

# Multi-Country Currency Unions in East Asia

L.K. Lim

School of Accounting, Finance and Economics, Edith Cowan University, Joondalup, Australia  
(l.lim@ecu.edu.au)

**Abstract:** With the growing integration of the world economy, many countries tend to experience relatively higher volatility in exchange rates under the floating exchange rate system due to destabilising speculation and money market disturbances. The Asian currency crisis and the successful launch of the euro in the European Monetary Union have increased interest in policy coordination to achieve greater regional exchange rate stability. A regional currency agreement would provide stable intra-regional exchange rates and maintain flexibility of the exchange rates against that of non-members. There are pros and cons for different countries to join a union and adopt a common currency. Several studies evaluate whether natural currency areas emerge based on historical pattern of international trade and of co-movements of prices and outputs, and found a well-defined dollar and euro areas but no clear yen area. This paper applies three different time series methods to determine if there are multi-country currency unions in the East Asian region. The countries included in this study are the high-performing Asian economies, namely Japan, Hong Kong, South Korea, and the five founding ASEAN member countries. The suitability of the yen as an anchor currency for these countries will be analysed.

**Keywords:** *Cointegration; Currency convergence; Exchange rates; Price co-movements*

## 1. INTRODUCTION

Rapid economic growth in several East Asian economies prior to the Asian currency crisis in 1997 brought increased integration to countries in the East Asian region, and strengthened its position in the world economy. After the fall of the Bretton Woods system in the 1970s, several East Asian countries have gradually switched from fixed exchange rate arrangements to allow their currency values to be determined in foreign exchange markets. Countries tend to experience relatively higher volatility in exchange rates under the floating exchange rate system due to destabilising speculation and money market disturbances. In the East Asian region, the floating of the Thai baht in 1997 led to the financial meltdown in Thailand, and started a wave of contagion effects, spreading quickly to its neighbouring countries in the region. This questions the suitability of floating exchange rates for these countries in a financially integrated world, where funds can be moved instantly between national financial markets. An interesting proposition is whether these countries can benefit from sharing a single currency. A regional currency agreement would provide stable intra-

regional exchange rates and maintain flexibility of the exchange rates against that of non-members.

There are pros and cons for different countries to join a union and adopt a common currency. Alesina et al. (2002) evaluate whether natural currency areas emerge based on historical pattern of international trade and of co-movements of prices and outputs, and found a well-defined dollar and euro areas but no clear yen area. They 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. 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. Alesina et al. suggest that increased trade may also be measured from an increase in the co-movements of outputs and prices.

Experience in the European Monetary Union informs that monetary union delivers both benefits and costs to its members, depending on the similarities in economic structures (see

Krugman and Obstfeld, 2000). 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. This is evidenced from the entry criteria listed in the Maastricht Treaty. Preconditions for nominal convergence involve numerical targets on the convergence of interest rates, inflation, exchange rates, and government debts and deficits. The purpose of such convergence requirements is to reduce the pre-integration levels of divergence among participating countries, so as to alleviate the costs of losing the exchange rate instrument in macroeconomic stabilization after integration.

The purchasing power parity theory based on the law of one price does not perform well in explaining actual exchange rates movements. Empirical evidence suggests a positive relationship between countries' price levels and their real incomes per capita, when measured in terms of a single currency (see Krugman and Obstfeld, 2000). Possible explanations for difference in overall price levels between rich and poor countries are trade barriers and differences in endowments of capital and labour and productivity.

There is 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 determine if there are multi-country currency unions in East Asia. This paper focuses on Japan, Hong Kong, South Korea and the five founding members of ASEAN, namely Indonesia, Malaysia, the Philippines, Singapore and Thailand (hereafter referred to as ASEAN-5). Convergence of real exchange rates is tested using time series data to determine the suitability of a monetary integration in East Asia.

The plan of the paper is as follows. Section 2 outlines the time series methods used to test the existence of multi-country currency unions. Section 3 examines the time series data and the historical pattern of price co-movements among the sample countries. Section 4 presents the test results for the eight East Asian countries. Some concluding remarks are given in Section 5.

## 2. METHODOLOGY

In this paper, three different time series methods are used to test if there are multi-country currency unions in the East Asian region. The first method examines the co-movement of prices, the second method applies a simple statistical test for currency trends, while the third method applies unit root tests and cointegration analysis to the real exchange rate series.

### 2.1 Co-movements of Prices

Alesina et al. (2002) proposed a measure of co-movement of prices between countries  $i$  and  $j$  using the following second-order autoregression:

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

where  $P_{i,t}$  measures how many units of U.S. 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 (1) is used to compute the following root mean square error:

$$VP_{ij} = \sqrt{\frac{1}{T-3} \sum_{t=1}^T \hat{\varepsilon}_{ij,t}^2}. \quad (2)$$

A higher value of  $VP_{ij}$  means less co-movement of prices between countries  $i$  and  $j$ .

### 2.2 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:

$$W_{i,t} = y_{i,t} - y_t^*, \quad (3)$$

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

$$W_{i,t+1} = \Psi W_{i,t} + \eta_{i,t}. \quad (4)$$

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.

### 2.3 Cointegration Method

A stochastic definition of income convergence requires per capita income disparities across countries to follow a stationary process. This definition is applied to test for convergence in currencies across countries. Bernard and Durlauf (1995) have proposed a time series test for convergence and common trends. The notion of convergence in multivariate exchange rates can be defined such that the long-term forecasts of real exchange rates for all countries,  $i = 1, \dots, n$ , are equal at a fixed time  $t$ :

$$\lim_{k \rightarrow \infty} E(y_{1,t+k} - y_{i,t+k} | I_t) = 0, \quad \forall i > 1, \quad (5)$$

where  $I_t$  is the information set at time  $t$ . Applying the concepts of unit roots and cointegration, the convergence test determines whether  $y_{1,t+k} - y_{i,t+k}$  in equation (5) is a zero mean stationary process in a cointegration framework. Convergence in exchange rates for two countries,  $p$  and  $q$ , implies that the exchange rates are cointegrated, with cointegrating vector  $[1, -1]$ .

Empirically, testing for convergence and common trends in a cointegration framework requires the individual exchange rate series to be integrated of order one. The following augmented Dickey-Fuller (1981) (ADF) test is used to determine the order of integration for real exchange rates of the nine East Asian countries:

$$\Delta y_{i,t} = a_{0i} + a_{1i}t + \beta_i y_{i,t-1} + \sum_{j=1}^p \delta_{ji} \Delta y_{i,t-j} + \varepsilon_{i,t}, \quad (6)$$

where  $\Delta y_{i,t}$  approximates the growth rate of real exchange rate,  $t$  is the deterministic trend,  $p$  is the order of the autoregressive process, and  $\Delta y_{i,t-j}$  is included to accommodate (possible) serial correlation in the errors.

The rank of the cointegrating matrix in a multivariate framework can be estimated using the following VAR representation (Johansen, 1991):

$$\Delta Y_t = \Gamma(L)\Delta Y_t + \Pi Y_{t-k} + \mu + \varepsilon_t, \quad (7)$$

where  $Y_t$  is a  $8 \times 1$  vector of the logarithms of real exchange rates for the nine East Asian countries,  $\Pi$  represents the long-run relationships of the cointegrating vectors,  $\Gamma(L)$  is a polynomial of order  $k-1$  to capture the short-run dynamics of the system, and  $\varepsilon_t$  are independent Gaussian errors with zero mean and covariance matrix  $\Omega$ . The reduced rank ( $0 \leq \text{rank}(\Pi) = r < n$ ) of the long-run impact matrix is formulated as follows:

$$\Pi = \alpha\beta', \quad (8)$$

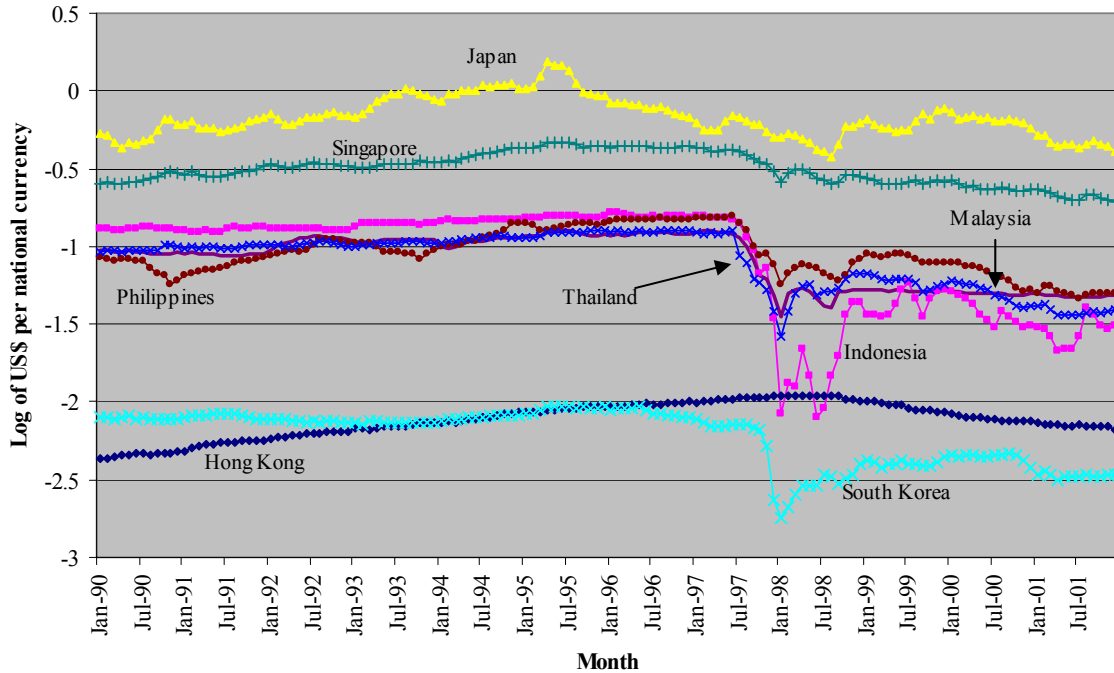
where  $\beta$  is the  $8 \times r$  matrix of cointegrating vectors and  $\alpha$  is the  $8 \times r$  matrix of adjustment coefficients.

Applying the Johansen maximum likelihood estimation method, convergence in multivariate currencies, as defined in equation (5), would require  $r = n - 1$  (or seven) cointegrating vectors for five ASEAN countries of the form  $[1, -1]$  (i.e. one common long-run trend for the individual exchange rate series in  $Y_t$ ). The Johansen procedure permits hypothesis testing of the cointegrating relations and their adjustment coefficients, using the likelihood ratio test which follows a chi-squared distribution. This method is necessary to determine whether the  $r$  cointegrating vectors are of the form  $[1, -1]$ , which requires a unit restriction imposed on all the coefficients of the  $r$  cointegrating vectors.

### 3. DATA

Testing for exchange rate convergence among the eight 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 U.S. dollar, each country's currency is expressed in U.S. dollars. Monthly nominal exchange rates of US\$ 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 1990(1) to 2001(12). Real exchange rates of US\$ per national currency are derived by multiplying the nominal exchange rates with the relative consumer price index<sup>1</sup> of the national currency to the US\$. Due to vast differences in the values of each East Asian currency, the real exchange rates used are US\$ per 100 yen, 1 HK\$, 100 won,

<sup>1</sup> The consumer price indices for each East Asian country and the USA have been converted to a common base year.



**Figure 1:** Logarithm of Real Exchange Rates for East Asian Countries, 1990(1)-2001(12)

1,000 rupiah, 1 ringgit, 10 peso, 1 S\$ and 10 baht, for Japan, Hong Kong, South Korea, Indonesia, Malaysia, the Philippines, Singapore and Thailand, respectively.

Figure 1 depicts the logarithm of real exchange rates for the eight East Asian countries over the period 1990(1)-2001(12). It is evident from Figure 1 that the exchange rates for all countries are fairly stable, apart from the Asian financial crisis which caused a substantial weakening in several currencies. Of the eight 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 and Singapore. Among the eight currencies, the Indonesian rupiah suffered the largest drop in value, particularly for 1997(12)-1998(10), as a result of political instability. The Malaysian government also chose to fix its exchange rate at ringgit 3.80 per US\$ in October 1998.

#### 4. EMPIRICAL RESULTS

The paper applies time series tests to monthly real exchange rates in natural logarithms (LER) for eight East Asian countries for 1990(1)-2001(12). Table 1 presents the estimated  $VP_{ij}$ , which measures the price co-movements between each East Asian country with the United States and

Japan.<sup>2</sup> The lower the value of  $VP_{ij}$ , the higher the co-movement of prices between country  $i$  and the anchor country. Apart from Indonesia, all countries have high co-movements of prices with both the United States and Japan. These results indicate that both the U.S. dollar and the Japanese yen can be a suitable common currency for the six East Asian countries.

**Table 1.** Co-movement of Prices with U.S. and Japan, 1990(3)-2001(12).

	U.S.	Japan
Hong Kong	0.0065	0.0299
South Korea	0.0321	0.0374
Indonesia	0.0833	0.0844
Malaysia	0.0263	0.0347
Philippines	0.0250	0.0364
Singapore	0.0148	0.0253
Thailand	0.0316	0.0365

Using the simple statistical test of Verspagen (1994) for converging or diverging trends of the

<sup>2</sup> The values of  $VP_{ij}$  computed from higher order autoregressions are similar to the results reported in Table 1.

LER series (see equations (3) and (4)), estimation results for eight East Asian countries are reported in Table 2. Among the ASEAN-5 countries, Singapore is the only diverging country, whereas the remaining four countries converge towards the mean LER level. Japan and South Korea are another two countries that diverge from the average LER. On the other hand, the countries that diverge from the Japanese exchange rates are South Korea, Malaysia and Thailand. As each estimated  $\Psi$  is fairly close to the value of one, which implies a stable currency movement between each currency and the Japanese yen over the study period.

**Table 2.** Test Results for Converging Trends, 1990(2)-2001(12).

	Group Average	Japanese Yen
Japan	1.0002* (0.0028)	–
Hong Kong	0.99666 (0.0020)	0.99879 (0.0013)
South Korea	1.0006* (0.0020)	1.0006* (0.0017)
Indonesia	0.95878 (0.0231)	0.99947 (0.0074)
Malaysia	0.97178 (0.0176)	1.0004* (0.0032)
Philippines	0.98789 (0.0131)	0.99984 (0.0037)
Singapore	1.0008* (0.0020)	0.99716 (0.0063)
Thailand	0.97376 (0.0175)	1.0010* (0.0035)

Notes: \* indicates that the LER of the country diverge from the sample group or the Japanese exchange rate.

Standard errors are given in parentheses.

Before testing for convergence based on the method of Bernard and Durlauf (1995), it is essential to determine the order of integration for each of the exchange rate series. ADF tests are used to test for the presence of unit roots in the logarithms of real exchange rates for the eight East Asian countries. For monthly data, an initial lag length of twelve is used for the ADF test. If the t-statistic for the largest lag is insignificant, the lag length is reduced successively until a significant lag length is obtained. Although detailed results are not reported to save space, the ADF t-statistics do not reject the null hypothesis of a unit root for the eight LER series, implying

that each is non-stationary. Upon taking first differences of the series, which indicate stationarity of the transformed series, the test results indicate that all eight LER series are integrated of order one. Thus, the Johansen maximum likelihood method can be used to test for the presence of cointegrating vectors or common trends.

Based on the definition in Bernard and Durlauf (1995), the eight LER series are tested for convergence between each East Asian country. The Akaike Information Criterion is used to determine the order of the VAR model, with the test statistics and choice criteria indicating a VAR model of order four. If the LER for two countries are cointegrated, the restriction  $[1, -1]$  is imposed on the cointegrating vector. Using unrestricted intercepts and no trends in the VAR, Table 3 reports the trace and maximal eigenvalue statistics of the stochastic matrix to determine the number of cointegrating vectors ( $r$ ) that are significant at the 5% and 10% levels.

**Table 3.** Maximal Eigenvalue and Trace Statistics for the VAR(4) Model, 1990(5)-2001(12).

Country	Maximal Eigenvalue $H_0: r=0,$ $H_a: r=1$	Trace $H_0: r=0,$ $H_a: r \geq 1$
<u>Hong Kong</u>		
Japan	12.6813	17.0592*
South Korea	24.3022**	26.3263**
Indonesia	22.9918**	25.2407**
Malaysia	32.4292**	35.3121**
Philippines	19.9649**	21.2532**
Singapore	45.4049**	48.6679**
Thailand	25.5172**	27.1960**
<u>Singapore</u>		
South Korea	18.2990**	19.0019**
Malaysia	13.3631*	14.2267
Philippines	19.8237**	19.8592**
Thailand	19.8075**	20.4027**
<u>Indonesia</u>		
South Korea	18.7260**	20.0953**
Thailand	21.9674**	22.7727**

Note: \* denotes significance at the 10% level.

\*\* denotes significance at the 5% level.

Both the trace and maximal eigenvalue statistics reject the existence of a long-run cointegrating relationship between Japan and each of the seven East Asian countries, with the possible exception of Hong Kong. On the other hand, Hong Kong is

found to have a long-run cointegrating relationship with all the countries. In the case of Singapore, both test statistics indicate that a long-run cointegrating relationship exists with South Korea, Indonesia, Malaysia and Thailand. In addition, the test statistics also reject the null hypothesis of no cointegrating relationship between Indonesia and South Korea, and Indonesia and Thailand. Overall, there are 13 cointegrating vectors for each pair of East Asian countries from the possible 28 cointegrating vectors. Of the 13 cointegrating vectors, the likelihood ratio test rejects the null hypothesis of a unit restriction for three cointegrating vectors (namely, for Singapore and the Philippines, Indonesia and South Korea, and Indonesia and Thailand) at the 5% significance level.

For the eight East Asian countries, tests for the presence of a common long-run trend for individual LER series in the group are also undertaken. The maximal eigenvalue and trace statistics suggest the presence of at least four cointegrating vectors at the 5% level of significance, which indicate non-convergence of the currencies for all eight countries. However, both test statistics suggest the presence of at least four cointegrating vectors for five East Asian countries, namely Hong Kong, South Korea, the Philippines, Singapore and Thailand, which support convergence of the currencies for these countries.

## 5. CONCLUSION

This paper examined the existence of multi-country currency unions in the East Asian region. Three time series methods were used to test for convergence of currencies for eight fast-growing East Asian countries. The test results from comovements of prices support a common dollar and yen areas for all countries, except for Indonesia. There was also evidence of currency convergence for five East Asian countries, namely Hong Kong, Indonesia, Malaysia, the Philippines and Thailand, to the group average using the statistical test for converging trend. In addition, the currency of each country seems to move at a rather constant rate from the Japanese yen over the sample period.

Using the cointegration method, convergence in currencies for all East Asian countries was not supported, except for convergence in ten pairs of East Asian currencies. Apart from Hong Kong, none of the East Asian currencies had a long-run cointegrating relationship with the Japanese yen. However, the cointegration tests found a common

long-run trend for five individual exchange rate series, namely Hong Kong, South Korea, the Philippines, Singapore and Thailand, which support a currency union for these countries.

It is important to emphasise that the time series methods used are limited to testing the time series properties of currency differences, without considering the factors that determine exchange rate movements. Thus, further research would be valuable on existing time series methods for testing the suitability of multi-country currency union and a consideration of other relevant variables, such as financial markets, financial flows and convergence in the levels of interest rates, inflation rates and outputs that are important for currency adoption.

## 6. ACKNOWLEDGEMENTS

The author wishes to acknowledge the financial support of the Faculty Small Grant, Faculty of Business and Public Management at the Edith Cowan University.

## 7. REFERENCES

- Alesina, A., and R. Barro, Currency Unions, *Quarterly Journal of Economics*, 117(2), 409-436, 2002.
- Alesina, A., R.J. Barro, and S. Tenreyro, Optimal Currency Areas, Harvard Institute of Economic Research Discussion Paper No. 1958, June 2002.
- Bernard, A.B. and S.N. Durlauf, Convergence in International Output, *Journal of Applied Econometrics*, 10, 97-108, 1995.
- Dickey, D.A. and W.A. Fuller, Likelihood Ratio Tests for Autoregressive Time Series with a Unit Root, *Econometrica*, 49, 1057-1072, 1981.
- Johansen, S., Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models, *Econometrica*, 59, 1551-1580, 1991.
- Krugman, P.R. and M. Obstfeld, *International Economics: Theory and Policy*, Fifth Edition, Addison-Wesley, New York, 2000.
- Verspagen, B., Technology and Growth: The Complex Dynamics of Convergence and Divergence, in G. Silverberg and L. Soete (eds.), *The Economics of Growth and Technical Change: Technologies, Nations, Agents*, Edward Elgar, England, pp. 154-181, 1994.