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Cointegration Tests and the Long-Run Purchasing Power Parity: Examination of Six Currencies in Asia*

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The validity of the long-run purchasing power parity hypothesis is tested by applying the Engle and Granger two-step cointegration procedure and the Johansen and Juselius multivariate cointegration technique to price and exchange rate data from six developing countries in Asia. The results of both methods reject the existence of long-run purchasing power parity for all the countries included in the analysis. This finding is confirmed by the unit root tests performed on the real effective exchange rates. Unit root test results reveal that, in each case, the real effective exchange rate follows a random walk.

I. Introduction

The long-run purchasing power parity (PPP) theory asserts that currencies of different countries posses the same purchasing power in the presence of international arbitrage. Testing for the long-run PPP hypothesis provides a useful insight into whether or not the competitiveness between a country and its trading partners, as measured by the real exchange rate, remains constant over time. Early studies that tested for the long-run PPP hypothesis relied upon standard econometric techniques.[1] The failure of these techniques, however, to take into account the nonstationary behavior of economic time series results in what has become known as "spurious regressions." With the development of cointegration modeling techniques that are capable of detecting the presence of long-run equilibrium relationships between nonstationary variables, testing for the long-run PPP hypothesis has been receiving renewed attention.[2]

Regardless of whether the long-run PPP theory holds true or not, the analyst's choice of the cointegration technique, whether it is the Engle and Granger two step procedure or the Johansen and Juselius multivariate technique, should not have any significant impact upon the outcome of the hypothesis testing. However, in a recent paper, Huan and Yang (1996) claim that when the Engle and Granger procedure rejects the long-run PPP hypothesis the Johansesn and Juselius procedure tends to accept it. Through Monte Carlo simulations applied to data from Canada, France, Germany, Switzerland, the U.K., and the U.S.A., Huan and Yang found that the Johansen

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1. See for example, Frenkel (1978, 1981), Officer (1978, 1980), Krugman (1978), Dornbush (1985), and Davutyan and Pippenger (1985).
2. Some of the examples are Taylor (1988), Corbae and Ouiliaris (1988), McNown and Wallace (1988), Karkakis and Moschos (1989), Layton and Stark (1990), Kim (1990), Bahmani-Oskooee and Rhee (1992), Bahmani-Oskooee (1993a, 1993b, 1995), In and Sugena (1995), and Pippenger (1993).

and Juselius cointegration technique is biased toward supporting the long-run PPP under conditions in which the assumption of normally and/or independently and identically distributed disturbance term is violated.

The present paper applies the two cointegration procedures to price and exchange rate data from six developing countries in Asia to test for the long-run PPP hypothesis. Specifically, it tests whether Huan and Yang's claim, that the two cointegration techniques yield conflicting results, holds true in the context of developing countries. The two cointegration techniques are applied to data from India, Indonesia, Malaysia, Pakistan, Sri Lanka, and Thailand. Unlike Huan and Yang's analysis which uses bilateral exchange rates, the present paper uses effective exchange rate as the measure of exchange rate. Since a country has more than one trading partner, the effective exchange rate is the appropriate measure of exchange rate (Officer (1980)).

The remainder of the paper is organized as follows. The formulation of the long-run PPP theory is presented in section II. Section III presents a brief review of the two cointegration techniques. Section IV presents a description of the data used for estimation. In section V, estimation procedure and empirical results are presented. Neither technique provides evidence in support of the long-run PPP theory for any of the countries included in the analysis. This is confirmed by the unit root tests performed on the real effective exchange rates for all six countries. They reveal that, in each case, the real effective exchange rate follows a random walk, implying that the tendency for the real effective exchange rate to remain constant in the long-run is weak. Section VI concludes the paper.

II. The PPP Postulate

The absolute version of PPP theory postulates $e = P_D / P_F$, where e is the exchange rate between two countries measured as number of domestic currency units per unit of foreign currency, and P_D and P_F are the price levels in the domestic country and foreign country, respectively. If we rewrite this as $P_D = e P_F$, then it states that, if the PPP holds in the long-run, domestic price level is equal to the foreign price level adjusted by the bilateral exchange rate. However, since a country has more than one trading partner, use of a weighted average exchange rate or the effective exchange rate rather than the bilateral exchange rate is more appropriate in testing for the long-run PPP (Bahmani-Oskooee (1995)). As in Layton and Stark (1990) and Bahmani-Oskooee (1995), we use two alternative methods for calculating effective exchange rates: arithmetic weighted averaging concept and geometric weighted averaging concept as given in equations (1) and (2), respectively,

$$P_D = \sum_{j=1}^{N} s_j e_j P_j, \tag{1}$$

and

$$P_D = \prod_{j=1}^{N} [e_j P_j]^{s_j}. \tag{2}$$

where s_i is the trade weight of partner i, e_i is the number of domestic currency units per unit of foreign currency, and P_i is the price level of trading partner i. Taking natural logarithms of (1) and (2) yields, respectively,

$$\ln P_D = \alpha_0 + \alpha_1[\ln(s_1(e_1P_1) + s_2(e_2P_2) + \ldots. + s_2(e_NP_N))] \quad \text{or} \tag{3}$$

$$LP_D = \alpha_0 + \alpha_1 LP_{FA},$$

and

$$\ln P_D = \beta_0 + \beta_1[s_1\ln(e_1P_1) + s_2\ln(e_2P_2) + \ldots. + s_N\ln(e_NP_N)] \quad \text{or} \tag{4}$$

$$LP_D = \beta_0 + \beta_1 LP_{FG}.$$

If the long-run PPP holds, then α_1 and β_1 should be equal to one in (3) and (4). Thus, testing whether $\alpha_1 = 1$ and $\beta_1 = 1$ is a test of the long-run PPP.

III. Cointegration Tests

a. *Engle-Granger Procedure*

Consider that two time series C_t and Y_t are integrated to the same order, d. According to Engle and Granger (1987), if there exists a linear combination $Z_t = C_t - bY_t$ such that Z_t is integrated to an order less than d, then C_t and Y_t are said to be cointegrated. Thus, testing for cointegration between C_t and Y_t using Engle and Granger procedure involves three steps. First, we must ensure that both C_t and Y_t are integrated to the same order. If they are, we then regress C_t on Y_t and Y_t on C_t, separately, by OLS technique to obtain residuals ε_t and ω_t. Third, we test for the order of integration of ε_t and ω_t. If ε_t and ω_t are integrated to an order less than d, then C_t and Y_t are said to be cointegrated.

b. *Johansen-Juselius Procedure*

Johansen-Juselius procedure (Johansen (1988) and Johansen and Juselius (1990)) begins with the following vector autoregressive (VAR) model:

$$\boldsymbol{X}_t = \prod_1 \boldsymbol{X}_{t-1} + \prod_2 \boldsymbol{X}_{t-2} + \ldots + \prod_k \boldsymbol{X}_{t-k} + \boldsymbol{\varepsilon}_t \qquad (t = 1, \cdots, T), \tag{5}$$

where $\boldsymbol{X}_t$ is a column vector of m endogenous variables. The stochastic terms $\boldsymbol{\varepsilon}_1, \cdots, \boldsymbol{\varepsilon}_T$ are drawn from an m-dimensional identically and independently normally distributed covariance matrix Λ. Since most economic time series are nonstationary, VAR models such as (5) are generally estimated in their first-difference forms. Equation (5) can be rewritten in first difference form as

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \cdots + \Gamma_{k-1} \Delta X_{t-k+1} - \prod X_{t-k} + \varepsilon_t \ (t=1, \cdots, T), \quad (6)$$

where

$$\Gamma_i = -(\mathrm{I} + \prod_1 + \prod_2 + \cdots + \prod) \quad (i = 1, \cdots, k-1), \quad (7)$$

and

$$\prod = \mathrm{I} - \prod_1 - \cdots - \prod_k . \quad (8)$$

Equation (6) differs from a standard first-difference version of a VAR model only by the presence of $\prod X_{t-k}$ term in it. It is this term that contains information about the long-run equilibrium relationship between the variables in X_t. If the rank of $\prod$ matrix γ is $0 < \gamma < m$, then there are two matrices α and β each with dimension m x γ such that $\alpha\beta' = \prod$. γ represents the number of cointegrating relationships among the variables in X_t. The matrix β contains the elements of γ cointegrating vectors and has the property that the elements of $\beta' X_t$ are stationary. α is the matrix of error correction parameters that measure the speed of adjustments in ΔX_t. Information contains in β matrix can be used to construct two loglikelihood ratio test statistics - the trace test and the maximum eigenvalue test.

IV. Data

Monthly data on prices and exchange rates for India, Indonesia, Malaysia, Pakistan, Sri Lanka, and Thailand for the period 1981:1-1994:12 were used for estimation. Due to the lack of a consistent series on either the *GDP* deflator or the Wholesale price index, the Consumer price index (CPI, 1990=100) was used to compute LP_{FA} and LP_{FG} (see Officer (1980) for details). The weights used to compute LP_{FA} and LP_{FG} are trade weights. The trading partners were selected based on each country's share of imports from its major trading partners in 1990 (*Direction of Trade Statistics Yearbook*, IMF). Eleven countries-Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Singapore, South Korea, the U.K., and the U.S.A.-were found to be common trading partners of all six countries. In addition, the following countries were also included in calculating trade weights for each country:

-Malaysia, Pakistan, Spain, Sweden, and Switzerland for *India*

-India, Malaysia, Pakistan, Spain, Sweden, Switzerland, and Thailand for *Indonesia*.

-Finland, India, Spain, Sweden, Switzerland, and Thailand for *Malaysia*.

-India, Indonesia, Kenya, Spain, Sweden, Switzerland, and Thailand for *Pakistan*.

-India, Indonesia, Malaysia, Pakistan, South Africa, and Thailand for *Sri Lanka*.

-Australia, Finland, India, Indonesia, Malaysia, Pakistan, Spain, Sweden, and Switzerland for *Thailand*.

Import data were taken from *Direction of Trade Statistics Yearbook* (IMF). The CPI and exchange rate data were obtained from *International Financial Statistics* (IMF). Exchange rates reported in international Financial Statistics are against the U.S. dollar. Bilateral exchange rates for each country were calculated using these data.

V. Estimation Procedure and Results

Before we test whether there exists a cointegrated relationship between the variables in Equations (3) and (4), variables must be tested for the presence of unit roots. To test for the presence of unit roots, the Augmented Dickey-Fuller (*ADF*) test and Phillip-Perron tests were performed on LP_D, LP_{FA}, and LP_{FG} for all six countries. The ADF and Phillips-Perron test results are reported in Table 1 and 2, respectively. These results reveal that LP_D, LP_{FA}, and LP_{FG}, for all six countries, have unit roots. Having confirmed that all the variables have unit roots, we tested Equations (3) and (4) for the presence of a cointegrated relationship using the Engle and Granger procedure and the Johansen and Juselius technique.

Table 1 ADF Test Statistics for LP_D, LP_{FA}, and LP_{FG}

Country	Variable	Level		First Difference	
		ADF[1]	ADF[2]	ADF[1]	ADF[2]
India	LP_D	0.50	-2.72	-7.72*	-7.73*
	LP_{FA}	0.44	-2.21	-8.79*	-8.84*
	LP_{FG}	0.55	-2.50	-7.75*	-7.59*
Indonesia	LP_D	-0.22	-2.39	-3.71*	-3.68*
	LP_{FA}	-1.27	-1.50	-7.51*	-9.19*
	LP_{FG}	-0.97	-1.37	-9.06*	-9.07*
Malaysia	LP_D	0.35	-1.03	-4.85*	-4.82*
	LP_{FA}	-0.47	-1.73	-9.07*	-8.63*
	LP_{FG}	-0.11	-2.04	-8.58*	-8.27*
Pakistan	LP_D	2.54	-0.47	-2.06*	-3.28*
	LP_{FA}	-0.38	-2.87	-4.49*	-4.53*
	LP_{FG}	-0.78	-3.01	-6.78*	-6.72*
Sri Lanka	LP_D	-0.25	-2.28	-7.87*	-7.83*
	LP_{FA}	-0.35	-2.21	-5.18*	-5.17*
	LP_{FG}	0.07	-2.76	-5.41*	-5.42*
Thailand	LP_D	1.35	-0.63	-9.21*	-9.36*
	LP_{FA}	-0.80	-2.24	-5.91*	-5.89*
	LP_{FG}	-0.68	-1.96	-9.02*	-9.00*

Notes: $ADF^1 \text{ tests } H_0: \beta = 0 \text{ in } \Delta Y_t = \alpha + \beta Y_{t-1} + \sum_{j=1}^{m} \gamma \Delta Y_{t-j} + \varepsilon_t$

$$ADF^2 \text{ tests } H_0: \beta = 0 \text{ in } \Delta Y_t = \alpha + \beta Y_{t-1} + \sum_{j=1}^{m} \gamma \Delta Y_{t-j} + \rho t + \varepsilon_t \tag{10}$$

* indicates statistical significance at the 99% level. The critical values for the ADF test can be found in Fuller (1976). Optimum lag length (m) in the ADF equation was chosen based on the Akaike's Final Prediction criterion.

Application of the Engle and Granger procedure in testing for the presence of a cointegrated relationship between the variables in (3) and (4) requires testing for the order of integration of the residuals obtained from Equations (3), (4) and their inverses. If the long-run PPP holds, the residuals should be stationary. Thus, we first estimated Equations (3), and (4) and their inverses for all six countries by the OLS technique. We then performed the *ADF* test and Phillips-Perron tests on each residual series. The results are presented in Table 2. They indicate that the residuals obtained from all cointegration equations for each country have unit roots. Since the variables included in regression equations and the residuals obtained from corresponding regressions have the same order of integration, we conclude that there does not exist a cointegrated relationship between the variables in the equation.

Table 2 Phillips-Perron Test Statistics for LP_D, LP_{FA}, and LP_{FG} (in Levels)

Country	Variable	$Z(\alpha^*)$	$Z(t_{\alpha^*})$	$Z(\bar{\alpha})$	$Z(t_{\bar{\alpha}})$	$Z(\phi_3)$
India	LP_D	-0.03	-0.13	-9.74	-2.21	2.45
	LP_{FA}	0.34	0.64	-6.89	-2.23	3.02
	LP_{FG}	0.35	0.64	-8.33	-2.47	3.59
Indonesia	LP_D	-0.16	-0.40	-11.74	-2.36	5.45
	LP_{FA}	-1.44	-1.19	-16.22	-2.84	4.18
	LP_{FG}	-0.75	-0.94	-5.15	-1.45	1.25
Malaysia	LP_D	-0.60	-0.99	-6.33	-2.11	2.39
	LP_{FA}	-0.42	-0.56	-5.09	-1.51	1.17
	LP_{FG}	-4.88	-1.60	-5.15	-2.86	4.77
Pakistan	LP_D	0.82	2.14	0.28	-0.12	2.18
	LP_{FA}	-0.70	-0.58	-13.62	-2.92	4.93
	LP_{FG}	-0.38	-0.38	-16.80	-2.89	1.73
Sri Lanka	LP_D	-0.23	-0.54	-7.90	-1.98	2.02
	LP_{FA}	-0.07	-0.13	-9.87	-2.29	2.65
	LP_{FG}	-0.00	-0.00	-13.79	-2.74	3.81
Thailand	LP_D	-0.14	-0.16	-12.14	-2.47	3.03
	LP_{FA}	-1.20	-1.15	-13.03	-2.51	3.39
	LP_{FG}	-0.55	-0.58	-8.15	-1.99	2.01

Notes: Testing for the presence of a unit root with Phillips-Perron tests involves estimating the following equations by OLS:

$$Y_t = \mu^* + \alpha^* Y_{t-1} + \varepsilon_t^*, \text{ and} \tag{12}$$

$$Y_t = \bar{\mu} + \bar{\beta}\left(t - \frac{T}{2}\right) + \bar{\alpha} Y_{t-1} + \bar{\varepsilon}_t, \tag{13}$$

where ε_t^* and $\bar{\varepsilon}_t$ are error terms and T is the sample size. Using the regression results of (12) and (13), we compute the following test statistics:

$Z(\alpha^*) - H_0: \alpha^* = 1$ in (12),
$Z(t_{\alpha^*}) - H_0: \alpha^* = 1$ in (12),
$Z(\bar{\alpha}) - H_0: \bar{\alpha} = 1$ in (13),
$Z(t_{\bar{\alpha}}) - H_0: \bar{\alpha} = 1$ in (13), and
$Z(\phi_3) - H_0: \bar{\beta} = 1$ and $\bar{\alpha} = 1$ in (13).

In each case, the H_0 that Y_t has a unit root is tested against the alternative that Y_t is stationary. Since these statistics are asymptotically equivalent to the corresponding Dickey-Fuller tests, the critical values from Fuller (1976) and Dickey and Fuller (1981) can be used in testing.

Table 3 presents the coefficients obtained for cointegration equations and some diagnostic statistics. Although lower in power compared to the *ADF* test, the Durbin-Watson test statistic (*DW*) of the OLS regression can be used as an auxiliary test to check whether the variables are cointegrated. A significantly large value for the *DW* test statistic is evidence that the variables are cointegrated while a significantly small value implies that they are not. At the 95 percent significance level, the *DW* test statistic in each case is lower than the critical value of 0.26 for a sample of 168 observations (Table 4, Engle and Yoo (1987)). These results also confirm our previous finding that there does not exist a cointegrated relationship between the variables in any of the regressions.

Table 3 Engle and Granger Procedure-Coefficient Estimates and Their Diagnostic Statistics

Cointegration Equation	S.E.	χ^2_1	R^2	DW
India				
$LP_D = 0.71 + 0.56\ LP_{FA}$	0.01	4030.2	0.97	0.09
$LP_{FA} = -1.07 + 1.73\ LP_D$	0.02	1189.7	0.97	0.09
$LP_D = 1.59 + 0.53\ LP_{FG}$	0.01	6109.8	0.97	0.10
$LP_{FG} = -2.83 + 1.84\ LP_D$	0.02	1638.2	0.98	0.10
Indonesia				
$LP_D = -1.03 + 0.50\ LP_{FA}$	0.01	2817.3	0.94	0.08
$LP_{FA} = 2.48 + 1.86\ LP_D$	0.03	650.9	0.94	0.08
$LP_D = 0.33 + 0.45\ LP_{FG}$	0.01	3868.7	0.94	0.07
$LP_{FG} = -0.17 + 2.06\ LP_D$	0.04	728.5	0.94	0.07
Malaysia				
$LP_D = 2.63 + 0.41\ LP_{FA}$	0.01	1791.5	0.84	0.03
$LP_{FA} = -4.62 + 2.04\ LP_D$	0.07	229.9	0.84	0.03
$LP_D = 3.50 + 0.33\ LP_{FG}$	0.01	3250.7	0.83	0.02
$LP_{FG} = -8.14 + 2.46\ LP_D$	0.08	304.6	0.83	0.02
Pakistan				
$LP_D = 0.75 + 0.55\ LP_{FA}$	0.01	2777.9	0.96	0.05
$LP_{FA} = -1.05 + 1.73\ LP_D$	0.01	776.1	0.96	0.05
$LP_D = 1.76 + 0.51\ LP_{FG}$	0.01	3214.3	0.95	0.05
$LP_{FG} = -3.04 + 1.84\ LP_D$	0.03	783.2	0.95	0.05
Sri Lanka				
$LP_D = -2.10 + 0.91\ LP_{FA}$	0.01	62.5	0.98	0.14
$LP_{FA} = 2.39 + 1.06\ LP_D$	0.01	30.6	0.98	0.14
$LP_D = -0.58 + 0.92\ LP_{FG}$	0.01	62.8	0.98	0.13
$LP_{FG} = 0.71 + 1.06\ LP_D$	0.01	31.9	0.98	0.13
Thailand				
$LP_D = 0.26 + 0.63\ LP_{FA}$	0.02	493.4	0.90	0.13
$LP_{FA} = 0.26 + 1.41\ LP_D$	0.04	132.5	0.90	0.13
$LP_D = 2.20 + 0.47\ LP_{FG}$	0.01	1339.6	0.87	0.09
$LP_{FG} = -3.40 + 1.82\ LP_D$	0.05	228.5	0.87	0.08

Notes: S.E. is the standard error of the slope coefficient in the cointegration equation, χ^2_1 is the Wald test statistic that tests whether the slope coefficient is significantly different from unity, and DW is the Durbin-Watson test statistic. At the 95 percent significance level, the critical value for the DW statistic for a sample of 168 observations is approximately 0.26 (Table 4, Engle and Yoo (1987)).

Table 4 Unit Root Test Statistics for the Residuals from Equations (3) and (4)

Cointegrating Equation	Level		First Difference		Level			
	ADF^1	ADF^2	ADF^1	ADF^2	$Z(\bar{\alpha})$	$Z(t_{\bar{\alpha}})$	$Z\phi_2$	$Z(\phi_3)$
India								
$LP_D = f(LP_{FA})$	-2.79	-2.71	-7.43	-7.46	-11.05	-2.88	3.39	4.58
$LP_{FA} = f(LP_D)$	-3.38	-3.07	-7.31	-7.34	-12.72	-3.11	3.86	5.31
$LP_D = f(LP_{FG})$	-2.68	-2.70	-7.40	-7.43	-10.88	-2.86	3.28	4.55
$LP_{FG} = f(LP_D)$	-3.03	-3.06	-7.28	-7.32	-12.57	-3.10	3.77	5.28
Indonesia								
$LP_D = f(LP_{FA})$	-1.12	-1.31	-9.53	-9.56	-5.32	-1.41	1.05	1.34
$LP_{FA} = f(LP_D)$	-1.16	-1.29	-9.61	-9.61	-5.44	-1.50	1.04	1.24
$LP_D = f(LP_{FG})$	-1.35	-1.31	-9.48	-9.52	-5.31	-1.41	0.97	1.34
$LP_{FG} = f(LP_D)$	-1.31	-1.28	-9.55	-9.55	-4.47	-1.33	0.81	1.03
Malaysia								
$LP_D = f(LP_{FA})$	-1.21	-1.25	-4.39	-4.37	-5.03	-1.66	1.49	1.39
$LP_{FA} = f(LP_D)$	-1.72	-1.68	-5.37	-5.31	-6.11	-1.95	1.85	1.98
$LP_D = f(LP_{FG})$	-1.31	-1.26	-4.49	-4.47	-3.36	-1.36	0.96	0.94
$LP_{FG} = f(LP_D)$	-1.58	-1.70	-5.29	-5.24	-6.12	-1.93	1.50	1.95
Pakistan								
$LP_D = f(LP_{FA})$	-0.69	-0.45	-6.35	-6.93	-1.76	-0.53	0.92	0.96
$LP_{FA} = f(LP_D)$	-0.69	-0.55	-6.33	-6.75	-3.40	-0.96	0.84	0.89
$LP_D = f(LP_{FG})$	-0.21	-0.48	-6.35	-6.92	-1.88	-0.56	0.80	0.95
$LP_{FG} = f(LP_D)$	-0.18	-0.58	-6.33	-6.74	-2.46	-0.76	0.69	0.79
Sri Lanka								
$LP_D = f(LP_{FA})$	-2.77	-2.77	-8.87	-8.83	-14.61	-2.85	2.86	4.14
$LP_{FA} = f(LP_D)$	-2.82	-2.81	-7.89	-7.86	-18.25	-3.20	3.49	5.17
$LP_D = f(LP_{FG})$	-2.77	-2.77	-8.87	-8.83	-14.61	-2.86	2.83	4.14
$LP_{FG} = f(LP_D)$	-2.80	-2.81	-7.88	-7.84	-13.82	-2.77	2.66	3.93
Thailand								
$LP_D = f(LP_{FA})$	-1.18	-0.92	-5.85	-6.01	-8.41	-1.91	1.43	2.01
$LP_{FA} = f(LP_D)$	-0.99	-1.12	-11.10	11.10	-5.97	-1.6	1.14	1.40
$LP_D = f(LP_{FG})$	-1.60	-1.01	-5.81	-5.96	-8.45	-1.91	1.37	2.03
$LP_{FG} = f(LP_D)$	-1.28	-1.18	-10.80	10.79	-6.12	-1.68	1.02	1.44

Note: See Tables 1 and 2.

Before we estimate Equations (3) and (4) using the Johansen and Juselius technique, we must determine the optimum lag length k in Equation (6) for each model specification. Following the procedure adopted in Haffer and Jansen (1991), we first estimated each equation as the unrestricted model with k arbitrarily set equal to 15. This unrestricted model was then tested against a restricted model with k = 14 by an *LR* test statistic distributed as χ^2 with degrees of freedom equal to 4. The test was conducted sequentially by further reducing k by one at a time from both the unrestricted and the restricted model. The procedure was repeated until the restriction could be rejected at the 95 percent significance level. The value of k in the unrestricted model, when the restriction is rejected, is taken as the optimum lag length for the model. Having determined the optimum lag length for each model, we performed the trace and the maximum eigenvalue tests for the presence of cointegrating vectors in each case. The results are presented in Table 5. Neither the trace test nor the maximum eigenvalue test reveals the presence of a cointegrating vector in any of the countries, implying that there does not exist a long-run equilibrium relationship between the variables.

Table 5 Cointegration Test Results of Johansen and Juselius Technique

Country	Cointegrating Equation	Trace Test		Maximum Eigenvalue Test	
		$r \leq 1$	$r = 0$	$r = 1$	$r = 0$
India	$LP_D = f(LP_{FA})$	7.55	0.83	6.71	0.83
	$LP_D = f(LP_{FG})$	9.86	0.98	8.88	0.98
Indonesia	$LP_D = f(LP_{FA})$	3.30	0.13	3.17	0.13
	$LP_D = f(LP_{FG})$	3.10	0.29	2.81	0.29
Malaysia	$LP_D = f(LP_{FA})$	5.15	0.31	4.84	0.31
	$LP_D = f(LP_{FG})$	3.09	0.07	3.01	0.07
Pakistan	$LP_D = f(LP_{FA})$	14.15	0.22	14.39	0.22
	$LP_D = f(LP_{FG})$	15.44	0.49	14.95	0.49
Sri Lanka	$LP_D = f(LP_{FA})$	9.76	0.01	9.74	0.01
	$LP_D = f(LP_{FG})$	9.19	0.24	8.95	0.24
Thailand	$LP_D = f(LP_{FA})$	5.64	0.08	5.56	0.08
	$LP_D = f(LP_{FG})$	4.70	0.05	4.64	0.05

Critical Values

Trace Test				Maximum Eigenvalue Test			
H_0	90%	95%	99%	H_0	90%	95%	99%
$r \leq 0$	13.33	15.41	20.04	$r = 0$	12.07	14.02	18.63
$r \leq 1$	2.69	3.76	6.65	$r = 1$	2.69	3.76	6.65

Notes: Critical values for the Trace and the Maximum Eigenvalue test are from Table 1, Osterwald-Lenum (1992).

The results of both cointegrating techniques clearly reject the long-run PPP. Since the long-run PPP also implies that the real exchange rate must be equal to one, it means that if the long-run PPP holds the real exchange rate must follow a stationary process. In other words, if the long-run PPP holds, the tendency for the real exchange rate to return to some long-run equilibrium level is very high. As a supplement to the two cointegration techniques, we tested whether the real effective exchange rate for each country has a unit root. Following Edwards (1989), we define country j's real effective exchange rate as

$$REX_{jt} = \frac{\sum_{i=1}^{N} s_i e_i P^*_{it}}{P_{jt}}, \tag{9}$$

where REX_{jt} is the index of the real effective exchange rate in period t for country j, s_{i} is the trade weight corresponding to partner i, e_{ij} is the nominal exchange rate between country i and country j in period t, P^{*}_{it} is the price index of partner i, and P_{jt} is the price index of the home country in period t. The REX indexes for all six countries were computed using import shares as the trade weight and tested for unit roots using the ADF test and Phillips-Perron tests. The results are presented in Table 6. The results of both tests indicate that the real effective exchange rate for each country has a unit root. These results strongly support our previous findings that the long-run PPP does not hold in any of the country's included in the analysis.

Table 6 ADF and Phillips-Perron Test Statistics for Real Exchange Rates (REX)

Country	Level		First Difference		
	ADF[1]	ADF[2]	ADF[1]	ADF[2]	
India	-0.28	-2.45	-8.95*	-8.97*	
Indonesia	-1.33	-1.32	-9.15*	-9.18*	
Malaysia	-0.81	-1.52	-8.59*	-8.56*	
Pakistan	-1.19	-1.53	-8.43*	-8.46*	
Sri Lanka	-2.53	-2.85	-9.07*	-9.04*	
Thailand	-1.80	-1.76	-10.55*	-10.61*	
Country	$Z(\alpha^*)$	$Z(t_{\alpha^*})$	$Z(\bar{\alpha})$	$Z(t_{\bar{\alpha}})$	$Z(\phi_3)$
India	-0.12	-0.08	-8.72	-2.45	3.41
Indonesia	-2.11	-1.33	-5.22	-1.40	1.31
Malaysia	-1.17	-0.78	-4.39	-1.44	1.05
Pakistan	-1.18	-1.04	-7.17	-1.52	1.41
Sri Lanka	-10.1	-2.38	-9.11	-1.99	2.22
Thailand	-5.20	-1.79	-9.11	-1.99	2.22

Notes: See Tables 1 and 2.

One possible reason for the failure of the PPP is that the economic structure of the countries considered here have changed significantly during the post 1980 period. In countries such as Malaysia, Thailand, and Indonesia, the service sector has become a major contributor to the GNP. National price levels of these countries, therefore, have become increasingly influenced by the prices of services most of which are nontradeable. In countries where service sectors are playing an important role, the domestic supply and demand conditions for services change over time relative to their trading partners, thus, resulting in departures from the PPP. Furthermore, in Indonesia, Malaysia, Pakistan, and Sri Lanka the exchange rates are not yet fully determined by the market forces. While the exchange rates in these countries are partly determined by monetary authorities, Thailand still has a fixed exchange rate system. Thus, it may be the case that exchange rates in these countries are not yet flexible enough to result in the long-run PPP.

VI. Concluding Remarks

The long-run purchasing power parity theory asserts that, in the long-run, the exchange rate between two currencies is equal to the ratio between the price levels in the two countries. Although there exists a voluminous literature on the testing for the validity of this hypothesis, no general consensus has emerged yet as to whether it holds true or not. Most of the recent studies that have tested for the validity of the hypothesis have used either the Engle and Granger two-step cointegration procedure or the Johansen and Juselius multivariate cointegration technique.

Applying Monte Carlo simulations to data from six developed countries, Huan and Yang (1996) have found that when the Engle and Granger procedure rejects the long-run PPP hypothesis the Johansen and Juselius procedure tends to accept it. The bias of the Johansen and Juselius procedure toward rejecting the null hypothesis of no cointegration when there does not exist one is attributed to the violation of the assumption that the disturbance term is normally and/or independently and identically distributed.

In this paper, we have applied the two cointegration techniques to data from six developing countries to examine whether the two procedures generate conflicting results. Unlike Huan and Yang's study which uses bilateral exchange rates, we have used the effective exchange rate as the measure of exchange rate. We experimented with two different weighted averaging concepts-arithmetic and geometric. For both concepts, the two cointegration procedures have generated similar results yielding to the conclusion that the long-run PPP theory does not hold true in any of the countries included in the analysis. As a supplement to the cointegration tests, we have also performed unit root tests on the real effective exchange rate for each country. The unit root test results show that, in each case, the real effective exchange rate follows a random walk. This finding confirms the cointegration test results that long-run PPP does not hold in the countries included in the analysis. The findings of the present study do not support those of Huan and Yang that the Johansen and Juselius procedure is biased toward accepting the long-run PPP hypothesis.

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