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TESTING THE EVIDENCE OF PURCHASING POWER PARITY FOR ASEAN-5 COUNTRIES USING PANEL ESTIMATION

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Abstract- This article examines the validity of purchasing power parity (PPP) hypothesis using panel methods for five founding members of the Association of Southeast Asian Nations (ASEAN) in US dollar and Japanese Yen. A range of heterogeneous panel unit root tests and panel cointegration analysis used in literature applied to test long run PPP for post Bretton Woods floating period (1980-2007). This study shows that a sequence of unit root tests does not favour mean reversion and found mixed result for Singapore. This outcome, however, might be due to generally limited power of conventional classical unit root test. Nevertheless, the PPP proposition seems to hold for post financial crises period (post-1997) in US and Japan as base country. Consequently, this study is broadly consistent with Baharumshah *et al.* (2007) results, invariant to numeraire currency, of mean reversion, mainly supporting PPP for Asian crises era. Furthermore, present study has used recent developed heterogeneous panel cointegration tests and found significant cointegration between nominal exchange rate, domestic and foreign prices. However, the results provide more evidence for ASEAN-5 in Japanese based in favour of cointegration in long run compared with US dollar is the numeraire currency.
Key words - Panel data, ASEAN-5, cointegration, Purchasing Power Parity (PPP)

1.0 Introduction

Purchasing Power Parity (PPP) theory was developed by Gustav Cassel in 1920. The PPP theory has a long history in economics, dating back several centuries, but the specific terminology of purchasing power parity was introduced in the years after World War I during the international policy debate concerning the appropriate level for nominal exchange rates among the major industrialized countries after the large-scale inflations during and after the war (Cassel ,1918) since then, the idea of PPP has become embedded in how many international economists think about the world.

PPP is a theory of exchange rate determination and a way to compare the average costs of goods and services between countries .A building block of the PPP theory is the Law of One price which states that under free competition and in the absence of trade impediments, goods must sell for a single price regardless of where in the world it is sold.

There are 2 approaches to study PPP theory, the monetary approach and real exchange rate approach .The monetary approach to the exchange rate uses PPP to explain long term exchange rate behaviour exclusively in term of money supply and demand. In this theory, long run international interest differentials result from different national rates of ongoing inflation. The real exchange rate approach to exchange rates generalizes the monetary approach. It defines the real exchange rate as the price of domestic products relative to foreign products. It predicts that changes in relatives demand and relative supply of products influence real and nominal exchange rates.

Many studies have been carrying out 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. Obviously previous studies demonstrated mixed results for the robustness of PPP theory, either in the short or long run by using different types of econometric procedures. One of the biggest problems found was the heterogeneity problem. Besides, the use of the cointegration techniques, especially the residual-based cointegration test, provides inconsistent results and misspecification findings.

After 43 years establishment of ASEAN, it is important to investigate whether goods market in ASEAN-5 had been more integrated. Indeed, LOOP stated that: “In an efficient market, identical goods should have sell for same price in difference country”. Whilst, PPP theory uses the long term equilibrium exchange rate of two currencies to equalize their purchasing power. With these references, the evidence of PPP should be sought

amongst the ASEAN-5 countries. However, previous empirical literature regarding long run PPP has found mixed results for the robustness of PPP hypothesis. Recent findings show that many macroeconomic time series, including price level and nominal exchange rate, are non-stationary I(1) process.

The main problem with the PPP theory is that the PPP condition is rarely satisfied within a country. There are several reasons that PPP may not hold:

1. Law of one price assumed that there are no transportation costs and no differential taxes applied between the two markets. Since transport costs and trade restrictions do exist in the real world, this would tend to drive prices for similar goods apart.
2. Monopolistic or oligopolistic practices in goods markets may interact with transport costs and other trade barriers to weaken further the link between the prices of similar goods sold in different counties.
3. Because the inflation data reported in different countries are based on different commodity baskets, there is no reason for exchange rate changes to offset official measure of inflation differences, even when there are no barriers to trade and all products are tradable.

This paper investigated the long run validity of PPP in ASEAN-5 countries, namely Malaysia, Philippines, Singapore, Indonesia, and Thailand by employs longer and recently time spans from January 1980 to December 2007. This is done by comparing the PPP proposition between two numeraire currencies (US dollar and Japanese yen) as based currencies by using panel's method. Furthermore, the behaviour of real exchange rates is analyzed for aftermath post crises period which not so attract much attention yet for recent empirical studies.

The rest of the paper is organized as follows. Section two presents the literature review, theoretical view of PPP hypothesis as well as sources of data. Section three provides the empirical methodology. Section four explains the results and analysis of the empirical work. Section five describes conclusions and policy implication.

2.0 Literature Review

A number of studies have been undertaken to test the validity of PPP in the Asian countries. Most of them could not find evidence in favour of PPP. For example, several techniques use by Baharumshah and Ariff (1997) also failed to support the long run PPP hypothesis in Malaysia, Singapore, Thailand, the Philippines and Indonesia. Their studies also one of an example utilized conventional tests that do not allow for structural breaks and have found no evidence or only weak evidence in favour of long run PPP.

Azali *et al.* (2001), for example, found evidence shows that the panel parametric and non-parametric tests either with a trend term or without a trend term support the hypothesis of cointegration between the bilateral exchange rates and relative prices against the selected foreign country Japan. Liew *et al.* (2004) using nonlinear stationary test (KSS) and ADF test on quarterly data for 11 Asian countries to examine the stationary property. The main findings were PPP in 8 US dollar-based and 6 Japanese yen-based out of 11 Asian countries hold.

Previous empirical studies on individual ADE countries have found mixed results and it turns out that our finding based on an array of panel unit root tests appears to be invariant to the choice of the numeraire currency, namely the US and Japanese yen. For example, Kim *et al. (*2008) showed the stability of the relationship between exchange rates and price differentials is strongly rejected. And then, a major structural change occurs at the outbreak of the Asian currency crisis in 1997. The sharp decline in our estimates of the time-varying PPP relationship in terms of the US dollar for that period results from the one-time, significant depreciation of Southeast Asian currencies that occurred in 1997.

Choudhry (2005) for example, shows the absent of G-PPP for the five Far East countries from the pre-crisis period. In contrast, results provide evidence of G-PPP between the real exchanges of the five Far East countries, regardless of the base currency, after the Asian crisis. Another study using heterogeneous panels attained a similar result. Baharumshah *et al.* (2005) investigates the six Asian countries and the results do not reject the unit root null for the pre-crisis period. However, it strongly rejected the unit root null for the sample period that included the post-crisis years.

Some economists have proposed using other powerful tests, such as tests that can be used to test the null of stationarity against the alternative of non-stationarity. This joint testing has been known as *"confirmatory analysis."* Nusair (2003), for example, tests PPP for 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 KPSS test to test the null of stationarity. The null of a unit root can be rejected for Indonesia, Korea and Thailand. The study cannot reject the null of stationarity for all countries except for Singapore. Joint testing of both nulls confirms stationarity for Indonesia and Korea.

Goh and Mithani (2000) which use a multivariate approach suggest that the Malaysia's real exchange rate follow a random walk contrary to the expectations of PPP equilibrium. It also confirms that the type of price index does matter in testing the PPP relation in this economy.

For European countries, PPP tends to hold. Zumaquero (2002), for example, they find evidence in favour of long-run PPP hypothesis when commodity prices are used in the presence of structural breaks. This result lends support to the integration process in the European Union. Another example, Coakley and Snaith (2004) using recently developed nonstationary panel regression estimators that can accommodate cross sectional dependence and both permanent and temporary shocks. The monthly data result shows long run relative PPP holds.

Previous studies also demonstrated mixed results for the robustness of PPP theory, either in the short or long-run by using different types of econometric procedures. For example, Drine and Rault (2007) showed strong PPP is verified for Organization for Economic Cooperation and Development (OECD) countries and weak PPP for Middle East and North Africa (MENA) countries. However in African, Asian, Latin American and Central, and East European countries, PPP does not seem relevant to characterize the long-run behaviour of the real exchange rate. Whereas, Alba and Papell (2007) show that PPP holds for panels of European and Latin American countries, but not for African and Asian countries. Their findings demonstrate that country characteristics can help explain both adherence to and deviations from long-run PPP. They also find stronger evidence of PPP in countries more open to trade, closer to the United States, with lower inflation and moderate nominal exchange rate volatility, and with similar economic growth rates as the United States.

Other than studies mention on above, many studies had been done to test PPP and different results were obtained. Boyd and Smith (1998), for example, used time series and panels to test PPP for a panel of 31 developing countries from 1966 to 1990. Using time-series data one cannot reject the null of a unit root in the real exchange rate, though one can reject the null of no cointegration between nominal exchange rates and price differentials for over half the countries. Similarly, Chiu (2002) tests the purchasing power parity (PPP) using panel unit root tests on data of 45 economies from 1980 to 1999. The study gives evidence on the long-run properties of the PPP hypothesis.

Aggarwala *et al.,* (2000) using quarterly data for Japanese yen-based CPI and PPI-based real exchange rates with one and two breaks shows evidence in favour of long-run quasi-PPP for most of the Southeast Asian currencies in terms of the Japanese yen by allowing changes in the mean of real exchange rates. They found weak evidence of PPP for these Southeast Asian exchange rates with the US dollar, the German mark and the Australian dollar. Cerrato and Sarantis (2003) applied heterogeneous panel unit root and cointegration tests to examine the PPP hypothesis using a unique panel of black market exchange rates for twenty emerging market economies. The overall empirical findings from the black market exchange rates seem to provide support for the weak form but not the strong form of the PPP hypothesis in the emerging market economies.

Nusair (2004), using quarterly data finds evidence of PPP vis-à-vis the USA for Indonesia, Korea, Malaysia and Thailand, after allowing for a break in the third quarter of 1997. After 4 years, Nusair re-examines the long-run PPP relationship for nine Asian countries relative to the USA and Japan during a period containing significant structural breaks. By applying the Johansen *et al*. procedure, one is able to reject the null of no cointegration for all the countries, regardless of the base country, except the Philippines vis-à-vis Japan.

Ramirez and Khan (1999) test the PPP hypothesis for five industrial countries using cointegration and error-correction modelling. The cointegration test indicated that for all countries the PPP hypothesis holds in the long run but not in the short run. Further, the error-correction models suggested that deviations of the actual exchange rate from its long-run PPP value were corrected in subsequent periods.

Finally, the high frequency monthly data models did a better job of tracking the turning points of the actual data than the low-frequency quarterly and yearly models. Another studies using error correction modelling in the same year was David (1999). He investigates the validity of PPP hypothesis as a long run equilibrium condition for thirteen Asia Pacific economies. The standard tests for unit roots in the real exchange rate confirm earlier empirical studies that there is little support for a long run relationship between exchange rate and price ratio. The hypothesis of a unit root can be rejected only for Mexico for the long sample period. Haug and Basher (2005) using monthly data from the post-Bretton Woods era for G-10 countries to test long run PPP. The finding shows a rejection of PPP for almost all countries.

2.1 Theoretical View of PPP Hypothesis[1]

In the absence of transportation costs, tariff and non tariff barriers, the same good should cost the same price across national boundaries. The basic building block of PPP is known as "Law of One Price" (LOP). The LOP states that in the absence of trade barriers, such as transportation costs, and tariff, competition will equalize the price of an identical and traded good across countries when prices are expressed in the same currency. The theory of PPP involves a relationship between the

[1] Sources: Nusair (2003)

nominal exchange rate and the price ratio of domestic to foreign country. Thus:-

$$E_{it} = \frac{P_{it}}{P_t^*} \quad (2.1)$$

where E_{it} = is the nominal exchange rate, defined as units of domestic currency per unit of foreign currency, for country *i* at time *t* per US dollar or Japanese Yen, P_{it} is the domestic price index (the CPI), P_t^* is the foreign price index (US or Japanese Yen), and *i* is an index for Malaysia, Thailand, Singapore, Philippines and Indonesia. Using lowercase letter denotes the natural logarithm of the variables in Equation (2.1) yields, $e_{it} = p_{it} - p_t^*$ the absolute PPP. Taking the first difference of the absolute PPP yields $\Delta e_{it} = \Delta p_{it} - \Delta p_t^*$, 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 to denote variables in their natural logarithm form yields

$$r_{it} = e_{it} + p_t^* - p_{it} \quad (2.2)$$

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, an X% increase/decrease in relative price should be matched by X% depreciation/appreciation in the nominal exchange rate. Thus, if we can show the real exchange rate is stationary, we can provide evidence in favour of PPP. If the stationarity of the real exchange rate is not found, the theory of PPP will be rejected.

2.2 Sources of Data

The empirical results of this study produced by using monthly time series on "end of period" nominal exchange rate (home currency / US dollar) and the Consumer Price Index for all ASEAN 5 countries over the period January 1970 until December 2007. Few adjustments have been made where all the data is computed into Real exchange rate. Besides, the ASEAN 5 countries are pegged into two major currencies. One is US dollar and the other one is Japanese Yen. The 5 ASEAN countries mention above consist of Indonesia, Singapore, Thailand, the Philippines, and Malaysia. These data can be obtained from the *International Financial Statistic* published by International Monetary Fund (IMF) version 2009.

3.0 Empirical methodology

This study employs the conventional Augmented Dickey-Fuller (ADF) unit root test and Phillips-Perron (PP) unit root test in order to test the stationary of the variables.

The ADF test is conducted with and without a deterministic trend (t). The ADF test is estimated as following regression:

$$\Delta y_t = \mu + \alpha y_{t-1} + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + \varepsilon_t \quad (3.1)$$

$$\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{j=1}^{p} \delta_j \Delta y_{t-j} + \varepsilon_t \quad (3.2)$$

where Δy is the first difference of the series, α and β are constant parameters, μ is intercept, the disturbance term ε_t is assumed to be white noise, t is time or trend variable and p is the number of lagged terms. Equation (3.1) is without the trend variable regression and equation (3.2) is with trend variable regression.

The PP, based on the work of Phillips and Perron (1988) has an advantage in which the non-parametric correction is used to allow for serial correlation and is usually represented as compared to ADF results. It is also known to have more powerful than ADF in small as well as moderate samples.

The test involved estimating the following equations for a variable, say y_t,

$$y_t = \mu_1 + \alpha y_{t-1} + \varepsilon_{1t} \quad (3.3)$$

$$y_t = \mu_2 + \theta t + \beta y_{t-1} + \varepsilon_{2t} \quad (3.4)$$

where μ_1 and μ_2 are constants (drift terms), α, θ and β are the estimator of the equilibrium parameters, t is a deterministic time trend and ε_{1t} and ε_{2t} are residuals.

For both tests, the null hypothesis of unit root may be tested against the alternative hypothesis of stationary by the t-statistic. Null hypothesis will be rejected if the t-statistic is greater than the relevant critical value. The critical values of PP test are the same as those used for ADF test since both tests have the same asymptotic distribution. The critical values for these tests are provided in Mackinon (1991). In applying both of these tests, the optimal lag structure is determined using the Akaike Information Criteria (AIC).

3.1 Panel Unit Root Tests

A set of panel unit root tests has been conducted to ensure the robustness of the results. This study incorporates the non-stationary panel unit root tests advocated by Levin, Lin and Chu (LLC, 2002), Im,

Pesaran and Shin (IPS, 2003), Breitung (2002), ADF-Fisher Chi-square base on Mandalla and Wu (1999) and Hadri (1999).

a) Levin, Lin and Chu (LLC, 2002)

Levin, Lin and Chu (2002) found that the panel approach substantially increases power in finite samples when compared with the single-equation ADF test. LLC proposed to modify the ADF statistics based on homogenous pooled statistics, which is opposed to the heterogeneous IPS test. An estimate of the coefficient α may be obtained from proxies for Δq_{it} and q_{it} which are standardized and free of autocorrelations and deterministic components, such that:

$$\Delta \tilde{q}_{it} = \alpha \tilde{q}_{it-1} + \eta_t \qquad (3.5)$$

where $\Delta \tilde{q}_{it}$ =($\Delta \bar{q}_{it}$ / se_i) and $\tilde{q}_{it-1}$ =($\bar{q}_{it-1}$ / se_i) with s_i being the estimated standard error from estimating single ADF statistics of the q_t.

Then LLC show that under the null, a modified t-statistics for the resulting $\hat{\alpha}$ is asymptotically normally distributed

$$t_\alpha^* = \frac{t_\alpha - (NT)S_N \hat{\alpha}^{-2} se(\hat{\alpha}) \mu_{mT}^*}{\alpha_{mT}^*} \longrightarrow N(0,1)$$

(3.6)

where t_α^* is the standard t-statistics for $\hat{\alpha}$ =0, $\hat{\alpha}^2$ is the estimated variance of the error term η, se($\hat{\alpha}$ is the standard error of $\hat{\alpha}$, S_N is the mean of the ratios of the long run standard deviation to the innovation standard deviation for each individual series, which is derived using kernel-based techniques, μ_{mT}^* and α_{mT}^* are adjustment terms for the mean and standard deviation respectively and lastly T = T - ($\sum_i p_i / N$) − 1.

b) Im, Pesaran and Shin (IPS, 2003)

Conceptually, the IPS test is a way of combining the evidence on the unit root hypothesis from the N unit tests performed on the N cross-section units. Through Monte Carlo experiments, the average LM and the t-statistics have better finite sample properties than the early homogenous panel tests. Briefly, the test statistics are given by:

$$\Gamma_{\bar{t}} = \frac{\sqrt{N}\{\bar{t}_{NT} - E(t_{iT} | \beta_i = 0\}}{\sqrt{Var(t_{iT} | \beta_i = 0)}}$$

⇨N(0,1)

where $\bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}$ (3.7)

and

$$\Gamma_{\overline{LM}} = \frac{\sqrt{N}\{\overline{LM}_{NT} - E(LM_{iT} | \beta_i = 0\}}{\sqrt{Var(LM_{iT} | \beta_i = 0)}}$$

⇨N(0,1)

where $\overline{LM}_{NT} = \frac{1}{N}\sum_{i=1}^{N} LM_{iT}$ (3.8)

such that $\bar{t}_{NT}$ is based on averaging individual ADF tests while $\overline{LM}_{NT}$ on averaging across groups. Both means $E(t_{iT}|\beta_i = 0$, $E(LM_{iT}|\beta_i = 0$ and both variances $\sqrt{Var(t_{iT}|\beta_i = 0)}$, $\sqrt{Var(LM_{iT}|\beta_i = 0)}$ are obtained from Monte Carlo simulations with i = 1, 2,...,N.

c) Breitung (2002)

Breitung found losses of power due to bias correction in LLC and detrending bias in IPS. In consequence, he proposes a λUB statistic to overcome these problems.

By defining the T x 1 vectors Y_i=[Δy_{i1},...,Δy_{iT}]'and X_i=[y_{i0},...,$y_{i,T-1}$]'whilst the transformed vectors Y_i^*=Ay_i=[y_{i1}^*,...,y_{iT}^*]'and X_i^*=Bx_i=[x_{i1}^*,..,x_{iT}^*]', the UB statistics is in short given by:

$$\lambda_{UB} = \frac{\sum_{i=1}^{N} \sigma_i^{-2} y_i^{*\prime} x_i^*}{\sqrt{\sum_{i=1}^{N} \sigma_i^{-2} x_i^{*\prime} A' A x_i^*}} \qquad (3.9)$$

⇨$(N,T \longrightarrow \infty)_{seq}$

under the assumption of

$E(y_i^{*\prime} x_i^*)$,
(3.10)
$\lim_{T\to\infty} E(T^{-1} y_i^{*\prime} y_i^*)>0$,
$\lim_{T\to\infty} E(T^{-1} x_i^{*\prime} A' A x_i^*)$

d) ADF-Fisher Chi-square (1999, 2001)

Another test, based on the P_λ test originally developed by Fisher (1932), is suggested by Maddala and Wu (1999), who show that it is more powerful than the t-bar test. Its disadvantage is that the significance levels have to derive by means of Monte Carlo simulations. Maddala and Wu (1999)

Test	Null	Alternative	Possible Deterministic Component	Autocorrelation Correction Method
Levin, Lin and Chu	unit root	no unit root	none, F, T	lags
Breitung	unit root	no unit root	none, F, T	lags
IPS	unit root	some cross-sections without unit root	F, T	lags
Fisher-ADF	unit root	some cross-sections without unit root	none, F, T	lags
Hadri	no unit root	unit root	F, T	kernel

argue that while the Im *et al* (1997) test relaxes the assumption of homogeneity of the root across units, several difficulties still remain. Specifically, this test assumes that T is the same for all the cross-section units and hence requires a balanced or complete panel. Also, it only allows for a limited amount of cross-correlation across units through common time effects.

Maddala and Wu point out that, in practice, the cross-correlation is unlikely to take this simple form. They propose the following test. Let π_i be the observed significance level (p-value) for the ith test. The P_λ test has a χ^2 distribution with d.o.f. 2N,

$$P_\lambda = \sum_{i=1}^{N} -2\ln\pi_i \qquad (3.11)$$

and it does not require a balanced panel. However, like the Im *et al* (1997) tests, it suffers from cross-sectional dependence. To solve the problem, Maddala and Wu (1999) suggest using bootstrap methods to obtain its empirical distribution.

e) Hadri (1999)

The Hadri panel unit root test is similar to the KPSS unit root test, and has a null hypothesis of no unit root in any of the series in the panel. The Hadri test is based on the residuals from the individual OLS regressions for y_{it} (on a constant, or on a constant and a trend. This test requires only the specification of the form of the OLS regressions: whether to include only individual specification constant terms, or whether to include both constant and trend terms.

Briefly, the test statistics are given by:

$$LM_1 = \frac{1}{N}\left(\sum_{i=1}^{N}\left(\sum_t S_i(t)^2/T^2\right)/f_0\right) \qquad (3.12)$$

and

$$LM_2 = \frac{1}{N}\left(\sum_{i=1}^{N}\left(\sum_t S_i(t)^2/T^2\right)/f_{i0}\right) \qquad (3.13)$$

where $S_i(t)$ are the cumulative sums of the residuals and f_0 is the average of the individual estimators of the residual spectrum at frequency zero. LM_1 is base on the associated homoskedasticity assumption and LM_2 is heteroskedasticity consistent.

The following table summarizes the basic characteristics
of the panel unit root tests:[2]

none–no exogenous variables; F–fixed effect; and T–individual effect and individual trend.

Panel Cointegration Test

Pedroni (1999, 2004) developed a number of statistics based on the residuals of the Engle and Granger (1987) cointegration regression. The tests proposed in Pedroni allow for heterogeneity among individual members of the panel, including heterogeneity in both the long-run cointegrating vectors and in the dynamics. Consequently, Pedroni allows for varying intercepts and varying slopes. Consider the following regression:

$$Y_{it} = \alpha_i + \delta t + \beta_{1i}X_{1i,t} + \beta_{2i}X_{2i,t} + \ldots + \beta_{Mi}X_{Mi,t} + \varepsilon_{it} \qquad (3.14)$$

For t=1,...,T; i=1,...,N; m=1,...,M; where Y and X are assumed to be integrated of order one. The parameters α_i and δ_i are individual and trend effects which may be set to zero if desired.

Under the null hypothesis of no cointegration, the residuals ε_{it} will be I(1). The general approach is to obtain residuals from equation (14) and then to test whether residuals are I(1) by running the auxiliary regression.

$$\varepsilon_{it} = \rho_i\varepsilon_{it-1} + \mu_{it}$$

for each cross-section.

Pedroni describes various methods of constructing statistics for testing for null hypothesis of no cointegration (ρ=1). There are two alternative hypotheses: the homogenous alternative ($\rho_i=\rho$)<1 for all i (which Pedroni terms the within-dimension test or panel statistics test) and the heterogeneous alternative ρ_i<1 for all i (also referred to as the between-dimension or group statistics test)

The Pedroni panel cointegration statistic $\aleph_{N,T}$ is constructed from the residuals from either equation (3.15). A total of eleven statistics with varying degree of properties are generated.

Pedroni shows that the standard statistic is asymptotically normally distributed,

$$\frac{\aleph_{N,T} - \mu\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1) \qquad (3.16)$$

[2] Sources: E-view 6 handbook

where μ and υ are Monte Carlo generated adjustment terms.

4.0 Results and Analysis

As a preliminary step in finding the evidence of PPP in ASEAN 5 countries, two unit root tests, namely Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were applied. Tables 1 and 2 represent the results for these tests for both US dollar base and Japanese Yen base. The null hypothesis of a unit root is tested with and without time trend for level and first difference. The null hypothesis of unit root for real exchange rate cannot be rejected for all ASEAN 5 countries at level except for the real exchange rate of Singapore (against Japanese Yen) for constant that show an evidence of stationary at 5 percent significance level and therefore it is categorized as I(0). Hence it is concluded that all series under concerned are non-stationary. As a consequence, higher order of differing is must. After first difference, the null hypothesis of unit root for both US dollar base and Japanese Yen base easily been rejected for all series tested. The results indicate that the null of non stationary real exchange rate can be rejected by the DF and ADF test for all ASEAN-5 countries at 1% significance levels, respectively. Therefore all the data can be categorized as I(1).

Result of PP unit root test from the Table 2 shows high evidence of stationarity for all ASEAN-5 countries at 1% significance level after first difference for both US dollar base and Japanese Yen base. Once again, the real exchange rate for Singapore against the Japanese Yen is found stationary at 1% significance level at constant for level. Therefore, this data can be categorized as I(0). These findings show very high support for PPP in ASEAN countries, which is in line with previous studies. Indeed, the results are consistent with the view that most variables are non-stationary in level but stationary in the first difference (Nelson and Plosser, 1982). All data that found stationary after first difference is then categorized as I(1).

4.1 Results for panel unit root tests

Although there is little empirical support for absolute purchasing power parity and found relative purchasing power parity more consistent with data[3]. However, some empirical evidence indicates that purchasing power parity represents a long run trend around the exchange rate fluctuates which stand to hold in long run. (for more detail refer Krugman, 2006) The limited power of univariate unit root tests is very often cited as a major reason for the non-rejection of unit root null. As such, a popular line of research uses panel methods to increase power of the tests. Whilst, several authors (Frankel and Rose, 1996; Koedijk *et al.*, 1998; Papell *et al.*, 1998; Joseph and David, 2005; Kalyoncu and Kalyoncu, 2008) have advocated the use of panel data in unit root testing and argue that cross-sectional variations in panel data are more capable to yield more powerful tests results and lessen the likelihood of rejecting the null of stationary behaviour of exchange rate series. We found benefits of using panel data such that the panel adds more informative data, more degree of freedom, variability (see Baltagi, 1995 for further discussion on the benefits and limitations of panel data) and so on.

Therefore, we apply traditional panel unit root tests which advocate by Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003) and Maddala and Wu (1999) [Fisher-type tests] to analyze the validity of purchasing power parity hypothesis in long run. To this end, two sets of panel of real exchange rates are constructed; one with respect to the US dollar and another one with respect to Japanese yen. Results for panel unit root tests for two difference base numeraire currency are reported in Table 3 and Table 4 respectively. Table 3 and Table 4 summarize panel unit root tests using dollar and yen as the reference currency, respectively. The tests fail to reject the null of a unit root in level; therefore, the results strongly indicate the presence of unit root in real exchange rates for ASEAN-5 countries over the period estimation.

To examine the purchasing power parity hypothesis aftermath financial crises. The same panel unit tests were re-run by using data set from 1997 until 2007 and interestingly, empirical results show that even though sample span is short, purchasing power parity hypothesis seems to hold for ASEAN-5 countries in post-crises period. All the panel unit root tests reinforced the earlier findings, that is, the behaviour of real exchange rate after Asian financial crises as a group is noticeably different from pre-crises period as discussed by Baharumshah *et al.* (2007).[4] Likewise, similar results were observed when yen was used as a based currency in presence analysis. However, most of the previous empirical evidence, including the tests in this study seems fail to reject unit root null for pre-crises period.

[3] Prices of identical commodity baskets, when converted to a single currency, will differ substantially across countries.

[4] Baharumshah *et al.* (2007) found the purchasing power parity proposition hold for post-crises period but real exchange rates seem failed to find evidence supporting validity of PPP for pre-crises period.

4.2 Results from panel cointegration tests

In this section, we test for a long run relationship between nominal exchange rate and relative prices with respect to two foreign currency (US dollar and Japanese yen) which known as weak long-run purchasing power parity by using Pedroni (1999, 2004) procedure. Pedroni panel cointegration test statistics which evaluate null against both homogenous and heterogeneous alternative. Before using cointegration analysis to test for a long-run relationship between nominal exchange rate and relative prices, we first performed panel unit root tests (LLC t-stat, Breitung t-stat, IPS W-stat, ADF-Fisher Chi-square and Hadri Z-stat) on each variable (nominal exchange rate and relative prices). This test results which exogenous variables include individual effects and individual linear trends are shown in Table 5. Results indicate that the unit root null could not be rejected and hence these two series are generated by a I(1) process despite US real or Japan being base country.

Summary of results for the Pedroni panel cointegrating regression are presented in Table 6. Pedroni (1999, 2004) conducted for panel data analysis in this study. Trend assumption based on no deterministic trend and deterministic intercept and trend are performed. This study select automatic selection based on AIC with 16 maximum lag. Pedroni (1999) refers to eleven difference statistics to test a null of no cointegration of these eleven statistics. [5]The first four are known as panel cointegration statistics (panel-v, panel-Rho, panel-PP, panel-ADF); the last three are group mean panel cointegration statistics (group-Rho, group-PP, group-ADF).

As indicated by panel and group statistics, most of statistics favour the weak purchasing power parity hypothesis in Japanese based real exchange rates because the null hypothesis is rejected most at 1% level of significance. Table 6 comparing results for US dollar based into those of Japanese yen base. However, it appears that only three statistics (i.e. the panel-v, panel- ADF and group-ADF) out of seven only able to reject the null of non-cointegration in US based real exchange rate. Nevertheless, Pedroni (1997) shows that the panel-ADF and group-ADF statistics have better small sample properties than the other statistics and hence they are more reliable than other statistics. These results imply that taken as a group, the theory of purchasing power parity does hold over the estimation period. Therefore, the evidence from Pedroni panel cointegration tests seem support the existence of a long-run relationship between nominal exchange rate, domestic and foreign prices for full panel of ASEAN-5 countries.

[5] Results for weighted statistic for panel statistics can be request upon authors.

5.0 Conclusion and Policy Implications

Prior empirical studies of purchasing power parity (PPP) both in developed and in developing countries still inconclusive. O'connell (1998), Holmes (2001) and Alba and Papell (2007) have not shown much evidence by using panel unit root tests to this end. This paper re-examines the validity of PPP hypothesis using panel methods for five leading members of the Association of Southeast Asian Nations (ASEAN) in US dollar and Japanese yen [Indonesia, Malaysia, the Philippines, Singapore, and Thailand]. For this purpose, a range of heterogeneous panel unit root tests and panel cointegration analysis used in literature applied to test long run PPP for post Bretton Woods floating period (1980-2007). The empirical evidence from a battery of unit root tests does not favour mean reversion and found mixed result for Singapore. This outcome, however, might be due to generally limited power of conventional classical unit root test. However, the PPP proposition seems to hold for post financial crises period (post-1997) in US and Japan as base country. Therefore, this study is broadly consistent with Baharumshah *et al.* (2007) results, invariant to numeraire currency, of mean reversion, mainly supporting PPP for Asian crises era. Furthermore, present study has used recent developed heterogeneous panel cointegration tests and found significant cointegration between nominal exchange rate, domestic and foreign prices. Nevertheless, the results provide more evidence for ASEAN-5 in Japanese based in favour of cointegration in long run if compare with US dollar is the numeraire currency. All in all our results are quite in line with our expectations and some empirical studies such as Azali *et al.* (2001).

Indeed, some researchers argue that a long run PPP is a valid equilibrium relationship if the yen is used as the numeraire currency which mainly due to close trade and financial linkages among the East Asian countries. The PPP hypothesis is important to economists not only because it is the centrepiece of many exchange rate models including the monetary model of exchange rate determination, but also because of its policy implications. If the purchasing power parity proposition hold in long run then national monetary authorities will be able successful to conduct independent monetary policy and simultaneously control the movement of exchange rates. Otherwise, invalid PPP will create high possibility unbounded gains from arbitrage in traded goods (Kapetanios *et al.,* 2003), disqualifies monetary approach to exchange rate determination and so on.

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Appendix

Table 1- Result for DF/ADF Test (Jan 1980 to Dec 2007)

	Real Exchange Rate, end of period (against US Dollar)				Real Exchange Rate, end of period (against Japanese Yen)			
	Level		First Difference		Level		First Difference	
	no trend	with trend	no trend	with trend	no trend	with trend	no trend	with trend
Indonesia	-2.02 (14)	-1.97 (14)	-5.65 (13)[a]	-5.78 (13)[a]	-1.92 (14)	-1.23 (14)	-5.09 (13)[a]	-5.22 (15)[a]
Philippines	-2.33 (8)	-2.03 (8)	-4.70 (14)[a]	-4.86 (14)[a]	-2.15 (0)	-1.60 (0)	-18.74 (0)[a]	-18.85 (0)[a]
Malaysia	-1.67 (8)	-2.37 (7)	-6.38 (7)[a]	-6.44 (7)[a]	-2.37 (2)	-2.73 (1)	-15.62 (1)[a]	-15.65 (1)[a]
Thailand	-2.07 (5)	-2.36 (5)	-7.15 (6)[a]	-7.21 (6)[a]	-1.93 (4)	-1.30 (4)	-9.60 (3)[a]	-8.09 (6)
Singapore	-1.60 (0)	-1.49 (0)	-18.39 (0)[a]	-18.39 (0)[a]	-3.35 (3)[b]	-3.35 (3)	-10.30 (3)[a]	-10.30 (3)[a]

Notes: The numbers in parenthesis are lag length. The tests employ a null hypothesis of a unit root. All series are log transformed. a and b denotes significance at 1% and 5% levels. Given the maximum number of lag are 16 for period January 1980 till December 2007. All test follow Akaike Info Criterion (AIC) to avoid white noise.

Table 2- Result for PP Test (Jan 1980 to Dec 2007)

	Real Exchange Rate, end of period (against US Dollar)				Real Exchange Rate, end of period (against Japanese Yen)			
	Level		First Difference		Level		First Difference	
	no trend	with trend	no trend	with trend	no trend	with trend	no trend	with trend
Indonesia	-2.01 (8)	-2.64 (9)	-17.32 (7)[a]	-17.33 (7)[a]	-1.90 (10)	-1.59 (10)	-18.27 (9)[a]	-18.36 (9)[a]
Philippines	-2.08 (5)	-1.68 (5)	-18.98 (4)[a]	-19.04 (4)[a]	-2.15 (4)	-1.61 (4)	-18.73 (3)[a]	-18.84 (2)[a]
Malaysia	-1.67 (7)	-2.17 (8)	-17.45 (7)[a]	-17.47 (7)[a]	-2.55 (9)	-3.24 (1)	-26.95 (13)[a]	-27.49 (14)[a]
Thailand	-1.84 (4)	-2.13 (5)	-15.92 (2)[a]	-16.00 (1)[a]	-1.95 (2)	-1.48 (3)	-18.78 (1)[a]	-18.88 (1)[a]
Singapore	-1.54 (7)	-1.41 (7)	-18.44 (9)[a]	-18.43 (9)[a]	-4.82 (10)[a]	-4.81 (10)[a]	-27.86 (3)[a]	-27.83 (3)[a]

Notes: The numbers in parenthesis are lag length. The tests employ a null hypothesis of a unit root. All series are log transformed. a and b denotes significance at 1% and 5% levels. All tests are conducted by following Newey West using Bartlett Kernel

Table 3- Panel unit root tests of real exchange rates

(US$ = base currency)

	common root	individual root	individual root
		Im, Pesaran and Shin	ADF - Fisher
Period	LLC t-stat	W-stat	Chi-square
1997-2007	-3.361***	-3.538***	37.916***
	(0.000)	*(0.000)*	*(0.000)*
1980-2007	1.674	0.839	4.226
	(-0.953)	*(-0.799)*	*(-0.937)*

Note: ***, **, * indicates significant at 1 %, 5% and 10% significance levels respectively. Exogenous variables: Individual effects, individual linear trends. Newey-West bandwidth selection using Bartlett kernel. Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality. () indicates p-value, respectively.

Table 4- Panel unit root tests of real exchange rates

(Japanese yen = base currency)

	common root	individual root	individual root
		Im, Pesaran and Shin	ADF - Fisher Chi-
Period	LLC t-stat	W-stat	square
1997-2007	-2.904***	-2.747***	26.137***
	(0.002)	*(0.003)*	*(0.004)*
1980-2007	2.500	0.609	7.509
	(0.994)	*(0.729)*	*(0.677)*

Notes: All notes remain the same as in Table 3.

It was observed that from the Figure 1 and Figure 4 (Appendix section), all of the currencies used in this study such as Rupiah, Pesos, Singapore dollars and Bath (except for Ringgit Malaysia) display a high degree of variability in ASEAN countries for post-crises era. One of the reasons Ringgit Malaysia shows low degree of volatility for post-1997 may due to the policy conducted by Malaysia monetary authorities whose pegged RM to US dollar especially during the period 1998:10 to 2005:7.

Table 5- Panel unit root tests for nominal exchange rate and relative prices methods

	US$ based		Japanese yen based	
	Nominal Exchange Rate	Relative Price	Nominal Exchange Rate	Relative Price
Methods	Statistic	Statistic	Statistic	Statistic
LLC t-stat	1.710	-0.924	1.589	0.218
	(0.956)	*(0.178)*	*(0.944)*	*(0.586)*
Breitung t-stat	1.852	-0.026	-0.923	1.065
	(0.968)	*(0.490)*	*(0.178)*	*(0.857)*
IPS W-stat	1.274	1.196	-0.212	2.281
	(0.899)	*(0.884)*	*(0.416)*	*(0.989)*
ADF-Fisher Chi-square	3.474	3.148	13.128	1.970
	(0.968)	*(0.978)*	*(0.217)*	*(0.997)*
Hadri Z-stat	5.409***	18.289***	9.946***	19.232***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*

Note: ***, **, * indicates significant at 1 %, 5% and 10% significance levels respectively. Exogenous variables: Individual effects, individual linear trends. Newey-West bandwidth selection using Bartlett kernel. Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality. () indicates p-value, respectively.

Table 6- Results of Panel Cointegration Test

	US based real exchange rates		Japanese based real exchange rates	
Statistics	Constant	Constant + Trend	Constant	Constant + Trend
	Alternative hypothesis: common AR coefs. (within-dimension)			
Panel v-statistics	2.831***	1.826*	2.248**	1.326
	(0.007)	*(0.075)*	*(0.032)*	*(0.166)*
Panel Rho-statistics	-1.347	-0.552	-5.309***	-8.763***
	(0.161)	*(0.343)*	*(0.000)*	*(0.000)*
Panel PP-statistics	-0.961	-0.142	-3.307***	-5.470***
	(0.252)	*(0.395)*	*(0.002)*	*(0.000)*
Panel ADF-statistics	4.047***	6.951***	-9.730***	-10.667***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*
	Alternative hypothesis: individual AR coefs. (between-dimension)			
Group Rho-statistics	0.376	1.179	-3.860***	-6.115***
	(0.372)	*(0.199)*	*(0.000)*	*(0.000)*
Group PP-statistics	0.280	1.428	-2.203**	-3.868***
	(0.384)	*(0.144)*	*(0.035)*	*(0.000)*
Group ADF-statistics	6.081***	8.802***	-5.681***	-4.756***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*

Note: (a) ***, **, * indicates significant at 1%, 5%, and 10% significant levels respectively. Trend assumption based on no deterministic trend and deterministic intercept and trend. Automatic lag selection based on AIC with 16 maximum lag. Newey-West bandwidth selection using Bartlett kernel. () indicates p-value, respectively.

Figure 1:

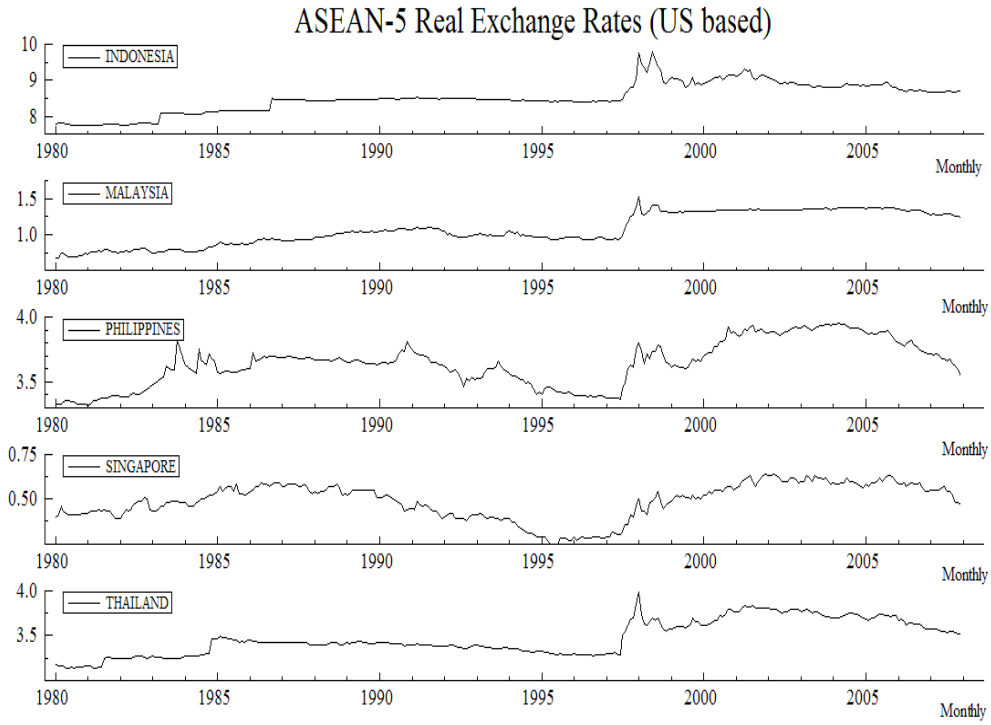

Figure 2:

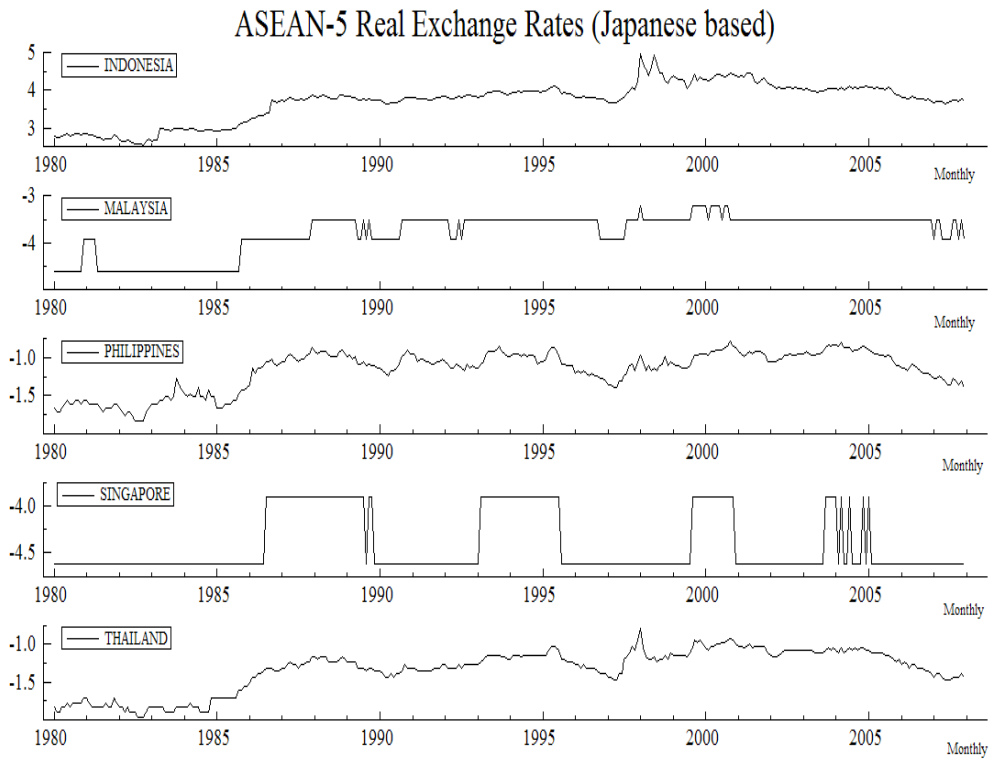

Figure 3:

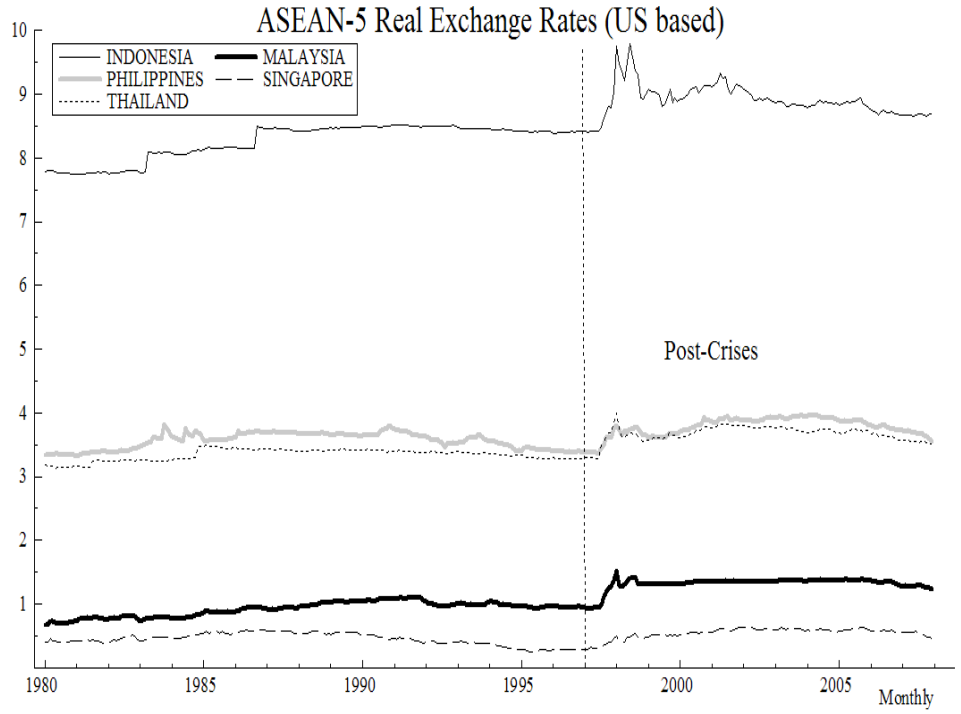

Figure 4: