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Abstract

This paper analyzes how the crisis in Asia spread during the second half of 1997. We cast our net wide and investigate several possible trade and financial linkages among the Asian economies. We construct a series of "contagion vulnerability indices," which capture the various manifestations of exposure through trade and finance to the initial crisis country and contrast the predictions of this index to actual outcomes during the Asian crisis. We pay attention to the reversal in bank lending of Japanese and European banks, which were lending heavily to emerging Asia on the eve of the crisis. Daily interest rate and exchange rate data for Indonesia, Malaysia, the Philippines, South Korea, and Thailand are used to assess whether the patterns of causality and interdependence changed as the crisis spread, as well as to answer question of whether interdependence among the Asian economies has changed as the result of the crisis.

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I. Introduction

There have been several major episodes of "contagious currency crises" during the 1990s. The first of these was the Exchange Rate Mechanism (ERM) crisis of 1992-93. Explanations of why currency instability spread through Europe frequently stressed the interdependence of ERM countries via extensive trade in goods and services.[1] Yet, the ERM crisis was later followed by the Mexican peso crisis in late 1994, with its "Tequila effect" on Argentina and other Latin American countries, and the Russian crisis of 1998, which paralyzed capital flows to emerging markets. There is ample evidence that trade links are not capable of explaining why Argentina was so hard hit by the devaluation of the Mexican peso, as there is minimal bilateral trade between Argentina and Mexico and there is little scope for competition in a common third market.[2] Similarly, Russia's importance in world trade is hardly capable of explaining why emerging markets came under such duress following its devaluation and default in August 1998. The absence of obvious trade links in these episodes and the growing importance of financial markets has led academics, policy makers, and the financial press to search for other possible explanations of contagion. Some of these explanations have relied on herding behavior in the part of investors.[3] Other stories have suggested that contagion can arise through exposure to common lenders, be it hedge funds (as in Calvo, 1998) or banks (as in Kaminsky and Reinhart, 1998).

The focus of this paper is to analyze how the crisis in Asia spread during the second half of 1997. We cast our net wide and investigate several possible trade and financial linkages among the

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[1]See, for instance, Eichengreen, Rose, and Wyplosz (1995).

[2] See Kaminsky and Reinhart (1998) on this issue.

[3] See Calvo and Mendoza (998) and Chari and Kehoe

Asian economies which may help explain why a devaluation in a relatively small country in the region (i.e., Thailand) had such widespread regional consequences. We proceed to construct a series of "contagion vulnerability indices," which capture the various manifestations of exposure through trade and finance to the initial crisis country. We contrast the predictions of this vulnerability index to the actual outcomes during the Asian crisis and compare these results to other recent crisis episodes in emerging markets. We also pay particular attention to the role played by Japanese and European banks, which were lending heavily to emerging Asia on the eve of the crisis.[4] Daily interest rate for Indonesia, Malaysia, the Philippines, South Korea, and Thailand. and exchange rate data is used to assess whether the patterns of causality and interdependence changed as the crisis spread as well as to answer the broader question of whether interdependence among selected Asian economies has changed as the result of the crisis. Our main findings can be summarized as follows:

First, as regards the propagation of shocks across national borders during the Asian crisis, the behavior of foreign banks, particularly Japanese banks who began to drastically curtail their lending to the affected Asian countries following the Thai devaluation, appears to play a role in spreading the crisis particularly to Indonesia, Malaysia, and South Korea.[5] The large exposure of European banks to South Korea and their subsequent retrenchment further deepens the regional liquidity crunch.

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[4] Besides Thailand, the affected countries are taken to include Indonesia, Malaysia, the Philippines, and South Korea.

[5] The Philippines had a much lower exposure to Japanese banks.

Second, only Malaysia and South Korea, in that order, appear to have any significant trade link to Thailand. However, these trade links are indirect, through exports to a common third party. Indeed, there is relatively little bilateral trade among these emerging Asian economies. Thus, the spread of crisis to Indonesia and the Philippines cannot be explained through interdependence arising from a substantial volume of trade in goods and services.

Third, the "contagion vulnerability indices" do reasonably well in anticipating which countries were most vulnerable to contagion in three recent crises episodes, which include the Mexican 1994 devaluation, Brazil's crisis in early 1999, as well as the Asian episode. The indices, however, are silent as to the severity of the these contagion effects. For example, Indonesia, Malaysia, and South Korea are all identified as potential candidates of spillovers from Thailand. Yet Indonesia is shown, ex-ante, as the one with the least intensive linkages to Thailand; ex-post, it was the most severe crisis of the three.[6]

Fourth, the evidence from the daily data suggests that the patterns of causality and interdependence do change during the course of the crisis, as turbulence in affected countries, like Indonesia begin to have additional feedback effects on the other countries, including the initial crisis country, Thailand. **Furthermore**, there is a marked difference in pre- and post- crisis interest rates and exchange rate linkages among the countries in our sample. Prior to the crisis, there is little evidence of systematic causality or interdependence among these five countries; the post-crisis patterns are markedly different, particularly for Indonesia, the Philippines and Thailand, all which show a much greater degree of dependence on external shocks.

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[6] Obviously, differences across countries in how the crisis is managed by policy makers can go a long way toward differences in the severity and duration of the crisis.

Lastly, Malaysia's interest rates remain uninfluenced by shocks to other interest rates in the region in the post crisis sample. Possibly, this result may be due to the presence of extensive capital controls--and issue which merits further scrutiny.

The paper is organized as follows. The next section discusses the patterns in Japanese, European, and U.S. bank lending to emerging Asia and analyzes the behavior of foreign bank lending as the crisis unfolds. Section III discusses trade linkages and other financial channels of contagion. In this section, "contagion vulnerability indices" are developed and used to analyze and compare recent crisis episodes. In Section IV, we study the issue of cross-country interdependence among daily interest rate and exchange rate shocks and how international linkages may have changed during the post-crisis period. The last section presents some brief concluding remarks.

II. Bank Lending and Contagion in Asia: Stylized Evidence

Much of the recent literature on contagion has suggested that trade links are a vehicle for the transmission of currency crises across national borders.[7] Other recent papers on the subject have focused on the role that capital markets play in spreading turbulence internationally.[8] Yet, nearly all this literature has ignored the role that banks can play in transmitting disturbances across countries. This channel of transmission is straightforward. Through its loan portfolio a bank may be exposed to a country that has a financial crisis. If the crisis occurs, it impacts the bank's balance sheet; the bank is faced with the need to re-balance its portfolio. To make up for the deterioration

[7] See, for instance, Gerlach and Smets and Glick and Rose (1999).

[8] See, for example Frankel and Schmukler (1998) and Calvo (1998).

in the quality of its loans, the bank may shift away from lending and increase its holdings of government bonds. Other countries which were borrowing from the affected bank will be vulnerable to a cutback in their lines of credit. Furthermore, if these countries' loan contracts were of short maturity and the bank's re-balancing needs are significant, the initial crisis could trigger large capital outflows from the other borrowers. That is, not only the bank may be unwilling to extend new credits to the other borrowers, it may refuse to roll over their existing loans--hence, the capital outflow. If the capital flow reversal is sufficiently large and abrupt, it could spark a financial crisis in one or more of the other borrowers. This type of problem is particularly acute if the borrowers were heavily dependent on that bank and do not have immediate recourse to alternative sources of financing. The bank's inability or unwillingness to lend may be compounded by the requirement that banks must provision for bad loans.

In an earlier paper, we examined the potential for contagion through exposure to a common lender.[9] We found evidence that common bank lenders have played a significant role in the spread of currency crises--indeed, the bank lending channel outperforms trade channels in explaining the vulnerability of a country to contagion. Using a different approach and methodology, Van Rijckeghem and Weder (1999) also find evidence of an important common lender channel.

Contagion during the Exchange Rate Mechanism crises of 1992 and 1993 in Europe and in Argentina and Brazil following the devaluation of the Mexican peso in 1994 appear to have little to do with the withdrawal of a common bank creditor. High and rising international interest rates and poor economic fundamentals have been blamed for the wave of currency and banking crises that

[9] See Kaminsky and Reinhart (1998).

swept developing countries (particularly in Latin America) in the early 1980s. Yet, badly burned by Mexico's default in August of 1982, U.S. banks were rapidly retrenching from the emerging world. The drive to reduce loan exposure was most acute for Latin America, which depended almost exclusively on U.S. banks. A more recent example of the role of banks in propagating disturbances internationally can be found in the Asian crisis of 1997. The remainder of this section is devoted to this issue.

1. Banks and contagion in Asia

International capital had been pouring into much of Asia, most notably Indonesia, Malaysia, and Thailand, throughout most of the 1990s. Other emerging markets, particularly the largest countries in Latin America, experienced a similar surge in capital inflows.[10] A key difference among the two regions, however, was that an important share of capital inflows to Latin America came through portfolio bond and equity flows while in Asia bank lending loomed large, particularly in the two years preceding the crisis. As shown in Table 1, lending to emerging Asia expanded by xx percent from June 1995 to June 1997.[11] There were two factors behind this sharp growth in bank credit. Part of the rise in lending was owing to the European banks' goal to achieve a higher profile in emerging markets and, particularly, in South Korea. But much of the lending boom, especially in the case of Thailand, Indonesia, and South Korea, was owing to a rapid expansion in credit from Japanese banks. Faced with a slumping economy and little domestic loan demand,

[10] See Calvo, Leiderman, and Reinhart (1996).

[11] Emerging Asia comprises Indonesia, Malaysia, the Philippines, South Korea, and Thailand.

Japanese banks increasingly looked overseas to the rapidly growing economies of Southeast Asia as potential borrowers.

Table 2 presents the distribution of lending of U.S., Japanese, and European banks to emerging Asia. Three features are worth noting. **First**, U.S. bank exposure to Asia was modest on the eve of the crisis; emerging Asia amounted to about US $24 billion (Table 1) and only accounted for 20 percent of all U.S. bank lending to developing countries (Table 2). **Second,** and by way of contrast, Japanese banks were lending four times as much as U.S. banks (i.e., US $97 billion) to emerging Asia; the five crisis countries listed in Table 2 accounted for two-third of all loans to emerging markets.[12] **Third,** Japanese banks' were most exposed to Thailand--which is the first country to experience a crisis. Indeed, the extent of their exposure is similar to that of U.S. banks to Mexico in 1982.[13] **Fourth**, European bank lending to Emerging Asia was also significant and accounted for about a half of all their lending to emerging markets; South Korea alone accounted for 40 percent of their lending to the developing world.

Fifth, Japanese banks were the first to pull out of emerging Asia. Between June and December of 1997, lending by Japanese banks fell by 10 percent, while lending by European banks actually rose slightly. This is not surprising in light of the previous discussion. Japanese banks were most exposed to Thailand; European and U.S. banks were most exposed to South Korea. The Thai devaluation occurs in early July, while South Korea abandons its defense of the won in mid-November. By June 1998, however the reduction in lending to emerging Asia was across the board. US bank lending falls by a cumulative 30 percent, but this represents a decline of about US

[12] Most of the remaining one-third was going to China.

[13] See Kaminsky and Reinhart (1998) for a comparison of these episodes.

$5 billion. The 24 percent decline in Japanese bank lending in June 1997-98, however, translates into a reduction of about US $26 billion.

The previous observations suggest that, even if the banks were not the immediate trigger of financial contagion, their actions certainly made the spillovers, first from Thailand and later from South Korea far more severe than they would otherwise be. In the following section, we construct a composite contagion vulnerability index–exposure to a common bank creditor figures prominently in this index.

III. A Contagion "Vulnerability" Index

In this section, we provide a brief review of the "signals" approach that we will use to assess the probability of a "contagious" currency crisis. This methodology was first used to analyze the performance of a variety of macroeconomic and financial indicators around "twin crises" (i.e., the joint occurrences of currency and banking crises) in Kaminsky and Reinhart (1999).[14]

In the analysis that follows, we focus on a sample of 20 countries over the period 1970 to 1998. The countries in our sample are Argentina, Bolivia, Brazil, Chile, Colombia, Denmark, Finland, Indonesia, Israel, Malaysia, Mexico, Norway, Peru, Philippines, Spain, Sweden, Thailand, Turkey, Uruguay, and Venezuela. As an out of sample exercise, we apply this approach to analyze South Korea's vulnerability to contagion during recent episodes of global financial turmoil.

While the preceding section stressed the key role played by foreign banks in spreading the

[14] This methodology is described in some detail in Kaminsky, Lizondo, and Reinhart (1998), Kaminsky (1998), and Goldstein, Kaminsky, and Reinhart (1999).

crises throughout Asia during 1997, in this section we develop a contagion vulnerability index that also allows for other types of links across countries. Specifically, we consider both bilateral and third-party trade links as well as contagion arising from other financial channels.

In order to implement the signals approach to analyze contagion, however, we need to clarify a minimum number of concepts which will be used throughout the analysis.

1. Defining currency crises

A currency crisis is defined as a situation in which an attack on the currency leads to substantial reserve losses and/or to a sharp depreciation of the currency--if the speculative attack is ultimately successful. This definition of currency crisis has the advantage that it is comprehensive enough to capture not only speculative attacks on fixed exchange rates (e.g., Thailand's experience prior to July 2, 1997) but also attacks that force a large devaluation beyond the established rules of a crawling-peg regime or an exchange rate band (e.g., Indonesia's widening of the band prior to its floatation of the rupiah on August 14, 1997.) Since reserve losses also count, the index also captures unsuccessful speculative attacks.

We constructed an index of currency market turbulence as a weighted average of exchange rate changes and reserve changes. Interest rates were excluded as many emerging markets in our sample had interest rate controls through much of the sample.

The index, I, is a weighted average of the rate of change of the exchange rate, Äe/e, and of reserves, ÄR/R, with weights such that the two components of the index have equal sample volatilities

$$I = (Äe/e) - (ó_e/ó_R)*(ÄR/R) \quad (1)$$

where $ó_e$ is the standard deviation of the rate of change of the exchange rate and $ó_R$ is the standard deviation of the rate of change of reserves. Since changes in the exchange rate enter with a positive weight and changes in reserves have a negative weight attached, readings of this index that were three standard deviations or more above the mean were cataloged as crises. For countries in the sample that had hyperinflation, the construction of the index was modified.[15] As noted in earlier studies which use the signals approach, the dates of the crises map well onto the dates obtained if one were to rely exclusively on events, such the closing of the exchange markets or a change in the exchange rate regime, to define crises.

2. Defining contagion

As noted earlier, the term contagion has been used to mean different things across studies. In this paper, contagion refers to the case where knowing that there is a currency crisis elsewhere increases the probability of a crisis at home.[16] We are interested in understanding the channels of transmission of what we call "fundamentals-based contagion," which arises when countries are linked via trade or finance. Masson (1999), for example, calls this type of phenomenon a "spillover" and the term "contagion" in his glossary is reserved for cases where there are no trade or financial links. In these latter cases, shifts in investor sentiment or herding spread the crisis

[15] While a 100 percent devaluation may be traumatic for a country with low-to-moderate inflation, a devaluation of that magnitude is commonplace during hyperinflation. A single index for the countries that had hyperinflation episodes would miss sizable devaluations and reserve losses in the moderate inflation periods, since the historic mean is distorted by the high-inflation episode. To avoid this, we divided the sample according to whether inflation in the previous six months was higher than 150% and then constructed an index for each subsample.

[16] This is the definition used in Eichengreen, Rose, and Wyplosz (1998) and Kaminsky and Reinhart (1998).

across national borders.

Since what we are interested in explaining is how turbulence is transmitted across countries which are connected by trade or finance and in assessing which of these links are most important, it matters greatly how we define "elsewhere." As in Kaminsky and Reinhart (1998), we define "elsewhere" by grouping the countries in our sample into various clusters. As noted in Section II, an important source of "fundamentals-based contagion" in the Asian crisis was countries' exposure to a common bank lender. We identify two distinct bank clusters in our sample; one of these clusters is made up of countries that borrow primarily from U.S. banks, while a second bank cluster consists of countries where an important share of their borrowing is concentrated among Japanese banks.

The growing practice of cross-market hedging in recent years also suggests that countries which have (for whatever reason) exhibited a moderately positive correlation of asset returns (with the crisis country) and have relatively liquid markets may be vulnerable to contagion via cross-market hedges. We identify two high-correlation clusters in our sample in Asia and Latin America.

A competitive devaluation story, as in Gerlach and Smets (1996), suggests that a currency crisis in one country may lead to a devaluation in a second country if the two countries engage in a significant amount of bilateral trade. In a similar vein, Corsetti, Pesenti, and Roubini (1998), stress that competitive devaluation pressures may arise even if two countries do not directly trade with one another. Such pressures may be present if the two countries are competing in a common third market.

The countries in each of clusters are listed in Table 4.[17] On the basis of the information in

[17] Details on the criteria used to define the clusters are given in Kaminsky and Reinhart (1998).

Table 4, we can construct a rough index of vulnerability to "fundamentals-based contagion" for each country in the sample at each point in time. Consider the case of the Asian crisis, which began on July 2, 1997 with the devaluation of the Thai baht. To assess how the Thai devaluation could potentially affect other countries, one could simply count the number of common clusters through which a country is exposed to Thailand. For example, Malaysia is in the same bank cluster as Thailand, as well as in the same high-correlation and third-party trade cluster--a total of three. The Philippines, is also a part of the same third-party trade and Asian high-correlation cluster but it is not a part of the Japanese bank cluster--a total of two. Indonesia shares the same high-correlation and Japanese bank cluster with Thailand--a total of two. South Korea borrows from Japanese banks, it is part of the Asian third-party trade cluster, but asset returns correlation with Thailand is low--also a total of two. While Argentina, for example, is not exposed to Thailand via any of the financial or trade links analyzed here.[18] On the basis of this simple tally, one would conclude that Malaysia is the most vulnerable to "fundamentals-based contagion" from Thailand and Argentina the least. But this simple tally does not allow us to rank the relative vulnerability of Indonesia, the Philippines, and South Korea, as they all share two, albeit different, clusters with Thailand. In the remainder of this section, we describe an approach that allows us to assign different weights in a "contagion vulnerability index" to the different trade an financial links; the weights will depend on the accuracy of these links in predicting the incidence of contagious crises.

[18] It is important to note that this is not an exhaustive analysis of all possible financial sector links. For instance, Brazil and Russia are directly impacted by the Korean crisis, as Korean financial intermediaries sold their holdings of Brazilian and Russian debt (see Calvo and Reinhart, 1996 for examples and discussion of other potential links.)

3. Signals, noise, and crises probabilities

A crisis elsewhere may or may not be a reliable "signal" of a future crisis at home. A summary of the possible outcomes is presented in the following two-by-two matrix,

	Crisis occurs in the following 24 months	**No crisis occurs in the following 24 months**
Signal =1, if there is a crisis elsewhere	A	B
No signal=0, if no crisis elsewhere	C	D

A perfect indicator would only have entries in cells A and D. Hence, with this matrix we can define several useful concepts which we will use to evaluate the predictive ability of each of the clusters.

We begin by calculating, for a given sample, the **unconditional probability of crisis**,

P© = (A+C)/(A+B+C+D). (2)

If knowing that there is a crisis elsewhere helps predict a crisis at home, then it can be expected that the **probability a of crisis, conditional on a signal**, P(C*S), is greater than the unconditional probability. Where

P(C*S) = A/(A+B). (3)

Formally,

P(C*S) - P© > 0. (4)

If crisis elsewhere is not a "noisy" indicator (prone to sending false alarms), then there are relatively few entries in cell B and P(C*S) . 1. But since elsewhere is defined differently for each of the clusters, their forecasting track record will differ.

We can also define the **noise-to-signal ratio**, N/S as,

$$N/S = [B(B+D)]/[A/(A+C)]. \quad (5)$$

In the remainder of this section, we employ these concepts to provide evidence on the relative merits in anticipating crises of the trade and finance clusters.

Table 5 presents the results from this exercise for each of the clusters. As noted in Kaminsky and Reinhart (1998), contagion appears to be a highly non-linear process, irrespective of which country grouping scheme is used. If a quarter to a half of the countries in a given cluster have a crisis, the probability of a crisis at home does not increase by much; this is shown under the rows labeled 25 to 50 percent. Yet, if more than one half of the countries in the cluster have a crisis, the probability of a crisis at home increases dramatically. This nonlinearity is evident in the marked declines in the noise-to-signal ratios as the proportion of countries affected by crises increases. The decline in the noise-to-signal ratio is most dramatic for the Latin American bilateral trade cluster, which falls from 2.34 to 0.08. This sharp improvement in forecasting accuracy is also evident in its marginal predictive ability, P(C*S) - P(C). The common bank lender cluster has the lowest noise-to-signal ratio while that third party trade cluster has the highest. While assessing the predictive ability of the individual clusters is a useful exercise to discriminate among competing explanations of contagion, countries which are linked in trade are also often linked in finance. This implies that multiple channels of contagion may be operating at once. To examine exposure to contagion via a variety of channels we now turn to the construction of a composite vulnerability index.

4. Trade and financial clusters, and a composite contagion index

Kaminsky (1998) and Goldstein, Kaminsky and Reinhart (1999) show how to construct a "composite index" to gauge the probability of a crisis conditioned on multiple signals from various indicators (i.e., economic fundamentals); the more reliable indicators receive a higher weight in this composite index. This methodology can be readily applied to construct a composite contagion vulnerability index.

In weighing individual indicators, a good argument can be made for by eliminating from our list of potential leading indicators those variables which had a noise-to-signal ratio above unity; this is tantamount to stating that their marginal forecasting ability P(C*S) of zero or less. Applying this criterion to our results, we would focus on the case where more than 50 percent of the countries in the cluster are experiencing a crisis. As shown in Table 5, the highest noise-to-signal ratio is 0.57, well below unity--but the track record of the signals in each of the clusters is far from uniform. Thus, we weigh the signals by the inverse of the noise-to-signal ratios reported in Tables 5.

Formally, we construct the following composite indicator,

$$I_t = \sum_{j=1}^{n} S_t^j / \omega^j \qquad (6)$$

In (6) it is assumed that there are *n* different indicators (i.e., clusters). Each cluster has a differentiated ability to forecast crises and, as before, this ability can be summarized by the noise-to-signal ratio, here denoted by ω^j. S_t^j is a dummy variable that is equal to one if the univariate indicator, S^j crosses its critical threshold and is thus signaling a crisis and zero otherwise. As before, the noise-to-signal ratio is calculated under the assumption that an indicator

issues a correct signal if a crisis occurs within the following 24 months. All other signals are considered false alarms.

The maximum value that this composite vulnerability index could score is 30.9 if a country belonged to the same four clusters as the crisis country. This score is a simple sum of the inverse of the noise-to-signal.

5. Evidence from three recent crisis episodes

We now consider, on the basis of the trade and financial sector linkages discussed here, which countries would have been classified as vulnerable to contagion during three recent episodes of currency crises in emerging markets. The first of these episodes begins with the devaluation of the Mexican peso in December 1994.

On the heels of the Mexican devaluation, Argentina and Brazil were the countries to come under the greatest speculative pressure. In a matter of a few weeks in early 1995, the central bank of Argentina lost about 20 percent of its foreign exchange reserves and bank deposits fell by about 18 percent, as capital fled the country. Such a severe outcome could hardly be attributed to trade linkages and competitive devaluation pressures, as Argentina does not trade with Mexico on a bilateral basis nor does it compete with Mexican exports in a common third market.[19] In the case of Brazil, the speculative attack was more brief, although the equity market sustained sharp losses. Both of these countries record high readings in their vulnerability index following the Mexican devaluation. While the effects on Asia of the Mexican crisis were relatively mild, the country

[19] See Kaminsky and Reinhart (1998) for details on the pattern of trade.

which encountered most turbulence in the region was the Philippines, which also registers a relatively high vulnerability score.

In the case of the Thai crisis, Malaysia shares both trade and finance links with Thailand. For the other Asian countries the potential channels of transmission are fewer. As noted earlier, the Philippines, is a part of the same third-party trade cluster as Thailand, which receives a weight of 1.75, (i.e. 1/0.57) in the composite index; it is also part of the Asian high-correlation cluster, which receives a weight of 2.57 (i.e. 1/0.39) in the index. Indonesia shares the same high-correlation cluster with Thailand and it is a part of the Japanese bank cluster, which receives a weight of 14.08 (i.e., 1/0.07). Hence, as shown in Table 6, Indonesia's and the Philippines contagion vulnerability index score 16.65 and 4.32, respectively. South Korea, as noted in Section II, also borrowed heavily from Japanese banks. Accordingly its exposure to Thailand came more from having a common lender than from conventional competitive trade pressures.

The most recent of these emerging market crises was Brazil's devaluation of the real in early 1999. Not surprisingly, Argentina which has both trade (Mercosur) and financial linkages with Brazil shows the highest vulnerability; other Mercosur countries come close in suit.

IV. Contagion and Interdependence: Interest Rates and Exchange Rates

The preceding discussion has suggested that, even in the absence of any shifts in market sentiment or herding behavior on the part of investors, there are multiple reasons why a crisis in one country may have important repercussions on other countries which are exposed to the crisis through financial or trade arrangements. Yet these fundamental channels of crisis transmission are not likely to emerge or disappear quickly. Developing mutually satisfactory trade arrangements or

building close ties with possible creditors may take time and is not likely to change dramatically from one moment to the next. For example, as shown in Table 2, countries which were in the Japanese bank cluster before the crisis remain so after the crisis; a similar statement can be made about the U.S. borrower group.

A proximate way to explore whether vulnerability to "true contagion," that is interdependence that cannot be accounted for by the kinds of conventional trade or finance links that we have focussed on thus far, may be to examine causal patterns (or interdependence) among the affected countries in market-determined variables such as interest rates, exchange rates, and stock returns. One possible explanation of contagion has to do with the "wake-up call hypothesis" (see Goldstein, Kaminsky, and Reinhart, 1999), which suggests that the initial crisis serves as a wake-up call, leading investors to reassess the risks of other countries which share some of the vulnerabilities with the crisis country--irrespective of whether they have a common bank lender or are linked in trade. Alternatively, herding may arise even when investors are rational if verifying rumors (or information in general) is costly.[20] If rumors become more frequent in the aftermath of a crisis, this may impart greater interdependence or increased comovement among financial indicators across countries.

1. Methodology issues

To examine whether there is greater interdependence or unidirectional causal links among five of the affected Asian countries following the financial crisis that began with the July 2, 1997

[20] See Calvo and Mendoza (1998).

devaluation of the Thai baht, we assembled daily data on domestic interest rates and exchange rates for Indonesia, Malaysia, the Phillippines, South Korea and Thailand. The data begins on January 1st of 1996 and runs through July 1999. Hence, there a roughly comparable number of observations prior to the crisis (392 observations) and following the crises (334 observations.) We employ a simple vector autoregression (VAR) framework which treats all variables as potentially endogenous and include ten lags of each of the variables in the system. Omitting time subscripts, a representative equation for domestic interest rates in Indonesia (denoted by the subscript I) in this five-equation system is given by,

$$r_i \;=\; \alpha_i + A_1(L)r_i + A_2(L)r_m + A_3(L)r_p + A_4(L)r_{sk} + A_5(L)r_t + \varepsilon_i. \qquad (7)$$

The subscripts *m, p, sk,* and *t* refer to Malaysia, the Philippines, South Korea, and Thailand, respectively. The lag operators are the *A*'s and å's denote the random shocks. A comparable system was estimated for daily changes in the exchange rate (in percent). For each block of regressors we conducted F- and log-likelihood ratio tests that tested the null hypothesis of no causal relationship.

2. Interest rate and exchange rates links: Evidence from Asia

Table 7 reports the results for interest rates; the detailed test statistics and their associated probability values are presented in Appendix Tables A.1-A.4. The columns "cause" the rows; an N denotes that the null hypothesis of no causality was not rejected while a Y indicates rejection of the null hypothesis at a 5 percent level of significance or higher. For example, the top row, which

summarizes the results for Indonesia for the January 1, 1996-July 1, 1997 period shows four N entries, indicating that interest rates in the four remaining countries in the system had no systematic influence on Indonesian interest rates. The last column of Table 7 tallies the number of significant entries. Table 8 summarizes in comparable manner the results for the daily exchange rate changes.

Several features of the pre- and post-crisis results for interest rate patterns are worth noting. **First,** for the pre-crisis sample none of the regressors (other than lags of the dependent variable) are statistically significant at standard confidence levels. **Second,** the post crisis period is quite different in that regard with a greater degree of interdependence among the countries. Fluctuation in Thai and Philippine interest rates significantly influence interest rates in Indonesia. Likewise interest rates in Indonesia influence the Philippines and Thailand. **Third,** interdependence was most intense during the period immediately following the Thai devaluation and the subsequent devaluation of the Korean won on November 17, 1997.

Fourth, Malaysian interest rates are not significantly affected by interest rate developments in the other four countries in the full post-crisis period. One could speculate this insulation may be due to the introduction of exchange controls in September 1998. Indeed, prior to the imposition of exchange restrictions Malaysian interest rates were influenced by other countries' interest rates during the height of the crisis in July 1997-April 1998.

Fifth, no clean unidirectional causality pattern from Thailand to the other countries emerges from this exercise--not even in the earlier stages of the crisis. For the period July 2, 1997-November 16, 1997 there is causality from Thailand to Indonesia and South Korea but not to the Philippines or Malaysia. Indeed, as the crisis progresses causal relationships among the countries most often go both ways.

Turning to the patterns that emerge from performing the same exercise on daily exchange rate changes there are important similarities with the results for interest rates. **First,** for the pre-crisis sample none of the regressors (other than lags of the dependent variable) are statistically significant at standard confidence levels--as was the case for interest rates. **Second,** during the post-crisis period there is a much a greater degree of interdependence among the exchange rates of the five countries--even greater than that exhibited by interest rates.

Third, exchange rates in the two smaller countries in the group, the Philippines and Thailand are the most influenced by exchange rate developments else where in the region. In the case of the Philippines, all four exchange rate (baht, ringgit, rupiah, and the won) are statistically significant in the regressions; for Thailand nearly all. This may be consistent with evidence of "large neighbor effects" on capital flow movements.[21] **Fourth**, changes in the Korean won (South Korea is the largest country of this group) significantly influence the remaining four currencies in the post crisis period.

Taken together, these results suggest that interdependence among currencies and interest rates among these five Asian economies has increased in the wake of the financial crisis. Given that trade and financial linkages have not changed markedly during this recent period, one interpretation for this greater interdependence is that in the aftermath of the crisis financial market participants are more likely to lump these economies into one group than they did previously.

V. Thoughts on Further Research

[21] See Calvo and Reinhart (1996) and (1998) for applications to Latin America and Africa, respectively.

This paper has suggested that financial sector links have played an increasingly important role in the 1990s in transmitting disturbances across national boundaries. Many of the channels of transmission (i.e., cross market hedges) and many of the agents (i.e. hedge funds and mutual funds) are still relatively novel, particularly in the context of emerging market finance. As such, these potential channels of interdependence merit much closer scrutiny both at the theoretical and empirical dimension. Microeconomic data at the institutional level is certainly bound to increase our understanding of the role played by capital markets and their new instruments in an increasingly globalized environment.

In addition, while banks in financial centers have a long history of lending to the developing world and booms and busts in such lending are not a new phenomenon, banks' lending strategies and decisions are still not well understood. Foreign banks' lending practices may be a source of instability to emerging markets when the shock originates at the center, as it did with the sharp rise in U.S. interest rates in October 1979, or when the shock originates in the difficulties faced by a relatively small borrower (i.e., Thailand) to whom the banks have substantial exposure. To gain insights into this phenomenon, it is necessary to go beyond the aggregate macroeconomic data and analyze the response of individual bank balance sheets and lending decisions to the kinds of shocks discussed in this paper. This analysis is not only useful to better understand past booms and busts in foreign lending--it is of increasing relevance to anticipate future ones. Indeed, given the trend in many emerging markets toward greater openness in their financial sectors and a rising presence of foreign or "truly international" banks, the issue of what role these banks play in transmitting disturbances across borders is of increasing relevance.

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Table 1. Bank lending to emerging Asia, June 1997-June 1998[1/]

		June 1997	**December 1997**	**June 1998**
European banks	Billions, US dollars	85,338	87,846	76,820
	Percent change since June 1997	n.a.	2.9	-10.0
Japanese banks	Billions, US dollars	97,232	86,651	74,297
	Percent change since June 1997	n.a.	-10.9	-23.6
U.S. banks	Billions, US dollars	23,738	21,974	16,566
	Percent change since June 1997	n.a.	-7.4	-30.2

[1/] Emerging Asia comprises Indonesia, Malaysia, Philippines, South Korea, and Thailand.

Table 2.Banks: Liabilities as a Percent of Borrowers's Total Liabilities. 1994-1998

Liabilities to the US								
	Dec-94	Jun-95	Dec-95	Jun-96	Dec-96	Jun-97	Dec-97	Jun-98
Indonesia	7.020	5.680	6.240	7.200	9.510	7.820	8.390	6.420
Malaysia	10.176	7.288	9.076	9.433	10.511	8.264	6.487	4.990
Philippines	37.408	35.830	35.379	31.042	29.363	19.450	16.336	16.992
South Korea	9.695	9.971	9.790	10.885	9.359	9.564	10.119	10.227
Thailand	6.131	5.791	6.522	6.387	7.198	5.761	4.304	3.754

Liabilities to Japan								
	Dec-94	Jun-95	Dec-95	Jun-96	Dec-96	Jun-97	Dec-97	Jun-98
Indonesia	52.476	50.758	47.103	43.853	39.686	39.421	37.712	37.857
Malaysia	43.215	41.373	43.627	40.453	36.925	36.420	31.057	34.334
Philippines	13.939	15.591	11.817	12.987	11.724	14.603	13.296	12.964
South Korea	30.792	29.223	27.673	25.574	24.335	22.787	21.525	26.136
Thailand	60.284	60.869	58.654	54.102	53.495	54.413	56.377	55.811

Liabilities to Europe								
	Dec-94	Jun-95	Dec-95	Jun-96	Dec-96	Jun-97	Dec-97	Jun-98
Indonesia	31.253	33.476	33.777	36.661	37.842	38.277	39.862	43.704
Malaysia	40.495	44.057	36.947	39.164	41.446	44.000	50.863	47.429
Philippines	41.376	40.275	42.020	43.520	47.618	49.363	53.088	60.203
South Korea	33.729	34.306	30.455	30.512	33.835	35.568	35.747	38.813
Thailand	24.187	24.853	23.730	26.066	27.283	28.546	29.182	32.809

Note: Each entry is amount owed by that country to the lender, divided by that country's total debt (grand total). Europe total includes Spain, UK, Sweden, Norway, Holland, Luxemburg, Italy, Ireland, Germany, France, Finland, Denmark, Belgium, and Austria.
Source: Bank of International Settlements.

Table 3. Banks: Liabilities as a Percent of Lender's Total Liabilities, 1994-1998

Liabilities to US

	Dec-94	Jun-95	Dec-95	Jun-96	Dec-96	Jun-97	Dec-97	Jun-98
Indonesia	2.82	2.63	2.94	3.45	5.59	4.04	4.32	2.95
Malaysia	1.58	1.23	1.61	1.84	2.47	2.09	1.58	1.05
Philippines	2.95	3.02	3.12	3.26	4.13	2.47	2.84	2.77
South Korea	6.33	8.15	8.03	9.32	9.90	8.75	8.41	6.78
Thailand	3.10	3.55	4.34	4.31	5.34	3.51	2.23	1.61

Liabilities to Japan

	Dec-94	Jun-95	Dec-95	Jun-96	Dec-96	Jun-97	Dec-97	Jun-98
Indonesia	15.23	15.09	15.14	15.43	15.91	15.58	15.75	15.49
Malaysia	4.84	4.48	5.29	5.80	5.93	7.06	6.12	6.44
Philippines	0.79	0.84	0.71	1.00	1.13	1.42	1.88	1.88
South Korea	14.47	15.36	15.49	16.06	17.56	15.97	14.51	15.42
Thailand	21.96	24.01	26.60	26.79	27.09	25.40	23.74	21.27

Liabilities to Europe

	Dec-94	Jun-95	Dec-95	Jun-96	Dec-96	Jun-97	Dec-97	Jun-98
Indonesia	3.22	3.67	4.21	4.79	5.89	5.15	4.65	4.28
Malaysia	1.61	1.75	1.74	2.09	2.58	2.90	2.80	2.13
Philippines	0.83	0.80	0.98	1.24	1.77	1.63	2.09	2.09
South Korea	25.39	28.14	30.12	31.71	43.15	38.77	30.86	22.98
Thailand	3.12	3.60	4.18	4.79	5.36	4.53	3.43	2.99

Notes: Each entry is the amount owed by that country to the lender, divided by the lender's total outstanding claims to developing countries, as reported to the BIS. The total claims of the lenders on developing countries is calculated as their total outstanding claims less the total claims to developed countries.

European data includes Spain, UK, Sweden, Norway, Holland, Luxemburg, Italy, Ireland, Germany, France, Finland, Denmark, Belgium, and Austria.
Source: Bank of International Settlements.

Table 4. Trade and Financial Clusters

Country	Bank Cluster		High-Correlation Cluster		Third-Party Trade Cluster		Bilateral Trade Cluster
	Japan	U.S.	Asia	Latin America	Asia	Latin America	Latin America
Argentina		1		1			1
Bolivia							
Brazil		1		1		1	1
Chile		1					1
Colombia		1				1	
Denmark							
Finland							
Indonesia			1				
Israel							
Malaysia			1		1		
Mexico		1		1		1	
Norway							
Peru				1			
Philippines		1	1		1		
South Korea [1]		1			1		
Spain							
Sweden							
Thailand			1		1		
Turkey							
Uruguay		1					1
Venezuela		1				1	

[1] Not part of our sample.

Table 5. Conditional Probabilities and noise-to-signal ratios for Trade and Financial Clusters

Noise-to-signal ratio	**Bank Cluster**	**High-Correlation Cluster**	**Third-Party Trade Cluster**	**Bilateral Trade Cluster**
25 to 50	0.90	0.58	1.54	2.34
50 and above	0.07	0.39	0.57	0.08
Weight in Vulnerability Index				
25 to 50	1.10	1.73	0.64	0.42
50 and above	14.08	2.57	1.75	12.5
P(C*CE)-P©				
25 to 50	-3.1	20.8	-6.3	-21.8
50 and above	52.0	47.1	30.7	47.3

Based on Kaminsky and Reinhart (1998)

Table 6. A contagion vulnerability index

Country	Contagion Vulnerability Index		
	December 1994: Mexican Crisis	July, 1997: Thai Crisis	January, 1999: Brazilian Crisis
Argentina	16.65	0	29.15
Bolivia	0	0	0
Brazil	18.4	0	n.a.
Chile	0	0	26.58
Colombia	12.5	0	15.83
Denmark	0	0	0
Finland	0	0	0
Indonesia	0	16.65	0
Israel	0	0	0
Malaysia	0	28.33	0
Mexico	n.a.	0	18.4
Norway	0	0	0
Peru	2.57	0	2.57
Philippines	14.08	4.32	14.08
South Korea [1]	0	26.58	0
Spain	0	0	0
Sweden	0	0	0
Thailand	0	n.a.	0
Turkey	0	0	0
Uruguay	0	0	26.58
Venezuela	12.5	0	15.83

Table 7. Daily Interest Rates: Causality Tests

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**	**Number that are signifi-cant**
Indonesia						
January 1, 1996-July 1, 1997		N	N	N	N	0
July 2, 1997-July 1, 1999		N	Y	N	Y	2
July 2, 1997-November 16, 1997		Y	N	N	Y	2
November 17, 1997-April 30, 1998		N	Y	Y	Y	3
Malaysia						
January 1, 1996-July 1, 1997	N		N	N	N	0
July 2, 1997-July 1, 1999	N		N	N	N	0
July 2, 1997-November 16, 1997	Y		Y	Y	N	3
November 17, 1997-April 30, 1998	N		N	Y	Y	2
Philippines						
January 1, 1996-July 1, 1997	N	N		N	N	0
July 2, 1997-July 1, 1999	N	N		N	Y	1
July 2, 1997-November 16, 1997	N	Y		N	N	1
November 17, 1997-April 30, 1998	Y	Y		N	N	2
South Korea						
January 1, 1996-July 1, 1997	N	N	N		N	0
July 2, 1997-July 1, 1999	N	N	N		N	0
July 2, 1997-November 16, 1997	Y	Y	Y		Y	4
November 17, 1997-April 30, 1998	Y	Y	N		Y	3
Thailand						
January 1, 1996-July 1, 1997	N	N	N	N		0
July 2, 1997-July 1, 1999	Y	N	Y	N		2
July 2, 1997-November 16, 1997	N	N	Y	Y		2
November 17, 1997-April 30, 1998	Y	N	Y	N		2

Table 8. Daily Exchange Rate Changes: Causality Tests

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**	**Number that are signifi-cant**
Indonesia						
January 1, 1996-July 1, 1997		N	N	N	N	0
July 2, 1997-July 1, 1999		Y	N	Y	N	2
July 2, 1997-November 16, 1997		Y	N	Y	N	2
November 17, 1997-April 30, 1998		N	Y	Y	N	2
Malaysia						
January 1, 1996-July 1, 1997	N		N	N	N	0
July 2, 1997-July 1, 1999	N		N	Y	N	1
July 2, 1997-November 16, 1997	N		N	N	N	0
November 17, 1997-April 30, 1998	N		N	N	Y	1
Philippines						
January 1, 1996-July 1, 1997	N	N		N	N	0
July 2, 1997-July 1, 1999	Y	Y		Y	Y	4
July 2, 1997-November 16, 1997	Y	Y		N	Y	3
November 17, 1997-April 30, 1998	Y	Y		Y	Y	4
South Korea						
January 1, 1996-July 1, 1997	N	N	N		N	0
July 2, 1997-July 1, 1999	Y	N	N		Y	2
July 2, 1997-November 16, 1997	Y	Y	N		N	2
November 17, 1997-April 30, 1998	Y	Y	Y		Y	4
Thailand						
January 1, 1996-July 1, 1997	N	N	N	N		0
July 2, 1997-July 1, 1999	Y	Y	N	Y		3
July 2, 1997-November 16, 1997	Y	Y	Y	Y		4
November 17, 1997-April 30, 1998	Y	N	N	Y		2

Appendix Table A.1. Daily Interest Rates: Causality Tests
January 1, 1996-July 1, 1997, 392 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic (probability) Log Likelihood (probability)		0.82 (0.61) 9.33 (0.50)	0.15 (0.99) 1.77 (0.99)	0.51 (0.88) 5.79 (0.83)	0.09 (0.99) 1.03 (0.99)
Malaysia					
F-Statistic (probability) Log Likelihood (probability)	1.02 (0.43) 11.54 (0.32)		0.45 (0.92) 5.13 (0.88)	1.25 (0.26) 14.10 (0.17)	0.78 (0.64) 8.92 (0.54)
Philippines					
F-Statistic (probability) Log Likelihood (probability)	1.31 (0.22) 14.73 (0.14)	0.45 (0.92) 5.18 (0.88)		0.70 (0.73) 7.96 (0.63)	0.55 (0.85) 6.30 (0.79)
South Korea					
F-Statistic (probability) Log Likelihood (probability)	0.69 (0.73) 7.87 (0.64)	1.15 (0.32) 13.04 (0.22)	1.23 (0.26) 13.90 (0.18)		0.43 (0.93) 4.90 (0.90)
Thailand					
F-Statistic (probability) Log Likelihood (probability)	0.18 (0.99) 2.02 (0.99)	0.57 (0.84) 6.49 (0.77)	0.46 (0.92) 5.20 (0.88)	1.09 (0.37) 12.31 (0.26)	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.

Appendix Table A.2. Daily Interest Rates: Causality Tests
July 2, 1997-July 1, 1999 334 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic (probability) Log Likelihood (probability)		0.37 (0.95) 4.36 (0.93)	2.44 (0.01)* 27.64 (0.00)*	0.38 (0.95) 4.47 (0.92)	2.34 (0.01)* 26.49 (0.00)*
Malaysia					
F-Statistic (probability) Log Likelihood (probability)	0.48 (0.90) 5.65 (0.84)		0.68 (0.74) 7.97 (0.63)	0.23 (0.99) 2.74 (0.99)	0.82 (0.61) 9.52 (0.48)
Philippines					
F-Statistic (probability) Log Likelihood (probability)	1.49 (0.14) 17.09 (0.07)**	1.24 (0.26) 14.36 (0.16)		0.71 (0.71) 8.29 (0.60)	1.61 (0.10)** 18.46 (0.05)*
South Korea					
F-Statistic (probability) Log Likelihood (probability)	0.38 (0.95) 4.49 (0.92)	0.30 (0.98) 3.57 (0.96)	0.22 (0.99) 2.63 (0.98)		0.30 (0.98) 3.51 (0.97)
Thailand					
F-Statistic (probability) Log Likelihood (probability)	3.12 (0.00)* 34.93 (0.00)*	0.58 (0.83) 6.80 (0.74)	2.19 (0.02)* 24.91 (0.01)*	0.43 (0.93) 5.09 (0.88)	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.

Appendix Table A.3. Daily Interest Rates: Causality Tests
July 2, 1997-November 16, 1997, 99 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic (probability) Log Likelihood (probability)		1.06 (0.41) 19.71 (0.03)*	0.72 (0.70) 13.90 (0.18)	0.48 (0.90) 9.39 (0.50)	1.66 (0.12) 29.42 (0.00)*
Malaysia					
F-Statistic (probability) Log Likelihood (probability)	1.11 (0.37) 20.68 (0.02)*		1.37 (0.22) 24.78 (0.01)*	1.17 (0.33) 21.28 (0.02)*	0.41 (0.93) 8.19 (0.48)
Philippines					
F-Statistic (probability) Log Likelihood (probability)	0.61 (0.80) 11.79 (0.30)	1.52 (0.16) 27.27 (0.00)*		0.46 (0.91) 9.11 (0.52)	0.77 (0.66) 14.66 (0.15)
South Korea					
F-Statistic (probability) Log Likelihood (probability)	1.49 (0.17) 26.69 (0.00)*	1.59 (0.14) 28.30 (0.00)*	1.40 (0.21) 25.37 (0.01)*		1.10 (0.38) 20.36 (0.03)*
Thailand					
F-Statistic (probability) Log Likelihood (probability)	0.79 (0.64) 15.02 (0.13)	0.64 (0.77) 12.35 (0.26)	1.68 (0.11) 29.78 (0.00)*	1.73 (0.10)** 30.44 (0.00)*	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.

Appendix Table A.4. Daily Interest Rates: Causality Tests
November 17, 1997-April 30, 1998, 119 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic		0.47	1.71	1.31	1.84
(probability)		(0.90)	(0.10)**	(0.24)	(0.07)**
Log Likelihood		8.01	26.65	20..95	28.55
(probability)		(0.63)	(0.00)*	(0.02)*	(0.00)*
Malaysia					
F-Statistic	0.47		0.19	1.19	1.18
(probability)	(0.90)		(0.99)	(0.32)	(0.32)
Log Likelihood	7.93		3.23	19.12	18.99
(probability)	(0.64)		(0.97)	(0.04)*	(0.04)*
Philippines					
F-Statistic	1.17	1.34		1.08	1.04
(probability)	(0.33)	(0.22)		(0.39)	(0.42)
Log Likelihood	18.92	21.34		17.62	17.00
(probability)	(0.04)*	(0.02)*		(0.06)**	(0.07)**
South Korea					
F-Statistic	3.72	1.17	1.06		1.58
(probability)	(0.00)*	(0.33)	(0.41)		(0.13)
Log Likelihood	51.99	18.89	17.20		24.84
(probability)	(0.00)*	(0.04)*	(0.07)**		(0.01)*
Thailand					
F-Statistic	2.49	0.57	1.52	1.13	
(probability)	(0.01)*	(0.83)	(0.15)	(0.35)	
Log Likelihood	37.11	9.65	23.94	18.281	
(probability)	(0.00)*	(0.47)	(0.01)*	(0.05)*	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.

Appendix Table A.5. Daily Exchange Rate Changes: Causality Tests
January 1, 1996-July 1, 1997, 392 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic (probability) Log Likelihood (probability)		0.71 (0.71) 8.03 (0.63)	0.50 (0.89) 5.71 (0.84)	0.51 (0.88) 5.83 (0.83)	0.71 (0.71) 8.13 (0.62)
Malaysia					
F-Statistic (probability) Log Likelihood (probability)	1.38 (0.19) 15.54 (0.11)		0.58 (0.83) 6.65 (0.76)	0.83 (0.60) 9.38 (0.50)	0.68 (0.74) 7.74 (0.65)
Philippines					
F-Statistic (probability) Log Likelihood (probability)	1.11 (0..35) 12.58 (0.25)	0.93 (0.50) 10.55 (0.39)		0.89 (0.54) 10.11 (0.43)	1.54 (0.12) 17.36 (0.07)**
South Korea					
F-Statistic (probability) Log Likelihood (probability)	0.48 (0.90) 5.52 (0.85)	0.78 (0.64) 8.90 (0.54)	0.97 (0.46) 11.01 (0.36)		0.45 (0.92) 5.16 (0.88)
Thailand					
F-Statistic (probability) Log Likelihood (probability)	0.17 (0.99) 1.91 (0.99)	0.73 (0.70) 8.29 (0.60)	1.41 (0.17) 15.86 (0.10)**	0.93 (0.51) 10.47 (0.40)	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.

Appendix Table A.6. Daily Exchange Rate Changes: Causality Tests
July 2, 1997-July 1, 1999 334 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic		1.95	1.07	3.19	0.85
(probability)		(0.04)*	(0.39)	(0.00)*	(0.59)
Log Likelihood		21.22	11.67	34.17	9.29
(probability)		(0.02)*	(0.31)	(0.00)*	(0.51)
Malaysia					
F-Statistic	1.09		1.08	1.89	1.27
(probability)	(0.37)		(0.38)	(0.04)*	(0.25)
Log Likelihood	11.98		11.83	20.57	13.85
(probability)	(0.29)		(0.30)	(0.02)*	(0.18)
Philippines					
F-Statistic	1.74	2.79		4.07	3.18
(probability)	(0.07)**	(0.00)*		(0.00)*	(0.00)*
Log Likelihood	18.94	30.00		43.22	34.08
(probability)	(0.04)*	(0.00)*		(0.00)*	(0.00)*
South Korea					
F-Statistic	1.87	1.36	0.97		0.45
(probability)	(0.05)*	(0.19)	(0.47)		(0.92)
Log Likelihood	20.28	14.85	11.01		5.16
(probability)	(0.03)*	(0.14)	(0.36)		(0.88)
Thailand					
F-Statistic	3.58	3.03	1.41	3.62	
(probability)	(0.00)*	(0.00)*	(0.17)	(0.00)*	
Log Likelihood	38.24	32.57	15.42	38.68	
(probability)	(0.00)*	(0.00)*	(0.12)	(0.00)*	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.

Appendix Table A.7. Daily Exchange Rate Changes: Causality Tests
July 2, 1997-November 16, 1997, 99 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic (probability) Log Likelihood (probability)		1.11 (0.38) 20.53 (0.02)*	0.76 (0.66) 14.61 (0.15)	1.67 (0.12) 29.56 (0.01)*	0.83 (0.61) 15.71 (0.11)
Malaysia					
F-Statistic (probability) Log Likelihood (probability)	0.49 (0.89) 9.64 (0.47)		0.25 (0.99) 5.00 (0.89)	0.57 (0.83) 11.06 (0.35)	0.53 (0.86) 10.34 (0.41)
Philippines					
F-Statistic (probability) Log Likelihood (probability)	1.13 (0.35) 20.99 (0.02)*	1.66 (0.12) 29.47 (0.00)*		0.66 (0.75) 12.80 (0.23)	4.06 (0.00)* 60.63 (0.00)*
South Korea					
F-Statistic (probability) Log Likelihood (probability)	2.15 (0.04)* 36.67 (0.00)*	1.93 (0.06) 33.51 (0.00)*	0.97 (0.49) 18.14 (0.05)*		0.62 (0.79) 12.00 (0.29)
Thailand					
F-Statistic (probability) Log Likelihood (probability)	1.87 (0.07)** 32.5 (0.00)*	1.59 (0.14) 28.31 (0.02)*	1.29 (0.26) 23.63 (0.01)*	2.17 (0.04)* 36.96 (0.00)*	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.

Appendix Table A.8. Daily Exchange Rate Changes: Causality Tests
November 17, 1997-April 30, 1998, 119 observations

	Indonesia	**Malaysia**	**Philippines**	**South Korea**	**Thailand**
Indonesia					
F-Statistic (probability) Log Likelihood (probability)		0.77 (0.66) 12.71 (0.24)	1.28 (0.26) 20.51 (0.02)*	1.44 (0.18) 22.84 (0.01)*	0.53 (0.87) 8.88 (0.54)
Malaysia					
F-Statistic (probability) Log Likelihood (probability)	0.75 (0.68) 12.45 (0.26)		0.38 (0.95) 6.54 (0.77)	0.57 (0.83) 9.62 (0.47)	1.24 (0.28) 19.88 (0.03)*
Philippines					
F-Statistic (probability) Log Likelihood (probability)	2.58 (0.01)* 38,22 (0.00)*	2.62 (0.01)* 38.82 (0.00)*		2.19 (0.03)* 33.16 (0.00)*	1.24 (0.28) 19.90 (0.03)*
South Korea					
F-Statistic (probability) Log Likelihood (probability)	1.99 (0.05)* 30.48 (0.00)*	1.43 (0.19) 22.65 (0.01)*	1.94 (0.05)* 29.90 (0.00)*		2.93 (0.00)* 42.67 (0.00)*
Thailand					
F-Statistic (probability) Log Likelihood (probability)	1.40 (0.20) 22.25 (0.01)*	0.82 (0.61) 13.57 (0.19)	0.75 (0.68) 12.42 (0.26)	1.36 (0.22) 21.68 (0.02)*	

* Significant at 5 percent confidence level.
** Significant at 10 percent confidence level.