Real Exchange Rate Behavior and Optimum Currency Area in East Asia: Evidence from Generalized Purchasing Power Parity

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Abstract

In the aftermath of the Asian financial crisis, the need for monetary and exchange rate co-operation among the Asian countries has increased considerably. In this context, we attempt to evaluate the potential of an optimum currency area (OCA) for a group of eight East Asian countries. For this purpose, this study tests Purchasing Power Parity (PPP) and Generalized PPP (GPPP) hypothesis, which provides stylized facts of real exchange rate. The results of our analysis suggest that weak form of PPP is a valid proposition in the East Asia in the post-Asian crisis period. Further, contrary to many previous studies, we also find some supportive evidence for GPPP which, in turn, provides support for a currency union in East Asia. The results further suggest that monetary integration in East Asia has increased in the Post-crisis period. However, the presence of asymmetries in the process through which countries adjust to shocks in the system indicates that still higher level of economic integration is required to strengthen the case of a currency union. More importantly, our overall results appear to be invariant to the choice of a base currency and therefore it provides support to the argument that both US dollar and Japanese Yen have potential to become a common currency in the East Asia region for the formation of a currency union.

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1. Introduction

The debate on economic prospect for enhanced exchange rate cooperation, economic convergence and the potential of an Optimum Currency Area (OCA) in East Asian region has intensified after the Asian financial crisis of 1997. It is true that the Asian financial crisis has increased the economic disparity in the region, but fortunately it has also regenerated a new wave of political and economic interest for a greater cooperation in managing exchange rate and monetary issues. In some sense, the crisis has exposed vulnerabilities of the exchange rate regime in the region and the difficulty of a small open economy in managing exchange rate unilaterally when the economy is experiencing massive in and out of foreign capital (Wilson and Choy, 2009). During the pre-crisis period East Asia was known to be a soft dollar zone under which currencies were loosely pegged to US dollar (Frankel, 1993; Frankel and Wei, 1994). It is argued that this *de facto* peg was one of the major causes of the financial crisis and consequently some important recent studies have emphasized the need for an alternative exchange rate arrangement to enhance exchange rate stability in East Asia. Some highly discussed alternative, for example, include the formation of a yen block in East Asia (Kwan, 1998), common basket peg (Williamson, 1999), restoration of dollar- based exchange rate regime with a well regulated banking system (McKinnon, 2000), basket peg to keep real effective exchange rate stable (Ogawa and Ito, 2002) and among these the formation of a common currency area got widespread attention (See Shirono, 2007 for a detailed discussion). With the implementation of ASEAN Free Trade Agreement (AFTA), ASEAN is rising rapidly as an important regional grouping. The degree of economic and financial integration among these countries has witnessed considerable improvement and

now the possibilities of greater monetary and exchange rate cooperation to form a currency union, which was very difficult to imagine till the recent past, seems to be a realistic event some time in future.

In the present study, we attempt to provide some further evidence on the feasibility of forming a currency union in East Asia.[1] Specifically, we have twin objectives in this paper. First, we attempt to test the mean reversion behavior of real exchange rates by testing the validity of Purchasing Power Parity (PPP) hypothesis for a group of eight East Asian countries. The concept of PPP has an important implication for East Asia, because it will help to figure out the best contender of a common currency in the region. Further, the degree of conformity to PPP can be considered as a helpful measure for evaluating the relation between the possible candidates of common currency and the potential members of OCA in East Asia (see Kim et. al., 2009). Our second aim in this paper is to test the empirical validity of Generalized PPP (GPPP) introduced by Enders and Hurn (1994). In doing so, we attempt to assess the potential of any favorable macroeconomic condition for an optimum currency area (OCA) among East Asian countries.[2] GPPP offers an effective way to examine the possibility of an OCA in the sense defined by Mundell (1961) that real output levels and probably expenditure pattern will share a common trend in an OCA. According to the GPPP theory, individually non-stationary bilateral real exchange rates may be cointegrated, if their long-run macroeconomic determinants or 'forcing variables' are highly associated. To test whether or not a system

[1] Unless otherwise stated, East Asia represents Indonesia, Malaysia, the Philippines, Singapore, Thailand Korea, India and Sri Lanka in this paper.

[2] In this study we include India as a potential member of OCA with other seven East Asian countries. Other countries are basically members of Association of Southeast Asian Nations (ASEAN). The members of ASEAN countries are also trying to expand the grouping with Japan, Korea and China (ASEAN+3) on the east and India on the west. In the recent past, trading relation of India with theses countries has witnessed substantial improvement and Indian policy makers have shown interest to become part of ASEAN. On this account we consider India as a potential member of OCA along with these countries in the region.

of countries form an OCA, the GPPP approach analyzes the behaviour of the real exchange rates of the economies with respect to a numeraire currency. The GPPP theory is based on the basic idea that real exchange rates of a group of countries may be individually non-stationary, but if the fundamental macroeconomic factors that drive exchange rate are sufficiently integrated across countries, a liner combination of these non-stationary real exchange rates will be stationary and they will share common trends in the long-run. Further, the theory of GPPP also suggests that if the economic integration among a group of countries is high, the bilateral real exchange rate of a country is influenced by the exchange rates and the fundamentals of other countries present in the group (see Sideris, 2009).

Generally any standard analysis of currency union starts with the theory of OCA. The OCA theory lists key conditions necessary for the formation of a successful currency union in a region. Many recent studies have employed the OCA criterion to evaluate the prospect of currency union in East Asia, but the overall results are rather mixed so far. For example, considering the OCA criterion Eichengreen and Bayoumi (1999) argue that East Asian countries are as likely candidates for a currency union as the countries of European Union. Whereas, Chow and Kim (2003) find that a common currency area may be a costly alternative and difficult to sustain in East Asia since these countries face asymmetric shocks. Similarly, Hoffmaister and Roldos (1997) also find that output fluctuations in East Asia are mainly driven by local supply shocks that make fixed exchange rate arrangement less attractive. In a slightly different study using a micro-founded gravity model Shirono (2007) show that the East Asian currency union will double bilateral trade in the region and if Japan is included in the union, the overall

welfare effects will increase substantially. Further, the study concludes that a regional currency arrangement in East Asia will increase the regional trade considerably and will result in economically significant welfare gains. Therefore, it is both interesting and relevant to take on further investigation to assess the potential of an OCA in the East Asia.

During the 1990s an increasing number of Asian countries have adopted market oriented economic policies. In a very short span of time their booming economies have emerged as high return investment destination for foreign investors. However, the massive in and out of foreign capital has led to excess volatility of the exchange rate imposing a serious challenge for macroeconomic stability of these countries. Consequently, the efficient management of capital account and exchange rate has become a crucial policy standpoint for central banks of these countries. Further, economic instability and big currency crisis like the one East Asian crisis (1997-1998) generally create an environment of risk and uncertainty for foreign investors. Investment decisions targeting longer horizons require long-term forecasting of currencies (Salehizadeh and Taylor, 1999). In this concern, the theory of Purchasing Power Parity (PPP) is frequently utilized to represent long-term equilibrium condition for exchange rate and to devise correct policy response to arrest the seasonal fluctuations in exchange rate.

Against this background, this study is set to examine the mean reversion behavior of real exchange rates in a case of the eight East Asian countries. This study contributes to the related literature in several ways. First, this study is mainly focused on emerging Asian countries and takes two different base countries, viz., US and Japan, to test the empirical validity of PPP and GPPP hypothesis. Inclusion of two different base countries allows us

to verify if the results are sensitive to the distance and choice of base currency. Further it will also help to figure out the possible contender of common currency for the proposed OCA among these countries. Second, we utilize both the traditional unit root tests and panel technique to test both strong and weak form of PPP. Finally, the GPPP hypothesis (Enders and Hurn, 1994) is tested for our sample group of countries to study the feasibility of an OCA in the region. Finally, it is well documented in the literature that a test of PPP is highly sensitive of sample size and from this viewpoint we utilize comparatively larger data set than previous studies.

Rest of the paper is organized as follows. Section II contains a brief description of the concept of PPP and GPP and subsequently discusses their empirical implications for OCA. Section III discusses the empirical methodologies and data related issues. Section IV presents empirical results and their implications and finally Section V provides summary and main conclusions.

2. PPP, GPPP and OCA: Theory and Model

2.1. Purchasing Power Parity

Purchasing Power Parity is a theory of exchange rate determination which asserts that the nominal exchange rate between two countries should be equal to the ratio of aggregate price levels between related countries. This version of PPP is known as the absolute version of Purchasing Power Parity (APPP). Symbolically:

$$S_t = \frac{P_t}{P_t^*} \tag{1}$$

where S_t the nominal exchange rate (expressed as domestic price of foreign currency), P_t and P_t^* are the domestic and foreign price levels respectively. Given the nature of the available data, it is quite difficult to measure the absolute PPP and hence we mainly focus on Relative PPP (RPPP). The concept of RPPP says that the percentage change in the exchange rate between two period, say for example t and $t+T$ is equal to the ratio of two related price indices (of domestic and foreign country).[3] The empirical validity of PPP is usually tested by examining the stationarity of real exchange rate through unit root test. The bilateral real exchange rate q_t is calculated as follows:

$$q_t = s_t + p_t^* - p_t \tag{2}$$

where p_t^* is the logarithm of the price index of the country chosen as base country. PPP hypothesis assumes that long run equilibrium exchange rate remains constant over time and any movement in price levels between countries is appropriately adjusted by an equal movement (appreciation or depreciation) in nominal exchange rate. Real exchange rate defined in the equation 2 can be explained as a measure of deviation from PPP (see Sarno and Taylor, 2002). Stationarity of real exchange rate is a very crucial condition for the validity of PPP which means that PPP hold in the long run and any percentage change in the price level between two countries would be adjusted by an equal appreciation or depreciation of the nominal exchange rate. If PPP holds continuously then real exchange rate will either be zero or a fixed constant. Whereas a non-stationary exchange rate suggests that shocks to real exchange rate are permanent in nature and as a consequence PPP does not hold. A Test of PPP by confirming the stationarity of real exchange rate strictly imposes the symmetry and proportionality conditions which are often not

[3] See Salehizadeh and Taylor (1999) for a detailed discussion.

supported by data in the real world. Pedroni (2004) argue that in the real world nominal exchange rate and prices may move together in the long run but movement may not be proportional and the cointegrating slope may differ from unity giving support to weak form of PPP. In the present study we use both stationarity and cointegration tests to test the validity of long-run PPP.

2.2 Generalized PPP and Optimum Currency Area

The concept of GPPP proposed by Enders and Hurn (1994) is essentially an alternative and effective way of evaluating exchange rate behavior across countries. It attempts to explain the long-run non-stationarity of real exchange rate as an outcome of the non-stationarity of the fundamental determinants (e.g. output and expenditure pattern) of real exchange rate. According to the GPPP theory, even though bilateral real exchange rates are generally non-stationary, they might be cointegrated in the long-run, if the forcing variables or long-run fundamental macroeconomic variables that determine real exchange rates, are highly associated. If this is true in a suitably defined currency area, then the real exchange rates in the area may share common stochastic trends and at least one linear combination of the various bilateral real exchange rates may exists that is stationary (see Enders and Hurn, 1994; Sarno, 1997; Choudhry, 2005). In this way it is possible to explain GPPP in terms of an OCA in the sense of Mundell (1961). According to the theory of OCA introduced by Mundell (1961) two regions constitute the domain of an optimum currency area if they experience the same types of real disturbances. In other words, theory of GPPP implies that, in an n country world, an m-country ($m \leq n$) currency area exists such that in the long-run an equilibrium relationship exists between $m-1$ bilateral exchange rates as expressed below:

$$q_{12t} = \alpha_0 + \alpha_{13} q_{13t} + \alpha_{14} q_{14t} + \alpha_{15} q_{15t} + \ldots\ldots\ldots + \alpha_{1m} q_{1mt} + e_t \quad \ldots\ldots\ldots(3)$$

where q_{1it} is the log of bilateral real exchange rates at period t between country 1 and country i and α_{1i} and e_t are the parameters of the cointegrating vectors and stationary stochastic disturbance term respectively. It is noteworthy that equation (3) reflects strict PPP relation if all the α_{1i} are equal to zero. And within an appropriately defined currency area there should be at least one linear combination of various non-stationary bilateral real exchange rates that is stationary. To test cointegration among real exchange rates we apply the test developed by Johansen (1988) and Johansen and Juselius (1990). Johansen cointegration technique uses likelihood procedure to determine the existence of cointegrating vectors in non-stationary time series. This procedure is said to provide comparatively more robust results especially when the number of variables involved is more than two (see Gonzalo, 1994).

3. Review of Related Literature

Regardless of copious research in this area, the validity of PPP as long-run equilibrium exchange rate relation still remains a subject of debate and controversy in the literature. However, now a wide international consensus has emerged that, though empirically not verified in short- run, PPP does hold in the long-run (Rogoff, 1996).[4] Similarly, empirical evidences on the possibility of currency union or OCA in the East Asian region and the

[4] Given the huge wealth of literature on PPP and keeping the space constraint in mind, we do not include a through review of literature on the PPP. However, for an excellent and comprehensive review of literature, Rogoff (1996); Taylor and Sarno (1998), Sarno and Taylor (2002) and Mohsen and Hegerty (2009) can be referred.

validity of GPPP are also mixed so far. Earlier studies by Frankel (1991, 1993) and Frankel and Wei (1994) show that a yen block does not exist in the East Asian region. They conclude that even though Asia has shown bias towards intra-regional trade, but the degree intra-regional bias has not increased in the recent past. Based on the European experience, Holloway (1990) identified some factors as necessary pre-conditions for the formation of monetary union. These factors include a common tariff wall and free mobility of labor, capital, goods and services within a common market. And while analyzing these factors the study reached to the same conclusion that the possibility of a yen block is an unrealistic economic reality at this stage. Further, a study by Park and Park (1990) also reached to the same conclusion and raised serious doubt over formation of a yen block between Japan and the East Asian countries. Chow and Kim (2003) find that a common currency area may be a costly alternative for East Asia since these countries face asymmetric shocks. Similarly, Hoffmaister and Roldos (1997) shown that output fluctuations in East Asia are mainly driven by local supply shocks that make fixed exchange rate arrangement less attractive.

However, some recent studies have consistently reported encouraging evidences giving support to the view that a common currency union is feasible in Asia. For example, Bayoumi and Eichengreen (1994) reached to the surprising conclusion that a subset of nine East Asian countries satisfied the necessary economic criteria for the formation of an OCA almost similar to Western Europe. In an another study, using principal component analysis Goto and Hamada (1994) show that major economic indicators such as interest rate, Consumer Price Index (CPI), money supply, real gross national product (GNP) and investment to GNP ratio are highly interrelated among Asian countries and hence East

Asia satisfies the minimum required criteria of an optimum currency area. While testing microeconomics foundations for various hypothesized Asian common currency areas, Swofford (2008) find favorable evidence for OCA in Asia.[5] Similarly, based on the results of GPPP Choudhry (2005) reached to the conclusion that evidences are supportive of an OCA only in the post-crisis period. In a slightly different study using a micro-founded gravity model Shirono (2007) show that an East Asian currency union will double bilateral trade in the region and if Japan is included in the union, the overall welfare effects will increase substantially. Further, the study concludes that a regional currency arrangement in East Asia will increase the regional trade considerably and will result in economically significant welfare gains.

Contrary to these findings some recent studies have raised serious concerns on the feasibility of OCA in the Asian region. For example, Bayoumi and Mauro (2001) show that ASEAN is comparatively less suitable for monetary integration than Europe, however, their analysis also show that the economic differences among ASEAN countries are not considerably large. Chow and Kim (2000) show that basically country specific shocks dominated the determination of output in East Asia and if the shocks facing countries are mostly country-specific rather than regional. Therefore, the case for the formation of OCA is actually seems to be rather weak. Similarly, Zhang et al., (2004) failed to find any valid support for an OCA for a subset of ten Asian countries. Wilson and Choy (2007) applied the concept of GPPP to assess the potential of an OCA for the members of the Association of Southeast Asian Nations (ASEAN5). The study failed to find any convincing evidence that ASEAN5 as a group forms a potential currency area

[5] It is noteworthy that Swofford (2008) include India as a potential member of OCA with other Asian countries.

either with USA or Japan. Further, Kim et al., (2009) using the concept of PPP reached to the conclusion that it seems unlikely that the currencies of eight Southeast Asia form a currency union. Soo and Choong (2009), while extending the debate a step further, find that most the East Asian countries were remained highly segmented during the pre-crisis period (before July 1997). However, over time, the degree of segmentation among these countries has reduced significantly. Their results also indicate that these economies have made swift progress towards higher levels of economic integration in response to the U.S. output growth. Further, the results from variance decomposition analysis show that influence of the Japanese economy on some of these countries have increased considerably which indicates that Japan is also making rapid progress towards East Asian economic integration, the but the progress seems to be little sluggish compared to U.S. Hence, it is very difficult to derive any clear conclusion from the previous studies and it is both interesting and relevant to explore the issue further that whether or not an OCA is feasible in East Asia.

4. Empirical Methodologies

4.1. Panel unit root tests and the stationarity of real exchange rate

It is well documented in the literature that the power of traditional unit root tests are sensitive to the span of data set used for testing long run PPP (see Shiller and Perron, 1985). An important feature of the Panel data approach is that it improves the power of unit root tests by increasing the number of observations. Along with the powerful panel

unit root tests we also apply traditional tests (ADF and PP) of unit root to confirm the stationarity of real exchange rates. [6]

IPS Unit Root Test

Im, Pesaran and Shin (1997) proposed a powerful unit root test for dynamic heterogeneous panels based on the mean-group approach. The IPS model for the testing PPP is given by:

$$\Delta q_{i,t} = \alpha_i + \rho_i q_{i,t-1} + \sum_{k=1}^{n} \phi_k \Delta q_{i,t-k} + \delta_i t + \theta_t + \varepsilon_{it} \qquad (5)$$

The null hypothesis of IPS test is $H_O : \rho_i = 0$ for all *i* against the alternative hypothesis of $H_1 : \rho < 0$ for some *i*. The IPS test statistics used for testing unit root in panels is defined as:

$$IPS(N,T) = \frac{\sqrt{N}\ (\bar{t} - 1/N \sum_{i=1}^{N} E[t_{iT} \mid \rho_i = 0])}{\sqrt{Var\ [\ t_{iT} | \rho_i = 0\ ]}} \qquad (6)$$

An important feature of IPS model is that it allows the speed of convergence towards long run equilibrium to vary across countries.

ADF – Fisher panel unit root test

Maddala and Wu (1999) proposed a panel unit root test based on the work of Fisher (1932). The test actually takes the significance levels of individual country test statistics obtained while estimating a unit root tests and combines it to a panel statistic for rejecting the null. The ADF-Fisher panel unit root test is non-parametric and has the following form:

[6] Traditional unit root tests, e.g. Augmented Dicky-Fuller (ADF) and Phillips-Perron (PP), have been widely used in testing long run PPP. Harris and Sollis (2006) provide detailed and rigorous discussion on traditional unit root tests.

$$p = -2\sum_{i=1}^{n} \log p_i \qquad (7)$$

Maddala and Wu (1999) found that this Fisher-type *p*-test is comparatively superior to the IPS test.

Hadri panel unit root test

The third test we apply is the one proposed by Hadri (2000). The other two panel unit roots tests are based on a null hypothesis that the individual series in the panel are jointly non-stationary, against alternative where some or all of these series are stationary. Hadri (2000) panel unit root recommends a test of the null that the time series for each i are stationary around a deterministic trend, against the alternative hypothesis of a unit root in the panel data. Hadri considers the following model:

$$q_t = r_{it} + \varepsilon_{it} \qquad (8)$$

Where $r_{it} = r_{i,t-1} + u_{it}$ is a random walk and u_{it} are iid $(0, \sigma_u^2)$. Under the null hypothesis of stationarity i.e. $(H_O : \sigma_u^t = 0)$, q_{it} is stationary around a deterministic component against the alternative of a unit root (Hadri, 2000).

4.2. PPP and panel cointegation tests

The panel unit root tests on the real exchange rate implicitly impose the restrictive conditions of symmetry and proportionality while testing PPP. And most of the studies based on these stationarity tests strongly reject the PPP hypothesis by reporting that real exchange rates are non-stationary. An important reason for this frequent rejection of PPP hypothesis in these studies is said to be the failure of strict symmetry and proportionality restrictions imposed on the real exchange rates (see Sarno and Taylor, 2002). The presence of transportation costs, barriers to trade, errors of measurement may distort the

strict proportional PPP relation and as a result cointegrating slope may differ from unity but still a weak form of PPP relation between nominal exchange rate relative prices may exist in the long. In the present study, we consider two different approaches proposed by Pedroni (1999, 2004) and Maddala and Wu (1999) for testing the cointegrating relationship between nominal exchange rate and relative prices. The panel cointegartion test developed by Pedroni (2004) gives much flexibility as it relaxes the restriction on the cointegrating vector imposed by strict PPP hypothesis. To accommodate the difference in the short run dynamics of the individual members of the panel, Pedroni's cointegaration test allow for heterogeneity in the intercept and slope of the cointegrating equation. The first part of Pedroni's panel cointegration test (2004) proposes four tests of cointegration based on pooling along the 'within dimension' of the panel. The second category suggest three tests based on pooling the 'between dimension'. All the seven test statistics are employed to test the null of no cointegration against the alternative hypothesis of cointegration. Further, we apply Johansen-type panel cointegration test developed by Maddala and Wu (1999) which uses Fisher's result to suggest an alternative approach for testing cointegration in panel data by combining test from individual cross sections to obtain a test statistics for the full panel.

5. Data and Empirical Results

5.1 Data

This study utilizes monthly data of nominal exchange rate (defined as market rate per US dollar) and price level, represented by consumer price index (CPI). All data are collected from the International Financial Statistics (IFS) database provided by the International Monetary Fund. The data spans from 1973:01 to 2007:12. We divide our sample in two

sub-periods: 1973:01-1997:05 and 1999:09-2008:12.[7] All series are seasonally unadjusted and expressed in logarithms before any econometric treatment. We consider US, and Japan as base countries to confirm if empirical results are sensitive to the choice of base country. The choice of base country is arbitrary except the one that both the countries have huge financial influence and trading relations with all the eight Asian countries included in the sample. The nominal exchange rate between Japanese yen and each of the Asian country is calculated using the cross-exchange rate rule. In the analysis, we cover eight Asian countries namely Indonesia, India, Korea, Malaysia, the Philippines, Singapore, Sri Lanka and Thailand. Nominal exchange rates of these countries are presented in Appendix 2.

5.2 Results of PPP

We begin our empirical analysis by examining the stationarity of real exchange rate constructed using two different numeraire or base currency namely US dollar and Japanese Yen. We conduct three panel unit root test, namely IPS, Fisher-ADF and Hadri, to test the stationarity of real exchange rate. The null of non-stationary real exchange rate is tested under IPS and Fisher-ADF panel unit root test whereas the null of stationary real exchange rate is tested by Hadri unit root test. Table 1 presents the results of unit root tests for the panel of eight Asian real exchange rates. A precise summary of results suggests that the real exchange rates are non- stationary in both of the sample periods considered**.** This implies that shocks to real exchange rates are permanent in nature and real exchange rate does not revert back to its mean or PPP defined equilibrium level after

[7] The period of the crisis (1997:06-1999:08) is not included in the analysis mainly to avoid the turbulent nature of the period and its biased impact on the overall results.

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any deviation. Therefore in this case the validity of PPP with strict symmetry and proportionality restrictions imposed on the real exchange rates is strongly rejected. Also, it is clearly evident that our results are not sensitive to the change in the base country since both US dollar and Japanese Yen based real exchange rates are found to be non-stationary. This is quite contrary to the results reported by Nusair (2004).

Table 1: Panel Unit Root tests of Real Exchange Rates

Panel A: Pre-crisis				
	US Dollar Based		**Japanese Yen Based**	
	C	C & T	C	C & T
IPS w-test	0.8431	0.89725	0.94784	0.33185
ADF- Fisher	8.95933	11.0395	8.53737	9.79991
Hadri-z test	32.1697*	20.5185*	32.2039*	11.8429*
Panel B: Post-crisis				
IPS w-test	0.81168	1.96733	-0.45744	-0.21908
ADF- Fisher	12.7054	12.3225	13.2787	18.3323
Hadri-z test	16.5106*	12.3618*	17.0136*	6.49323*

Notes: (i) * denotes significant at 5% significance level. (ii) C denotes with constant and C & T denotes with trend and constant (iii) Optimal lags for IPS and ADF- Fisher are determined based on AIC and for Hadri it is Newey-West bandwidth selection using Bartlett kernel. (iv) Probability values for IPS and Hadri unit root test is computed assuming asymptotic normality and for Fisher unit root test using an asymptotic chi-square distribution.

We next proceed to test the stationarity of real exchange rate for individual country to confirm if any country specific real exchange rate of the panel is stationary. Along with ADF unit root test we also conduct the Phillips-Perron test for confirming the stationarity of real exchange rates. We do this mainly because the Dickey-Fuller test requires that the error term should be both serially uncorrelated and homogeneous. Whereas the PP test is valid even if the errors are serially correlated and heterogeneous. Table 2 presents the results of traditional unit root tests (ADF and PP) conducted on real exchange rate of all the eight countries included in the panel. It is clear from the result that none of the individual real exchange rate is stationary in the pre-crisis sample period. However, we

do have some supportive evidence for PPP in the post-crisis period since US dollar based real exchange rate of Indonesia is found to be stationary at the conventional significance level. However, stationarity of US dollar based India's real exchange rate is not very clear as even though PP test indicates that the real exchange rate stationary at 5% significance level but the same is confirmed by ADF test only at 10% level. Further, Japanese Yen based the real exchange rate of Sri Lanka is confirmed to be stationary by both the unit root tests at 5% significance level. In short, our overall results suggest that most of the bilateral real exchange rates are non-stationary, with a few exceptions namely Indonesia and Sri Lanka in the post-crisis period, and therefore strict PPP does not hold.

Table 2: Results of Stationarity Tests of Individual Real Exchange Rates

	US Based		**Japan Based**	
Country	ADF	PP	ADF	PP
Panel A: Pre-crisis period 1973:01 - 1997:05				
Indonesia	0.3371	0.1894	-0.4989	-0.3150
India	-2.2072	-2.3897	-2.0324	-1.8177
Korea	-1.4899	-1.5605	-3.3309	-2.9855
Malaysia	-2.0699	-2.9097	-2.3443	-2.3872
Philippines	-2.4677	-2.4237	-2.2406	-2.5358
Singapore	-2.0020	-2.3539	-1.8719	-1.7418
Thailand	-2.4427	-2.7576	-2.6342	-2.6089
Sri Lanka	-1.0748	-1.9821	-1.2146	-2.1346
Panel B: Post-crisis period 1999:09- 2008:12				
Indonesia	-3.8156*	-3.9893*	-1.5171	-2.4935
India	-1.8391**	-2.0174*	-1.2159	-2.4205
Korea	-1.4503	-1.4741	-1.1407	0.1941
Malaysia	0.3253	-0.3606	-2.5948	-2.7506
Philippines	-0.7501	-0.8816	-2.4293	-1.8732
Singapore	-1.2006	-1.0610	-3.3407**	-3.3427**
Thailand	-1.5948	-1.6242	-1.8623	-2.3862
Sri Lanka	-1.8048	-2.1365	-3.5895*	-3.5231*

Notes: (i) * and ** denote rejection of the null hypothesis at 5% and 10% level respectively (ii) Optimal lags for ADF is determined based on AIC and for PP test it is Newey-West bandwidth selection using Bartlett kernel. (iv) Probability values for ADF and PP test is as per MacKinnon (1996) one-sided p-values.

We proceed further to examine the empirical validity of weak form of PPP by applying the panel cointegration tests suggested by Pedroni (1999, 2004) and Maddala and Wu (1999). An important prerequisite for conducting the cointegration test is that all the variables selected in the cointegration model must be integrated of the same order. As a starting point, we apply the IPS, ADF- Fisher and Hadri panel unit root test on the panel of nominal exchange rate and relative prices and the results show that both nominal exchange rate and relative prices are integrated of order one and therefore it is appropriate to conduct cointegration analysis involving these variables.[8] After confirming the order of integration, we begin the cointegration analysis by conducting Pedroni (1999, 2004) panel cointegration test to examine the presence of cointegrating relation between variables. The results of all seven panel test statistics are reported in Table 3. The result of Pedroni's panel cointegration clearly indicates that the null hypothesis of no cointegration is rejected in most of the cases at conventional level of significance for both US dollar and Japanese Yen based real exchange rates. In other words the results suggest that bilateral real exchange rates of East Asian countries do share a long-run equilibrium relationship. Therefore, the empirical validity of weak PPP is established for these countries.

Table 3. Results of Pedroni's Panel Cointegration Test

	USA Based		**Japan Based**	
Test	Pre-crisis	Post-crisis	Pre-crisis	Post-crisis
Within-dimension				
Panel v-Statistic	1.1740	1.3572	2.1790*	2.3828*
Panel ρ - statistic	-1.1585	-1.3973*	-0.1624	-0.2538
Panel PP-Statistic	-2.1340*	-1.5281	0.2612	0.5504
Panel ADF-Statistic	-1.9415*	-2.0341*	1.2498	1.9539*
Between-dimension				

[8] Keeping the space constraint in mind we have not reported the table of unit root test results for nominal exchange rate and prices but it is available upon request from the authors.

Group ρ-statistic	-1.222538	-0.0832	0.765473	0.765473
Group PP-statistic	-2.662801*	-0.4172	0.986051	0.986051
Group ADF-statistic	-2.268550*	-1.1801	2.100283*	2.100283*

Notes: (i) Asterisks * denote rejection of the null hypothesis at 5% significant level. (ii) The asymptotic distribution of all seven tests is distributed under the standard normal distribution and hence standard normal tables provide the critical values.

Having reported a strong evidence for the weak form of PPP by Pedroni's tests, in the second stage we proceed to apply combined Fisher-Johansen cointegration test to investigate the weak form of PPP for all the countries included in the panel. Table 4 reports the results of Fisher-Johansen cointegration test. The result of combined Fisher-Johansen cointegration test indicates towards the presence of one cointegrating vector. The null of no cointegation is rejected in favor of alternative hypothesis: at most one cointegrating vector. This is again a favourable evidence for the weak form of PPP as the presence of one cointegrating vector indicates that nominal exchange rate and prices do move together in the long-run and hence PPP in its weak form is a valid proposition.

Table 4: Results of Combined Johansen -Fisher Panel Cointegration Test

	Pre-crisis		Post-crisis	
Maximum rank	F- trace	F- Max-eigen	F- trace	F- Max-eigen
USA Based				
r = 0	231.3*	186.2*	75.46*	63.38*
r≤1	53.12	44.52	23.52	23.08
r≤2	22.43	22.43	16.06	16.06
Japan Based				
r = 0	336.1*	308.8*	77.41*	80.27*
r≤1	170.1	59.81	15.86	11.17
r≤2	11.61	11.61	14.42	14.42

Notes: (i) * indicates significant at 5% significance level (ii) Probabilities are computed using asymptotic Chi-square distribution. (iii) The optimal lag length selected by AIC (iv) F- trace is the Fisher Stat. from trace test and F- Max-eigen is Fisher Stat. from max-eigen test.

5.1 Results of GPPP and OCA

Now we advance our analysis further to test the potential of an OCA in the East Asian region by examining the empirical validity of GPPP. As a matter of fact for GPPP to hold, all the bilateral real exchange rates must be non-stationary individually and there should be at least one linear combination of all non-stationary real exchange rate which is *I*(0). As a prerequisite to cointegration analysis we first test the order on integration of all the eight real exchange rates. For this we carry out ADF and PP unit root tests and the results are reported in Table 5 which shows that all the real exchange rates are integrated of order one.

Table 5: Unit Root Results of Real Exchange Rates

US Dollar Based real exchange rates				
Countries	ADF (Level)	PP (Level)	ADF (1^{st} Diff)	PP (1^{st} Diff)
Indonesia	-2.793979	-2.730168	-9.307610*	-13.98435*
India	-2.610610	-2.366308	-8.207679*	-8.143852*
Korea	-1.450274	-1.474180	-4.194101*	-8.799987*
Sri Lanka	-1.804811	-2.136515	-9.426966*	-14.49336*
Malaysia	0.325310	-0.360682	-4.650030*	-7.439881*
Philippines	-0.750142	-0.881662	-10.01815*	-10.01150*
Singapore	-1.200614	-1.061091	-4.512639*	-10.85103*
Thailand	-1.594813	-1.624233	-7.333349*	-10.72266*
JPY Based real exchange rates				
Indonesia	-1.517116	-2.493567	-8.880638*	-10.89090*
India	-1.215965	-2.420548	-10.65729*	-10.64490*
Korea	-1.140769	0.194133	-10.38957*	-10.44572
Sri Lanka	-1.569949	-1.511577	-13.64523*	-13.67793*
Malaysia	-2.594841	-2.750618	-12.61039*	-12.61039*
Philippines	-2.429318	-1.873218	-5.955052*	-10.72209*
Singapore	-3.340725	-3.342700	-12.61231*	-12.44247*
Thailand	-1.862304	-2.386295	-5.235587*	-11.01633*

Notes: (i) * and ** denote rejection of the null hypothesis at 5% and 10% level respectively (ii) Optimal lags for ADF is determined based on AIC and for PP test it is Newey-West bandwidth selection using Bartlett kernel. (iv) Probability values for ADF and PP test is as per MacKinnon (1996) one-sided p-values.

Following this Johansen cointegration tests are conducted and the results are presented in Table 6. Although the model of Enders and Hurn (1994) provides some directions on the

explanation of the cointegration results, it is still quite difficult to establish a benchmark for interpreting the estimated coefficients.[9] More precisely, it is not clear a priori whether the sign of the estimated beta coefficients in the normalized vector should be positive or negative. Presence of cointegration is supportive of an OCA insofar as the fundamental macroeconomic factors which drive the real exchange rates of countries in the group are sufficiently integrated and hence they share a similar real disturbance. However, a negative sign is indicative of an asymmetry in the process through which countries adjust to shocks (see Wilson and Choy, 2007 for more discussion).

The results of pair-wise Johansen cointegartion trace test are presented in Table 6.[10] In the post crisis period there are 12 significant pairs from the bilateral trace tests conducted on the JPY based real exchange rate. Similarly, in the case of US based real exchange rates pair wise trace test confirms the presence of 14 significant pairs. It is clearly evident from the results that the integration of Sri Lankan and Indian with other East Asian countries in the system has increased considerably and hence these two countries may be considered as potential member of currency union.

Table 6. Post-crisis Pair wise Johansen trace test results

JPY based Real exchange rates							
	Malaysia	Sri Lanka	Philippines	Korea	Singapore	Thailand	India
Indonesia	12.0431	22.2135*	10.5467	21.0452*	11.8425	13.2041	14.0805
India	8.0193	36.7985*	20.6863	8.5921	11.4103	13.8076	
Thailand	14.6779	26.0378*	8.9055	32.6768*	9.9149		
Singapore	15.5025*	28.2387*	12.2825	22.4849*			
Korea	11.4139	20.8160*	31.1889*				
Philippines	9.1277	24.0330*					
Sri Lanka	33.1221*						
US dollar based Real exchange rates							

[9] In this concerned Ogawa and Kawasaki (2003) argued that it is not very difficult to find a significant cointegrating vector when testing GPPP, but it is indeed difficult to select meaningful cases on the basis of standard robustness tests.

[10] Juselius (2006) shown that the trace test is more robust than the maximum eigenvalue test and following the same we include the results of trace test.

Indonesia	13.5292	28.2691*	15.8104*	8.4187	18.3077	15.814*	21.8989
India	34.3375*	31.1858*	29.5238*	27.4622*	30.0203*	20.853	
Thailand	22.4699*	27.0363*	20.3176	16.5216	26.8888*		
Singapore	17.0978	25.7241*	28.0064*	18.5296			
Korea	18.5485	11.4594	16.2729				
Philippines	16.7421*	17.5659					
Sri Lanka	13.0112						

Notes: (i) λ_{trace} test is the trace test statistic for the number of cointegrating vectors under the null hypothesis that the number of cointegrating vectors is zero against the alternative that it is greater than zero. (ii) * indicates significance at the 5% probability level (iii) the optimal lag length selected by AIC.

In the study of GPPP, the presence or absence of significant cointegrating vector for a pair of countries in a system does not explain anything about the cointegrating relationships for the group of countries likely to form a currency union.[11] In this context, to assess whether the eight East Asian countries constitute an OCA using the concept of GPPP, we perform the Johansen multivariate cointegration test and results are reported in Table 7. At the group level, the results multivariate Johansen cointegration test confirms the presence of cointegrating relationship among the countries of East Asia.[12] GPPP theory postulates that although the bilateral real exchange rates are non-stationary individually but within the currency union there should be at least one linear combination of various real exchange rates included in the sample that is stationary. The results from Johansen cointegration show that the null hypothesis of no cointegation is strongly rejected in both cases and presence of significant cointegrating relationship is confirmed using both US dollar and Japanese Yen as base currency. This is a supportive evidence

[11] We basically focus on the feasibility of OCA in the post-crisis period and for the same reason we test the cointegration among real exchange rates in the Post-crisis period only.

[12] After the Asian crisis most of the Asian countries allowed their exchange rate to fluctuate more freely. But Malaysian Ringgit was pegged to US dollar and the same arrangement continued till July 2005. After that, however, Malaysia decided to enter into a little flexible arrangement. We run another cointegration test for GPPP without Malaysia to confirm the result that the presence of one cointegarting vector is not because of the presence of Malaysia in the US dollar based real exchange rates system. Even after excluding Malaysia from the system there is no change in the results and presence of one cointegrating vector is reconfirmed. The results are reported in the appendix.

for the validity of GPPP and OCA in the region. The presence of cointegration among real exchange rates of the East Asian countries implies that macroeconomic fundamentals that drive real exchange rates are sufficiently interrelated and hence bilateral real exchange rates of these countries share common stochastic trends in the long-run. Another important point is that results are seems to be invariant of the choice of base currency as existence of cointegration is confirmed using both US dollar and Japanese Yen as base currency.

Table 7. Post-crisis: Cointegration Test Results for Asian Real Exchange Rates

US dollar based real exchange rates						
Rank	Eigenvalue	Trace stat.	p-value	Eigenvalue	Max-Eigen	p-value
r = 0	0.394515	206.7994*	0.0035	0.394515	60.70879*	0.0189
r≤1	0.290763	146.0906	0.0868	0.290763	41.57144	0.3146
r≤2	0.243505	104.5191	0.2521	0.243505	33.76619	0.4405
r≤3	0.195594	70.75294	0.4778	0.195594	26.33585	0.5747
r≤4	0.116465	44.41709	0.6737	0.116465	14.98277	0.9486
r≤5	0.100968	29.43432	0.5359	0.100968	12.87877	0.8127
r≤6	0.082727	16.55555	0.4488	0.082727	10.44839	0.5710
r≤7	0.049220	6.107164	0.4468	0.049220	6.107164	0.4468
Japanese Yen based real exchange rates						
r = 0	0.358294	207.2339*	0.0033	0.358294	53.67864	0.0973
r≤1	0.274489	153.5553*	0.0335	0.274489	38.82643	0.4710
r≤2	0.246733	114.7288	0.0760	0.246733	34.28364	0.4080
r≤3	0.188354	80.44520	0.1722	0.188354	25.25160	0.6537
r≤4	0.161909	55.19360	0.2161	0.161909	21.37199	0.5427
r≤5	0.108941	33.82160	0.2967	0.108941	13.95673	0.7262
r≤6	0.080401	19.86488	0.2328	0.080401	10.14187	0.6037
r≤7	0.077212	9.723011	0.1403	0.077212	9.723011	0.1403

Notes: (i) λ_{trace} test is the trace test statistic for the number of cointegrating vectors under the null hypothesis that the number of cointegrating vectors is zero against the alternative that it is greater than zero. (ii) * indicates significance at the 5% probability level (iii) the optimal lag length selected by AIC.

Table 8 presents the results of normalized coefficients and speed of adjustment parameters. We use Indonesian Rupiah to obtain the normalized equations in the model,

however, there is no specific reason for the choice of Indonesian Rupiah to create the normalized equations of real exchange rates and any bilateral real exchange rate could have been applied for the purpose. In our case the normalized vectors provide information on the interrelation among real exchange rates included in the study. These normalized coefficients can be interpreted as long-run elasticities between the real exchange rates. There seems to be some asymmetries in exchange rate adjustment process in response to any disequilibrium in the system. While considering the US dollar based real exchange rates a 1% rise in the Indonesian Rupiah (real depreciation) induces a 6% depreciation of the real value of the Malaysian Ringgit and a 3% depreciation in the real value of Singapore Dollar, but a 7% appreciation in the real value of Thailand Bhat. Further, while considering JPY based real exchange rates the normalized coefficients show that a 1% rise in Indonesian Rupiah (real depreciation) induces 3% depreciation in the real value of Malaysian Ringgit and a 8% depreciation in the real value of Singapore Dollar, but a 6% appreciation in the real value of Thailand Bhat. Further some beta coefficients look rather large which indicates that aggregate demand patterns are dissimilar between a pair of countries (see Enders and Hurn, 1994 for further details). Further, the adjustment coefficients indicate the speed at which various real exchange rates in the system adjust towards their long-run equilibrium in response to any shock or deviation from GPPP.

Now we shift our attention on the results of speed of adjustment. We utilize this result to explain how quickly a change in the real exchange rate in the system is inclined to correct itself in VAR framework. For the JPY based real exchange rate system, the largest coefficients are found in the case of India, Sri Lanka and Malaysia. The coefficient 0.197

for the Indian Rupees implies that JPY based Indian real exchange rate adjusts at the rate of 19.7% per month towards the long-run equilibrium. The adjustment coefficients of Indonesia-Sri Lanka-the Philippines in the US dollar based system and Indonesia-Korea-the Philippines in the JPY based system not significant which indicates towards the possibility that these exchange rates are weakly exogenous. To some extent our results are in agreements with the results reported by Choudhry (2005) and Wilson and Choy (2007).

Table 8. Normalized Equations and Speed of Adjustment Parameters

	IDR	INR	KRW	LKR	MYR	PHP	SGUS	THB
Normalized coefficients								
USD Based	1.000	1.738*	1.171*	1.676*	6.026*	-0.144	2.997*	-6.475*
JPY Based	1.000	0.642	2.194*	1.841*	3.787*	-1.895*	8.361*	-5.726*
Speed of Adjustment Parameters								
USD Based	-0.021	-0.028*	-0.091*	-0.003	-0.019*	-0.015	-0.025*	0.029*
JPY Based	-0.063	-0.197*	-0.084	-0.141*	-0.124*	-0.076	0.091*	-0.093*

Notes: *indicates significance at the 5% probability level.

6. Summary and Conclusion

Interest in monetary and exchange rate cooperation has revived in the post-crisis period in East Asia (Indonesia, Malaysia, the Philippines, Singapore, Thailand, Korea, India and Sri Lanka) and the integration of these countries in terms of trading relations has witnessed considerable improvement. The main objective of this article has been to examine the stochastic nature and co-movements of East Asian real exchange rate to provide further evidence on whether or not a subset of East Asian countries forms an OCA in the region. In the first stage, we examine the mean reversion property of US dollar and JPY based real exchange rates of eight East Asian countries by testing PPP.

To examine the effect of change in base country, we have considered USA, and Japan as base countries since US dollar and Japanese Yen are main contender of common currency in the region. The results of panel unit root tests conducted on the panel of two real exchange rate systems (US dollar and Japanese Yen based) for two sub sample periods i.e. pre and post-crisis, suggests that all the real exchange rates are non-stationary. Therefore, PPP in its strict form does not hold in both of the sample periods. However, the results of panel cointegration tests suggest that nominal exchange rate and relative prices do move together in the long-run and hence the empirical validity of the weak form of PPP is established. Further, the inclusion of different base countries also does not have any major impact on the results.

In the second stage, we apply GPPP hypothesis to evaluate the potential of an OCA for a subset of East Asian countries in terms of a yen block or dollar block. GPPP theory postulates that although the bilateral real exchange rates are non-stationary individually but within the currency union there should be at least one linear combination of various real exchange rates included in the sample that is stationary. The results from Johansen cointegration show that the null hypothesis of no cointegation is strongly rejected in both cases and presence of significant cointegrating relationship is confirmed using both US dollar and Japanese Yen as base currency. In other words, the results suggest that bilateral real exchange rates of these Asian countries do share a common stochastic trend and hence they satisfy the minimum standard criteria to form a currency union as required by the theory of OCA introduced by Mundell (1961). The presence of cointegration is confirmed in the post-crisis period which is a supportive evidence for GPPP in East Asia region.

The results of this study have several important policy implications. Although there are many other criteria for successful formation of OCA, but the results of this study do provides some support to the argument that economic convergence and financial integration in East Asia is increasing at a faster rate in the post-crisis period. The presence of asymmetries in the adjustment process and some insignificant adjustment coefficients suggest that still a higher degree of economic integration and monetary cooperation is required to satisfy the highly demanding conditions of OCA. And hence these countries should move further with new initiative in the areas of political and economic cooperation, like further progress in Chiang Mai Initiative (CMI), inclusion of India and Sri Lanka in the extended ASEAN+3 (ASEAN+3 includes Japan, China and Korea) group. The results of pair wise cointegration indicate real exchange rate of Indian Rupees and Sri Lankan Rupees are highly integrated with other currencies of East Asian countries and therefore these two countries seems to have the potential to become the member of this group. Finally, our results also indicate that both US dollar and Japanese Yen is important in the region and therefore as argued by Choudhry (2005), a common currency basket consisting of both dollar and yen should be considered as an optimum currency than just the US dollar or yen. Validity of GPPP is one of the minimum standard conditions which must be satisfied to form an OCA. However, there are some other macro and microeconomic conditions for successful formation of a currency union. Therefore, further study is needed to re-assess the potential of an OCA for the East Asian countries using the sigma-convergence criteria and microeconomic foundations and of an optimum currency area.

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Appendix-1

A1. Post-crisis: cointegration test results for Asian real exchange rates (without Malaysia)

Rank	Eigenvalue	Trace stat.	Eigenvalue	Max-Eigen Stat.
$r = 0$	0.382592	169.9880*	0.382592	57.38488*
$r \leq 1$	0.258925	112.6031	0.258925	35.65868
$r \leq 2$	0.213567	76.94440	0.213567	28.58952
$r \leq 3$	0.197876	48.35488	0.197876	26.23850
$r \leq 4$	0.077704	22.11638	0.077704	9.625821
$r \leq 5$	0.057869	12.49056	0.057869	7.093716
$r \leq 6$	0.044339	5.396846	0.044339	5.396846

Notes: (i) Trace stat. is the trace test statistic for the number of cointegrating vectors under the null hypothesis that the number of cointegrating vectors is zero against the alternative that it is greater than zero. (ii) * indicates significance at the 5% probability level (iii) the optimal lag length selected by AIC

Appendix-2

Nominal Exchange rates of East Asian Countries (US dollar and JPY Based), 1973-2008

Figure 1
India

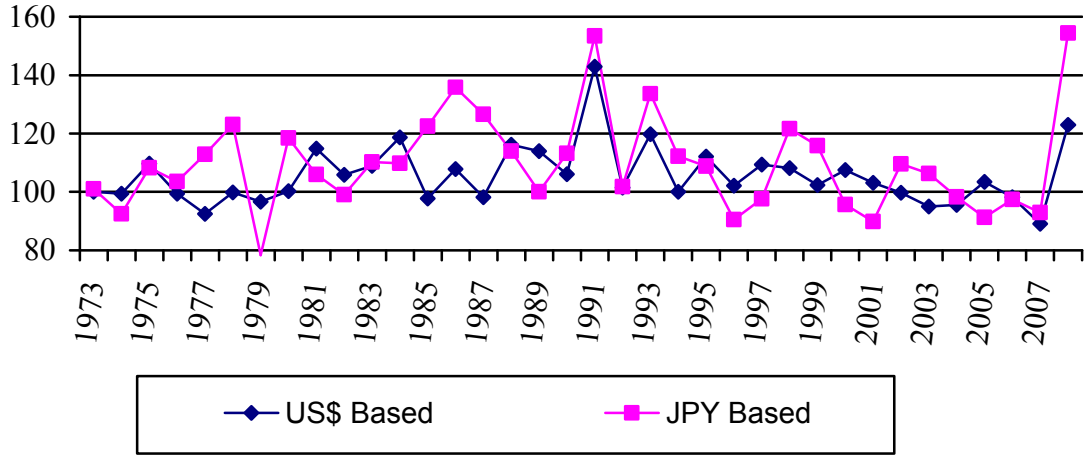


Figure 2
Indonesia

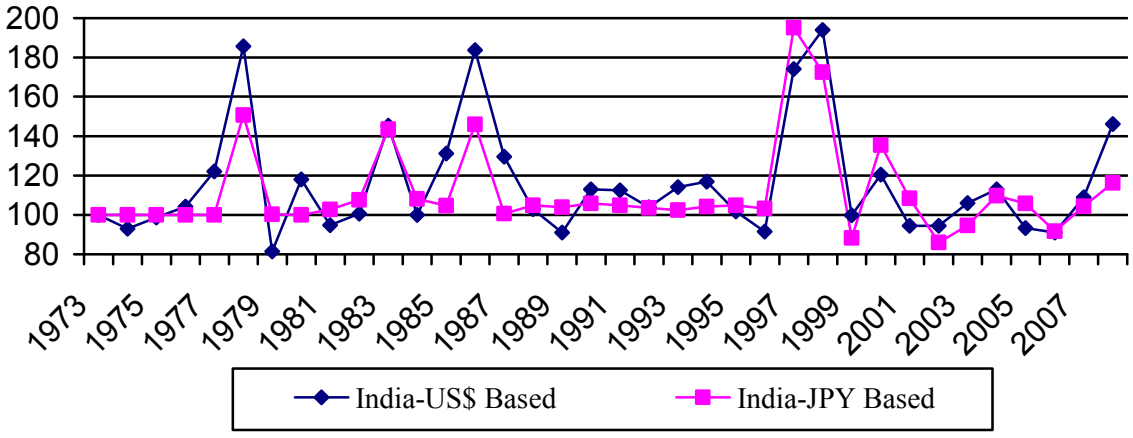


Figure 3
Korea

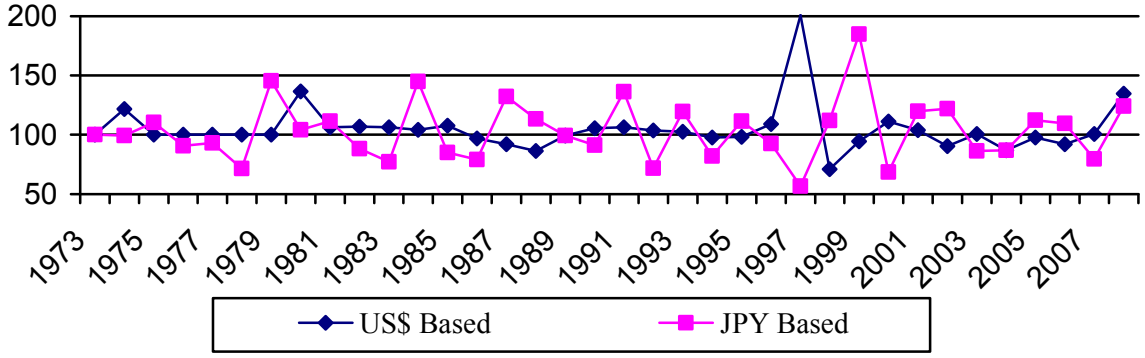


Figure 4
Sri Lanka

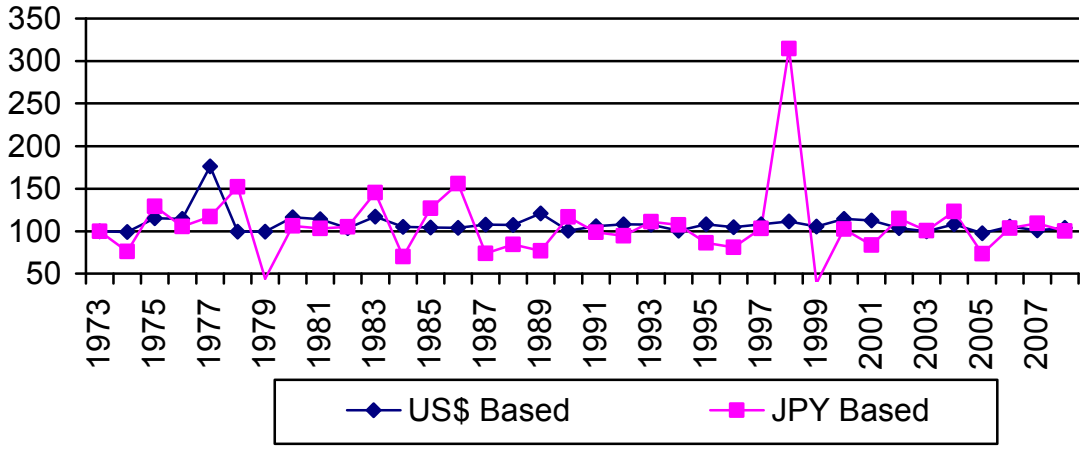


Figure 5
Malaysia

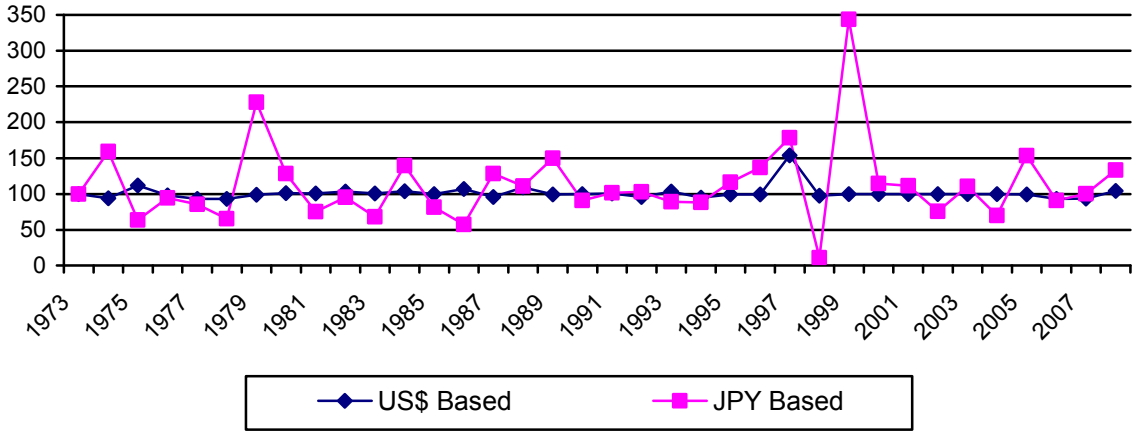


Figure 6
Philippines

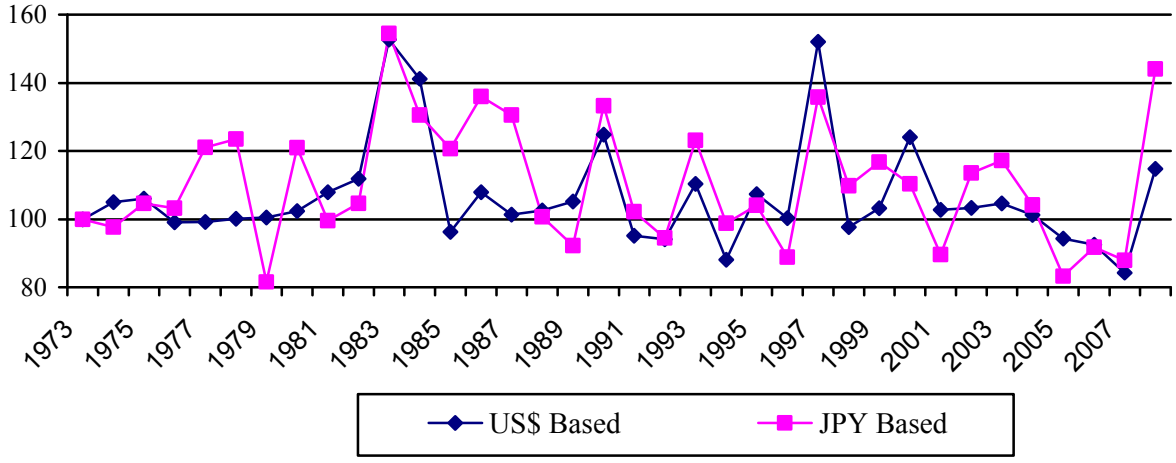


Figure 7
Singapore

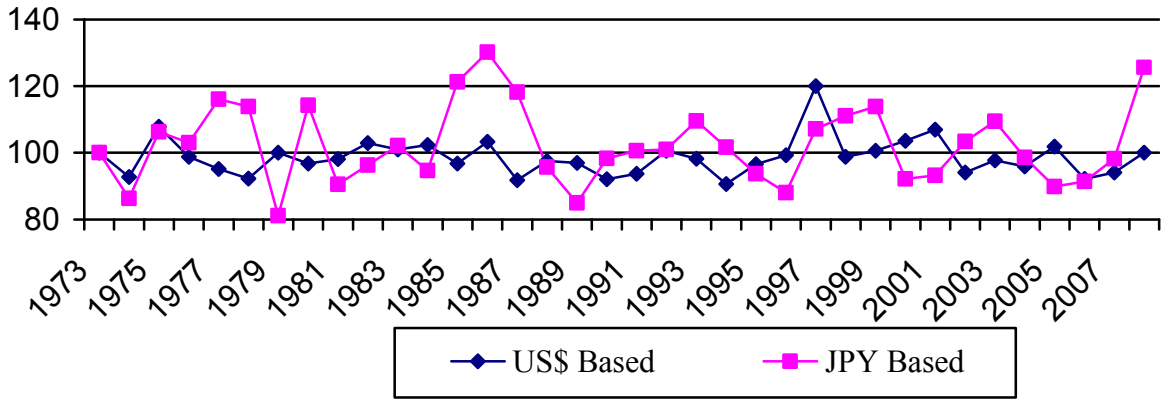
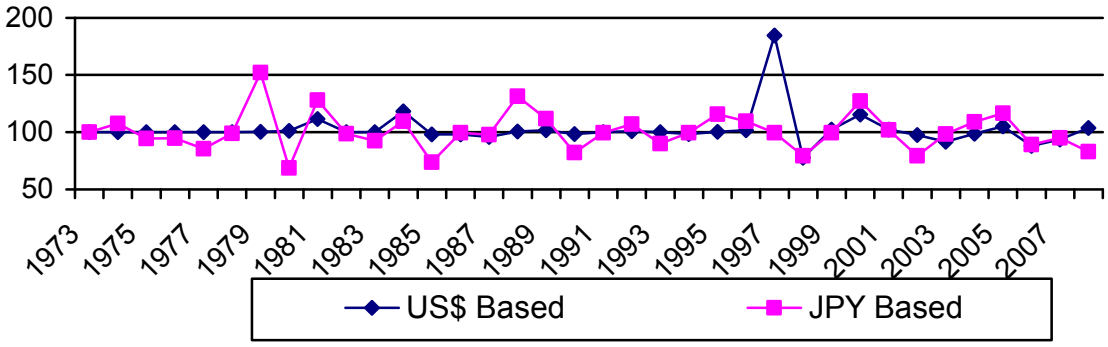


Figure 8
Thailand



Note: Annual Nominal Exchange rates against the US Dollar and Japanese Yen (1973 = 100)