MONETARY INTEGRATION AND CONTAGION*

Jason Chee Wei Nam and Michael McAleer

Department of Economics
University of Western Australia

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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, the Malaysia, the Philippines, Singapore and Thailand) the need for closer monetary cooperation. Based on the Optimum Currency Area (OCA) theory, the Euro was successfully launched in early 2002, which provided ASEAN-5 with an attractive model for achieving monetary stability. 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. Zhang, Sato and McAleer (2001) found evidence of an increase in the positive correlation of shocks after the Asian financial crisis. Their paper prompts a re-examination of the economic phenomena that have caused an increase in the positive correlation of shocks during and after a financial crisis. Some answers for such an economic phenomenon may be provided by the theory of contagion. The presence of contagion necessarily means there is an increase in the correlation of shocks experienced within a region. Thus, the aim of this paper is to examine the suitability of establishing a common currency area for the ASEAN-5 countries from the perspective of contagion. Caporale, Cipollini and Spagnolo (2002) used a method which corrected for heteroscedasticity, endogeneity and omitted variables, and did not require the splitting of the sample into two subsets. According to Dungey and Zhumabekova (2001), such sample splitting has serious implications for inference. In this paper, improvision is made in the sequential dummy variable method for selecting the breakpoints endogenously. The empirical results show that contagion is present between all country pairs in ASEAN-5, which is consistent with the studies of Rigobon (2001a), Park and Song (2001), and Caporale, Cipollini and Spagnolo (2002). This indicates that the degree of correlation among ASEAN-5 economies has increased during the Asian financial crisis. According to the OCA theory, this means that the region will experience lower economic costs in monetary unification.

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

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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 ASEAN members' exchange rates in times of need. In 2002, the successful establishment of the Euro captured the imagination of ASEAN, in that means to a stable monetary environment could lie in a system similar to that of the Euro. The benefits of monetary unification can be enormous. A single currency enhances the role of money as a unit of account and decreases transaction costs. Most importantly, the economies in ASEAN would be less vulnerable 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). It provides a holistic view through weighing up the costs and benefits of monetary unification. The OCA theory proposes that if a country is highly integrated with a geographical area in factor mobility, commodity trading and financial transactions, and 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 (Tavlas, 1993).

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 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 the increase in positive correlation of shocks during and after a financial crisis.

The theory of contagion may have answers for this economic phenomenon as it examines the spread of country-specific shocks to other countries that have a stable economic environment. Specifically, contagion has been 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.

Therefore, the strategy of 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 experienced 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 frequency data are employed to examine contagion in the exchange rate markets of ASEAN-5.

The plan of the paper is as follows. Section 2 provides a review of the relevant literature on the theory of OCA, the measuring of asymmetric shocks, and contagion. Section 3 discusses the data and methodology adopted in testing for contagion in currency markets. Section 4 presents the empirical findings, and analyses the suitability of ASEAN-5 in establishing a common currency area. It also includes policy implications for ASEAN-5 to follow the successful model of European monetary unification. Section 5 provides some concluding remarks.

2. Literature Review

This section provides the background information on the theory of Optimum Currency Areas (OCA), in particular, the OCA criteria that render a common currency area optimal. This is followed by discussions on the modern contributions and limitations of the theory. Some empirical models for evaluating the costs of monetary unification are discussed. Earlier models have the problem of fusing information of the effects of shocks and their responses. A discussion as to how the Blanchard and Quah (1989) vector autoregressive (VAR) model resolves the problem will also be presented. The relevance of contagion for assessing the costs of monetary unification is also highlighted. Empirical models to test for the presence of contagion will also be discussed.

2.1. The Theory of OCA

Mundell's (1961) seminal work on the theory of OCA has become the standard platform for evaluating alternative exchange rate regimes. It seeks to weight the costs and benefits of flexible and fixed exchange rate regimes. The initial theory lacked empirical content, but later generations of researchers gave the original concepts empirical content. With the means of testing the initial theory, it has held on surprisingly well over the years (Mongelli, 2002). However, with the Euro as its first practical implementation, it remains to be seen how well the theory works in practice.

2.1.1. The Classical Theory of OCA

The theory of OCA proposes that a currency's circulation limit should be based on the degree of labour mobility, not national boundaries (Mundell, 1961). With the exception of the Euro, currencies are nationalised in a manner described by John Stuart Mill (1859, p. 23) as "barbarism". The OCA theory advocates against currencies based on sovereign boundaries, but supports currencies organised on the basis of the propensity to migrate.

A macroeconomic shock affects economies in different ways. Economies that experience an unanticipated temporary or permanent increase in the level of total output are considered to be positively shocked, while economies that experience an unanticipated temporary or permanent decrease in the level of total output are considered to be negatively shocked. Flexible exchange rates are used to restore macroeconomic equilibrium, without which they would suffer from inflation or unemployment (Meade, 1955). In the presence of labour mobility, the movement of labour from unemployed areas to demand-induced wage inflation areas could replace devaluation and revaluation in adjusting for the asymmetric shocks among countries. Therefore, labour mobility eliminates the need for flexibility exchange rates (Grauwe, 1994, pp. 8-12).

For example, Singapore and Indonesia could be affected in opposite directions by an external demand shock. Were Singapore to be positively affected, it would experience considerable inflationary pressure from a tight labour market, as there would be an upward shift in its Aggregate Demand (AD) curve. If Indonesia were negatively affected, it would experience an increase in unemployment as there would be a downward shift in its AD

curve. Under flexible exchange rates, the Indonesia rupiah could devalue against the Singapore dollar, thereby restoring their respective macroeconomic equilibria. With a high degree of labour mobility between them, the unemployed in Indonesia could move to Singapore, thereby restoring each country's macroeconomic equilibrium without exchange rate adjustments.

In considering the suitability of ASEAN-5 establishing a common currency area using the theory of OCA, a crucial issue is whether there would be sufficient labour mobility. In the case of a high degree of labour mobility, Mundell proposed that they form a currency hard-pegged area, or a common currency area, because currency conversion costs would be unnecessary. The role of money as a medium of exchange would also be enhanced in a common currency area (Colander, 1998, p. 210).

2.1.2. Additional Adjustment Mechanisms

The establishment of a monetary union in ASEAN-5 means the appropriation of national monetary policy and flexible exchange rates as stabilising tools. Mundell argues that, with a high degree of labour mobility, it could replace these stabilising tools in the adjustment of asymmetric shocks. Therefore, the costs of monetary unification would be high for countries that have insufficient labour mobility.

It is apparent that there exist considerable barriers for labour to move freely across countries within ASEAN-5. This is especially so for unskilled labour as there are no specific provisions made to facilitate their movement within the ASEAN Free Trade Area (AFTA) (Lim, 1999). Other barriers could take the form of cultural and language differences, which is significant as ASEAN-5 is a culturally diverse region. Nevertheless, there are additional mechanisms that aid in the adjustment of asymmetric shocks, thereby lessening the costs of monetary unions without a sufficient degree of labour mobility.

Economies that are low in price and wage rigidities would find it easier to adjust to asymmetric shocks within a monetary union (Fleming, 1971). With price and wage flexibility, positively shocked regions could adjust to market signals by allowing their wages and prices to rise. More expensive goods and services relative to the rest of the monetary union results in a loss of competitiveness, so that changes in relative prices

would restore macroeconomic equilibrium in the respective regions. However, a successful monetary union has stable price levels, which is in line with the monetary objective of competent central banks (McKinnon, 1963). Real wage flexibility is viewed more favourably than price flexibility as an adjustment tool for policy-makers. Thus, the costs of monetary unification could be considerably lower in the presence of a high degree of real wage flexibility, assuming central banks seek price stability.

Fleming (1971) observed that the extent of real wage flexibility could be affected by productivity growth rates and/or trade union aggressiveness. Collective bargaining, monopolistic and oligopolistic markets, and natural or stated induced monopolies influence trade union aggressiveness. This highlights the importance of labour institutional factors in considering the establishment of a common currency area.

In Malaysia and Singapore, there are no explicit laws setting minimum wages, so that wages are not downwardly rigid. This would be advantageous towards the adjustment of asymmetric shocks. However, in Indonesia, Thailand and the Philippines, there are laws established at either the national or regional levels that set minimum wages (ERI Economic Research Institute, 2002). This could pose a hurdle for monetary unification as these countries are most likely to be severely affected by negative shocks, as compared with Malaysia and Singapore.

The existence of a fiscal tax-and-transfer policy is required to smooth out the asymmetric macroeconomic shocks within a monetary union (Kenen, 1969). Budgetary transfers are thought to aid in restoring the balance of payments within a monetary union. By increasing taxes on positively shocked regions and transferring them to negatively shocked regions, it could lessen the incidence of inflation in the former regions and unemployment in the latter. Therefore, an OCA should possess a central budgetary mechanism to aid in the adjustment of asymmetric shocks. However, it may seem inconceivable for governments in ASEAN-5 to transfer a considerable amount of their budget surplus to deficit countries within the union, as each would like to serve its national interests.

A monetary union with an existing high degree of labour mobility, real wage flexibility and a strong central budgetary transfer arrangement would weather the adjustments of

asymmetric shocks better than a union that lacks these adjustment mechanisms. However, the need for such adjustment mechanisms depends on the degree of asymmetric shocks experienced within the region. If the monetary union experiences a low degree of asymmetric shocks, a high degree of labour mobility, real wage flexibility and a strong central budgetary transfer arrangement would not be obvious.

The associated costs of a monetary union could be viewed from the perspective of the severity and the degree of asymmetric shocks experienced (Bayoumi and Eichengreen, 1992). This meaning of the OCA theory has proliferated in the empirical literature on testing the degree of asymmetric shocks and the synchronicity of business cycles to investigate the suitability of establishing a common currency.

2.1.3. Contemporary Contributions to the OCA Theory

McKinnon (1963) states that the openness of an economy is important in determining the benefits of establishing a monetary union. The openness of an economy is measured by the ratio of traded to non-traded goods. Under the assumption that monetary authorities seek to stabilise prices, the more open is an economy, the more beneficial it is to join a monetary union. This is because of the high ratio of traded goods to non-traded goods, which could cause greater fluctuations in domestic prices. McKinnon (1963) also noted that a small open economy would find it more beneficial to join a monetary union as its base of non-traded goods is small, thereby making it more susceptible to domestic price instability. ASEAN-5 is composed of small economies with a high degree of openness, and their reliance on export-led strategy spurred much of the growth over the last decade. Ricci (1997) developed a formal two-country trade model with nominal rigidities that allows real and nominal variables. However, he draws ambiguous results on McKinnon's (1963) proposition of the benefits of openness in forming a monetary union.

The more open is an economy, the more flexible are its prices and wages because of the large exposure to international markets. With a large amount of an economy's output being exported, world demand would have a considerable effect on domestic prices (Mundell, 1961). This could mean smaller adjustment costs for the economy in a monetary union that experiences asymmetric shocks.

Kenen (1969) argues that the more diversified are the economies in a union, the less are they likely to suffer from asymmetric shocks because the economy is not overly dependent on particular industries for growth. Thus, a shock in one industry will be reasonably small given the base of the economy. However, the ASEAN-5 economies may not be sufficiently diversified. Indonesia has an economy that is heavily involved in a few industries such as textiles, agriculture, and petroleum and natural gas. The Philippines has an economic structure similar to Indonesia, whereas Thailand, Singapore and Malaysia have rather well diversified economies and are heavily dependent on exports for growth. Therefore, perhaps more important is their need to diversify their exports because about 60% of total exports are in electronics (Lim, 1999). This demonstrates the vulnerability of ASEAN-5 to shocks affecting particular industries.

Habeler (1970) commented that the initial economic characteristics, such as inflation, growth and unemployment levels, of the various economies establishing the monetary union are of secondary importance compared with their *ex post* preferences for these variables. They must agree on rather similar preferences for these variables to make the union work. Tower and Willet (1976) added that a successful common currency area needs a reasonable degree of compatibility with regard to growth, inflation and unemployment levels.

Capital mobility should also be important because the capital account can offset any trade imbalance. As noted by Ingram (1973), even when labour mobility remains perfectly immobile, capital mobility can substitute for labour migration as a mechanism for reallocating resources across regions. However, capital mobility eliminates the need for labour mobility only under constant returns to scale in production.

Krugman and Obstfeld (2000) define an OCA as a region with economies closely linked by trade in goods and services, and by factor mobility. High intra-regional trade would mean shocks can be transmitted easily from one economy to another through extensive trade links, resulting in similar effects from such a shock. Lim (1999) showed that intra-East Asian trade in total has increased from 34.4% in 1981 to 50.4% for 10 East Asian countries in 1997.

Income convergence helps to promote economic and monetary integration in the long run (Barro and Sala-i-Martin, 1992). Countries at different stages of economic development would most likely experience asymmetric shocks because of differences in economic structures. Using convergence tests, namely beta convergence, sigma convergence, and common trends, Singapore, Malaysia and Thailand seem to be one convergence club, and Indonesia and the Philippines another (Lim, 1999). However, the convergence of income remains a controversial issue.

The "endogeneity" versus "specialisation" argument of establishing a monetary union also needs to be considered. Advocates of the endogeneity proposition suggest that establishing a monetary union would reduce the degree of asymmetric shocks among participating economies because trade links will deepen, which leads to more correlated business cycles (Frankel and Rose, 1998). However, Krugman and Venables (1996) argue that monetary unification would lead to a higher degree of asymmetric shocks, as participating economies tend to specialise in industries in which they have a comparative advantage.

2.1.4. Critics of the OCA Theory

McKinnon (2000) criticises Mundell's OCA theory as it assumes there is no forward-looking behaviour undertaken by private agents in the market. Individuals do not anticipate future movements in prices, interest rates, the exchange rate and government policy in Mundell's model. If they did, a negatively shocked region could spiral downwards as consumers postpone purchases in anticipation of lower future prices. Mundell showed how common currency countries could mitigate asymmetric shocks by improved reserve pooling and more efficient forward contracting. However, Frankel and Mussa (1980) succeeded in further developing the forward-looking asset approach to exchange rates.

Giersch (1973) argues that migration is inferior to flexible exchange rates as a stabilising tool because migration has a longer response time and is irreversible. However, Dornbusch's (1976) overshooting and Nurske's (1961) speculation destabilisation propositions show that flexible exchange rates may be more destabilising than stabilising due to its rapid response to market conditions.

Boone (1997) suggests that the OCA criteria may not be relevant in determining the suitability of forming a monetary union. When economies are integrated through monetary unification, the *ex ante* degree of asymmetric shocks experienced would be different from the *ex post*. According to the endogeneity argument, the degree of asymmetric shocks experienced will decrease after unification as participating economies become more integrated through trade links. On the contrary, the specialisation argument suggests the degree of asymmetric shocks will increase as economies specialise in industries in which they have a comparative advantage. These arguments present a problem of anticipating how participating economies will evolve after monetary unification. However, researchers state that their purpose in examining the costs of monetary unification for a region is to know the situation before unification. With this information, governments can then decide whether the benefits of monetary unification are more compelling than the costs.

The pioneering work of Mundell lacks an empirical framework for analysing monetary unions based on the OCA properties. Empirical content is not available to quantify variables such as the degree of labour mobility required to consider a common currency area as optimal. Moreover, the degree of fiscal federalism needed to smooth out asymmetric shocks may not be explicit empirically. In view of these limitations, researchers have adopted techniques to quantify the concept while retaining the OCA properties as pivotal guidelines. They have measured the degree of labour mobility using the USA as a yardstick for comparison since, by definition, it is a smoothly functioning monetary union. Thomas (1994) examined the differences between European and US responses to an employment shock. Decressin and Fatas (1993) studied the differences between Europe and the USA in their unemployment rates between regions. Another approach is to study the degree of asymmetric shocks across countries, as will be discussed in the next section.

2.2. Investigating Asymmetric Shocks

2.2.1. Earlier Empirical Methods

The empirical literature of investigating the degree of asymmetric shocks for gauging the costs of establishing a common currency area has been focused almost entirely on

European countries. This is understandable as European countries were actively working towards a monetary union during this period.

It is important to note that, although the contemporaneous correlation of shocks between two countries might be relatively low, the two economies could still be in similar positions in the business cycle and not require divergent monetary policies or exchange rate adjustments. While the correlation of shocks might be very high, the transmission mechanisms might be sufficiently different to justify an exchange rate adjustment (Lafrance and St-Amant, 1999). Thus, the similarity of business cycles is an important factor in analysing whether there would be considerable adjustment costs for ASEAN-5.

Poloz (1990) estimated the degree of asymmetric shocks in France, the UK, Italy and Germany by computing the variability of national real exchange rates. He argued that changes in real exchange rates would shift the demand and supply curves of economies relative to each other because the real exchange rate is a relative measure of the prices of goods and services. Therefore, their changes reflect the shocks the economy has received. However, this method does not account for the fact that the economy could have adjusted from shocks through other means, and changes in real exchange rates would not reflect the full extent of the shock. Poloz compared the results of France, the UK, Italy and Germany against the results from regional real exchange rates within Canada, and found that the four countries were less variable than Canada. He concluded that a monetary union of France, the UK, Italy and Germany could be as successful as Canada, which is a smoothly functioning monetary union (Mundell, 1961).

Eichengreen (1990) used Poloz's (1990) approach to measure the variability of real exchange rates of ten European Committee (EC) member states. He compared the exchange rate variability of the 10 EC member states with four US regions, namely North East, North Central, South and West, as the USA is considered to be a smoothly running monetary union and with a similar economic size. Eichengreen found greater variability in real exchange rates within the EC than within the USA, thereby suggesting that the ten EC member states do not constitute an OCA.

Another approach for measuring the degree of asymmetric shocks is to compute the variability of output. Cohen and Wyplosz (1989) used time series data of output to

investigate the asymmetry of shocks. They transformed the real GDP of France and Germany into sums and differences, interpreting changes in the sums as symmetric disturbances and changes in the differences as asymmetric disturbances. Using alternative detrending methods, they compared the variance of the detrended sum to that of the detrended difference between the same series. Following their interpretation, symmetric shocks are predominantly permanent, while asymmetric shocks are predominantly temporary. They found that the variance of the sum is relatively larger than the variance of the difference, so that fluctuations in output are largely symmetric in France and Germany.

Eichengreen (1990) investigated the degree of asymmetric shocks by analysing the covariance of economic indicators between pairs of countries. According to the efficient market hypothesis, real share prices should reflect the present value of current and expected future profits. In the presence of asymmetric shocks, profits will rise in one market relative to another, and this is reflected in the real share prices. He analysed the covariance of real share prices of Toronto and Montreal, and of Paris and Dusseldorf. Real share prices in the Canadian pair were found to have a higher covariance compared with the European pair, thereby suggesting that shocks are more asymmetric in the latter than in the former.

The main drawback of the approaches mentioned above is that, by examining the variance of an aggregate series such as real output, real share prices or real exchange rates, it is not possible to distinguish between the effects of shocks (impulse) and the dynamic response to these shocks (propagation). This difficulty arises because markets could quickly adjust by the flow of labour, capital and relative prices, thereby smoothing out the actual effects of asymmetric shocks. Such a problem leads to the investigation of asymmetric shocks using the Blanchard and Quah (1989) vector autoregressive (VAR) approach.

2.2.2. Investigating Asymmetric Shocks using VAR

Bayoumi and Eichengreen (1992) applied the Blanchard and Quah (1989) vector autoregressive (VAR) approach to identify the underlying structural shocks. The isolation of shocks allows a study of the symmetry of shocks to be separated from their speed of adjustment. Hence, it overcomes the problem of fused information on the symmetry of shocks and on the speed of adjustment in earlier methods of analysing symmetry.

Consider an infinite moving average (MA) system as follows:

$$\Delta x_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + \cdots = A(L)\varepsilon_t \qquad (2.2.1)$$

where $\Delta x_t = [\Delta y_t, \Delta p_t]'$ and $\varepsilon_t = [\varepsilon_{dt}, \varepsilon_{st}]'$. The variables y_t and p_t are the logarithms of output and prices, respectively, and ε_{dt} and ε_{st} are mutually orthogonal supply and demand shocks, with covariance normalised to the identity matrix. Rewrite (2.2.1) as follows:

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{dt} \\ \varepsilon_{st} \end{bmatrix} \qquad (2.2.2)$$

where $A_{ij}(L) = a_{ij}^0 + a_{ij}^1 L + a_{ij}^2 L^2 + \cdots$. Each element of Δx_t in equation (2.2.1) can be regressed on lagged values of all the elements of x. Therefore, the reduced form VAR model is:

$$\Delta x_t = B(L)\Delta x_{t-1} + u_t \qquad (2.2.3)$$

where B represents the estimated coefficients and u_t is a vector of reduced form disturbances. Since the elements of Δx_t are stationary, we can invert it to obtain the MA representation of equation (2.2.4) as follows:

$$\Delta x_t = C(L)u_t \qquad (2.2.4)$$

where $C(L) = [1 - B(L)]^{-1}$ and the lead matrix of C(L) is, by construction, $C_0 = I$. As the relationship between the structural and reduced form disturbances is $u_t = A_0\varepsilon_t$, it is necessary to obtain estimates of A_0 to recover the supply and demand shocks. Bayoumi and Eichengreen (1992) impose four restrictions, namely two of simple normalisation, one of orthogonal supply and demand shocks, and another of demand shocks having a temporary effect on output. The last restriction implies $A_{11}(L) = 0$ in (2.2.2). These restrictions allow the lead matrix C to be uniquely defined. Henceforth, the following

relationship between the covariance matrices is obtained: $C(1)\Sigma C(1)' = A(1)A(1)'$, where $\Sigma = Eu_t u_t' = EA_0 \varepsilon_t \varepsilon_t' A_0' = A_0 A_0'$. Subsequently, letting H denote the lower triangular Choleski decomposition of $C(1)\Sigma C(1)'$, they obtain $A(1) = H$ and $A_0 = C(1)^{-1} A(1) = C(1)^{-1} H$. Given an estimate of A_0, the time series of structural shocks can be recovered (Zhang, Sato and McAleer, 2002).

Following the decomposition of the structural shocks, Bayoumi and Eichengreen (1992) measure how the demand and supply shocks affecting the different countries of the EC and different regions of the USA are correlated with benchmark countries (Germany for Europe and the Mid-East for the USA). They found that disturbances tend to be more highly correlated in the USA compared with the EC, even when the comparison is limited to the EC and USA core group of countries (Germany, France, Belgium, Luxembourg, the Netherlands and Denmark for the EC, and Mid-East, New England, Great Lakes, Plains, South East and Far West for the USA). From this, they inferred that the EC suffers from a higher degree of asymmetric shocks compared with the US regions.

Additionally, Bayoumi and Eichengreen (1992) measured the relative size of the underlying supply and demand shocks for the EC and US regions, and found that the US regions experienced supply shocks of similar size to the core EC. However, relative to the EC, the USA experienced smaller supply shocks. For demand shocks, a surprising finding is that the US regions have somewhat larger shocks than does the EC.

Moreover, the impulse response functions, which determine output and price response to the demand and supply shocks, suggest that the USA shows a faster response to shocks than the EC, even though they do not have flexible exchange rates. The authors concluded that there are considerable costs for the EC to form a monetary union.

Following the Bayoumi and Eichengreen (1992) methodology, Chamie, DeSerres and Lalonde (1994) use a three-variable rather than two-variable VAR system. They argued that monetary shocks akin to demand shocks also have temporary effects on output. Establishing a monetary union necessarily means appropriating the national monetary policy, so that it is important to identify this component of the shocks. Their findings

agree with those of Bayoumi and Eichengreen (1992) in that the EC does not appear to be an OCA.

Zhang, Sato and McAleer (2002) apply a three-variable VAR model as in Blanchard and Quah (1989) to East Asian countries. They recovered the supply, demand and monetary shocks in a manner similar to the decompositions of Bayoumi and Eichengreen (1992). Realising that the estimation of structural shocks includes the effects of foreign shocks, namely global, regional and country-specific shocks, they employed the seemingly unrelated regression (SUR) method to remove the effect of global (or US) shocks on local structural shocks. Their results showed that supply shocks are significantly correlated among some ASEAN countries, namely Indonesia, Malaysia, Singapore and Thailand. However, demand and monetary shocks are less correlated among these economies during the sample period, which suggests that the ASEAN countries may not be prepared for monetary unification.

These authors measured the correlations of the three identified shocks for the periods 1980Q1-1997Q1 and 1980Q1-2000Q3. An interesting result is that they found an improvement in the number of significant positive correlations of shocks, as well as an increase in the degree of positive correlation of shocks experienced among these economies after the “Asian flu” of 1997. This suggests that the correlations of shocks increase during a crisis. Such an increase in the correlations of shocks would mean that shocks are more symmetric across the region after shocks, suggesting that they might not suffer from such high adjustment costs. Therefore, countries that are linked by contagion would incur lower costs of establishing a monetary union. During contagion, appropriate government intervention is extremely important. Having a high symmetry of shocks would suggest that the linked countries benefit from using the same policy tools, and hence are suitable for a monetary union.

Examining a group of countries as to their suitability of establishing a common currency area from a contagion perspective is helpful as it provides insight as to whether their correlations increase in times of crisis. If their correlations increase, the degree of asymmetric shocks experienced will be lower, thereby decreasing the costs of monetary unification. Measuring the degree of correlation of shocks using contagion reflects the dynamic effects of shocks.

2.3. The Effects of Contagion

Economies that experience a high degree of asymmetric shocks are not affected in a similar manner by the same shock in that some are hit hard while some may even gain. Indonesia, Malaysia, Singapore and Thailand have positively and significantly correlated shocks for the period 1980 to 1997. There was an increase in the positive correlation after the Asian crisis, which suggests that these economies may be more closely integrated than was previously thought (Zhang, Sato and McAleer, 2002). Even if they are not as highly integrated as might be perceived, they are viewed as a group that is similar in economic structure and heavily dependent on one another.

An interesting case arises in the increase in the positive correlation of shocks among ASEAN-4 (comprising Indonesia, Malaysia, Singapore and Thailand) during the Asian financial crisis. According to the OCA, if a group of economies has a high positive correlation in shocks, they are unlikely to experience substantial costs of monetary unification. If the positive correlations of shocks experienced in ASEAN-4 increased during the Asian crisis, it would be expected that these economies would have experienced lower costs in establishing a monetary union.

Such an increased correlation during a crisis may indicate that a group of economies is suitable for establishing a monetary union. The positive and significant correlation of shocks among ASEAN-4, as shown in Zhang, Sato and McAleer (2002) before the crisis, is likely to be an indication of the extensive trade, financial and political connections in the region. Krugman and Obstfeld (2000) argue that economies that are closely linked by trade are less likely to suffer from asymmetric shocks because of transmissions through fundamental links such as trade, financial markets and political relationships. Hence, the increase in the correlation of shocks after a crisis suggests that there are increases in fundamental linkages, or that the shocks are transmitted across economies beyond fundamental links. If these fundamental links are indeed strengthened among these countries then, according to Krugman and Obstfeld (2000), the degree of asymmetric shocks would decrease, and they would experience lower costs in monetary unification. However, if the transmission was beyond fundamental links, then the economies of ASEAN-4 could be more of an OCA than was previously thought, according to the fundamental links. If such links among economies extend beyond the fundamentals, the

transmissions of shocks would be more pronounced. Therefore, the degree of asymmetric shocks would be reduced, especially in times of crises when government intervention is perceived to be crucial. Hereafter, the presence of contagion is relevant in determining the suitability of economies in establishing a common currency area.

2.3.1. The Theory of Contagion

In 1997, East Asia experienced the Asian financial crisis that saw tumbling currency and financial markets. Similar to the "Tequila effect" in 1994, the "Russian cold" in 1998, and the "Brazilian fever" in 1999, these events began as asymmetric shocks but quickly spread to other countries, especially those in the same region (Glick and Rose, 1998).

The phenomena of these cross-country transmissions of macroeconomic shocks have been termed "contagion". There is no consensus among economists as to the definition of, and what constitutes, contagion. According to the World Bank (2002), contagion involves the transmission of macroeconomic shocks through channels that are beyond fundamental links across countries. The interaction of economies is usually through the established links of trade, financial markets and political institutions, such that the properties of one economy spread to another. However, contagion is beyond such established links and cannot be explained easily.

A useful approach for analysing contagion is to examine the fundamentals of a country, such as the trade account balance, the budget account balance, and foreign debt levels. Advocates of this approach view financial and currency crises as the unavoidable outcome of unsustainable policy stances or structural imbalances (Krugman, 1979). They investigate crisis-hit economies for similarities in fundamentals, and examine how a crisis in one market affects the fundamentals in other economies (Kaminsky, 1998).

An alternative strategy to analyse contagion is from the self-fulfilling approach, whereby the fundamentals of the economy are sound, but the interactions between investor expectations and actual policy outcomes lead to crises (Eichengreen and Wyplosz, 1993). This interaction of expectations and policy leads to multiple equilibria (Masson, 1999).

Contagion may also be perceived as being based on “herding” behaviour. This approach assumes that information is costly to acquire, and hence investors infer information from one market and apply it indiscriminately to other markets (Banerjee, 1992). Calvo and Mendoza (1997) argue that herding behaviour is increased by globalisation of financial markets. When the share of a particular country’s assets in an investor’s portfolio declines, the value of country-specific information becomes smaller and the incentives for herding behaviour grow stronger.

In spite of the different definitions of contagion, researchers agree that contagion extends beyond fundamental links. Even supporters of the “fundamental” approach concede that the evidence from examining the fundamentals is insufficient to analyse contagion adequately.

2.3.2. Strategies to Test for Contagion

Several strategies are available to examine the spillover effects beyond fundamental links. The first strategy tests whether a stock market responds to bad foreign news. Kaminsky and Schmukler (1999) examine the reaction of financial markets to news, and develop a simple regression model to test for the significance of the coefficient of news. Using 8 dummy variables, each representing one kind of news, and a no-news dummy, they found that, except for fiscal news, information released has significant impacts on the prices of stock market returns. This is especially so for news that is related to agreements with international organisations and credit rating agencies.

Another strategy determines whether a country’s probability of experiencing a crisis increases during a crisis in other countries, after controlling for economic fundamentals. Eichengreen, Rose and Wyplosz (1997) found that the probability of a country experiencing a crisis is correlated with the incidence of a crisis in other countries, after controlling for economic fundamentals, based on a probit model and sensitivity analysis. However, they noted that this increased probability could be due to a common shock affecting all countries.

A more common strategy is to evaluate contagion by testing whether asset prices across countries have a significant increase in correlation, after controlling for market

fundamentals. King and Wadhwani (1990) measured contagion as a significant increase in the correlation between assets returns, and tested for an increase in stock market correlations among USA, UK and Japan. They found that correlations increased after the US stock market crash. Similarly, Frankel and Schmukler (1996) showed that the prices of country funds in Latin America and East Asia displayed a higher correlation than Mexican funds.

Forbes and Rigobon (2001a) observed that an increase in market volatility biases the estimates of cross-market correlation coefficients due to heteroscedasticity in market returns. Their solution to the problem is to adjust the conditional correlation coefficient for the bias according to the following procedure. They assume that the model is given by:

$$y_t = \alpha + \beta x_t + \varepsilon_t \qquad (2.3.1)$$

where $E(\varepsilon_t) = 0,\ E(\varepsilon_t^2) < \infty,$ and $E(x_t \varepsilon_t) = 0$. Such models measure contagion using two samples to compare differences in the covariances. One group is perceived to be tranquil (*l*), and the other to have contagion present (*h*). Since $E(x_t \varepsilon_t) = 0$, the OLS estimates for equation (2.3.1) would be consistent and efficient for both groups of data, so that $\hat{\beta}^h = \hat{\beta}^l$. Next they define:

$$1 + \delta = \frac{\sigma_{xx}^h}{\sigma_{xx}^l} \qquad (2.3.2)$$

as the variance of stock price changes are

$$\sigma_{yy}^h = \beta^2 \sigma_{xx}^h + \sigma_{ee}. \qquad (2.3.3)$$

Substituting equation (2.3.2) into (2.3.3) yields the following:

$$\sigma_{yy}^{h} = \beta^2(1+\delta)\sigma_{xx}^{l} + \sigma_{ee}$$

$$= (\beta^2\sigma_{xx}^{l} + \sigma_{ee}) + \delta\beta^2\sigma_{xx}^{l}$$

$$= \sigma_{yy}^{l} + \delta\beta^2\sigma_{xx}^{l}$$

$$= \sigma_{yy}^{l}\left(1 + \delta\beta^2\frac{\sigma_{xx}^{l}}{\sigma_{yy}^{l}}\right). \qquad (2.3.4)$$

Combining (2.3.4) with the correlation coefficient yields:

$$\sigma_{yy}^{h} = \sigma_{yy}^{l}\left[1 + \delta\left(\rho^{l}\right)^2\right]. \qquad (2.3.5)$$

It follows from equation (2.3.5) that:

$$\rho^{h} = \frac{\sigma_{xy}^{h}}{\sigma_{x}^{h}\sigma_{y}^{h}}$$

$$= \frac{(1+\delta)\sigma_{xy}^{l}}{(1+\delta)^{1/2}\sigma_{x}^{l}\left[1+\delta\left(\rho^{l}\right)^2\right]^{1/2}\sigma_{y}^{l}}$$

$$= \rho^{l}\sqrt{\frac{1+\delta}{1+\delta\left(\rho^{l}\right)^2}}\ . \qquad (2.3.6)$$

Equation (2.3.6) shows that the correlation coefficient is an increasing function of δ, and quantifies the bias and establishes the adjustment necessary to the conditional correlation coefficient.

Given the adjustment to the correlation coefficient, Forbes and Rigobon (2001a) show that there is little evidence of contagion between stock markets in the 1987 US stock market crash, the 1994 Mexican peso crisis, and the 1997 Asian crisis. Although the markets were closely linked, no evidence of contagion was detected.

Measuring contagion as a significant increase in the correlation coefficient yields bias in estimation. As highlighted in Forbes and Rigobon (1999), the problems in such empirical work are heteroscedasticity, simultaneous equations bias and omitted variables. Rigobon (2001a) developed the Determinant of the Change in Covariance (DCC) matrix test to overcome these problems. The method uses the differences in covariances to eliminate such problems, with the problems in the previous covariance eliminating those in the current covariance. It is concluded that the unconditional correlations of returns across emerging markets, such as ASEAN, are generally high. Volatility, as measured by the fourth moment of expected returns in equity and bond markets, increases sharply during periods of crisis.

The methods discussed above for measuring contagion require a determination of the period of tranquillity and crisis. As shown in Dungey and Zhumabekova (2001), this affects the power of the tests. The splitting of the sample data into tranquil and crisis (or contagion) periods results in a test with low power, and extending the crisis sample period can reverse the inferences. Caporale, Cipollini and Spagnola (2002) overcome this problem by allowing for full sample estimation using a dummy variable. Moreover, using the sequential dummy variable method of selecting the breakpoints for tranquility and contagion, it is not necessary to select the beginning and end of a crisis arbitrarily. An incorrect division of a sample into tranquility and contagion could affect the credibility of the results because data from contagion could be in the tranquil data set, and vice-versa.

Caporale, Cipollini and Spagnola (2002) also modelled the variances of the stock market price changes as a generalised autoregressive conditional heteroscedasticity (GARCH) process to circumvent the heteroscedasticity problem, and included a common shock to accommodate omitted variables. They found evidence of contagion for most of the country pairs, specifically, from Thailand to Indonesia, Malaysia, South Korea, Hong Kong, Singapore, Taiwan and the Philippines. Moreover, contagion is evident from Singapore and the Philippines to all of these countries. Both Malaysia and Indonesia are found to be contagious for Indonesia and South Korea.

The advantages of the Guglielmo, Cipollini and Spagnola (2002) approach allow contagion to be measured credibly. Therefore, this approach is adopted in the empirical section below to test for the evidence of contagion between pairs of countries in ASEAN-

5. Instead of using stock market returns, contagion will be examined for pairs of currency exchange markets.

3. Data and Methodology

3.1. Data

Foreign exchange rate data for seven countries, namely Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, 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 (Kaminsky and Schmukler, 1999). 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.

It is worth highlighting that the sample data enable an investigation of the presence of contagion between pairs of ASEAN-5 countries during the “Asian flu” in 1997. However, over the same period, other crises, namely the “Tequila effect” in 1994, the “Russian cold” in 1998, and the “Brazilian fever” in 1999, were also developing in their respective regions.

3.1.1. Preliminary Observations

Of primary concern are changes in the value of foreign exchange rates, which are given as:

$$y_t = \frac{Y_t - Y_{t-1}}{Y_{t-1}}$$

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 plots of the returns of foreign exchange rates for Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, and Thailand are given in Figures 3.1.1 – 3.1.7:

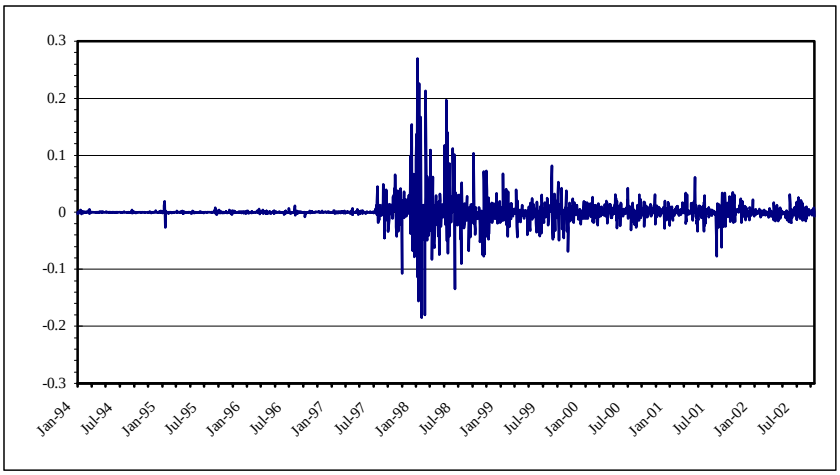

Figure 3.1.1: Indonesia Rupiah Returns

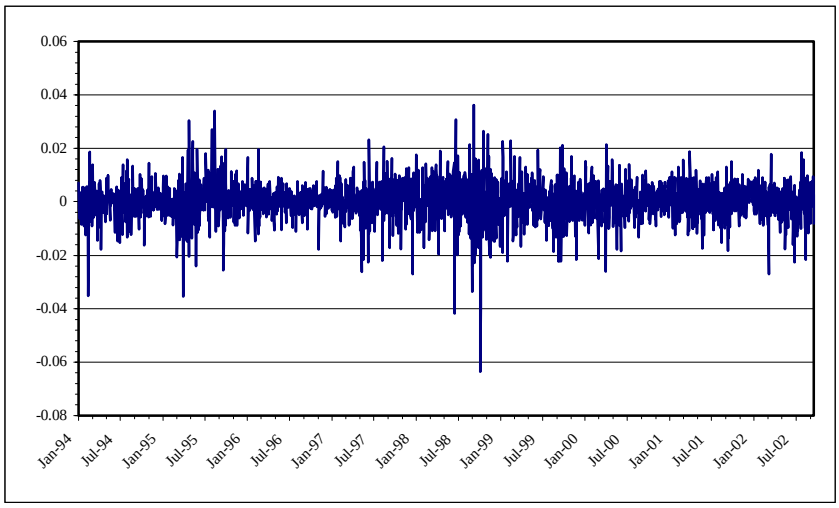

Figure 3.1.2: Japan Yen Returns

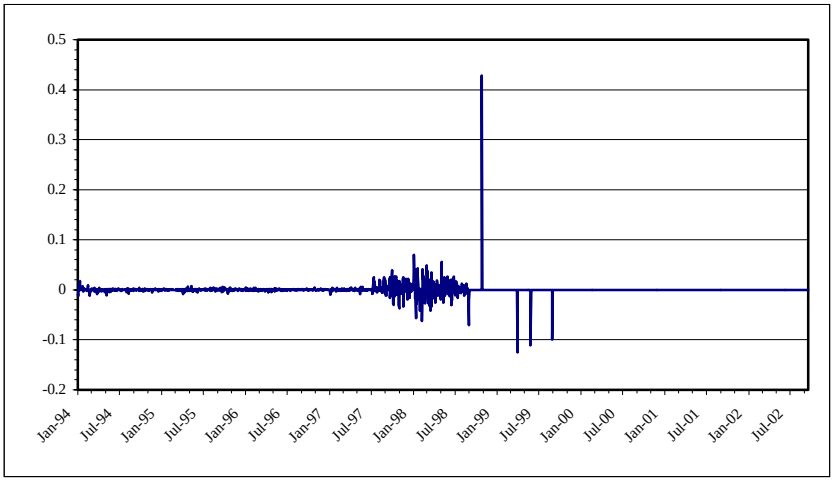

Figure 3.1.3: Malaysia Ringgit Returns

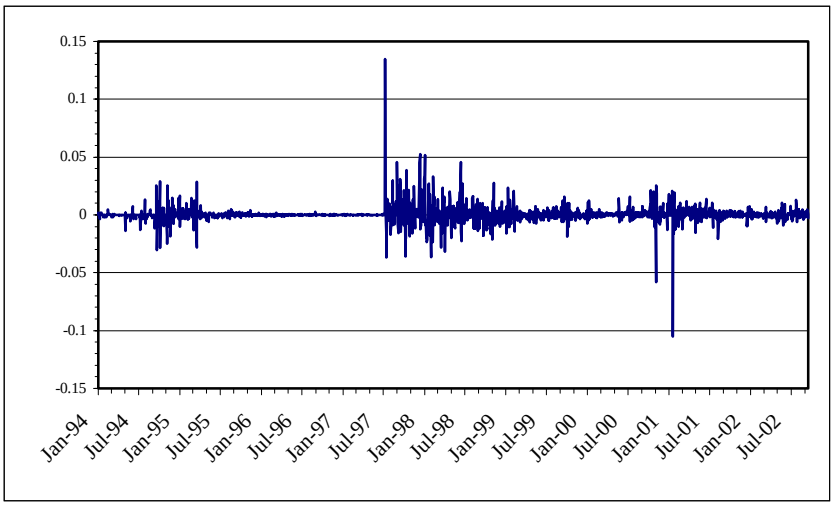

Figure 3.1.4: Philippines Peso Returns

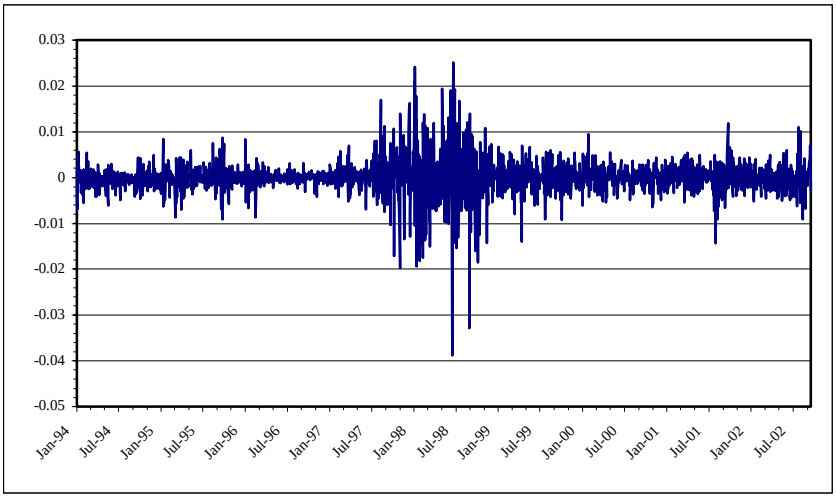

Figure 3.1.5: Singapore Dollar Returns

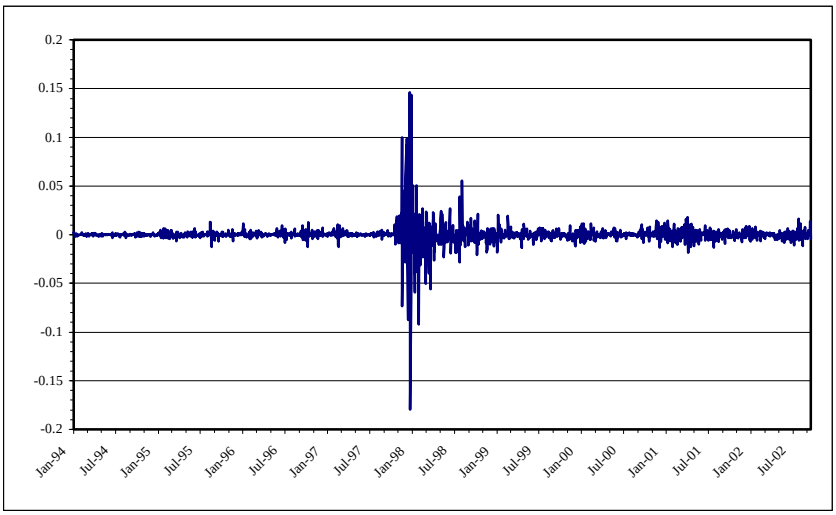

Figure 3.1.6: South Korea Won Returns

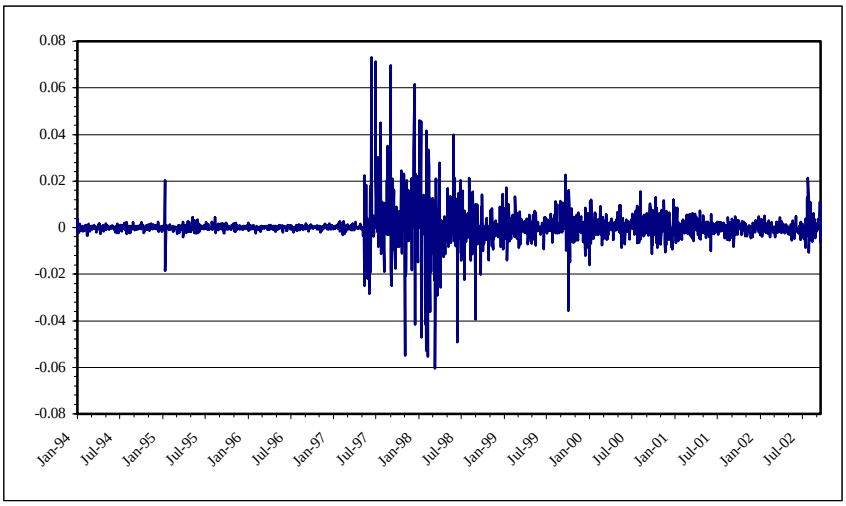

Figure 3.1.7: Thailand Baht Returns

From the above plots, an obvious increase in volatility is observed after July 1997 for all the foreign exchange rates of the ASEAN-5 economies. This corresponds with the Asian economic and financial crises, and suggests that these countries were affected similarly by the same macroeconomic shocks.

The Indonesia rupiah seems to be the most volatile currency in ASEAN-5, especially after the Asian crisis, which reflects the economic and political upheavals plaguing the country. From the figure, the largest devaluation of the Indonesia rupiah was by 27 percent at observation 1049, which corresponds to the share market crash of 18.5 percent in mid-afternoon trading.

After the Asian crisis, the Malaysia ringgit was pegged to the US dollar. Outliers observed after the crisis indicate pegging adjustments made by Bank Negara, Malaysia's central bank. The largest adjustment to the US Dollar peg is at observation 1258, which is a 42.9 percent downward revision of the ringgit.

A significant outlier for the Philippine peso is at observation 920, when the value of the currency plummeted by 13.5 percent. This corresponds with the beginning of Philippine economic woes when speculators attacked the currency. Subsequently, the Bangko Sentral ng Philipinas, the Philippine central bank, floated the peso freely after initially failing to defend it.

The Thailand baht appears to have the largest number of outliers, which is evident during the crisis period. Thailand has been labelled as the first ASEAN-5 country to experience the crisis when speculators attacked the baht on 14 and 15 May 1997, after the government failed to make payments on foreign debt.

Singapore's dollar appears to be the least volatile currency in ASEAN-5. Although there are some obvious outliers and extreme observations, the outliers are not particularly large in comparison with the other currencies.

During late-1997, the South Korea won increased in volatility, which is attributable to the contagion effect from the Asian crisis. Even after the crisis, volatility still remained high compared with the tranquil pre-crisis period.

Volatility in the Japan yen appears to be regular, even during the Asian crisis, which shows that the yen was not affected by the crisis. However, the average volatility in the yen is still higher than the average volatility in the Singapore dollar. This suggests that the yen is a heavily traded currency, and could have been marginally affected by the "Tequila effect", the "Russian cold", or the "Brazilian fever".

Comparing the pre-crisis and post-crisis foreign exchange rate volatility, the Indonesia rupiah, the Philippines peso and the Thailand baht reflect higher *ex post* volatility, thereby suggesting their specific-country risk may have increased after the crisis.

3.1.2. Testing for Unit Roots

The purpose of this section is to establish whether the relevant variables are stationary. In the presence of non-stationarity, the correlations can be (at least) partly spurious, particularly when the variables involved exhibit consistent trends (Nelson and Kang, 1984). Stationarity means that both the joint probability distribution and the conditional probability distribution are invariant with respect to time. Classical statistical inference, in general, is designed for variables which are stationary, in the sense that their mean, variance and covariance remain time invariant.

Dickey and Fuller's (1979) Augmented Dickey-Fuller (ADF) test was used to determine the relevant orders of integration. Consistent with prior studies using exchange rates, the null hypothesis of a unit root for the logarithmic differences of foreign exchange rates was rejected. According to prior studies using foreign exchange rates, the data in levels can be plagued by non-stationarity. Taking logarithmic differences of foreign exchange rates in levels rids the data of non-stationarity. The ADF test also indicates there is no deterministic trend in the data, as can be seen by comparing the ADF test statistic with trend against one without trend. An order up to twelve lags was chosen for the ADF test statistics. In testing for unit roots with the ADF test, the Dickey-Fuller distribution is used instead of the standard normal distribution to determine critical values because the t-statistic for the ADF test is not asymptotically normal (Dickey and Fuller, 1979).

In the case of failing to reject the null hypothesis of a unit root, the apparent unit root could be a structural change. Visual inspection of the data does, in fact, suggest a

structural change. Alternatively, the Phillips-Perron test (1988) could be used, which is known to have a higher power of rejecting the null hypothesis.

3.2. Empirical Method

The empirical method examines two key issues: (1) to ascertain the presence of contagion between pairs of ASEAN-5 countries, and its effect on foreign exchange rates in ASEAN-5; and (2) to examine the effect of omitting an important country from the analysis. This is achieved through robustness checks by including an additional country that has been affected by contagion during the Asian crisis.

3.2.1. The Analytical Model

In Section 2, several shortcomings of existing empirical models for testing contagion were noted, in particular, the requirement 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). This is an improvement from the dominant approaches in the contagion literature, such as King and Wadhwani's (1990) method of measuring contagion as a significant increase in the correlation between asset returns, and Rigobon's (2001a) DCC test.

As contagion does not necessarily have a widely accepted interpretation, the definition introduced by Forbes and Rigobon (2001b), 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:

$$y_t = \alpha_0 x_t + \alpha_1 * D_t * x_t + \gamma z_t + \varepsilon_{yt}$$
$$x_t = \beta_0 y_t + \beta_1 * D_t * y_t + z_t + \varepsilon_{xt} \qquad (3.2.1)$$

$$h_{yt} = (1 - \delta_1 - \delta_2) + \delta_2 \varepsilon^2_{yt-1} + \delta_1 h_{yt-1}$$
$$h_{xt} = (1 - \delta_3 - \delta_4) + \delta_4 \varepsilon^2_{xt-1} + \delta_3 h_{xt-1} \qquad (3.2.2)$$

Equation (3.1.1) 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 (3.2.1) 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. Structural shocks ε_{yt} and ε_{xt} are assumed to follow a GARCH (1,1) process, as represented by (3.2.2).

Imposing identifying restrictions of the following type in the simultaneous equations system (3.2.1) 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 Chow's (1960) first 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 (as suggested by Sentana (1992) and Sentana and Fiorentini (2001); for an application, see King, Sentana and Wadhwani (1994)).

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)

and (2). The unrestricted model with $\alpha_1 \neq 0$ in (1) and (2) is exactly identified (Caporale, Cipollini and Spagnolo, 2002).

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.

3.2.2. Modelling the Structural Shocks

There is substantial evidence that financial data, such as exchange rates, exhibit conditional heteroscedasticity, which is the clustering of large and small disturbances (see Domowitz and Hakkio, 1985). OLS estimation for a model with heteroscedastic errors generally produces standard errors and confidence intervals that are too small, leading to incorrect inferences. Caporale, Cipollini and Spagnolo (2000) model the structural shocks ε_{yt} and ε_{xt} as following a GARCH (1,1) process, as shown in (3.2.2).

Bollerslev (1986) developed the GARCH process to model time-varying conditional variances as a function of lagged squared unconditional shocks and lagged conditional variances. The GARCH (p,q) model is given as:

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_i h_{t-i} \qquad (3.2.3)$$

where $\omega > 0$, $\alpha_i \geq 0$ (i = 1, ..., p) and $\beta_i \geq 0$ (i = 1, ..., q) are sufficient conditions to ensure that $h_t > 0$. Although GARCH is designed to model time-varying conditional variances, it often fails to capture highly irregular phenomena, such as extensive market fluctuations and other unanticipated events that lead to structural change. This result arises because of the restrictions that need to be imposed on the parameters in GARCH to ensure that the conditional variances are positive. Such difficulties can cause problems in correctly

modelling the errors, especially when the data exhibit extreme observations and outliers. Hence, the GARCH model is a parametric specification that operates best under relatively stable market conditions (Gourieroux, 1997, pp. 29-51). From the above, GARCH may not be appropriate to model the errors in the data set used here because the data displayed extensive market fluctuations during the Asian crisis. Incorrect modelling of the errors using GARCH can lead to bias in the inferences.

In view of the above, an alternative to the GARCH model, Nelson's (1991) Exponential GARCH (E-GARCH), could be used for modelling the errors because it models the logarithm of the conditional volatility. The model is available in several alternative forms, but the most common is:

$$\log h_t = \omega + \sum_{i=1}^{p} \alpha_i \left\{ \left| \frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} \right| - E\left| \frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} \right| + \gamma_i \frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} \right\} + \sum_{i=1}^{q} \beta_i \log h_{t-i} \qquad (3.2.4)$$

E-GARCH can model errors without imposing positivity restrictions on the coefficients, since the range of $\log h_t$ is the real number line. Additionally, it is able to model empirical irregularities, such as large negative shocks having a greater impact than large positive shocks, and small positive shocks having a greater impact than small negative shocks. Unfortunately, there are as yet few theoretical results regarding the regularity conditions for the existence of moments, or any theoretical results as to the statistical properties of the quasi-maximum likelihood estimates. Such lack of knowledge of the asymptotic distribution makes the calculated t-ratios of the estimates problematic.

3.2.3. Orthogonality of Shocks

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 [$cov(z_t, \varepsilon_{yt}) = 0$ 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 the regressors.

Consider the following system:

$$y_t = \alpha_0 x_t + \alpha_1 * D_t * x_t + \upsilon_{yt}$$
$$x_t = \beta_0 y_t + \beta_1 * D_t * y_t + \upsilon_{xt} \qquad (3.2.5)$$

where (3.2.5) is similar to (3.2.1), but without a common shock in both equations. A common shock such as the devaluation of the Japan 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 Japan yen and US dollar (Lim, 1999). In (3.2.5), the effect of the Japan 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 accomodate the problem. The Japan 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.

As mentioned above, the existence of other crises, namely the "Tequila effect", the "Russian cold" in 1998, and the "Brazilian fever" in 1999, may also have had an impact. This is the same argument as the influence of a common shock to both y_t and x_t, rendering OLS estimates inconsistent. The solution is to model these as common shocks. However, as the Japan yen is sensitive to the shocks in the global economy, as seen from the fluctuations of the yen in Figure 3.1.2, it should capture the disturbances that arise in ε_{yt} and ε_{xt}.

4. Empirical Results

4.1 Estimation

Estimating the model in (3.2.1) using Microfit 4 for each pair of countries for the entire sample yields the results given in Tables 1-6. Table 1 reports the estimates for the coefficients associated with the dummy variables and the corresponding OLS t-ratios in parentheses. White's (1980) 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, 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, 2002).

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 (Lim, 1999). 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
		0.19	0.06	0.05	0.09
		(8.15)	(4.37)	(7.46)	(6.58)
INDONESIA		[4.87]	[1.57]	[3.27]	[2.57]
	1.90		0.34	0.30	0.62
	(22.42)		(12.07)	(25.34)	(21.28)
MALAYSIA	[7.70]		[6.48]	[11.64]	[8.42]
	2.04	0.68		0.22	0.59
	(13.90)	(9.26)		(10.37)	(13.26)
PHILIPPINES	[4.25]	[6.07]		[4.62]	[5.45]
	4.60	1.41	0.50		1.16
	(20.97)	(10.83)	(5.71)		(14.27)
SINGAPORE	[6.28]	[6.91]	[2.16]		[4.81]
	1.43	0.68	0.21	0.20	
	(12.61)	(10.56)	(5.46)	(11.62)	
THAILAND	[4.94]	[5.00]	[1.83]	[5.05]	

Note: The variables in each row are the independent 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 Thailand 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 (Lim, 1999). 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 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.

As discussed above, 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 (3.2.1), 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.

Section 3.1.1 above showed that 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 Indonesia 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 number 20, Indonesia has only a small contagion effect on Singapore. This suggests that investors do not rely heavily on the performance of the Indonesia 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 Indonesian rupiah would not cause a slide in the fundamentally more stable Singapore dollar. Additionally, in Table 3 from rank number 17 to 19, the Indonesia rupiah does not have a large contagion effect on the rest of ASEAN-5. Following the arguments above, the Indonesia 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 Indonesia 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 Indonesia 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 Thailand baht and Malaysia 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.

4.1.1. Robustness Checks

The results presented above are obtained by examining ASEAN-5 in isolation from the other economies in the East-Asian region that are affected by the same crisis. However, the contagion effects from the other East-Asian economies on ASEAN-5 may also affect the results given above.

Possible effects of contagion from economies outside ASEAN-5 are examined by including the South Korea won in the analysis. The South Korea won was labelled one of the first economies to start the Asian crisis, so that it could have substantial explanatory power for the increase in volatility of ASEAN-5 exchange rates during the crisis. Using (3.2.1), each ASEAN-5 economy is considered with the South Korea won to determine the presence of contagion for individual pairs of countries.

Table 4 is an expanded version of Table 1 to include the results of South Korea. The table shows the results of including the South Korea won with each ASEAN-5 exchange rate using (3.2.1) to determine the contagion effects of South Korea on each of the ASEAN-5 economies, and vice-versa. As can be seen from Table 4, there is evidence of contagion

from Malaysia to South Korea, and vice-versa. There is no evidence of contagion from the rest of the ASEAN-5 countries to South Korea, and vice-versa. Combined, this suggests that the correlation of the South Korea won with each of the ASEAN-5 currencies did not have a significant positive improvement, except for the Malaysia and South Korea pair, during the crisis. Interestingly, there is a significant negative coefficient (α_1) for the dummy variable, which tests for contagion from the South Korea won to the Philippines peso. According to Caporale, Cipollini and Spagnolo (2002), such an outcome has not yet been defined.

Table 4: Results for Contagion in ASEAN-5 and South Korea

	INDONESIA	KOREA	MALAYSIA	PHILIPPINES	SINGAPORE	THAILAND
		0.10	0.19*	0.06**	0.05*	0.09*
		(4.61)	(8.15)	(4.37)	(7.46)	(6.58)
INDONESIA		[1.17]	[4.87]	[1.57]	[3.27]	[2.57]
	0.13		0.13*	-0.09	-0.01	-0.03
	(1.28)		(1.91)	(-2.44)	(-0.52)	(-0.77)
KOREA	[0.91]		[2.35]	[-1.68]	[-0.37]	[-0.42]
	1.90*	0.50*		0.34*	0.30*	0.62*
	(22.42)	(7.91)		(12.07)	(25.34)	(21.28)
MALAYSIA	[7.70]	[2.04]		[6.48]	[11.64]	[8.42]
	2.04*	0.17	0.68*		0.22*	0.59*
	(13.90)	(2.41)	(9.26)		(10.37)	(13.26)
PHILIPPINES	[4.25]	[0.70]	[6.07]		[4.62]	[5.45]
	4.60*	0.28	1.41*	0.50*		1.16*
	(20.97)	(1.22)	(10.83)	(5.71)		(14.27)
SINGAPORE	[6.28]	[0.23]	[6.91]	[2.16]		[4.81]
	1.43*	0.46	0.68*	0.21*	0.20*	
	(12.61)	(6.23)	(10.56)	(5.46)	(11.62)	
THAILAND	[4.94]	[1.07]	[5.00]	[1.83]	[5.05]	

Note: The variables in each row are the independent variables, while those in each column are the dependent variables in the corresponding regression. The one-sided 5% critical value is 1.65, and the 10% critical value is 1.28. Numbers with * indicate evidence of contagion at 5%, and ** indicates significance at 10%.

Nonetheless, this empirical finding should not be dismissed as irrelevant. Investors may view the two markets as moving in opposite directions during the Asian financial crisis.

Massive capital movements from Hong Kong to Canada during the return of Hong Kong to China in 1997 is an example of markets being viewed as negatively correlated. However, for the rest of ASEAN-5, there is no evidence of contagion from South Korea, or vice-versa, suggesting that the Asian crisis may be self-contained within ASEAN-5 itself. ASEAN-5 may experience an external negative shock, say from South Korea, and subsequently infect countries only within the region. Although these economies could have been infected by contagion from Hong Kong and/ or Taiwan, the second tier contagion effects established in Table 2 show that the subsequent contagion effects will spread among the economies of ASEAN-5.

Table 5 is an expanded version of Table 2, which includes South Korea. The results show that the initial contagion effects from Thailand did not infect South Korea, thereby suggesting that South Korea could also be an initiator of the crisis. Such a crisis in South Korea seems to have started after the first insolvency of a large Korean Chaebol. Malaysia seems to have infected South Korea before the reverse. The contagion from Indonesia could have affected Malaysia, thereby leading to subsequent contagion effects from Malaysia to South Korea. Nonetheless, these results suggest that South Korea is not a major factor in spreading contagion in ASEAN-5. Henceforth, its exclusion from the analysis of contagion effects in ASEAN-5 seems empirically plausible.

The appropriateness of examining ASEAN-5 from a self-contained perspective can be analysed by ranking the magnitude of the contagion effects with the inclusion of South Korea to determine if it had a major role in affecting the exchange rates in ASEAN-5. For example, in the case of Singapore, which was ranked first in Table 3, it has substantial power in explaining the exchange rate volatility of Indonesia during the crisis. Singapore seems to be a major indicator of the direction of future prices in the regional markets. It is also important to determine if South Korea has such a pivotal role in ASEAN-5.

Table 5: Results for Contagion Periods in ASEAN-5 & South Korea

	INDONESIA	KOREA	MALAYSIA	PHILIPPINES	SINGAPORE	THAILAND
INDONESIA			11/07/97 (06/05/98)		23/07/97 (10/06/98)	01/09/97 (23/03/98)
KOREA			10/11/97 (03/07/98)			
MALAYSIA	03/11/97 (15/06/98)	24/10/97 (02/02/98)		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.

Table 6 reports the results of ranking the magnitude of contagion among pairs of ASEAN-5 economies and South Korea. Table 6 is an expanded version of Table 3, which includes the magnitude of contagion from Malaysia to South Korea, and vice-versa. These results show that South Korea is not important in explaining the changes in the exchange rates of ASEAN-5 because the magnitude of the sole contagion from Malaysia to South Korea is not substantial. In comparison with the first pair, which is contagion from Singapore to Indonesia, the results indicate that South Korea is not closely linked to ASEAN-5. Investors do not seem to infer substantial information from the South Korean market and apply it to ASEAN-5. Therefore, the effects of contagion from South Korea to ASEAN-5, and vice-versa, seem to be of little consequence for the results established in Tables 1 - 3.

Table 6: Ranking the Magnitude of Contagion in ASEAN-5 and South Korea

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
Malaysia	Korea	0.50	11
Singapore	Philippines	0.50	11
Malaysia	Philippines	0.34	13
Malaysia	Singapore	0.30	14
Philippines	Singapore	0.22	15
Thailand	Philippines	0.21	16
Thailand	Singapore	0.20	17
Indonesia	Malaysia	0.19	18
Korea	Malaysia	0.13	19
Indonesia	Thailand	0.09	20
Indonesia	Philippines	0.06	21
Indonesia	Singapore	0.05	22

4.1.2. Limitations of the Analysis

As government intervention can artificially prop up exchange rates by selling foreign reserves, using exchange rates to ascertain the starting and ending dates of contagion may not provide an accurate reflection of the length of a crisis. In a successful defence, the devaluation of the currency may be minimal. However, the news of such an action by the Central Bank could trigger contagion in another currency market, and speculators would converge to attack it. This may well have been the case for Indonesia. The empirical results suggest that Indonesia infected Thailand before the reverse, thereby suggesting that Indonesia might have started the crisis and not Thailand. As the Thailand bath was heavily

and successfully defended by the Central Banks of Singapore and Thailand in the early stages of the crisis, there was only a small devaluation in the baht. However, the news that the Thailand baht was being attacked by speculators sparked off market panic and the Indonesia rupiah was hit. Without the strong intervention of the Central Banks of Indonesia and Singapore, the rupiah tumbled. Based on examining exchange rate movements, Indonesia rupiah seems to have started the crisis rather than Thailand.

An examination of contagion from an exchange rate perspective is limited because there is likely to be integration between the exchange rate and the share market of a country. Movements in the share market index of an economy could have a considerable impact on its exchange rate, as investors are likely to use them to assess the stability of its economy. For example, the large one-day devaluation in the Indonesia rupiah may have been triggered by news of its stock market crash, instead of regional news of exchange rates in ASEAN-5. Therefore, the information set in this analysis may be somewhat limited. Caporale, Cipollini and Spagnolo (2002) examined contagion solely from a share market perspective. Therefore, their analysis has potentially the same limitation as given above. A model that allows the integration of the exchange rates and share market indices of all the economies in ASEAN-5 would be likely to contain stronger evidence of contagion during the Asian financial crisis.

4.2. Monetary Unification in ASEAN-5

From the above analysis, it appears that contagion is present between pairs of ASEAN-5 countries. The economies of ASEAN-5 seem to have experienced a significant increase in the positive correlation of shocks during the Asian financial crisis, where the increase is registered as a parametric shift in the coefficient of the dummy variable in (3.2.1). Contagion may suggest that channels link the economies of ASEAN-5, where these contagion channels extend beyond the fundamental transmission of shocks, such as trade, financial and political relationships. Such channels are evident in the exchange rate market, as given above, and also in the financial market analysed in Caporale, Cipollini and Spagnolo (2002).

According to the OCA theory, the higher is the degree of asymmetric shocks experienced by a group of economies, the higher is the cost to establish a monetary union. The

economies of ASEAN-5 are integrated through the established links of trade, financial and political relationships, as is evident from the volume of trade within ASEAN, the integration of financial markets, and the cooperation of political institutions through ASEAN and the ASEAN Free Trade Area (AFTA) (Lim, 1999). Therefore, they are unlikely to experience a high degree of asymmetric shocks. Together with the channels of contagion, it would lower the degree of asymmetric shocks, thereby lowering the costs of monetary unification for ASEAN-5.

The analysis presented above gives a favourable argument for monetary unification of the ASEAN-5 economies, which display a significant positive correlation to shocks. Furthermore, these positive correlations have improved significantly during the Asian financial crisis. Even with limited mobility of labour within the region, the results suggest that there are greater benefits than costs in monetary unification.

Evidence of contagion provides a rationale for policy-makers towards closer monetary cooperation. The malicious contagion effects from the Asian financial crisis have derailed, at least during the crisis period, the ASEAN-5 economies from their high growth and monetary stability targets. Although most of these economies have successfully re-established their monetary standards with the US dollar and Japan yen, they nevertheless remain vulnerable to contagion from regional crises. Additionally, the present Indonesian and Philippine economies do not seem to have recovered fully from the effects of the Asian financial crisis. The formation of a monetary union in ASEAN-5 could protect Malaysia, Singapore and Thailand from future crises, and provide a stable monetary environment for Indonesia and the Philippines to recover from the Asian financial crisis and return to a high growth world. In the Chiang Mai Initiative of 2000, closer cooperation was formally established by Indonesia, the Philippines, Malaysia, Singapore and Thailand. Multilateral swap arrangements of currencies were established, and there are further plans to include Japan, China and Korea in future arrangements.

The Chiang Mai Initiative of 2000 is as far as monetary cooperation has proceeded in ASEAN-5, with these economies still having an implicit peg to the US dollar. However, the prospect of an unstable US economy is not difficult to conceive after the 11 September 2001 terrorist attacks. This means that ASEAN-5 must expedite their efforts for closer monetary cooperation to avoid future financial and economic crises.

ASEAN-5 could work towards monetary unification using the Euro as a guide. They could work towards establishing an ASEAN-5 monetary system, similar to the European Monetary System (EMS), which pegs the respective ASEAN-5 currencies within a trading band to a basket of ASEAN-5 currencies. This would require closer cooperation between the central banks of ASEAN-5. The labour ministries in ASEAN-5 would also have to establish closer cooperation to improve and facilitate the movement of labour, which has a pivotal role in lowering the degree of asymmetric shocks experienced in the region. Further liberalisation of domestic markets to the rest of ASEAN-5 should be made to increase trade and financial linkages, as they are important channels through which shocks are transmitted.

The case for monetary unification is closely tied to economic integration, which rests on economic, social, political, military, cultural and intellectual grounds. Evidence of contagion suggests that the economies in ASEAN-5 are coming closer as a monetary union, according to the OCA theory, than was previously thought.

5. Conclusion

This paper has tested for the presence of monetary integration and contagion. Following Forbes and Rigobon (2001b), contagion is defined as a significant increase in the degree of co-movement between exchange rate returns, to establish whether ASEAN-5 countries would experience high costs in monetary unification. Following Caporale, Cipollini and Spagnolo (2002), the null hypothesis of interdependence (or no contagion) was tested against the alternative of contagion as an over-identifying restriction.

Corrections for the heteroscedasticity, endogeneity and omitted variable bias which affect standard parameter stability tests, as noted by Rigobon (2001a), were incorporated in the model. Caporale, Cipollini and Spagnolo (2002) controlled for both heteroscedasticity and endogeneity bias by modelling the conditional variance as a GARCH (1,1) process, and introduced a common shock to deal with the omitted variable problem. In this paper, the Japan yen was used as the common shock for the exchange rates in ASEAN-5, and fluctuations in the Japan yen should have significant explanatory power in explaining fluctuations in ASEAN-5 exchange rates.

The method used in the analysis is superior to other existing methods as it does not require the splitting of the sample into two subsets, which is needed to identify the contagion period. It selects the breakpoints of a contagion period endogenously by using the sequential dummy variable method. Moreover, the approach circumvents the problem of a low-powered test, as noted by Dungey and Zhumabekova (2001), which has serious implications for inference. The sequential dummy variable method was adapted to select the breakpoints based on the highest t-ratio associated with the coefficient of a dummy variable. Moreover, the adapted method allows a set of (over-)identifying restrictions which are appropriate for analysing the Asian financial crisis, and are weaker than those used in Forbes and Rigobon (2001b).

Contagion is evident in the region during the Asian financial crisis of 1997. Since the crisis, the significance of positively correlated shocks has increased, rendering lower costs in monetary unification under the OCA theory of asymmetric shocks. The results are directly comparable with other studies that have used a conditional correlation analysis to investigate contagion in the East Asian region. Although the results are different from those of Forbes and Rigobon (2001b), they are consistent with the evidence presented in Rigobon (2001a), Park and Song (2001), and Caporale, Cipollini and Spagnolo (2002). Specifically, contagion was found in all pairs of countries in ASEAN-5.

The results coincided with the observed order of market collapse, and are consistent with the chronology of the Asian crisis. Rankings of the magnitudes of the contagion effects provide evidence that stronger economies such as Singapore are used as a market indicator by investors to forecast the direction of the crisis, namely a deepening of the crisis or a recovery. Additionally, by including the South Korea won in the analysis, it was determined that the crisis was self-contained after an external shock hit one of the ASEAN-5 countries.

Contagion is evident from the empirical results, and is consistent with the studies of Rigobon (2001a), Park and Song (2001), and Caporale, Cipollini and Spagnolo (2002). This indicates that the degree of correlation among ASEAN-5 economies has increased during the Asian crisis. According to the OCA theory, the region will likely experience lower costs in monetary unification.

The paper has examined the costs of monetary unification from an economic perspective. A more holistic approach would require the inclusion of social, political, military and cultural factors. Nevertheless, from the economic viewpoint, the ASEAN-5 countries seem to be more of an OCA than was previously thought.

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