Testing for Monetary Integration and Contagion in ASEAN Exchange Rates

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Abstract: The Asian financial crisis in 1997 brought to the attention of member countries of the Association of South East Asian Countries (ASEAN-5) (comprising Indonesia, Malaysia, the Philippines, Singapore and Thailand) the need for closer monetary co-operation. Central to the OCA literature is the nature and symmetry of underlying economic disturbances. If the economic disturbances are similar across the countries in a region, then the costs of establishing a common currency area are likely to be small. As the presence of contagion necessarily means there is an increase in the correlation of shocks experienced within a region, this paper examines the suitability of establishing a common currency area for ASEAN-5 from the perspective of contagion. In order to select the breakpoints for contagion endogenously, a modified sequential dummy variable method is developed. The empirical results show that contagion is present between all country pairs in ASEAN-5, which indicates that the degree of correlation among the ASEAN-5 economies has increased during the Asian financial crisis.

Keywords: Monetary unification; Optimum currency area; Asymmetric shocks; Correlated shocks; Contagion; Parameter stability; Ranking of contagion magnitudes

1. INTRODUCTION

Following the Asian financial crisis in 1997, the Association of South-East Asian Nations (ASEAN) renewed their interest in closer monetary cooperation. The Chiang Mai Initiative 2000 saw multilateral agreements on stabilising exchange rates in ASEAN. In 2002, the successful establishment of the Euro captured the imagination of ASEAN. The benefits of monetary unification can be enormous. A single currency enhances the role of money as a unit of account, decreases transaction costs, and reduces vulnerability to another crisis.

Establishing a single currency involves costs, predominantly the loss of national monetary autonomy. The framework for studying the costs associated with monetary unification rests on the theory of an Optimum Currency Area (OCA), which provides a holistic view through weighing up the costs and benefits of monetary unification. The OCA theory proposes that: (1) if a country is highly integrated with a geographical area in factor mobility, commodity trading and financial transactions; and (2) if the country is small, open, and has a diversified production structure, then fixed exchange rates for that area may be economically more sensible than flexible exchange rates.

A central discussion in the OCA literature is the nature and symmetry of underlying economic disturbances. If the economic disturbances are similar across the countries in a region, then the costs of establishing a common currency area are likely to be small. Researchers have studied the degree of asymmetric shocks experienced in ASEAN, and have identified a core group of economies that are most likely to be suitable candidates for a monetary union, namely ASEAN-5 (comprising Indonesia, the Malaysia, the Philippines, Singapore and Thailand). This region has a significant positive correlation of shocks, which evidently increased during the Asian financial crisis. By examining data for the period 1980Q1-1997Q1 and 1980Q1-2000Q3, Zhang, Sato and McAleer (2001) found evidence of an increase in the positive correlation of shocks in the latter period. Their paper prompts a re-examination of economic phenomena that have caused an increase in the positive correlation of shocks during and after a financial crisis.

The theory of contagion may provide some answers for this economic phenomenon as it examines the spread of country-specific shocks to other countries with stable economic environments. Specifically, contagion is measured as an increase in the co-movement of market prices. The presence of contagion necessarily means there is an increase in the correlation of shocks experienced within a region.

A strategy for examining the presence of contagion is adopted to assess the costs of monetary unification in ASEAN-5. This method seeks to examine whether there was an increase in the correlation of shocks within ASEAN-5 during the Asian financial crisis. An increase in the correlation would imply the region is suitable for establishing a common currency area on the grounds of closely correlated shocks. The contagion model of Caporale, Cipollini and Spagnolo (2002) is used, and daily data are employed to examine contagion in the exchange rate markets of ASEAN-5.

The plan of the paper is as follows. Section 2 discusses the data and methods to test for contagion in currency markets. Section 3 presents the empirical findings, and analyses the suitability of ASEAN-5 for establishing a common currency area.

2. DATA AND METHODOLOGY

Foreign exchange rate data for six countries, namely Indonesia, Japan, Malaysia, the Philippines, Singapore and Thailand, are used in the empirical analysis. The foreign exchange rates are denominated in US dollars, and are obtained through the DataStream database service. A total of 2,273 daily observations is available for each country from 03/01/1994 to 18/09/2002.

The rationale for using daily data to test for contagion is to capture the volatility in exchange rates attributable to investor response to news. Daily exchange rates are news driven. Announcements such as interest rate changes and changes in perception of the growth path of economies are factors that drive exchange rates in the short run. However, investor responses to news can vary widely. For example, the news of the insolvency of a banking group in a country might affect only the share prices of associated firms, but could also have a catastrophic effect on the share markets of one or more countries. The extent of market movements is based mainly on investor expectations, sentiments and confidence. Contagion is associated with negative investor sentiments and expectations, and is typically beyond the explanatory power of aggregate indexes. Tests of contagion investigate how price movements in one currency market affect prices in other currency markets. Daily data permit an investigation of how market psychology is transmitted from one economy to another. Although tick-by-tick (or minute-by-minute) data would register even greater volatility, daily frequency data are sufficient to determine any regularities between pairs of currency markets.

Of primary concern are changes in the value of foreign exchange rates, which are given as $y_t = (Y_t - Y_{t-1}) / Y_{t-1}$, where Y_t denotes the foreign exchange rate denominated in US dollars, expressed in levels at time *t*. A devaluation (revaluation) is represented by an increase (decrease) in y_t.

The empirical method ascertains the presence of contagion between pairs of ASEAN-5 countries, and its effect on foreign exchange rates in ASEAN-5. In order to test for contagion, it is necessary to split the sample data into two sets for the crisis and tranquil periods. This typically leads to a small crisis data set compared with a larger tranquil data set. As explained in Dungey and Zhumabekova (2001), this has serious effects on the power of the test. A lopsided sample size might reduce the ability to produce reliable correlation coefficients and standard errors, which would decrease the power of the test of no contagion. With this in mind, the empirical analysis below uses an approach which accommodates full sample estimation (Caporale, Cipollini and Spagnolo, 2002).

As contagion does not necessarily have a widely accepted interpretation, the definition introduced by Forbes and Rigobon (2001), namely a significant increase in the co-movement of markets prices, will be used below. This definition assumes that a crisis is intrinsically different from a tranquil period, and is consistent with the empirical regularity that crisis periods display greater volatility than tranquil periods.

The empirical analysis uses the following model:

$$\begin{aligned} y_t &= \alpha_0 x_t + \alpha_1 * D_t * x_t + \gamma z_t + \varepsilon_{yt} \\ x_t &= \beta_0 y_t + \beta_1 * D_t * y_t + z_t + \varepsilon_{xt} \end{aligned} \tag{1}$$

$$\begin{aligned} h_{yt} &= (1-\delta_1-\delta_2) + \delta_2 \varepsilon^2_{yt-1} + \delta_1 h_{yt-1} \\ h_{xt} &= (1-\delta_3-\delta_4) + \delta_4 \varepsilon^2_{xt-1} + \delta_3 h_{xt-1} \end{aligned} \tag{2}$$

Equation (1) describes the conditional mean specification of y_t and x_t, which represent foreign exchange rates of the countries to be tested for contagion. Variable z_t is the exchange rate of a third country that is common to both equations in the system. The model tests for the presence of contagion between pairs of countries, and (1) tests for the presence of contagion from country x_t to y_t. Subsequently, the system can be used to test for contagion from country y_t to x_t by interchanging the variables. Interaction of the variables yields a simultaneous equations model, and imposing restrictions is necessary to identify the system. A dummy variable D_t is included to analyse data from two different regimes, namely the crisis and tranquil periods, and captures a coefficient that indicates occurrence of a structural change. The structural shocks ε_{yt} and ε_{xt} are assumed to follow a GARCH (1,1) process, as given in (2). For further details, see Nam and McAleer (2002).

Imposing identifying restrictions of the following type in the simultaneous equations system (1) exactly identifies the system:

a) Structural shocks ε_{yt} and ε_{xt} are homoscedastic;
b) Structural shocks are uncorrelated with each other, that is, $cov(\varepsilon_{yt}, \varepsilon_{xt}) = 0$, and are uncorrelated with the common shock, that is, $cov(z_t, \varepsilon_{yt}) = 0$ and $cov(z_t, \varepsilon_{xt}) = 0$;
c) Normalisation to unity of the effect of the common shock z_t on one of the two endogenous variables.

The dummy variable which takes the value one during a crisis period and zero elsewhere, allows estimation to be performed with the full data set without sample splitting.

Specification of the starting and ending dates of the Asian crisis is chosen endogenously. Caporale, Cipollini and Spagnolo (2002) base the starting and ending dates of the crisis on the sequential dummy variable test. This procedure, which was introduced by Andrews (1993), locates breakpoints in the data set endogeneously by choosing the dummy variable that corresponds to the largest quasi t-ratio of the coefficient of the dummy variable. Specifically, it calculates the Lagrange Multiplier (LM) test statistics for the Chow test for structural change of the different possible breakpoints. Upon obtaining the highest LM test statistics, the asymptotic critical values of Andrews (1993) are used to locate the breakpoint.

The data used by Caporale, Cipollini and Spagnolo (2002) essentially consist of three breakpoints, namely pre-crisis, crisis, and post-crisis. In this paper, an improvised method is used which switches the dummy variables off for observations that do not contribute to the highest t-ratio of the coefficient of the dummy variable. This procedure produces a set of dummy variable observations that has the highest t-ratio, and the set of observations examined are those associated with crisis periods, as specified in Caporale, Cipollini and Spagnolo (2002). Consequently, the possible starting date of the contagion period is from June 1997 to November 1997, while the possible ending date is from February 1998 to July 1998.

The implicit assumptions are as follows:

a) normalisation to unity of the main diagonal elements of A;
b) uncorrelated structural shocks;
c) stability of the parameters;
d) heteroscedasticity through switches in the conditional variances;
e) normalisation to unity of the unconditional variances.

Therefore, the assumption of heteroscedasticity through switches in the conditional variances and the normalisation to unity in the unconditional variances imply one over-identifying restriction under the null hypothesis of parameter stability, that is, $\alpha_1 = 0$ in (1). The unrestricted model with $\alpha_1 \neq 0$ in (1) is exactly identified.

Contagion is present if there is a significant increase in the degree of co-movement between pairs of foreign exchange rates, as reflected in $\alpha_1 > 0$. The null hypothesis $H_0 : \alpha_1 = 0$ of independence is tested against the alternative hypothesis $H_1 : \alpha_1 > 0$, signifying contagion from country *x* to *y*. In effect, this tests for structural change, namely whether the coefficient of the dummy variable is positive and significant. If the structural change is negative and significant, the results are inconclusive, in that there could be undetected contagion, or there might simply not be contagion.

One of the identifying restrictions in the model is the assumption of the lack of correlation between the structural shocks ε_{yt} and ε_{xt} [or $cov(\varepsilon_{yt}, \varepsilon_{xt}) = 0$], and between the shocks and z_t [or $cov(z_t, \varepsilon_{yt}) = 0$ and $cov(z_t, \varepsilon_{xt}) = 0$]. Unless this restriction is imposed, the system is not identifiable. The system includes a common shock to deal with the problems of omitted variables and/or orthogonal structural shocks. Without the introduction of the common shock z_t, the simultaneous equations system is likely to have correlated errors and regressors.

Consider the following system:

$$\begin{aligned} y_t &= \alpha_0 x_t + \alpha_1 * D_t * x_t + \upsilon_{yt} \\ x_t &= \beta_0 y_t + \beta_1 * D_t * y_t + \upsilon_{xt} \end{aligned} \qquad (3)$$

where (3) is similar to (1), but without a common shock in both equations. A common shock such as the devaluation of the Japanese yen against the US dollar is likely to have effects on both y_t and x_t because most currencies in ASEAN have an implicit peg to a basket of currencies, with significant weights of the yen and US dollar. In (3), the effect of the yen would likely be contained in υ_{yt} and υ_{xt}, so that $cov(v_{yt}, v_{xt}) \neq 0$, leading to $cov(z_t, \varepsilon_{yt}) \neq 0$ because υ_{xt}, in part, determines x_t. This result renders OLS inconsistent. Therefore, the model explicitly includes a common shock to accommodate the problem. The yen is selected as the common shock because its movements have significant impacts on the exchange rates of ASEAN-5. As the empirical analysis uses foreign exchange rates quoted in US dollars, changes in the value of the US dollar will be reflected in the foreign exchange rates of all the currencies considered concurrently.

3. EMPIRICAL RESULTS

Estimating the model in (1) using Microfit 4 for each pair of countries for the entire sample yields the results given in Tables 1-3. Table 1 reports the estimates for the coefficients associated with the dummy variables and the corresponding OLS t-ratios in parentheses. White's robust heteroscedasticity adjusted t-ratios are given in brackets because heteroscedasticity was diagnosed using the LM test based on squared fitted values. Table 2 reports the results of the endogenous breakpoints (with the starting and ending dates of the period denoting instability in the cross-market linkages). The breakpoints are determined by selecting the largest t-ratio corresponding to the estimated coefficient of a dummy variable.

As can be seen from Table 1, based on the robust t-ratios there is evidence of contagion at the 5% significance level for all country pairs, except from Indonesia to the Philippines (which holds only at the 10% level). The finding of widespread contagion in ASEAN-5 indicates that there is a significant increase in the positive correlation between pairs of ASEAN-5 exchange rates during the Asian crisis, and implies that the degree of asymmetric shocks experienced in ASEAN-5 has decreased during the crisis. Such an outcome is consistent with the findings of an increase in the positive correlation of shocks in East Asia (Zhang, Sato and McAleer, 2001).

Furthermore, at the 5% level, the results show there is no contagion from Indonesia to the Philippines, except at the 10% level. Thus, among all pairs of countries examined, the presence of contagion from Indonesia to the Philippines is the least likely, in spite of the fact that Indonesia is one of the largest export markets for the Philippines. Such a finding supports the definition that contagion extends beyond the links of trade. If contagion is transmitted through such trade links, contagion would be expected in the presence of such extensive links between Indonesia and the Philippines. However, as there is no evidence of contagion from Indonesia to the Philippines, this suggests that contagion cannot be explained by the transmission of shocks through fundamental linkages.

Table 1: Results for Contagion in ASEAN-5

	Indonesia	Malaysia	Philippines	Singapore	Thailand
Indonesia		0.19 (8.15) [4.87]	0.06 (4.37) [1.57]	0.05 (7.46) [3.27]	0.09 (6.58) [2.57]
Malaysia	1.90 (22.42) [7.70]		0.34 (12.07) [6.48]	0.30 (25.34) [11.64]	0.62 (21.28) [8.42]
Philippines	2.04 (13.90) [4.25]	0.68 (9.26) [6.07]		0.22 (10.37) [4.62]	0.59 (13.26) [5.45]
Singapore	4.60 (20.97) [6.28]	1.41 (10.83) [6.91]	0.50 (5.71) [2.16]		1.16 (14.27) [4.81]
Thailand	1.43 (12.61) [4.94]	0.68 (10.56) [5.00]	0.21 (5.46) [1.83]	0.20 (11.62) [5.05]	

Note: The variables in each row are the explanatory variables, while those in each column are the dependent variables in the corresponding regression. For instance, the coefficient in the row labelled INDONESIA and in the column labelled THAILAND corresponds to the dummy variable which describes the change in the effect of the exchange rate return in Indonesia on the exchange rate return in Thailand during the contagion period. The one-sided 5% critical value is 1.65, and the 10% critical value is 1.28.

Next, the results are highlighted for the order of contagion within ASEAN-5. The endogenous breakpoints reported in Table 2 show that the order of contagion seems to coincide with the observed order of market collapse within ASEAN-5. However, the result of Indonesia infecting Thailand before Thailand could infect Indonesia is hard to fathom. Starting from the initial collapse of the Thai baht, shocks are transmitted from Thailand to the rest of ASEAN-5. Contagion from Thailand seems to affect the Philippine economy first, followed by the economies of Indonesia, Malaysia, and finally Singapore, which seems to suggest that the weaker economies in ASEAN-5 are the earliest to be affected by contagion.

The results for the order of contagion also support the argument that contagion proceeds beyond the transmission of shocks through fundamental links because Singapore is ASEAN's fourth largest trading partner, trailing Taiwan, Hong Kong and Korea. Singapore has the most extensive trade links with the rest of ASEAN, as compared with Indonesia, Malaysia and the Philippines. If contagion is based on fundamental links such as trade, then Singapore should be the first to be affected by the crisis, rather than the last.

Furthermore, the results in Table 2 show that when the economies in ASEAN-5 have been infected by contagion from Thailand, there are second tier contagion effects from each to the rest of ASEAN-5.

After being infected by contagion from Thailand, Indonesia infects ASEAN-5 in the order of the Philippines (significant at 10%), Malaysia, Singapore and Thailand. These results suggest that Indonesia infected the Philippines, Malaysia and Singapore before they infected Indonesia, which indicates that the Indonesian market was the first to collapse after being infected by Thailand, even though the Philippines was the second economy to be affected after Thailand.

After ASEAN-5 is infected by contagion from Thailand, and followed by contagion effects from Indonesia, Malaysia infects ASEAN-5 in the order of Singapore, the Philippines, Indonesia and Thailand. Malaysia infected Singapore and the Philippines before they could infect Malaysia. Subsequently, Singapore infected ASEAN-5 in the order of Malaysia, the Philippines, Indonesia and Thailand. Singapore infected the Philippines before the reverse could occur. The Philippines is infected by first and second tier contagion, but has not infected others. This suggests that the Philippines is not an epicentre for spreading contagion during the Asian crisis, but rather a major recipient.

Table 2: Results for Contagion Periods in ASEAN-5

	Indonesia	**Malaysia**	**Philippines**	**Singapore**	**Thailand**
Indonesia		11/07/97 (06/05/98)	10/07/97 (12/02/98)	23/07/97 (10/06/98)	01/09/97 (23/03/98)
Malaysia	03/11/97 (15/06/98)		11/07/97 (09/07/98)	09/07/97 (30/07/98)	25/11/97 (28/07/98)
Philippines	25/11/97 (25/03/98)	12/11/97 (15/07/98)		20/11/97 (10/07/98)	30/10/97 (21/04/98)
Singapore	03/11/97 (21/05/98)	10/07/97 (06/05/98)	11/07/97 (16/02/98)		25/11/97 (06/04/98)
Thailand	12/11/97 (28/05/98)	13/11/97 (28/07/98)	11/07/97 (03/02/98)	14/11/97 (28/07/98)	

Note: The dates in each cell indicate the period during which contagion occurred.

The evidence in Table 2 also suggests that the contagion period did not have a short duration, varying from a minimum of approximately four months (from Singapore to Thailand, and from the Philippines to Indonesia), to a maximum of twelve months (from Malaysia to the Philippines, and from Malaysia to Singapore). The mean contagion period lasted approximately seven and a half months, which is comparable in length to the crisis experienced in the financial markets in Caporale, Cipollini and Spagnolo (2002). In the financial markets of ASEAN-5, the contagion effects lasted approximately eight months.

Thus, there is evidence of contagion between all country pairs (except for contagion from Indonesia to the Philippines, which is significant at 10%). The order of market collapse seems to coincide with the observed market collapse, except for Indonesia and Thailand. The results may be analysed further by ranking the magnitude of contagion, with the coefficients of the dummy variables providing an estimate of the magnitude of contagion for each country pair. As can be seen in (1), the coefficient of the dummy variable explains the change in the dependent variable during the contagion period, such that the larger is the absolute value of the coefficient, the greater is its explanatory power. Table 3 reports the results of ranking contagion by magnitude.

Table 3: Ranking the Magnitude of Contagion in ASEAN-5

From	**To**	**Coefficient of Dummy**	**Rank**
Singapore	Indonesia	4.60	1
Philippines	Indonesia	2.04	2
Malaysia	Indonesia	1.90	3
Thailand	Indonesia	1.43	4
Singapore	Malaysia	1.41	5
Singapore	Thailand	1.16	6
Thailand	Malaysia	0.67	7
Philippines	Malaysia	0.67	7
Malaysia	Thailand	0.62	9
Philippines	Thailand	0.59	10
Singapore	Philippines	0.50	11
Malaysia	Philippines	0.34	12
Malaysia	Singapore	0.30	13
Philippines	Singapore	0.22	14
Thailand	Philippines	0.21	15
Thailand	Singapore	0.20	16
Indonesia	Malaysia	0.19	17
Indonesia	Thailand	0.09	18
Indonesia	Philippines	0.06	19
Indonesia	Singapore	0.05	20

As can be seen from Table 3, the largest contagion effect is from Singapore to Indonesia, meaning that the independent variable Singapore has substantial power to affect the dependent variable, namely Indonesia. The large magnitude of contagion from Singapore to Indonesia can be explained by investors taking a cue from the Singapore exchange rate as a signal for the exchange rate of Indonesia. As shown in Table 2, Indonesia infected Singapore with contagion before the reverse could occur. When contagion hit Singapore, it might be a market in which investors check for signals as to the direction of the Indonesia rupiah.

An increase in y_t represents a devaluation of the exchange rate. A unit increase in the percent change of Singapore exchange rates would mean there is a corresponding increase in the percent change of the

Indonesian exchange rate. In this case, the corresponding increase would be large because of the large coefficient of the dummy variable. Therefore, investors might infer information from the Singapore market and apply it to the Indonesian market. Investors might view devaluation in the Singapore dollar as a negative signal for the exchange rate of Indonesia during the crisis, as Indonesia is much weaker economically than Singapore. Therefore, devaluation in the Singapore dollar might lead to a large devaluation in the Indonesian rupiah as investors expect negative shocks for Indonesia following the devaluation in Singapore. Hence, the contagion effect from Singapore to Indonesia could be expected to be large.

On the other hand, ranked last at number 20, Indonesia has only a small contagion effect on Singapore. This suggests that investors do not rely heavily on the performance of the Indonesian rupiah as a signal for the value of the Singapore dollar. As suggested earlier, this could be due to investor attitudes that devaluation in the rupiah would not cause a slide in the fundamentally more stable Singapore dollar. Additionally, in Table 3 from rank number 17 to 19, the rupiah does not have a large contagion effect on the rest of ASEAN-5. Following the arguments above, the rupiah does not have an impact on the exchange rates of ASEAN-5 during the crisis because investors view it as being relatively weak.

In Table 3, from rank number 2 to 4, the Indonesian rupiah is substantially infected by contagion from the Philippines, Malaysia and Thailand. Indonesia is the weakest market, and most fundamentally unstable, in ASEAN-5 because devaluations in the rest of the ASEAN-5 exchange rates have a substantial impact on the value of the Indonesian rupiah. This is evident from the fact that most of the infected economies have recovered fully from the Asian crisis to their pre-crisis growth levels, while Indonesia has not, with high volatility still plaguing the rupiah.

Table 3 shows that the Singapore dollar has substantial contagion effects on the other ASEAN-5 economies, especially Malaysia and Thailand. This may be due to the competitive nature of these economies as they compete for the same international markets for their exports such as electronics. Devaluation in the Singapore dollar could be a strong signal for the Thai baht and Malaysian ringgit to devalue as they become less competitive internationally compared with Singapore.

In Table 3, the results from rank number 15 to 16 suggest Thailand does not have strong contagion effects on the economies of the Philippines and Singapore. Although the Thai economy started the crisis and affected the other economies of ASEAN-5, it may not be viewed as the lead market for signals regarding future movements in exchange rates in later stages of the crisis. Thailand may have triggered the Asian financial crisis, but when a more important economy such as Singapore is infected, investors will use the Singapore market as an important signal.

Contagion can, therefore, be decomposed into first and subsequent hits, just as with the results from Table 2. The first hit countries are normally the weaker countries, such as Indonesia and the Philippines, and even Thailand. They are infected by contagion early in the crisis period, and would most likely spread contagion to the rest of ASEAN-5. When all the economies in ASEAN-5 have been infected, the weaker economies do not have a substantial impact on the other markets. Moreover, stronger economies such as Singapore act as a yardstick for investors.

4. ACKNOWLEDGMENT

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