1-1-2011

Common Currency in East Asia: An Analysis of Currency Convergence

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COMMON CURRENCY IN EAST ASIA: AN ANALYSIS OF CURRENCY CONVERGENCE

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The recent global financial crisis of 2007-2009 and fears of a sovereign debt crisis in some European countries have fuelled the debates among economic analysts and policy makers on the future directions of monetary and exchange rate arrangements in the East Asian region. This paper applies both the cluster analysis and time series tests to determine whether increased trade and financial integration has led to currency convergence in the region over the period January 1990 to June 2010. The countries included in this study are the high-performing East Asian economies, namely China, Hong Kong, Japan, South Korea, Taiwan and the five founding ASEAN member countries. The Chinese yuan is found to be more suited than the Japanese yen as the anchor currency in East Asia.

***Keywords**: convergence, common currency, cluster analysis, exchange rates*

I. INTRODUCTION

With a population of 590.6 million people and a combined gross domestic product of US$1,499.4 billion, the Association of South-East Asian Nations (ASEAN) is the fourth largest trading region in the world.[1] Over the last four decades, the rapid growth in East Asia has brought increased integration to economies in the South-East Asian region, and strengthened its position in the world economy. Despite the 1997 Asian financial crisis, the Asian economies are gaining importance in term of their contribution to global growth. Most notably, the rapid growth of the People's Republic of China economy in recent times and its signing of the Free Trade Agreement with ASEAN in building a single market and production base has attracted international attention. The success of China has shifted the economic power toward East Asia which fosters a deeper level of interaction between ASEAN and the region.

Debates on the importance of openness to international trade on regional monetary and financial cooperation in East Asia have been keenly discussed among economic analysts and policy makers followed the global financial crisis (GFC) of 2007-2009. The global crisis has affected both the developed and emerging-market economies in East Asia where major stock markets plunged along with the United States (US) market and many currencies also fell against the US dollar (see Cline, 2010). Many currencies of East Asian economies have yet to recover fully from the aftermath of the 1997 Asian financial crisis, though the impact of the US-led GFC was less severe. In the last decade, a large empirical literature has emerged examining the future

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[1] These figures are extracted from selected basic ASEAN indicators for 10 ASEAN countries in 2009 provided by the ASEAN Secretariat Homepage at website http://www.aseansec.org/.

directions of monetary and exchange rate arrangements for many of the countries in the region (see Angresano, 2004; Grauwe, 2007; Lim, 2005; Ruland, 2000; Shirono, 2009; Wyplosz, 2001). The popular question asked in the literature: Is East Asia the next optimum currency area after the European Monetary Union (EMU)? However, there have been heightened fears of a sovereign debt crisis in some European countries from 2010 which would raise doubt on the viability of a monetary union.

The literature on optimum currency area started in the early 1960s with the seminal contributions by Mundell (1962) and McKinnon (1963). There are costs and benefits for different countries to join a monetary union and adopt a single currency of its member countries. The benefits (in terms of reduction in transaction costs, increased price stability and positive external effects) and costs (in terms of the loss of control of monetary policies and macroeconomic management of the economy) to the union members largely depend on the existence of similarities in their economic structures. The economic theory of convergence implies that relatively similar economies would make better candidates for monetary integration. If economies diverge in their development levels and macroeconomic conditions, the costs of monetary integration and sustaining integration would be high.

The Asian financial crisis of the late 1990s has raised doubt on the suitability of floating exchange rates for these countries in a financially integrated world, where funds can be moved instantly between national financial markets. To manage regional short-term liquidity problems, the Chiang Mai Initiative announced in May 2000 is to provide a network of bilateral currency swap arrangements among ASEAN+3 countries, namely the members of ASEAN, China, Japan, and South Korea (see Grauwe, 2007). An interesting proposition is whether these economies can be integrated to form a monetary union or to adopt a common currency. A regional currency agreement would provide stable intra-regional exchange rates and maintain flexibility of the exchange rates against that of non-members. Experience in the EMU also supports that a currency union generates fewer costs and delivers greater benefits to its members. Empirical studies (see Grauwe, 2007) found the degree of trade integration[2] and asymmetry in the demand and supply shocks in East Asian countries were very much like the European Union member countries. In Alesina and Barro's (2002) study, countries that trade more with each other are found to benefit more from adopting the same currency under reasonable assumptions about elasticities of substitution between goods. This suggests that East Asia is close to forming an optimum currency area. However, the political obstacles and cultural differences are cited as major obstacles for a successful integration to forming a monetary union.

Some East Asian currencies continue to peg to the US dollar after the 1997currency crisis. Study by Alesina *et al.* (2002) evaluates whether natural currency areas have emerged across the world. Based on historical pattern of international trade and of co-movements of prices and outputs (from 1960 to 1997), they find a well-defined dollar and euro areas but no clear yen area. On the other hand, Shirono (2009) finds that a single currency in East Asia will substantially stimulate the regional trade and generate significant welfare gains for the region. The analysis shows that forming a currency union in East Asia with China will tend to generate larger welfare gains than a currency union with Japan or the US. To maintain stable exchange rates and intra-

[2] It is measured using the exports of East Asian countries to the rest of East Asia as a percentage of their gross domestic products.

regional capital flows, other studies (see Girardin, 2011) favour the pegging of East Asian currencies to a basket where regional currencies are included. Ogawa and Shimizu (2011) also propose the creation of both an Asian Monetary Unit (AMU) which is computed as a weighted average of the ASEAN+3 currencies and the AMU deviation indicators which are used to detect exchange rate misalignment among Asian currencies.

One of the important requirements for monetary integration is convergence in real exchange rates among its member countries. Currency convergence is the tendency of differences in real exchange rate between countries to disappear over time. There is no single precise definition of convergence in the literature and different statistical methods can be used to test whether convergence is present (Durlauf and Johnson, 2010). Cluster analysis is viewed as an exploratory data-analysis technique which attempts to determine the natural groupings of observations (Stata, 2009). Hierarchical clustering that creates related sets of clusters would be useful to detect similarity or dissimilarity in exchange rates between the East Asian countries and to determine whether the clusters have changed over the years.

There has been a large literature on testing the income convergence hypothesis, arising from the diversity in average growth rates and income levels across countries, and found several convergence clubs, in which real per capita incomes have converged for selected groupings of countries and regions. Empirically, similar time series tests of convergence can be applied to evaluate currency convergence in East Asia. In this paper, tests for converging trends and co-movements of real exchange rates are conducted to determine the suitability of a monetary integration in East Asia. The countries included in the study are China, Hong Kong, Japan, South Korea, Taiwan and the five founding members of ASEAN, namely Indonesia, Malaysia, the Philippines, Singapore and Thailand (hereafter referred to as ASEAN-5). In the past, attention has been focused on the Japanese yen as an alternative anchor to the US dollar given Japan's close economic ties with East Asia through trade, foreign direct investment and official development assistance. In view of the growing role of China as a hub of regional trade, this paper also examines the role of Chinese yuan against that of Japanese yen as the anchor currency in East Asia.

The plan of the paper is as follows. Section II outlines both the hierarchical clustering and time series methods used to determine the convergence of currency in the East Asian region. Section III examines the exchange rate data for the 10 countries. Section IV presents the test results and some concluding remarks are given in Section V.

II. METHODOLOGY

In this paper, a hierarchical clustering and two different time series methods are used to test the convergence of currencies within the East Asian region. The first method determines the similarity and dissimilarity between the currencies and formed that into differ groups, the second method examines the co-movement of currencies, and the third method applies a simple statistical test for converging trends in the real exchange rate series.

Cluster Analysis

Cluster analysis is a useful data analysis tool that groups objects into clusters based on the characteristics that they possess. The objects in the same cluster should be more similar to one another than they are to objects in another cluster. This technique is used to group the exchange rate series of East Asian countries that exhibit high similarity in the same cluster. There are two types of hierarchical clustering methods: (i) agglomerative and (ii) divisive. The agglomerative clustering method begins with each observation is being considered a separate cluster, and two most similar observations are fused to form a new aggregate cluster. This process is applied repeatedly until all exchange rate series are combined into a single cluster. On the other hand, the divisive hierarchical clustering begins with all observations belonging to one group, and this group is then split to create separate groups.

This paper applies the hierarchical agglomerative clustering method and the Euclidean distance between each pair of exchange rate series is used as a measure of similarity. A number of Euclidean metrics can be used in clustering techniques. Some of the best-known methods are the average and Ward's. According to Stata (2009, p.88), the average-linkage clustering uses the average difference of observations between the variables as the measure between two groups, while Ward's (1963) method joins the two groups that result in the minimum increase in the error sum of squares. Mojena (1977) found Ward's method gave a superior performance across all data set. Hence, this study uses Ward's method of clustering where groups are joined to minimise an error-sum-of-squares objective function. The squared Euclidean distance between two countries for T period is calculated as:

$$D_{ij}^2 = \sum_{t=1}^{T} (x_{it} - x_{jt})^2 \quad (1)$$

where x_{it} is the real exchange rate value for country i at time t. Larger values of D indicate less similarity between the two currencies. The Euclidean distances are calculated for all possible pairs of n currencies. It is important to note that the Euclidean distance used on raw data is not invariant to linear or other transformations that distort the distance relationships (see Everitt, 1986). One way to achieve invariance or to prevent certain features, such as changes in the scale of the variables or large numerical values, to dominate distance calculations is to normalise the data to have zero mean and unit variance prior to clustering.

After the hierarchical cluster analysis, the grouping currencies are presented in a dendrogram or cluster tree which presents the simplest way of selecting the optimal number of clusters. There are many cluster stopping rules and two of the best rules identified by Milligan and Cooper (1985) after evaluating 30 stopping rules were the Duda-Hart index and the Calinski and Harabasz pseudo-F index. This paper uses the simple step-size stopping rule of the Huda-Hart index to determine the number of clusters since the Calinski and Harabasz index is not defined for the degenerate one-group cluster solution. The Duda-Hart (DH) stopping rule index value is given by:

$$DH = \frac{Je(2)}{Je(1)} \quad (2)$$

where $Je(1)$ is the sum of squared errors within the group that is to be divided, and $Je(2)$ is the sum of squared errors in the two resulting subgroups (see Stata, p.165).

The *DH* index requires hierarchical information from the group that is being split and large values of *DH* stopping-rule index indicate distinct cluster structure. The *DH* index has an associated pseudo *T*-squared value and the relationship is given by (see Stata, p.166):

$$\frac{1}{DH} = 1 + \frac{T^2}{N_1 + N_2 - 2} \tag{3}$$

where N_1 and N_2 are the numbers of observations in the two subgroups. In this case, a small pseudo *T*-squared indicates distinct clustering.

Co-movements of Currencies

Aesina *et al.* (2002) proposed a measure of co-movement of prices between countries *i* and *j* using the second-order autoregression. Below is the same method used to measure co-movements of currencies between two countries:

$$\ln \frac{P_{i,t}}{P_{j,t}} = a_0 + a_1 \ln \frac{P_{i,t-1}}{P_{j,t-1}} + a_2 \ln \frac{P_{i,t-2}}{P_{j,t-2}} + \varepsilon_{ij,t} \tag{4}$$

where $P_{i,t}$ measures how many units of US dollar can be exchanged with one unit of country *i*'s currency at time *t*. By definition, this exchange rate is always one when country *i* is the United States.

The estimated residual from equation (4) is used to compute the following root mean square error:

$$VP_{ij} = \sqrt{\frac{1}{T-3} \sum_{t=1}^{T} \hat{\varepsilon}_{ij,t}^2} \tag{5}$$

A higher value of VP_{ij} means less co-movement of currencies between countries *i* and *j*. Alesina *et al.* (2002) suggest that the costs of adopting another country's currency as an anchor will be lower if the countries have high co-movements of outputs and prices with potential anchors.

Test for Converging Trend

In a time series framework, a simple statistical test for converging or diverging trends of an exchange rate series, as proposed by Verspagen (1994), can be written as follows:

$$W_{i,t} = \ln P_{i,t} - \ln P_t^* \tag{6}$$

where $P_{i,t}$ is the real exchange rate for country *i* at time *t* and P_t^* is the average real exchange rate for *n* countries in the sample ($P_t^* = \left(\sum_{i=1}^{n} P_{i,t}\right) \Big/ n$). It is assumed that, for each time period, W_i changes according to the following process:

$$W_{i,t+1} = \Psi W_{i,t} + \eta_{i,t} \tag{7}$$

If $\Psi > 1$, the currency in country *i* diverges from the sample group; if $\Psi < 1$, convergence of the currency occurs. This paper also examines if the currency of individual country in the sample diverges from the Japanese yen and the Chinese yuan.

III. DATA

Testing for exchange rate convergence among the 10 East Asian countries in a time series framework requires comparative data for these countries over an extended period. As most countries traditionally pegged their currencies against the US dollar (USD), each country's currency is expressed in USD. Monthly nominal exchange rates of USD per national currency for each East Asian country are extracted from the Datastream (and the source is from the International Financial Statistics) over the period January 1990 to June 2010. To examine the effect of the 1997 Asian financial crisis and the GFC of 2007-2009, the whole sampling period is divided into two sub-periods from January 1990 to December 1999 (120 observations) and from January 2000 to June 2010 (126 observations).

Real exchange rates of USD per national currency are derived by multiplying the nominal exchange rates with the relative consumer price index[3] of the US economy to the national economy. Due to vast differences in the values of each East Asian currency, they are redenominated to one USD at the beginning of the sample period (i.e. January 1990 for the whole sample period and January 2000 for the sub-period 2000m1–2010m6) to keep the exchange rate disparity from dominating the analysis.

TABLE 1: SUMMARY STATISTICS (LOG OF REAL EXCHANGE RATE), 1990M1-2010M6

Currency[a]	1990m1-2010m6		1990m1-1999m12[b]		2000m1-2010m6[b]	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
CNY	-0.741	0.300	-0.523	0.300	-0.062	0.038
HKD	0.193	0.124	0.264	0.128	-0.178	0.072
JPY	0.026	0.146	0.125	0.130	-0.185	0.086
KRW	-0.149	0.156	-0.080	0.161	0.027	0.120
TWD	-0.192	0.164	-0.044	0.096	-0.163	0.055
IDR	-0.240	0.277	-0.126	0.317	0.088	0.175
MYR	-0.149	0.163	-0.025	0.146	-0.002	0.052
PHP	-0.073	0.173	0.045	0.119	-0.078	0.138
SGD	0.029	0.111	0.111	0.085	-0.032	0.069
THB	-0.125	0.175	-0.008	0.141	-0.037	0.126

Source: Datastream

Notes: [a] Chinese yuan (CNY), Hong Kong dollar (HKD), Japanese yen (JPY), Korean won (KRW), Taiwan dollar (TWD), Indonesian rupiah (IDR), Malaysian ringgit (MYR), Philippine peso (PHP), Singapore dollar (SGD) and Thai baht (THB).

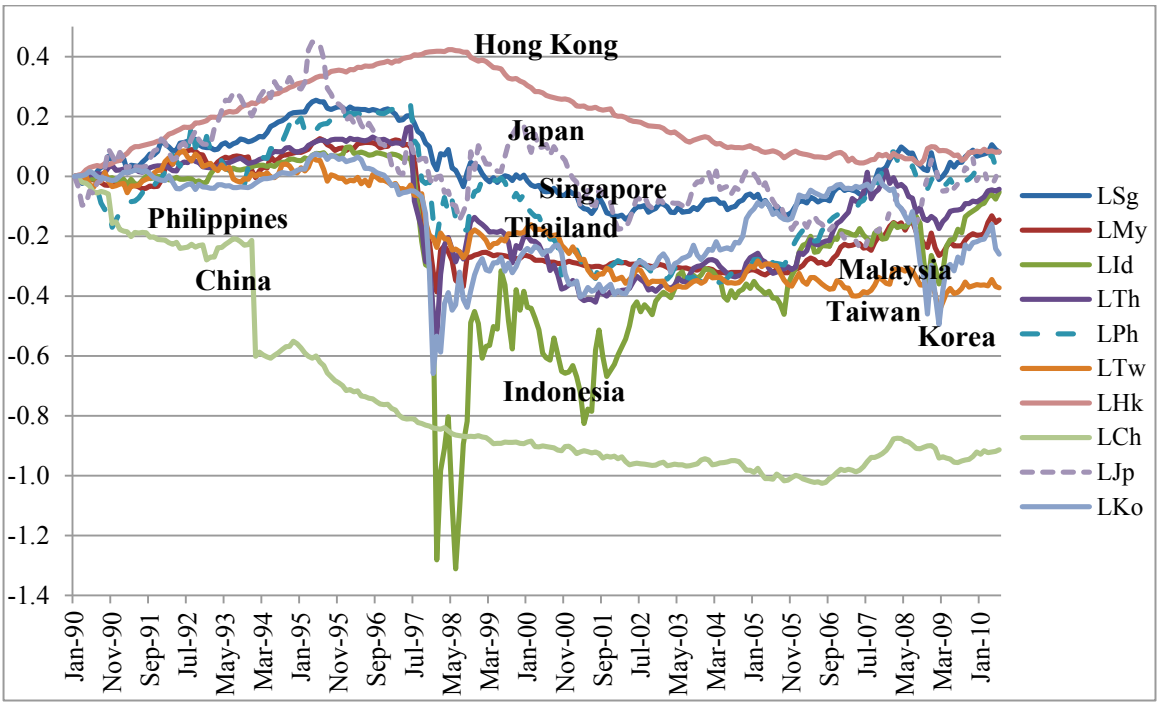
[b] The real exchange rates for all countries were re-scaled to the value of one USD at the beginning of both sub-periods.

[3] The consumer price indices for all East Asian countries and the United States have been converted to a common base year in January 1990 for the whole sample period and January 2000 for the sub-period 2000m1-2010m6.

Summary statistics of the 10 exchange rate series are given in Table 1. As shown in Table 1, China had the highest value of real exchange rate volatility[4], followed by the Indonesia rupiah. On the other hand, the Singapore dollar had the lowest variability, followed by the Hong Kong dollar. Comparing the two sub-periods, the exchange rate volatilities for all 10 currencies were relatively lower in the recent 10 years with the exception of the Philippine peso. The higher volatility of Chinese yuan in the first sub-period was due to the devaluation of yuan on many occasions since the beginning of its economic reform process in 1979. While the volatility of the Indonesia rupiah was caused by the 1997 currency crisis.

Figure 1 depicts the logarithm of real exchange rates for the 10 East Asian countries over the period 1990m1-2010m6. Apart from the Chinese yuan, most East Asian currencies had appreciated against the US dollar prior to the 1997 currency crisis. Of the 10 East Asian economies, Indonesia, Malaysia, the Philippines, South Korea and Thailand were badly affected by the currency crisis which, to a lesser extent, also affected countries like Japan, Taiwan and Singapore. Among the 10 currencies, the Indonesian rupiah suffered the largest drop in value, particularly for the period 1997m12-1998m10, as a result of political instability. The Malaysian government also chose to fix its exchange rate at ringgit 3.80 per USD in October 1998. As shown in Figure 1, the GFC had a lesser impact on the East Asian currencies compared to the Asian financial crisis. Of the 10 East Asian economies, only Indonesia and South Korea were more severely affected.

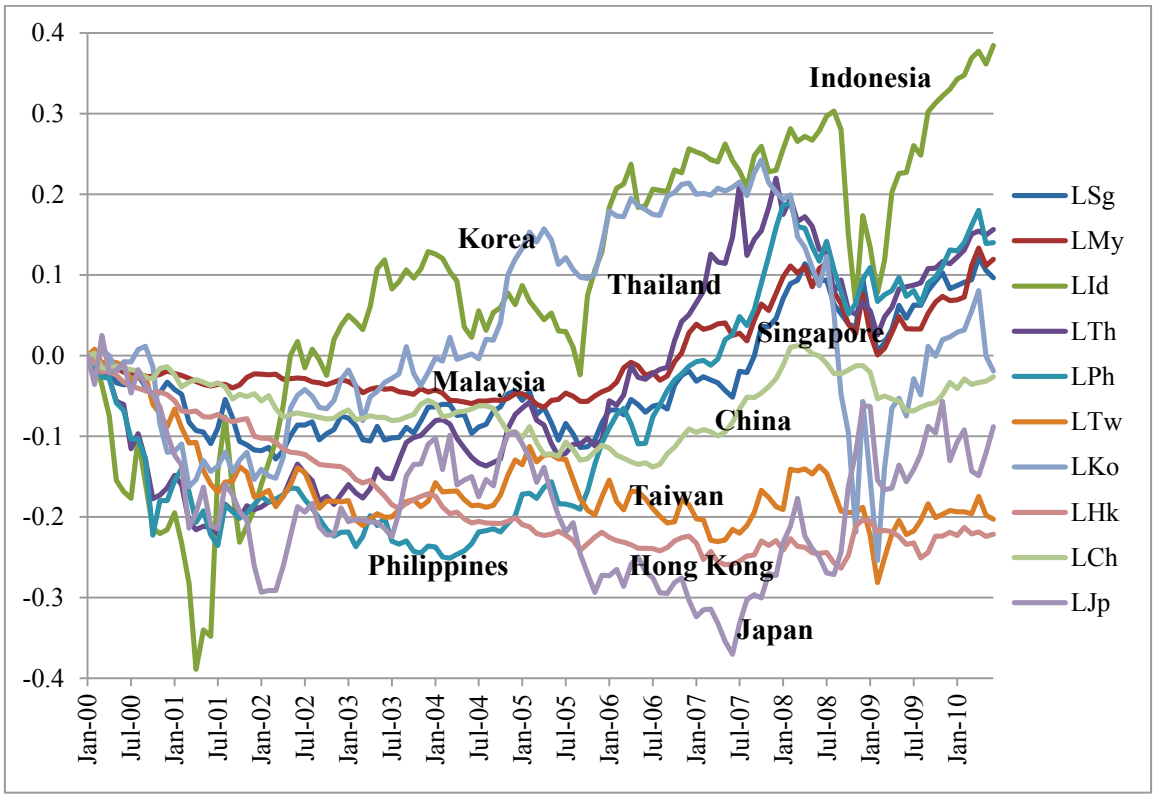
FIGURE 1: LOGARITHM OF REAL EXCHANGE RATES FOR EAST ASIAN COUNTRIES, 1990M1-2010M6



Source: Datastream

[4] It is calculated as the standard deviation of log of real exchange rate over the sample period.

FIGURE 2: LOGARITHM OF REAL EXCHANGE RATES FOR EAST ASIAN COUNTRIES, 2000M1-2010M6



Source: Datastream.

The logarithm of real exchange rates for the 10 East Asian countries for the second sub-period is shown in Figure 2. To assess the extent of currency convergence in East Asia over the last 10 years, the real exchange rates were re-scaled to a common value of one USD per national currency on January 2000. Although it is not evident from Figure 2 that all East Asian currencies have converged over time, the currencies of Malaysia, Singapore and Thailand seem to move closely together in recent years and the diverging currencies are the Indonesian rupiah, Hong Kong dollar and Taiwan dollar.

IV. EMPIRICAL RESULTS

The paper applies both the hierarchical agglomerative clustering and time series methods to examine the convergence of monthly real exchange rates for 10 East Asian countries over the period 1990m1-2010m6. All estimation and test results are derived using the Stata 11.1 statistics/data analysis program and EViews 6 software.

Cluster Analysis

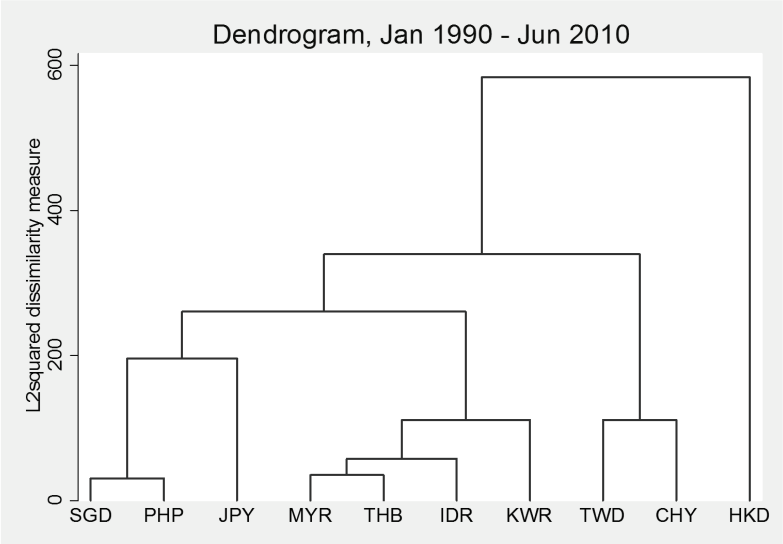
The results of dissimilarity measures or fusion values for the 10 normalised real exchange rates are presented in Table 2 and the dendrograms of the hierarchical cluster analyses for three sample periods are shown in Figures 3 to 5. The dissimilarity value increases monotonically as the agglomerative clustering progresses from many to few clusters.

TABLE 2: CLUSTER ANALYSIS (DISSIMILARITY MEASURE), 1990M1-2010M6

1990m1-2010m6	1990m1-1999m12	2000m1-2010m6
SGD, 30.79, PHP, 195.85, JPY, 260.16, MYR, 35.19, THB, 57.79, IDR, 111.27, KRW, 339.52, TWD, 111.06, CHY, 583.66, HKD	SGD, 19.20, PHP, 92.64, JPY, 172.59, MYR, 10.39, THB, 32.79, TWD, 64.94, IDR, 15.15, KRW, 290.39, CHY, 451.48, HKD	SGD, 21.67, MYR, 16.08, PHP, 32.68, THB, 89.18, IDR, 237.83, KRW, 1025.48, TWD, 63.28, HKD, 129.12, JPY, 166.65, CHY

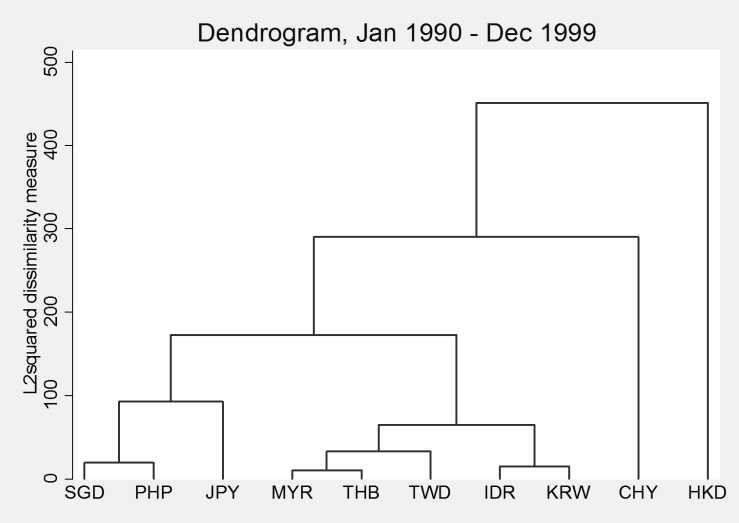
It is evident from Figure 3 that the Hong Kong dollar was dissimilar from the rest of the currencies over the sample period 1990m1-2010m6. The smallest *DH* pseudo T-squared value of 1.64 indicates there might be seven distinct groups. Based on a seven-group solution, the clustering would stop at a dissimilarity value of 57.787. The seven groups in the order of their fusion values were: (i) Singapore and the Philippines; (ii) Malaysia, Thailand and Indonesia; (iii) Korea; (iv) Taiwan; (v) China, (vi) Japan; and (vii) Hong Kong.

FIGURE 3: CLUSTERS OF EAST ASIAN CURRENCIES, 1990M1-2010M6



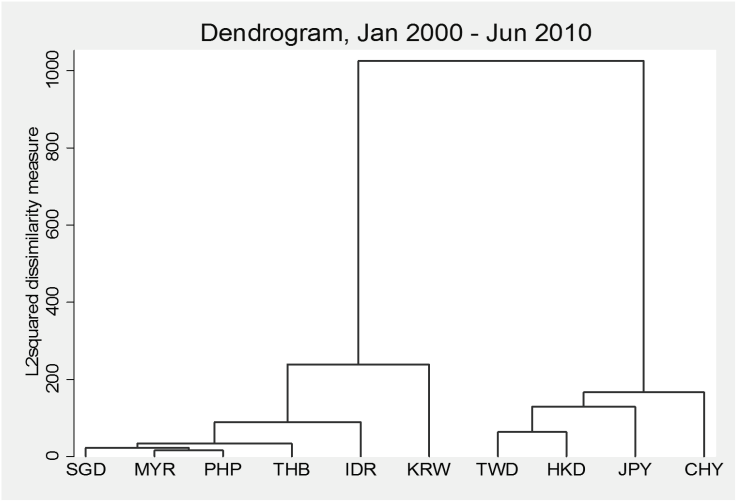
It would seem the Figure 4 dendrogram for the sub-period 1990m1-1999m12 was not significantly different from the Figure 3 dendrogram. The *DH* index with the smallest pseudo *T*-squared value of 3.16 indicated a smaller grouping of six for the sub-period 1990m1-1999m12. The six distinct groups stopped at a dissimilarity value of 32.790 were: (i) Singapore and the Philippines; (ii) Malaysia, Thailand and Taiwan; (iii) Indonesia and Korea; (iv) Japan; (v) China; and (vi) Hong Kong. As shown in Figure 4, the fusion of the Hong Kong dollar and the Chinese yuan into the group would yield a much higher dissimilarity measure. The results indicate that they were distinctly dissimilar from the rest of the East Asian currencies in the first sub-period.

FIGURE 4: CLUSTERS OF EAST ASIAN CURRENCIES, 1990M1-1999M12



Comparing the dendrogram for the two sub-periods (see Figures 4 and 5), the dissimilarities were lower between currency groups in the recent sub-period 2000m1-2010m6. In this period, the largest *DH* index of 0.536 (or a pseudo *T*-squared value of 1.73) corresponded to a three-group solution. As shown in Figure 5, the three currency groups were: (i) the ASEAN-5; (ii) Taiwan, Hong Kong, Japan and China; and (iii) Korea. The results support the convergence of currencies among groups of East Asian countries in recent years.

FIGURE 5: CLUSTERS OF EAST ASIAN CURRENCIES, 2000M1-2010M6



Currency Co-movements

Table 3 presents the estimated VP_{ij}, which measures the currency co-movements between each East Asian country with the United States, Japan and China.[5] The lower the value of VP_{ij} indicates the higher the co-movement of currencies between country *i* and the anchor country. Apart from Indonesia, all countries had higher co-movements of currencies with the United States. It is not surprising to find Hong Kong had the lowest estimated *VP* given that its currency is pegged against the US dollar. Overall, all East Asian currencies had relatively higher co-movements with the US dollar than the Japanese yen or the Chinese yuan with the exception of the Indonesian rupiah. The Malaysian ringgit is the only currency that did not move closely with the Japanese yen or the Chinese yuan.

The results of currency co-movements for the two sub-periods are presented in Table 3A and Table 3B. Comparing the two sub-periods, the co-movement of each currency with either the US dollar, yen or yuan, has increased in the second sub-period (see Table 3B). Although the estimated *VP* values for each currency with either the yen or yuan were rather similar over the whole sample period, the estimated *VP* values were much smaller for the yuan in the second sub-period (see Tables 3A and 3B). These results indicate that all East Asian currencies with the exception of Hong Kong dollar had a relatively higher co-movement with the Chinese yuan than the Japanese yen in recent 10 years.

TABLE 3:
CO-MOVEMENT OF CURRENCIES WITH USD, YEN AND YUAN, 1990M1-2010M6

	US	Japan	China
Japan	0.0327	–	–
China	0.0267	0.0417	–
Hong Kong	0.0071	0.0334	0.0590
South Korea	0.0410	0.0473	0.0380
Taiwan	0.0184	0.0676	0.0688
Indonesia	0.0784*	0.0581	0.0588
Malaysia	0.0203	0.1154*	0.1163*
Philippines	0.0278	0.0452	0.0434
Singapore	0.0166	0.0522	0.0450
Thailand	0.0321	0.0589	0.0532

Note: * indicates the lowest co-movement of that currency with the US dollar, the Japanese yen, or the Chinese yuan.

TABLE 3A:
CO-MOVEMENT OF CURRENCIES WITH USD, YEN AND YUAN, 1990M1-1999M12

	US	Japan	China
Japan	0.0357	–	–
China	0.0375	0.0520	–
Hong Kong	0.0056	0.0375	0.0735
South Korea	0.0462	0.0530	0.0529
Taiwan	0.0204	0.0769	0.0841
Indonesia	0.1049*	0.0690	0.0785
Malaysia	0.0262	0.1507*	0.1562*
Philippines	0.0338	0.0490	0.0584
Singapore	0.0167	0.0596	0.0623
Thailand	0.0403	0.0687	0.0706

Note: * indicates the lowest co-movement of that currency with the US dollar, the Japanese yen, or the Chinese yuan.

[5] The values of VP_{ij} computed from higher order autoregressions are similar to the results reported in Table 3.

TABLE 3B:
CO-MOVEMENT OF CURRENCIES WITH USD, YEN AND YUAN, 2000M1-2010M6

	US	Japan	China
Japan	0.0291	–	–
China	0.0084	0.0290	–
Hong Kong	0.0076	0.0289	0.0410
South Korea	0.0360	0.0409	0.0124
Taiwan	0.0157	0.0575	0.0517
Indonesia	0.0411*	0.0581	0.0315
Malaysia	0.0125	0.0685*	0.0580*
Philippines	0.0206	0.0455	0.0211
Singapore	0.0166	0.0447	0.0184
Thailand	0.0216	0.0481	0.0286

Note: * indicates the lowest co-movement of that currency with the US dollar, the Japanese yen, or the Chinese yuan.

Converging Trends

Using the simple statistical test of Verspagen (1994) for converging or diverging trends of the exchange rate series (see equations (6) and (7)), estimation results for 10 East Asian countries are reported in Table 4. An estimated value of less than one implies two currency units have converged over time.

It is evident from Table 4 that currencies of China, Taiwan and Singapore diverged from the group average over the study period.[6] With the exception of the Chinese yuan, all currencies converged with the Japanese yen over the same period. On the other hand, the Korean won and Indonesia rupiah were the only two currencies that converged with the Chinese yuan.

TABLE 4: TEST RESULTS FOR CONVERGING TRENDS (Ψ), 1990M1-2010M6

	Group Average	Japanese Yen	Chinese Yuan
Japan	0.9863 (0.0112)	–	–
China	1.0019 (0.0028)	1.0014 (0.0034)	–
Hong Kong	0.9995 (0.0031)	0.9880 (0.0100)	1.0017 (0.0018)
South Korea	0.9536 (0.0200)	0.9827 (0.0128)	0.9992 (0.0049)
Taiwan	1.0006 (0.0094)	0.9966 (0.0086)	1.0003 (0.0034)
Indonesia	0.9546 (0.0191)	0.9741 (0.0145)	0.9941 (0.0093)
Malaysia	0.9654 (0.0168)	0.9858 (0.0113)	1.0017 (0.0033)
Philippines	0.9783 (0.0150)	0.9715 (0.0152)	1.0021 (0.0034)
Singapore	1.0011 (0.0045)	0.9555 (0.0190)	1.0023 (0.0024)
Thailand	0.9521 (0.0201)	0.9810 (0.0125)	1.0015 (0.0041)

Note: Standard errors are given in parentheses.

[6] Similar study by Lim (2005) found the Japanese yen, the Korean won and the Singapore dollar diverged from the group average over the period 1990m3-2001m12. However, the study did not include the Chinese yuan and the Taiwan dollar.

It would be more important to examine the converging trend in recent years and the results for the period 2000m1-2010m6 are presented in Table 5. The results for the first sub-period were not significantly different from Table 4 and hence are not reported here. As shown in Table 5, the two currencies that diverged from the group average over this period were the Hong Kong and Taiwan dollars. There was no currency that diverged from the Japanese yen. On the other hand, the currencies that diverged from the Chinese yuan have reduced to three, namely the Hong Kong dollar, Taiwan dollar and Malaysian ringgit.

TABLE 5: TEST RESULTS FOR CONVERGING TRENDS (Ψ), 2000M1-2010M6

	Group Average	Japanese Yen	Chinese Yuan
Japan	0.9897 (0.0145)	–	–
China	0.9781 (0.0022)	0.9803 (0.0181)	–
Hong Kong	1.0072 (0.0075)	0.9447 (0.0324)	1.0064 (0.0060)
South Korea	0.9811 (0.0179)	0.9894 (0.0132)	0.9762 (0.0195)
Taiwan	1.0092 (0.0089)	0.9310 (0.0351)	1.0004 (0.0123)
Indonesia	0.9976 (0.0151)	0.9975 (0.0127)	0.9968 (0.0158)
Malaysia	0.9890 (0.0164)	0.9924 (0.0136)	1.0001 (0.0157)
Philippines	0.9889 (0.0156)	0.9905 (0.0155)	0.9943 (0.0034)
Singapore	0.9741 (0.0229)	0.9930 (0.0134)	0.9841 (0.0221)
Thailand	0.9850 (0.0193)	0.9943 (0.0131)	0.9927 (0.0161)

Note: Standard errors are given in parentheses.

V. CONCLUSION

This paper uses both the cluster analysis and time series methods to examine the convergence of currencies for 10 fast-growing East Asian economies, namely China, Hong Kong, Japan, South Korea, Taiwan and the five founding ASEAN member countries. The stopping-rule statistic (the *DH* index) from the hierarchical cluster analysis indicates there might be seven distinct currency groups over the period from January 1990 to June 2010. An interesting finding is that the dissimilarities occurred predominantly in the 1990s driven by the divergence of the Chinese yuan and the Hong Kong dollar from the group. For the sub-period 2000m1-2010m6, a three-group solution was identified suggesting that some of the East Asian currencies were not that dissimilar in recent years. These results indicate a greater economic integration among the four East Asian countries (i.e. China, Hong Kong, Japan and Taiwan) and the ASEAN-5 countries plus Korea over time.

Similarly, there is also evidence of currency convergence for all 10 East Asian economies to the group average using the statistical test for converging trends with the exception of Hong Kong and Taiwan dollars. The test results from currency co-movements showed all 10 currencies have a relatively strong tie with the US dollar

than the Japanese yen or the Chinese yuan. Among the 10 currencies, the Indonesian rupiah had the lowest co-movement with the US dollar, while the Malaysian ringgit had the lowest co-movement with the Japanese yen and the Chinese yuan. Overall, the co-movements of each East Asian currency with the US dollar, yen or yuan were higher in the recent 10 years. In addition, the currency co-movements with the yuan were stronger than the yen.

The results of this study would suggest the Chinese yuan is a better candidate than the Japanese yen as an anchor currency in the East Asian region. However, it is important to emphasise that both the cluster analysis and the time series methods used are limited to finding groupings that may exist in the data and testing the time series properties of currency differences, without considering the factors that determine exchange rate movements. Thus, further research on the suitability of a common currency area should also consider other relevant variables, such as financial markets, financial flows, political conditions, and convergence in the levels of interest rates and outputs that are important for currency adoption.

ACKNOWLEDGEMENTS

The author would like to thank two anonymous referees and the participants of the 2010 GMIEER Conference for helpful comments and suggestions.

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