPS (2003), LLC (2002), Hadri (1999). Also, in order to consider structural changes, we applied the panel Lagrange Multiplier (LM) test proposed by Im et al (2005) that allows for the number of structural breaks to vary by country and allows for heterogeneous break points, which are endogenously determined for each country. Our conclusions are summarized below:

When we applied the univariate ADF unit root test, the null unit roots wasn't rejecting in none of conventional significant levels. In order to increase the power of unit root tests, we apply various panel unit root tests and obtained inconsistence results. The Results that were found with conventional panel unit root tests have shown that the null hypothesis of unit roots in real exchange rate series wasn't rejected. But when the panel LM unit roots tests with one and two structural breaks were applied, we couldn't reject the null hypothesis of unit root tests for all real exchange rate series and found generally supportive of the PPP hypothesis for OIC countries.

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