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TESTING THE VALIDITY OF PURCHASING POWER PARITY FOR ASIAN COUNTRIES DURING THE CURRENT FLOAT

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Previous studies on purchasing power parity (PPP), using unit root tests, have tested either the null hypothesis of a unit root or the null of stationary real exchange rate. It has been argued that using either approach is insufficient to confirm the existence or non-existence of PPP. To strengthen inferences made about a series, the two approaches should be applied within the same study. In contrast to previous studies undertaken to test PPP in developing countries, this paper tests PPP for a sample of developing countries in the Asian financial crisis countries during the current float. The paper applies the ADF and PP tests to test the null of a unit root and the newly developed KPSS test to test the null of stationarity. The null of a unit root can be rejected for Indonesia, Korea and Thailand. We cannot reject the null of stationarity for all countries except for Singapore. Joint testing of both nulls confirms stationarity for Indonesia and Korea. The impact of the Asian financial crisis on the behavior of the real exchange rates in the crisis countries is examined using Perron's unit root test that accounts for potential structural breaks. The results indicate evidence of stationarity for Indonesia, Korea, Malaysia, and Thailand.

Keywords: PPP, The ADF Test, The KPSS Test, Confirmatory Analysis, Structural Break
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1. INTRODUCTION

Purchasing power parity (PPP) is an exchange rate determination model formalized and developed by Gustav Cassel in the 1920s. As an important theory in international economics, PPP states in it is absolute version that the nominal exchange rate, defined as units of the domestic currency per unit of the foreign currency, should be equal to the price ratio of domestic to foreign country. The relative version states that changes in the nominal exchange rate should be equal to the inflation differential between the home and foreign countries.

Many studies have been undertaken to test the validity of PPP especially after the collapse of the Bretton Woods system in 1973 and the transition to the flexible exchange rate system. While it is generally accepted that relative PPP fails to hold in the short run, long run PPP is still under investigation. Depending on the sample size, and type of tests employed, some studies are able to find some evidence in favor of long run PPP. Yet, the speed of convergence to PPP is extremely slow since deviations appear to damp out at a rate of roughly 15% per year implying a half-life for PPP deviations between 3 and 5 years.

Most of the early literature on PPP is based on the time-series analysis of short spans of data for the post-Bretton Woods era where the focus was developed countries. Most of this literature did not find evidence in favor of PPP; and therefore, concluded that PPP does not hold. Engle (2000), for instance, using quarterly data from 1970 to 1995 for the U.S. and U.K. could not reject the null of a unit root and the null of no-cointegration (other studies include Baum *et al*. (1999), and Mark (1990)).

Recently, however, some economists have argued that the reason for the failure to find evidence in favor of PPP is due to the short sample size used for the current float and / or the lack of power in the standard tests (the Augmented Dickey-Fuller test (ADF) and Phillip-Perron test (PP)). Frankel (1986, 1990) argued that the reason that some studies could not reject the random walk hypothesis in the real exchange rate was a lack of power. He pointed out that if the speed of convergence to PPP is extremely slow, then it might require sufficiently long data sets for one to be able to reliably reject the random walk hypothesis in the real exchange rate. He tested a long data set on the US$-DM exchange rate for the period 1869-1984, where he was able to reject the random walk hypothesis with a point estimates of 14% per year, implying a half-life for the real exchange rate deviations of 4.6 years. Lothian and Taylor (1996) using data on the dollar-pound rate for the period 1791-1990 and the franc-pound rate for the period 1803-1990 were able to reject the random walk model with an estimated half-life of about six years for the dollar-pound rate and a little under three years for the franc-pound rate (other studies include Glen (1992), Froot and Rogoff (1994), and Kuo and Mikkola (1999)).

Using long run data has been criticized since it combines data from fixed and floating exchange rate systems. Therefore, rejecting the null of a unit root or no-cointegration does not provide direct evidence on the validity of PPP under the current float. Inspired by the work of Levin and Lin (1992 and 1993), economists have turned to panel data tests to test the validity of PPP for the current float. Levin and Lin show that the power of unit root tests in short time periods can be improved by increasing the number of countries.

The results from the panel data approach during the current float are mixed. Wu and Chen (1999), for example, using two panel unit root tests on monthly data from 1980 to 1996 for 9 Pacific Basin countries could not find evidence of stationarity. MacDonald (1996), using annual data for 40 OECD CPI and WPI-based real exchange rates for the period 1973-1992 is able to reject the null hypothesis of a unit root (other examples include Abuaf and Jorion (1990), Frankel and Rose (1996), Papell (1997), and Heimonen (1999)). O'Connell (1998, p. 2) argues that previous panel unit root tests that are able to find evidence in favor of PPP "are incorrectly sized, owing to their failure to control for cross-sectional dependence in real exchange rates". But after controlling for cross-sectional dependence, he does not find evidence in favor of PPP.

The mixed results from long-run and panel data tests have led economists to question the power of the standard unit root tests. It is now generally accepted that in the standard unit root tests the null of non-stationarity for many aggregate economic time series cannot be rejected unless there is strong evidence against it. Therefore, the reason for the failure to reject the null of non-stationarity is due to lack of power in these tests. Diebold and Rudebusch (1991) show that the unit root tests proposed by Dickey and Fuller have low power against fractionally-integrated processes. DeJong *et al*. (1992) argue that the Dickey-Fuller unit root test has low power against trend stationary processes. Perron (1989) argue that if the time-series contains a structural break, then the standard unit root tests will lead to the acceptance of the null of a unit root, when in fact the series is stationary.

Consequently, many economists have argued against using the standard unit root tests and proposed using other powerful tests, such as tests that can be used to test the null of stationarity against the alternative of non-stationarity. A number of tests have been developed; the most popular one is the KPSS test developed by Kwiatkowski, Phillips, Schmidt, and Shin (1992).[1] Kwiatkowski *et al*. (1992, p. 176) argue that their test is "intended to complement unit root tests, such as the Dickey-Fuller tests. By testing both the unit root hypothesis and the stationarity hypothesis, we can distinguish between series that appear to be stationary, series that appear to have unit root, and series for which the data (or the tests) are not sufficiently informative to be sure whether they are stationary or integrated." Henricsson and Lundbäck (1995) point out that a lot of information can be gained by comparing the outcomes of testing both the null of stationarity and the null of non-stationarity. Joint testing of both nulls can strengthen inferences made about the stationarity or non-stationarity of a time series especially when the outcomes of the two nulls corroborate each other. This joint testing has been known as *"confirmatory analysis."* For example, if the null of stationarity is accepted (rejected) and the null of non-stationarity is rejected (accepted), we have confirmation that the series is stationary (non-stationary). Conversely, we can not have confirmation if both nulls are accepted or both are rejected. The possible outcomes of this joint testing are summarized in Table 1.

[1] Another test is the LMC test developed by Leybourne and McCabe (1993). The two tests differ in their treatment of autocorrelation under the null hypothesis. The KPSS test adjusts for autocorrelation non-parametrically by choosing a lag truncation parameter, whereas the LMC test adjusts for autocorrelation parametrically by choosing an appropriate lag length in the ARMA model.

Table 1. The Possible Outcomes of the ADF and KPSS Tests

	ADF Test[1)]	
KPSS Test[2)]	Accept	Reject
Accept	Inconclusive decision (Insufficient information)	Conclusive decision (Stationary)
Reject	Conclusive decision (Non-stationary)	Inconclusive decision (Fractional integration)

Notes: [1)] indicates the null hypothesis of non-stationarity in the ADF test. [2)] indicates the null hypothesis of stationarity in the KPSS test.

Other tests proposed to test PPP are tests that account for potential structural breaks in the series, such as the Augmented Perron's unit root test. It is argued that in the presence of structural breaks standard unit root tests are biased towards accepting the null of a unit root when in fact the series is stationary; therefore, allowing for structural breaks in modeling processes behavior is important.[2]

In contrast to previous studies, this paper tests PPP for a sample of developing countries in the Asian financial crisis countries during the current float. To strengthen inferences made about the real exchange rate series, the paper conducts confirmatory analysis by applying the ADF and PP tests to test the null hypothesis of a unit root and the newly developed KPSS test to test the null of stationary real exchange rate exchange rate. In addition to using confirmatory analysis, the paper applies Perron's unit root test that accounts for potential structural breaks in the real exchange rate series arising from the Asian financial crisis.

The rest of the paper is organized as follows. Section two presents the theory of PPP and methodology. Section three provides a brief literature review. Section four describes the data and its source. Section five presents the results and analysis of the empirical work. Section six sheds some light on the Asian financial crisis and provides the results of applying Perron' test, and finally section seven gives the summary and conclusions.

2. THE THEORY OF PPP AND METHODOLOGY

The basic building block of PPP is the '*Law of One Price*' (LOP). The LOP states that in the absence of trade barriers, such as transportation costs, and tariffs, competition will equalize the price of an identical and traded good across countries when the prices are expressed in the same currency. PPP is derived by extending LOP to n identical

[2] Other tests used to test PPP are the variance ratio analysis developed by Lo and MacKinley (1988) to test the null of a random walk, and the multivariate cointegration procedures to test for r cointegrating vectors developed by Johansen and Juselius (1990), and Johansen (1991).

and traded goods and assuming that LOP holds for each of the n goods. The theory of PPP involves a relationship between the nominal exchange rate and the price ratio of domestic to foreign country. Thus;

$$E_{it} = \frac{P_{it}}{P_t^{US}}, \tag{1}$$

where E_{it} is the nominal exchange rate, defined as units of domestic currency per unit of the foreign currency, for country i at time t per U.S. dollar, P_{it} is the domestic price index (the CPI), P_t^{US} is the foreign price index (the U.S. in this case), and i is an index for country i = Indonesia, Korea, Malaysia, Singapore, the Philippines, and Thailand. Using lowercase letters to denote the natural logarithm of the variables in Equation (1) yields $e_{it} = p_{it} - p_t^{US}$, the absolute PPP. Taking the first difference of the absolute PPP yields $\Delta e_{it} = \Delta p_{it} - \Delta p_t^{US}$, the relative PPP. The real exchange rate is defined as the nominal exchange rate adjusted for changes in the home and foreign price levels. Using lowercase letters to denote the variables in their natural logarithm form yields

$$r_{it} = e_{it} + p_t^{US} - p_{it}, \tag{2}$$

where r_{it} is the natural logarithm of the real exchange rate for country i at time t. For PPP to hold the real exchange rate r_{it} should be constant (stationary), that is, a $X\%$ increase/decrease in relative prices should be matched by a $X\%$ depreciation/ appreciation in the nominal exchange rate. Thus, if we can show that the real exchange rate is stationary, we can provide evidence in favor of PPP. If the stationarity of the real exchange rate is not found, the theory of PPP will be rejected.

2.1. The ADF and PP Tests

To test the null hypothesis of non-stationary real exchange rate using the ADF test, the following model is used

$$\Delta r_{it} = \mu_i + \delta t + \rho_i r_{it-1} + \sum_{j=1}^{k_i} \mu_{ij} \Delta r_{it-j} + \upsilon_{it}, \tag{3}$$

where k is the number of lags in the ADF test chosen by minimizing Schwartz Information Criterion (SIC) to ensure that the errors are white noise. The coefficient of interest is ρ; a finding that $\rho < 0$ is statistically significant implies that the real exchange rate is stationary. The null hypothesis of a unit root is $\rho = 0$ against the alternative $\rho < 0$. A time trend is included to allow for the possibility of deterministic trend in the alternative hypothesis.

The ADF test assumes statistically independent residuals with constant variance. The PP test relaxes these assumptions and allows the residuals to be weakly dependent with heterogeneous variance. The PP test applied using the following model with a constant and a time trend:

$$r_{it} = \theta_{i0} + \theta_{i1}(t - \frac{T}{2}) + \theta_{i2} r_{t-1} + \varsigma_{it} \tag{4}$$

with a test statistic $Z(\theta_{i2})$ for the null hypothesis $\theta_{i2} = 1$. The number of lag truncation in the PP test is selected automatically by Newey and West Bandwidth using Barlett Kernal Spectral estimation method.

2.2. The KPSS Test

To test the null hypothesis of stationarity using the KPSS test, we follow Kwiatkowski *et al*. (1992). They consider a series y_t that can be decomposed into the sum of deterministic trend, a random walk, and a stationary error:

$$y_t = \xi t + r_t + \varepsilon_t , \tag{5}$$

where ε_t a stationary is process and r_t is a random walk given by: $r_t = r_{t-1} + u_t$ with $u_t \sim iid(0, \sigma_u^2)$. The initial value r_0 is fixed and serves as the intercept. Under these assumptions, the null hypothesis of stationarity is $\sigma_u^2 = 0$. Since ε_t is assumed to be a stationary process, under the null hypothesis the series y_t is trend stationary. To test the null hypothesis of level stationarity ξ is set equal to zero (Culver and Papell, 1999 test the null of level stationary real exchange rate). The null of trend stationary is tested by estimating Equation (5) on an intercept and trend. The KPSS test statistic is given by

$$L\hat{M} = T^{-2} \sum_{t=1}^{T} S_t^2 \big/ s^2(l) , \tag{6}$$

where S_t is the partial sum of deviations of residuals from the sample mean, $s^2(l) = T^{-1} \sum_{t=1}^{T} \hat{\varepsilon}_t^2 + (\frac{2}{T}) \sum_{s=1}^{l} w(s,l) \sum_{t=s+1}^{T} \hat{\varepsilon}_t \hat{\varepsilon}_{t-s}$ is a consistent estimator of the long run variance (σ^2) of the regression error, l is a lag truncation parameter, and $w(s,l) = 1 - [s/(l+1)]$ is an optional weighting function (Bartlett weights) used to smooth the sample autocovariance function, which ensures that $s^2(l)$ is non-negative (Newey and West (1987)). The number of lags truncation in the KPSS test is selected automatically by Newey and West Bandwidth using Barlett Kernal Spectral estimation method. The null hypothesis of stationarity is accepted if the value of the KPSS test statistic is less than it is critical value.

2.3. Perron's Test

One major drawback of standard unit root tests is that they implicitly assume that the deterministic trend is correctly specified. Perron (1989) argue that if the time-series contains a structural break, then standard unit root tests will lead to the acceptance of the null of a unit root, when in fact the series is stationary. There are a number of studies showing the relevance of allowing structural breaks in modeling the long-run behavior of real exchange rates (see, for example, Baum *et al*. (1999)). For this purpose, the Perron (1989) Augmented (PA) unit root test is applied. The test allows under both the null and alternative hypotheses for the presence of a one-time change in the level or in the slope of the series. The test consist of three models

Model A: the "crash model" which allows for a one-time change in the level of the series

$$y_t = \beta_0 + \beta_1 DMU_t + \beta_2 t + \delta DTB_t + \alpha y_{t-1} + \sum_{p=1}^{k} \theta_p \Delta y_{t-p} + \varepsilon_t \,. \tag{7}$$

Model B: the "changing growth model" which allows for a one-time change in the slope of the trend function

$$y_t = \beta_0 + \beta_1 DMU_t + \beta_2 t + \phi DTS_t + \alpha y_{t-1} + \sum_{p=1}^{k} \theta_p \Delta y_{t-p} + \varepsilon_t \,. \tag{8}$$

Model C: this allows "both effects" a one-time change in the level and the slope of the trend function

$$y_t = \beta_0 + \beta_1 DMU_t + \beta_2 t + \delta DTB_t + \psi DT_t +_t \alpha y_{t-1} + \sum_{p=1}^{k} \theta_p \Delta y_{t-p} + \varepsilon_t \,, \tag{9}$$

where TB is the time break, and $DTB = 1$ if $t = TB + 1$ and 0 otherwise.

Under Model A: $DMU_t = 0$ if $t <= TB$, and 1 if $t > TB$. The null hypothesis is a unit root with a one-time change in the level of the series against the alternative of a one-time change in the level of a trend stationary series.

Under Model B: $DTS_t = 0$ if $t <= TB$, and $t - TB$ if $t > TB$. The null hypothesis is a unit root with a one-time change in the drift against the alternative of a one-time change in the slope of a trend stationary series.

Under Model C: $DMU_t = DT$ if $t \le TB$, and $DMU_t = 1$, $DT_t = t$ if $t > TB$. The null hypothesis is a unit root with a one-time change in both level and drift against the alternative of a one-time change in the intercept and slope of a trend stationary series.

Perron's test assumes that the break time is given exogenously. The three models are estimated assuming the break time is 1997:2. The appropriate number of lags (k) is determined by adding lags until the Ljung-Box test fails to reject no serial correlation at the 5% significance level. The $t-$value on the coefficient α is compared against its critical value calculated by Perron for the appropriate value of $\lambda = TB/T$, which represents the ratio of the break sample size to the total sample size at some significance level.

3. LITERATURE REVIEW

A number of studies have been undertaken to test the validity of PPP in the Asian countries. None of which has used confirmatory analysis, and most of them could not find evidence in favor of PPP. Luintel (2000), for example, using monthly panel data from 1958 to 1989 for 8 Asian countries could not accept the null of a unit root. Wang (2000), using monthly data during the current float, examines PPP for seven Asian countries (Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, and Thailand) against the U.S. Using Johansen cointegration procedure, the author finds evidence of cointegration but could not accept the symmetry and proportionality restrictions. Doğanlar (1999), using quarterly time-series from 1980 to 1995 for India, Indonesia, Pakistan, Turkey, and the Philippines could reject the null of no-cointegration. Montiel (1997), using annual data tests the absolute version of PPP for five Asian countries: Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The main finding of the paper is lack of stationarity in the real exchange rate for all countries except Singapore (other studies include Gan (1994), Baharaumshah and Ariff (1997), Weliwita (1998), and Achy (2003)).

4. DATA

We employ quarterly data from 1973:2-1999:4 for six Asian countries. The countries are Indonesia, Korea, Malaysia, Singapore, the Philippines, and Thailand. The data are obtained from IMF's International Financial Statistics and contain the nominal exchange defined as the market rate per U.S. dollar (line rf), and the consumer price index (CPI, line 63). The CPI is the standard choice in the literature due to its availability and consistency. The U.S. is treated as the foreign or base country to reflect its important role in the world economy and the availability and consistency of its data.

5. RESULTS AND ANALYSIS

Table 2 shows the cross-correlation between changes in the log of the nominal exchange rates and changes in the log of the relative prices from three lags to three leads. The results indicate that changes in nominal exchange rates and the inflation differential are weakly correlated. Table 3 shows the contemporaneous correlation between changes in the in the log of the nominal and log of the real exchange rates. The table indicates that the correlation is almost perfect for all countries. This implies that nominal exchange rate movements dominate real exchange rate movements. Tables 2 and 3 show that changes in the nominal exchange rates are not offset by changes in relative prices; rather most of the change in the nominal exchange rates is reflected in the real exchange rates. This can be used to explain why relative PPP fails to hold in the short-run, and why real exchange rates can be represented by a martingale process. Since nominal exchange rates can be approximated by a martingale process and most of the changes in them are reflected in real exchange rates, it is reasonable to say that real exchange rates follow a martingale process.

Table 2. Cross-correlation of Changes in the Log of Nominal Exchange Rates and Relative Price Levels

Country	Lag 3	Lag 2	Lag 1	0	Lead 1	Lead 2	Lead 3
Indonesia	-0.273	-0.213	-0.041	0.251	0.519	0.470	0.378
Korea	0.124	0.056	0.022	0.023	0.336	0.109	0.046
Malaysia	-0.050	0.015	0.022	-0.004	0.052	0.269	0.094
Philippines	-0.077	-0.007	0.146	0.120	0.398	0.251	0.391
Singapore	-0.063	0.030	0.073	-0.001	0.034	0.068	-0.021
Thailand	-0.074	-0.037	0.014	0.095	0.123	0.143	0.096

Note: The correlation coefficient is calculated for the entire sample (1973:2 - 1999:4).

Table 3. Correlation between Changes in Nominal and Real Exchange Rates

Country	Correlation Coefficient
Indonesia	0.9624
Korea	0.9738
Malaysia	0.9563
Philippines	0.8911
Singapore	0.9054
Thailand	0.9738

Note: The correlation coefficient is calculated for the entire sample (1973:2 - 1999:4).

5.1. The Null of Non-stationarity

As a preliminary step, the stationarity of the nominal exchange rates and relative prices is investigated using the ADF and PP tests. The null of a unit root is tested with and without time trend. The trend term is kept in the estimation only if it is significant at the 10 percent significance level. The results of testing the variables in their levels and first difference are shown in Table 4. The results show that the nominal exchange rates and relative prices are non-stationary in their levels for all countries; however, the first difference of the variables is stationary.

The null of non-stationary real exchange rate is tested by applying the ADF and PP unit root tests with a constant, a time trend, and lagged first difference of the real exchange rate. The results in Table 5 indicate that the null of non-stationary real exchange rate can be rejected by the ADF test for Indonesia and Korea at the 5 and 10 percent significance levels, respectively. The results from the PP unit root test show evidence of stationarity for Indonesia, Korea and Thailand at the 10 percent significance level. These findings show very little support for PPP in the Asian countries, which is line with previous studies. These findings may be due to lack of power in the ADF and PP unit root tests. Therefore, in the next section we apply the newly developed KPSS test to test the null of stationary real exchange against the alternative of non-stationarity.

Table 4. Unit Root Tests for Level and First Difference of Nominal Exchange Rates and Relative Prices

Country	Variable	ADF Test[1)]	PP Test[2)]
Indonesia	$Ln(E)$	-2.9291(1)	-2.5496(2)
	$Ln(CPI)$	-2.1715(1)	-1.5119(5)
	$\Delta Ln(E)$	-7.2250(0)*	-7.2277(1)*
	$\Delta Ln(CPI)$	-5.2496(0)*	-5.2624(1)*
Korea	$Ln(E)$	-2.2622(0)†	-2.2317(4)†
	$Ln(CPI)$	-2.5957(3)	-2.8873(6)
	$\Delta Ln(E)$	-10.8260(0)*	-10.7488(4)*
	$\Delta Ln(CPI)$	-4.2247(2)*	-7.5527(6)*
Malaysia	$Ln(E)$	-0.3412(0)†	-0.5439(2)†
	$Ln(CPI)$	-0.8597(3)	-0.3155(5)
	$\Delta Ln(E)$	-9.2049(0)*	-9.1893(4)*
	$\Delta Ln(CPI)$	-9.3052(0)*	-9.4646(6)*
Philippine	$Ln(E)$	-0.2072(0)	-0.3446(5)
	$Ln(CPI)$	-3.1391(3)	-2.3523(6)
	$\Delta Ln(E)$	-5.3683(1)*	-10.0712(5)*
	$\Delta Ln(CPI)$	-5.2041(2)*	-6.3731(3)*

Table 4. (Continued)

Country	Variable	ADF Test[1)]	PP Test[2)]
Singapore	$Ln(E)$	-0.9408(0)†	-0.9159(3)†
	$Ln(CPI)$	-2.6891(6)	-1.6802(5)
	$\Delta Ln(E)$	-10.5223(0)*	-10.5273(3)*
	$\Delta Ln(CPI)$	-8.6285(0)*	-8.9236(7)*
Thailand	$Ln(E)$	-1.2952(0)†	-1.3163(2)†
	$Ln(CPI)$	-2.0406(1)	-1.84143)
	$\Delta Ln(E)$	-7.5929(0)*	-7.5930(1)*
	$\Delta Ln(CPI)$	-6.6714(0)*	-6.6372(2)*

Notes: [1)] is the ADF test for the null hypothesis of a unit root. The numbers in parentheses are the numbers of lags in the ADF test chosen by minimizing Schwartz Information Criteria (SIC) to ensure that the residuals are white-noise. A maximum of 12 lags are used. [2)] is the Phillips-Perron (PP). The numbers in parentheses are the lags truncation selected automatically by Newey and West Bandwidth using Barlett Kernal Spectral estimation method. [3)] *, **, *** denotes rejection of the null hypothesis at the 1%, 5%, and 10% significance levels. No asterisk indicates that the series in not stationary. [4)] All variables are transformed by taking their natural logarithm. The series are quarterly data from 1973:2 - 1999:4 obtained from the IMF's International Financial Statistics (CD-Ram). $Ln(E)$ is natural logarithm of the nominal exchange rate defined as units of the domestic currency per US dollar (line rf of the IMF's International Financial Statistics), $Ln(CPI)$ is the natural logarithm of the Consumer Price Index (CPI) in the home country relative to the foreign country (the USA) (line 63 of the IMF's International Financial Statistics). Δ denotes the first difference operator. [5)] No time trend is included for the first difference of the variables. † indicates insignificant time trend at the 10 percent significance level.

Table 5. Unit Root Tests for the Real Exchange Rates (1973:2 - 1999:4)

Country	ADF Test		PP Test	
	ADF	ρ_i	$Z(\theta)$	β_{1i}
Indonesia	-3.890(1)**	-0.203	-3.437(8)***	-0.172
Korea	-2.769(0)***†	-0.141	-2.632(3)***†	-0.141
Malaysia	-2.5490(0)	-0.123	-2.7547(2)	-0.123
Philippines	-1.8023(0)†	-0.064	-1.9484(4)†	-0.064
Singapore	-1.5699(0)†	-0.047	-1.7585(6)†	-0.047
Thailand	-3.1432(0)	-0.168	-3.207(2)***	-0.168

Notes: *, **, *** denotes rejection of the null hypothesis of a unit root at the 1%, 5%, and 10% significance level. No asterisk indicates that the series is non-stationary. The ADF equations used are:

$$\text{ADF:}\quad \Delta r_{it} = \mu_i + \delta t + \rho_i r_{it-1} + \sum_{j=1}^{k_i} \mu_{ij} \Delta r_{it-j} + \upsilon_{it}\ .$$

The Phillips-Perron (PP) test is applied using the following equations with four lag truncations:

$r_{it} = \beta_{oi} + \beta_{1i} r_{it-1} + \beta_{2i}(t - \frac{T}{2}) + \zeta_{it}$ with a test statistic $Z(\beta)$ for the null hypothesis $\beta_{1i} = 1$. The numbers in parentheses in the ADF test are the numbers of lags in the ADF test chosen by minimizing Schwartz Information Criteria (SIC). The numbers in parentheses in the PP test are the lags truncation selected automatically by Newey and West Bandwidth using Barlett Kernal Spectral estimation method. † indicates insignificant time trend at the 10 percent significance level.

5.2. The Null of Stationarity

To circumvent the low power in the standard unit root tests, the newly developed KPSS test is applied to test the null of stationary real exchange against the alternative of non-stationarity. The results on the nominal and real exchange rates in Table 6 show that the null of stationary nominal exchange rate could not be rejected for all countries, which implies that the nominal exchange rates are stationary. These results are not consistent with those obtained from the standard tests since the null of a unit root is accepted and the null of stationarity is also accepted.

Table 6. The KPSS Stationarity Test for Nominal and Real Exchange Rates

Country	The Nominal Exchange Rate The KPSS Test Statistic	The Real Exchange Rate The KPSS Test Statistic
Indonesia	0.1002(6)***	0.0768(7)***
Korea	0.1581(6)*	0.1045(8)*** †
Malaysia	0.1297(8)**	0.0711(8)***
Philippines	0.1324(8)**	0.1681(8)*
Singapore	0.1162(8)***	0.2219(8)
Thailand	0.2058(5)*	0.0775(8)***

Notes: 1) The 1%, 5%, and 10% critical values for the KPSS test of trend stationarity are 0.216, 0.146, and 0.119, respectively. 2) The 1%, 5%, and 10% critical values for the KPSS test of level stationarity are 0.739, 0.463, and 0.347, respectively. 3) *, **, *** denotes acceptance of the null hypothesis of trend stationarity at the 1%, 5%, and 10% significance levels, respectively. 4) The null hypothesis of stationarity is accepted if the value of the KPSS test statistics is less than it is critical value. 5) The numbers in parentheses are the lags truncation selected automatically by Newey and West Bandwidth using Barlett Kernal Spectral estimation method. 6) † the null of level stationarity is tested.

The results of applying the KPSS test on the real exchange rates show strong evidence of stationarity for four countries: Indonesia, Korea, Malaysia and Thailand since the null of stationarity is accepted at the 10 percent significance level. Weak evidence of stationarity is found for the Philippines since the null is accepted at the 1 percent significance level. The null could not be accepted for Singapore, which implies that the real exchange rate in Singapore is non-stationary. These findings differ markedly from those of the standard unit root tests and give evidence in favor of long-run PPP in these countries. As argued, standard unit root tests lack power; therefore, the null hypothesis of a unit root can not be rejected unless there is strong evidence against it. In the next section we conduct confirmatory analysis to strengthen inferences made about the stationarity or non-stationarity of the real exchange rates.

5.3. Confirmatory Analysis

In confirmatory analysis, the null of a unit root and the null of stationarity are jointly tested to confirm the existence or non-existence of PPP. Table 7 presents the results of the confirmatory analysis for the nominal and real exchange rates in the Asian countries. The results show no confirmation on the stationarity or non-stationarity of the nominal exchange rates for all the countries since the null of a unit root is accepted and the null of stationarity is accepted. This may be due to the data being insufficiently informative about the behavior of the nominal exchange rates.

Table 7. Confirmatory Analysis for the Nominal and Real Exchange Rates

Country	The Nominal Exchange Rate			The Real Exchange Rate		
	H_{ADF}	H_{KPSS}	Conclusion	H_{ADF}	H_{KPSS}	Conclusion
Indonesia	Accept	Accept	Inconclusive	Reject	Accept	Stationary
Korea	Accept	Accept	Inconclusive	Reject	Accept	Stationary
Malaysia	Accept	Accept	Inconclusive	Accept	Accept	Inconclusive
Philippines	Accept	Accept	Inconclusive	Accept	Accept	Inconclusive
Singapore	Accept	Accept	Inconclusive	Accept	Reject	Non-stationary
Thailand	Accept	Accept	Inconclusive	Accept	Accept	Inconclusive

Notes: H_{ADF} is the null hypothesis of a unit root under the ADF test. H_{KPSS} is the null hypothesis of level stationarity under the KPSS test.

As for the real exchange rates, stationarity is confirmed for only two countries: Indonesia and Korea since the null of a unit root is rejected and the null of stationarity is accepted. Non-stationarity is confirmed for Singapore since the null of a unit root is accepted and the null of stationarity is rejected. We have no confirmation for the remaining countries: Malaysia, the Philippines and Thailand since both nulls are accepted. Thus, we are able to provide and confirm stationarity of real exchange rates for Indonesia and Korea with a point estimate for half-life deviations of approximately 20.3 and 14.1 percent per quarter, respectively. This implies a half-life of 0.76 years for Indonesia and 1.14 years for Korea.

We further explore the behavior of the real exchange rates in the Asian countries by examining the impact of the 1997 Asian financial crisis on the real exchange rates in the crisis countries. The financial crisis should have changed the behavior of the real exchange rates in the crisis countries and caused structural break. Perron (1989) argues that most macroeconomic variables are not unit root processes; rather they are trend stationary processes with structural breaks. He argues that if a series contains a structural break, then standard unit root tests will fail to reject the null of a unit root when in fact the series is stationary. Therefore, it seems relevant to allow for structural breaks when testing real exchange rates for stationarity. In the next section we shed some light on the

Asian crisis and then test the null of a unit root allowing for a one-time structural break to capture the effect of the crisis.

6. THE ASIAN CRISIS

Prior to the Asian financial crisis, banks and businesses in the crisis countries had borrowed heavily short-term in yen and dollars (Tobin (1998)). Reports from the International Monetary Fund (IMF (1998)) have indicated the following major reasons for the crisis: high yields in the crisis countries relative to the rest of the world, high volumes of unproductive capital inflows into the crisis countries,[3] inconsistent domestic macroeconomic and exchange rate policies, and weaknesses in the financial sectors. These policies have resulted in overvaluation of the currencies of the crisis countries, stronger than if left to market forces. Signs of weakness began to appear, creditors of the crisis countries began worrying about their money. Markets overreacted, causing massive capital outflows. The result was a financial panic; a quick and huge decrease in the value of the crisis countries currencies. The depreciation was bigger than was required to offset the initial over-valuation, which resulted in deviations from PPP.

If PPP holds in the long-run, deviations from PPP should be transitory. Arbitrage opportunities will put pressure on the exchange rate and price levels to adjust, either the exchange rate will depreciate or the price ratio of domestic to foreign country will decrease. Since the exchange rates in the crisis countries were pegged to the U.S. dollar under a managed float system (except the Philippines which operated under an independent float system), the price level was the only mechanism for adjustment. But since prices are relatively sticky in the short-run (Rogoff (1996)), this caused the pegged system to be removed, which resulted in depreciation of the crisis countries currencies with respect to the U.S. dollar.

Figure 1 shows the cumulative deviations (cd_t) from PPP from 1990:1 to 1999:4. The choice of 1990:1 as the base year is based on Figure 2, which shows the cumulative deviations from PPP from 1973:2 to 1999:4. Figure 2 shows that the build-up pressure for the crisis countries currencies to devalue started for most of the countries a little after 1990. Prior to the crisis, if the crisis countries currencies were overvalued, the slope of cd_t should have been negative indicating appreciation in the real exchange rate. Figure 1 shows that the slope of cd_t prior to the crisis was indeed negative for the crisis countries. The 1997 Asian crisis should have caused a structural break due to the adjustment in the exchange rate (depreciation). The depreciation should have caused the slope of cd_t to change from negative to positive. The figure indicates that after the crisis there was a change in the slope from negative to positive. This marks a structural

[3] Almost half of total capital inflows to developing countries went to Asia 1996-nearly $100 billion (IMF, June 1998).

break in the slopes of the real exchange rate series for the crisis countries. Therefore, a unit root test in the presence of a structural break which allows for a change in the slope of the series is relevant. For this purpose, the Perron (1989) augmented unit root test is applied. The results of the estimation are given in Table 8 for only Model B "the changing growth model", which allows for a one-time change in the slope of the series.[4] We can reject the null of a unit root for Indonesia and Korea at the 5 percent significance level and for Malaysia and Thailand at the 10 and 1 percent significance levels, respectively. Thus, allowing for a one-time break in the slope of the real exchange rate series provides strong evidence in favor of PPP for Indonesia, Korea and Thailand and weak evidence for Malaysia. The null of a unit root could not be rejected For the Philippines and Singapore, even with structural breaks taken into account.

Table 8. Unit Root Test in the Presence of Structural Break for the Real Exchange Rate Series[‡]

Country	k	β_0	β_1	β_2	ϕ	α
Indonesia	0	1.4028	0.3721	0.0026	-0.0487	-0.2067
		(4.181)	(5.056)	(3.757)	(-4.336)	(-4.197)**
Korea	0	1.6039	0.2035	-0.0001	-0.0204	-0.2359
		(4.005)	(4.071)	(-0.590)	(-2.758)	(-4.020)**
Malaysia	0	0.1008	0.1532	0.0008	-0.0165	-0.1672
		(3.661)	(5.667)	(2.796)	(-3.884)	(-3.533)*
Philippines	0	0.2870	0.1279	0.0001	-0.0169	-0.0892
		(2.275)	(3.217)	(0.721)	(-2.752)	(-2.272)
Singapore	0	0.0239	0.0645	-0.0001	-0.0067	-0.0394
		(1.570)	(3.034)	(-0.907)	(-2.038)	(-1.322)
Thailand	0	0.8218	0.1905	0.0006	-0.0195	-0.2654
		(4.869)	(5.723)	(2.982)	(-3.884)	(-4.876)***

Notes: The 1%, 5%, and 10% critical values for $\lambda = 0.9$ are -4.26, -3.68, and -3.35, respectively. *, **, and *** denote significance at the 10%, 5%, and 1%, respectively. t-values are parentheses. ‡ Model B: the "changing growth model" which allows for a one-time change in the slope of the trend function.

$$y_t = \beta_0 + \beta_1 DMU_t + \beta_2 t + \phi DTS_t + \alpha y_{t-1} + \sum_{p=1}^{k} \theta_p \Delta y_{t-p} + \varepsilon_t .$$

The null hypothesis is a unit root with a one-time change in the drift against the alternative of a one-time change in the slope of a trend stationary series.

[4] The results obtained from estimating Model A indicated rejection of the null for Indonesia and Korea at the 5 and 1 percent significance levels, respectively. The results from Model C indicated rejection of the null for Indonesia and Korea at the 1 percent significance levels. The three models are also estimated assuming the break date is 1997:3. For Model A, the null of a unit root could not be rejected for all cases. For Model B, the null is rejected for Indonesia and Korea at the 5 percent significance level, and for Thailand at the 10 percent level. For Model C, the null is rejected for Indonesia at the 1 percent level.

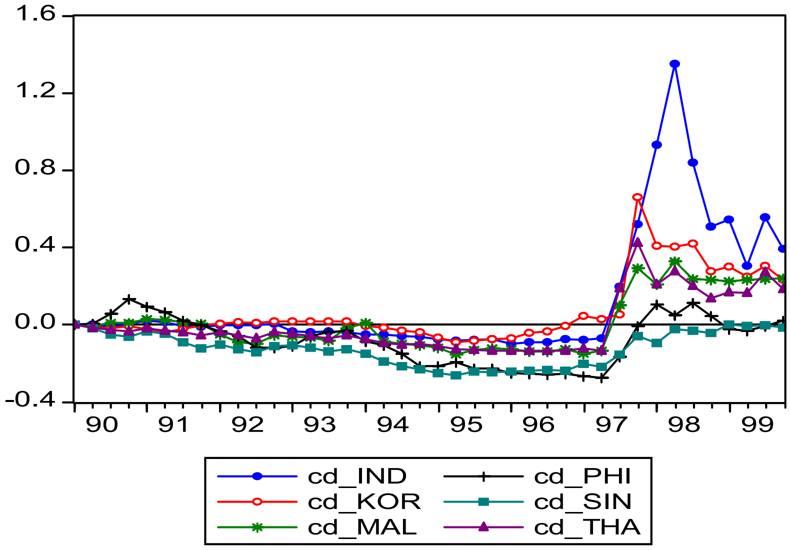

Figure 1. Cumulative Deviations from PPP from 1990:2 to 1999:4

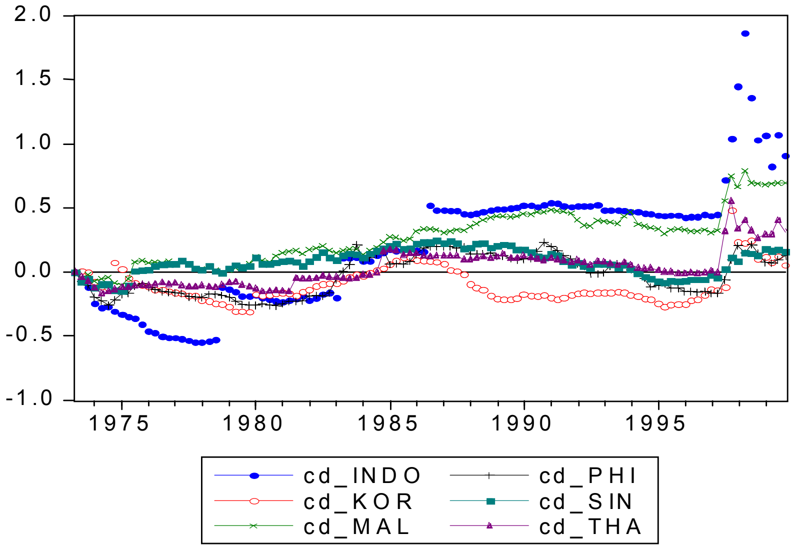

Figure 2. Cumulative Deviations from PPP from 1973:2 to 1999:4

7. SUMMARY AND CONCLUSIONS

This paper has attempted to test the validity of PPP for a sample of developing countries in the Asian financial crisis countries during the current float. Using the ADF and PP unit root tests, strong evidence of stationary real exchange is found for only Indonesia, and weak evidence at the 10 percent significance level is detected for Korea and Thailand. Strong evidence in favor of PPP is detected by the KPSS test for Indonesia, Korea, Malaysia, and Thailand. Combining the null of a unit root with the null of stationarity confirmed real exchange rate stationarity for Indonesia and Korea. Non-stationarity is confirmed for Singapore. The results from applying Perron's test that accounts for potential structural breaks in the real exchange rate series shows evidence of stationarity for Indonesia and Korea at the 5 percent significance level, and for Malaysia and Thailand at the 10 and 1 percent significance levels. Thus, we conclude that PPP does hold in four out of the six Asian countries under study, which implies that deviations from PPP are transitory.

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