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Regional Financial Crises and Equity Market Reactions: The Case of East Asia

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ABSTRACT

In this paper we investigate the relationship between regional financial turmoil and equity markets of three emerging Asian economies: Indonesia, Malaysia, and Thailand. The study focuses on the contagion of the regional banking and financial difficulties to security markets in these three countries. The VAR and bivariate GARCH model results show that, once the regional financial crisis spreads, equity markets decline and exacerbate the crisis. The speed with which equity markets respond to the regional liquidity and financial turmoil is quite similar despite disparate market capitalization and GDP of the regional economies. The volatility becomes persistent and the equity market and financial sector volatility appear to fuel further volatility in one another. However, we show that Malaysia, the most developed of the sample markets, weathered the crisis quicker and more successfully than the other two. These results have important ramifications for financial market participants, local regulators, and international governing bodies such as the IMF.

JEL: G14, G15

Keywords: Volatility spillover, Bivariate GARCH Models, Asian Emerging Markets

I. INTRODUCTION

By the early 1990's, the countries of East Asia were experiencing astonishing widespread economic growth compared with other regions around the globe. Following Japan's lead, the four original "Asian Tiger" countries, Hong Kong, Singapore, Taiwan, and South Korea, were exporting twice as many goods as the whole of Latin America (Tudor, 2000). As the four original Tigers were becoming developed economies, three emerging Southeast Asian economies, Thailand, Indonesia, and Malaysia (dubbed the "new Tigers") also began to experience phenomenal growth and became a focus of international investors. However, by 1997, the economic growth of the new Tigers began to plummet and a full-fledged economic and financial crisis was suddenly at hand. There are many similarities in the ways in which the financial systems of Thailand, Indonesia, and Malaysia reacted during this period.

There have been several theories developed when searching for causes of the Asian financial crisis, although, three major causes are prevalent in these discussions (see Miller and Langaram, 1998, Corsetti et al., 1998). The financial sector of the Asian economies shared the following characteristics. First, there was a heavy reliance on short-term debt, often from foreign lenders. This leaves an emerging market borrower vulnerable to liquidity problems if rates increase dramatically or if capital flows are reversed.[1] Second, holding much of this debt denominated in dollars left the new Tigers susceptible to exchange rate risk when depreciation of the host country currency occurred. Third, inadequate supervision of the banking and financial sectors led to questionable investment choices by financial intermediaries with much of the new infusion of capital.[2] In the extent to which the new Tigers were linked by trade and common credit sources, there is reason to expect that there would be rapid transmission of the economic crisis among Thailand, Indonesia, and Malaysia (Pesenti and Tille, 2000). There is also reason, then, to expect that the crisis in the financial sector would affect individual equity markets of each nation similarly in both speed and manner.

Thailand is a case in point. With the economic slow-down in 1996 and 1997, many questionable investments became unprofitable. When the baht was floated on July 2, 1997, investors lost confidence in the baht and rushed to covert their bahts to dollars. The baht quickly depreciated against the dollar, rendering Thai businesses unable to service their dollar-denominated investments. With banks and financial institutions rushing to reduce their exposure to exchange rate risk, the baht experienced a massive melt down. Financial crisis spread to other sectors of the economy. The loss of investor confidence immediately resulted in the flight of short-term capital out of Thailand and the rest of the Asian economies, which were in a very similar situation. Furthermore, the baht depreciation was putting pressure on other Asian economies to devalue their currencies in order to protect their export competitiveness.

Most of the prior analysis focuses on the similarities of the three new Tigers, all classified as "emerging" markets and all sharing economic problems that often accompany fast growth. But, there are also important differences among the three economies. Although the crisis affected several Asian economies, the three new Tigers suffered comparatively more (see Tudor, 2000). Statistics for GDP for each country

show that Thailand first experienced downturns in 1997, while both Indonesia and Malaysia first experienced declines in 1998. By 1999, all three had returned to positive growth (see Tudor, 2000, Table 1, p. 161). On a percentage basis, Indonesia experienced the steepest decline in GDP, followed by Thailand, then Malaysia. These three countries also differ in the size of their financial markets, thus, in their stage of financial and economic development.[3] Malaysia's equity market is the largest, followed by Thailand, then Indonesia. However, The Thai stock market recovered from the crisis more quickly, showing gains for 1998, while both Malaysia and Indonesia suffered equity losses for that year. Overall, it is obvious that the economic dynamics of the crisis were different for each of the new Tigers.

We study the contagion of the problems in the regional banking and financial sector to the national equity markets of Thailand, Indonesia, and Malaysia. We investigate equity market reaction to regional banking and financial difficulties to determine how market reaction may have been similar or different across Asia's primary emerging markets. As concluded by Pesenti and Tille (2000),

"The central role of the financial sector has led to a reassessment of the optimal pace of financial liberalization, due to the necessity of setting up adequate supervisory and regulatory mechanisms-and being able to enforce them-as preconditions for the removal of obstacles to international borrowing and lending."

Our results show how the crisis in the regional financial sector affected the national equity markets of the three new Tigers. This research may provide information for developing market regulatory and other financial agencies which may be employed to avoid similar problems in the future. It is also important to monitor reactions in domestic equity markets since fluctuations in these markets often fuel further problems in other economic sectors.

II. BACKGROUND AND THE REVIEW OF LITERATURE

The financial and economic crisis that engulfed pacific basin emerging markets, has been named the Asia crisis. What is so special about the East Asian crisis? According to Radelet and Sachs (1998), the East Asian financial crisis is remarkable in several ways. First, the most rapidly growing economies in the world were affected. It prompted the largest financial bailouts in history. It was the most serious financial crisis to roil the developing world since the 1982 debt crisis. Finally, it was relatively unexpected. The effects of Asian financial crisis were felt by most economies and consequently financial markets of the world (see Bhattacharya et al., 1998).

Many researchers have investigated various aspects of the Asian financial crisis. Baig and Goldfajn (1999) find Evidence of contagion between the financial markets of the five most affected economies: Thailand, Malaysia, Indonesia, Korea, and the Philippines. It is found that correlations in currency and sovereign spreads increased significantly during the crisis period, whereas the equity market correlations offered mixed evidence. They show that after controlling for own-country news and other fundamentals, there is evidence of cross-border contagion in the currency and equity markets. The popular financial media often observe similar cross-border contagion.

However, Baig and Goldfajn (1999) do not focus on the contagion of the crisis in the regional financial sector to the individual economies.

Masson (1997) defines contagion as spillover of a crisis in one country to elsewhere for reasons unexplained by economic fundamentals. The contagion may be for psychological reasons or because lack of liquidity in one market leads financial intermediary to liquidate other emerging market assets. Thus, contagion refers to cases which essentially involve shifts of expectation in models of multiple equilibria where a crisis in one country would trigger a shift from one of the equilibria to another somewhere else. Obstfeld (1994) had pointed out that the market for international sovereign debt can have multiple equilibria; and in his paper, Masson (1997) extends the idea to explain the elements of contagion present in East Asia. He constructs a simple model to see which countries were liable to suffer from this phenomenon.

Other researchers have discussed particular aspects of the financial crisis in Asia. For example, Glick and Rose (1999) study regional currency crises. They show that currency crises tend to be regional. Using data for five different currency crises (in 1971, 1973, 1992, 1994 and 1997), their findings support the hypothesis that patterns of international trade may determine how currency crises spread. However, macroeconomic and financial influences are not closely associated with the cross-country incidence of speculative attacks.

Barrell et al. (1998) discuss the global effects of the Asian financial crisis. They show that the Asian crisis had a marked effect on the world economy. The collapse of private demand in the Asian markets affected economies of the world and exacerbated the effects of deflationary forces in the Japanese economy. Risk premia in most emerging markets, particularly in Russia and Latin America, rose sharply partly because of the events in East Asia. Equity markets across all emerging markets reacted adversely as capital flowed from emerging market debt and equities into government debt in the major OECD countries.

Miller and Langaram (1998) discuss the root causes of the Asian financial crisis from a historic and institutional point of view. They argue that two decades of rapid economic growth were backed by surging capital inflows. Thus, they outline three main views of the Asian crisis. First, that it was simply due to reversal of capital flows. The failure of collective action on the part of creditors could have reversed the process by supplying extra liquidity-or by forcing creditors to roll over their loans. Second, the view that the miracle had grown into a bubble that had finally had to burst: so the problem was essentially one of insolvency. Finally, that the panic was not wholly groundless (and rescue efforts were bound to be difficult) mainly because weak regulation combined with implicit deposit guarantees had left local bankers free to gamble with the money that global capital markets had poured into their parlors. Panic set in when foreign depositors realized that there were not enough dollar reserves left for the guarantee to be credible. This account (championed most notably by Paul Krugman of MIT) involves both illiquidity and insolvency and helps to explain why the IMF was unwilling simply to throw money at the problem. Why did the crisis spread like wild fire around the region? Was it because a bank run due to shaky fundamentals in one country was imitated elsewhere, as investors joined the herd heading for the

exit? Stock markets of the region responded to the financial crisis in dramatic ways. Although the timing and the severity of the crisis came as a surprise, some stock markets in the region had been signaling caution for some time. Using a base of hundred in January 1990, the stock market in Thailand, for example, having risen to a plateau of about one hundred fifty, began falling in early 1996 so that by early 1997 it was standing below one hundred. It fell significantly to around fifty in the late 1997. By contrast, the Indonesian stock market gave little indication of the coming crisis: rising through 1995 and 1996 to reach a peak of about one hundred eighty in mid 1997.

The purpose of this paper is to investigate the contagion of the regional financial sector crisis to the entire equity markets of the affected economies and vice versa.[4] The objective is to study the degree to which emerging equity markets are susceptible to volatility and loss of investor confidence once there is a crisis in the financial sector. Our results show that generally financial sector may be considered a leader. However, once the turmoil spreads to the entire market, the equity markets decline and exacerbate the crisis in the financial sector. The volatility becomes persistent and the equity market and financial sector volatility appear to fuel further volatility in one another.

The organization of the rest of this paper is as follows. Section III presents the sources of data and the paper methodology. In section IV, the empirical results are explained. Summary and conclusions are the subject of the final section of this paper.

III. DATA AND METHODOLOGY

Daily closing values of Regional Dow Jones Financial Sector Index (FI) and three national market indices of Indonesia, Malaysia, and Thailand, are taken from the Dow Jones Global Index.[5] The study period covers from December 1991 through September 1997, which is the period leading up to the Asian financial crisis. This period is chosen in order to see if the pre-crisis financial relations could have been employed to examine the effects of the regional financial crisis. Furthermore, the financial and country indices used in our empirical analysis indices were not available prior to 1990. Because the purpose of the study is to examine the "contagion effects" in equity markets, we employ indices in domestic currency and do not convert them to real terms. Converting to real terms might taint the test results if the inflation effects are significant in either low or high direction.

Returns are given by $100*\ln(P_t/P_{t-1})$, or $100* \Delta\ln(P_t)$, where P_t is the index value at the end of the day. Prior research on information flows between markets has typically focused on lead-lag relationships between asset returns. Such an approach may provide only limited or biased inferences of information flows between markets. Informationally linked markets may share some common stochastic trends, react asymmetrically to information, and/or exhibit time varying volatility. Failure to incorporate such effects can invalidate the statistical inferences relating to the relationships. Furthermore, it becomes important to recognize that information effects and volatility effects may be highly related (Ross, 1989), so that they must be studied together. This study employs a general approach to investigate the flow of information between the regional financial sector and the equity markets in these emerging economies. The approach takes into account the time varying

volatility in these markets while allowing for intermarket volatility spillover, and asymmetrical effects of the variation in index divergence.

Consider the VAR system:

$$\Delta \ln F_t = \mu_o + \sum_{i=1}^{n} \mu_i \Delta \ln M_{t-i} + \sum_{i=1}^{n} \theta_i \Delta \ln F_{t-i} + \lambda_F (\ln F - \ln M)_{t-1} + \varepsilon_{F,t} \quad (1)$$

$$\Delta \ln M_t = \gamma_o + \sum_{i=1}^{n} \gamma_i \Delta \ln F_{t-i} + \sum_{i=1}^{n} \xi_i \Delta \ln M_{t-i} + \lambda_M (\ln F - \ln M)_{t-1} + \varepsilon_{M,t} , \quad (2)$$

where $\Delta \ln F_t$ and $\Delta \ln M_t$ are percentage returns on the regional financial index and the equity market index in a country, respectively; $(\ln F - \ln M)_{t-1}$ is the lagged difference in the natural log of financial sector and equity market indices which measures the convergence pressures in the two index series, and $\varepsilon_{C,t}$ and $\varepsilon_{U,t}$ are the random disturbance terms. The above error-correction specification is widely used to investigate the lead-lag relationship in financial markets. For instance, the estimation of significant coefficients on lagged changes in the financial index in the market index equation would typically be interpreted as the existence of information flows from the financial sector to the equity market. The λ coefficients indicate the burden of convergence between the two indices. If $\lambda_F > 0$ and $\lambda_M = 0$, then once the indices diverge, the regional financial index and equity market index do not revert to their equilibrium long-run relationship. Conversely, If $\lambda_M > 0$ and $\lambda_F = 0$, the indices converge, once out of their long-run equilibrium. The magnitude of the coefficient indicates the speed of adjustment. As discussed later, the two indices are cointegrated so that and error correction term is warranted in equations (1) and (2).

There are strong reasons to suspect that the variance of the error terms in the above VAR equations are time varying. Theory suggests that informed trading will induce persisting changes in the volatility of these commodities (Kyle, 1985), and there is a great deal of evidence that many financial price series exhibit time varying volatility. Specific to debt securities, several researchers have argued that interest rate risk premia are time variant (for instance, Shiller, 1979 and Singleton, 1980). Weiss (1984), Engle, Ng, and Rothschild (1990), and Engle, Lilien, and Robins (1987) find significant ARCH effects or serial correlation in variances in short term rates over several decades. In the present study, variance persistence or clustering may arise from market features unique to each of these emerging markets.

There is also reason to suspect that these variance effects are correlated across the two indices. Engle, Ng, and Rothschild (1990) indicate that the underlying forces behind volatility for shorter end of term structure are common across different rates - indicative of co-persistence of variance. Such co-persistence will have important implications for empirical analysis of variance behavior. While financial series may exhibit high variance persistence in their univariate representations, this persistence may be common across different and related series, so that linear combinations of the variables show lesser persistence. Ross (1989) argues that volatility may be regarded as a measure of information flow. Thus, if information arrives first in the financial sector, one should see a volatility spillover from that sector to the entire market. Therefore, to study the index movements, an

appropriate extension to the above VAR model will be employed to simultaneously allow for time varying volatility and volatility spillovers between the sectors.

The statistics in Table 1 justify some of the above suspicions relating to the variance of returns in the two series analyzed. The Ljung-Box and $Q^2(24)$ statistics indicate significant levels of serial correlation in the returns and the square of the returns. These statistics indicate linear and nonlinear dependencies in daily indices. Test statistics for ARCH errors (Engle, 1982) further suggest serial correlation in the errors. On the other hand, there is less evidence of serial dependencies in the standardized residuals from fitting the returns to a GARCH (1, 2) model.[6] The Q(24) statistics are substantially smaller and the $Q^2(24)$ statistics are insignificant. Such evidence indicates that a basic GARCH model effectively captures the nonlinearities in the data. Moreover, the standardized residuals exhibit relatively smaller kurtosis, further evidence of the GARCH model providing a superior fit to the data (Hsieh, 1989).

The relationship between the two indices while simultaneously controlling for the likely variance and covariance persistence are studied via variations of the bivariate GARCH model (similar models have been employed by Hamao, Masulis and Ng, 1990, Chan, Chan and Karolyi, 1991, and Chatrath and Song, 1998, among others)

$$\sigma_{F,t} = \alpha_0 + \alpha_1 \sigma_{F,t-1} + \alpha_2 \varepsilon^2_{F,t-1} + \alpha_3 \varepsilon^2_{M,t-1} \tag{3}$$

$$\sigma_{M,t} = \beta_0 + \beta_1 \sigma_{M,t-1} + \beta_2 \varepsilon^2_{M,t-1} + \beta_3 \varepsilon^2_{F,t-1}, \tag{4}$$

and

$$\sigma_{FM,t} = \pi_0 + \pi_1 \sigma_{FM,t-1} + \pi_2 \varepsilon_{F,t-1} \varepsilon_{M,t-1}, \tag{5}$$

assuming

$$\begin{pmatrix} \hat{\varepsilon}_{F,t} \\ \hat{\varepsilon}_{M,t} \end{pmatrix} | \Omega_{t-1} \_ t\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{F,t} & \sigma_{FM,t} \\ \sigma_{FM,t} & \sigma_{M,t} \end{pmatrix} \right), \tag{6}$$

where: $\sigma_{F,t}$ and $\sigma_{M,t}$ are the variance functions of. $\varepsilon_{F,t}$ and $\varepsilon_{M,t}$ (respectively) conditional on information set Ω available up to time t-1; $\sigma_{FM,t}$ represents the conditional covariance given by an autoregressive linear function of the cross product in the past squared errors; σ_{FM} represents the conditional covariance given by an autoregressive linear function of the cross products in the past squared errors, and the conditional correlation,

$$\rho_{FM,t} = \sigma_{FM,t} (\sigma_{F,t} \sigma_{M,,t})^{-\frac{1}{2}} \tag{7}$$

is allowed to vary over time.[7] Equation (6) indicates that the estimated $\varepsilon_{F,t}$ and $\varepsilon_{M,t}$ are t distributed with zero means and the given variance/covariance matrix. The parameters α_1 and $ß_1$ in (3) and (4) are the measures of volatility persistence in the two indices, respectively, with a large value indicating that the conditional variance remains elevated for extended periods of time following return shocks. The parameters α_3 and $ß_3$ are intended to capture the volatility spillovers ($\varepsilon^2_{F,t-1}$. $\varepsilon^2_{M,t-1}$.between markets. For instance, $\alpha_3>0$ and $ß_3=0$ would be consistent with the hypothesis that the volatility spills over from the market to the financial sector, and not *vice versa*.

IV. EMPIRICAL RESULTS

The Panel A of Table 1 presents the summary statistic for each series under consideration. Ljung-Box (Q) statistic indicates significant linear and nonlinear dependencies in all financial indices. Engle's ARCH test shows ARCH (10) effects in the regional financial index as well as equity indices of each market. Panel B of Table 1 presents support for GARCH (1, 1) model. It is evident that standardized residuals from GARCH (1, 1) model show no ARCH effect or linear and nonlinear dependencies. In sum, findings presented in Table 1 indicate that the equity index and the regional financial index series are affected by time varying volatility. Furthermore, the modeling of regional financial behavior would require considering the existing nonlinearities.

Tables 2, panel A reports the results of stationarity tests. The Augmented Dickey Fuller (Dickey and Fuller, 1979 and Phillips-Perron test statistics, Phillips and Perron, 1986) reject the null hypotheses that the first difference in logarithm of the financial and market index series are non-stationary, but cannot reject the null for the level series. Thus, as with most other financial series, there is evidence of one unit root in these indices. In panel B, Table 2 shows that the test statistics does not reject the null that the spread (difference in the natural logarithm of the regional financial index and individual equity market indices) is stationary, providing evidence for the possibility that the two series are cointegrated.

The Johansen trace and maximum-eigenvalue test statistics (Johansen and Juselius, 1990) presented in Table 3 provide a direct test for cointegration between the regional financial index and national index series. The null hypothesis of zero cointegrating vectors between the two indices (r=0) is rejected at the one percent level. We can conclude that there is at least one cointegrating vector between the two indices as the trace and eigenvalue statistics fail to reject the null of less than one cointegrating vectors.

Given prior evidence that the Johansen and Juselius tests are sensitive to the inclusion of drift terms in its near-VAR specification (for instance, Diebold, Gardeazabal, and Yilmaz, 1994), it is worth noting that the Johansen and Juselius tests provided similar results across models with and without controls for trend. Therefore, the empirical findings substantiate the plausible assumption that every one of the equity markets under study is sensitive to regional financial variables. This finding is not trivial and emphasizes the point that regardless of the strength in the economies of the region, they are not immune to economic fluctuations of even the smaller and the less significant players in the region.

Table 1
Financial industry and country indices

A.	Δ (ln Index)*100	Mean	Sd.dev.	Skewness	Kurtosis	Q (24)	Q^2 (24)	ARCH (10)
	Financial Industry	-0.007	1.31	0.54***	12.2***	55.64**	271.28***	125.5***
	Indonesia	0.04	1.08	0.79***	22.36***	257.59***	642.00***	44.24***
	Malaysia	0.03	1.17	0.74***	18.82***	68.0***	497.4***	230.41***
	Thailand	-0.006	1.54	0.19	8.33	72.02***	470.13***	160.48***
B.	Index Return Standard Residuals - Univariate GARCH (1, 1) model							
	Financial Industry	-0.02	1.00	0.16*	7.24***	17.22	24.9	14.05
	Indonesia	-0.02	1.00	0.16*	7.25***	17.44	24.87	5.05
	Malaysia	-0.02	1.00	0.06	6.32***	19.25	28.69	14.83
	Thailand	-0.02	1.00	-0.01	5.42***	33.59	29.66	16.57

Notes: The univariate GARCH model is given by

$$r_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i r_{t-i} + \varepsilon_t; \quad \sigma_t^2 = \beta_0 + \beta_1 \sigma_{t-1}^2 + \beta_2 \varepsilon_{t-1}^2$$

where r=Δ ln (index) *100 and i (6, 4, 4, 5, respectively) is determined by the Akaike (1974) information criterion, AIC.
*** Significant at 1 percent level.

Table 2
Augmented Dickey- Fuller and Phillips-Perron stationarity tests

	ADF ln(index)	PP	ADF Δ ln(index)	PP
Panel A				
Regional Financial Index				
a.	-1.72	-1.69	-18.06***	-36.42***
b.	-1.71	-1.60	-18.06***	-36.41***
Indonesia				
a.	-2.78*	-2.85*	-17.68***	-31.28***
b.	-2.39	-2.24	-17.77***	-31.31***
Malaysia				
a.	-2.17	-2.18	-17.71***	-36.89***
b.	-0.66	-0.49	-17.90***	-36.98***
Thailand				
a.	-1.01	-0.99	-17.10***	-36.78***
b.	-1.02	-0.99	-17.26***	-36.87***
Panel B				
Indonesia: ln F- lnM				
a.	-3.84***	-3.61***		
b.	-4.13***	-3.82***		
Malaysia: ln F- lnM				
a.	-3.32**	-3.12**		
b.	-3.27*	-3.00		
Thailand: ln F- lnM				
a.	-3.36**	-3.20**		
b.	-3.81***	-3.63***		

Notes: The ADF test entails estimating $\Delta x_t = \alpha + \beta x_{t-1} + \gamma_j \Sigma_{j=1}^{k} \Delta x_{t-j} + \mu_t$ and testing the null hypothesis that $\beta=0$ versus the alternative of $\beta<0$, for any x. The number of lags on the right-hand-side of ADF regressions as suggested by AIC and SIC are 6, 4, and 4, for Indonesia, Malaysia, and Thailand indices, respectively. The PP test requires estimating $\Delta x_t = \alpha + \beta x_{t-1} + \mu_t$ and testing the null hypothesis $\beta=0$ versus the alternative of $\beta<0$. The PP test may be more appropriate if autocorrelation in the series under investigation is suspected. Lag truncation (7, 5, and 5 for Indonesia, Malaysia and Thailand, respectively) for Bartlett-kernel in Phillips-Perron test are suggested by Newey-West (1987). The critical values given by MacKinnon (1990) are: with trend: -3.12 (10%), -3.41 (5%), -3.96 (1%), without trend: -2.57 (10%), -2.96 (5%), -3.43 (1%).
a: without trend
b: with trend
***, ** significant at 1 and 5 percent levels.

Table 3
Long-term equilibrium: Johansen-Juselius maximum likelihood procedure

Bilateral Cointegration between the Regional Financial Index and the Individual Equity Indices LR Test Based on Maximal Eigenvalue and Trace of the Stochastic Matrix					
		Indonesia	Malaysia	Thailand	Critical Value
Ho	`Ha	λ_{max}	λ_{max}	λ_{max}	95%
r=0	r=1	19.35a**	18.12a**	11.80a	15.67
		19.43b**	18.13b	24.82b**	18.96
r ≤ 1	r=2	2.53a	1.90a	0.91a	9.24
		2.40b	2.43b	2.00b	12.25
Ho	Ha	λ_{trace}	λ_{trace}	λ_{trace}	Critical Value 95%
r = 0	r ≥ 1	20.68a**	19.98a**	12.67a	19.96
		21.18b	20.53b	26.75b**	25.30
r ≤ 1	r ≥ 2	2.53a	1.90a	0.91a	9.24
		2.39b	2.42b	2.00b	12.25

Notes: r stands for the number of cointegrating vectors. Critical values are taken from Oterwald-Lenum (1992).
a. No deterministic trend in data, intercept but no trend in cointegrating vector.
b. Linear deterministic trend in data, intercept and trend in cointegration vector, and no trend in VAR.
** represents significant at 5percent level.

Tables 4a-4c present the results from equations (1) and (2) estimated outside of the GARCH system. The lag length in the VAR system for each market is based on the Akaike information criterion (1974). As there is some evidence of a long- run relationship between the two series, an error correction term is appended to the VAR system. The specifications produces independently distributed residuals as indicated by the Q(24) statistics. The results from this estimation are shortly compared to those from the joint estimation of the mean and variance equations.

The coefficients and F-values reported in Tables 4a-4c suggest strong uni-directional causality in emerging equity markets. In each market, there is strong evidence

that equity market fluctuations will have a significant effect on the regional financial health. These findings corroborate the findings reported in Table 3. One more time it becomes evident that regardless of the size of equity markets of the region, they play a significant role in spreading financial instability to the rest of the markets of the region. The policy ramification of the findings of Tables 3 and 4(a-c) thus far is that the international financial organizations such as the IMF may not be able to ignore signs of financial distress in any of the regional equity markets. Financial problems are sure to spread to the entire region. A surprising finding is that the causality appears to be uni-directional as one would expect the causal relationship to be bilateral. Given that the lag length and the linearity of the model may affect the results of causality tests, further investigation of the bilateral relationship between regional index and equity indices of each market is appropriate. We shall address this issue shortly.

Table 4a
VAR model with error correction

	Dependent variable (Δ (ln Index) * 100)			
	FI		Indo	
Constant	0.23**	(1.94)	0.17*	(1.78)
FI (t-1)	0.14***	(5.75)	0.00	(0.01)
FI (t-2)	-0.05***	(-2.17)	0.02	(0.78)
FI (t-3)	0.01	(0.25)	-0.01	(-0.45)
FI (t-4)	0.03	(1.32)	0.01	(0.33)
FI (t-5)	-0.01	(-0.52)	0.00	(0.17)
FI (t-6)	-0.02	(-0.75)	0.04**	(2.16)
Indo (t-1)	-0.04	(-1.39)	0.26***	(10.87)
Indo (t-2)	0.01	(0.26)	0.07***	(2.80)
Indo (t-3)	-0.00	(-0.02)	0.00	(0.12)
Indo (t-4)	0.04	(1.18)	0.05**	(2.03)
Indo (t-5)	-0.02	(-0.53)	-0.07***	(-2.79)
Indo (t-6)	-0.11***	(-3.52)	-0.06***	(-2.56)
lnF-lnM	0.36**	(2.01)	0.22	(1.54)
Q(24)	19.07		28.07	
Regional Financial index does not cause Indonesia index				F=1.04
Indonesia index does not cause the Regional Financial index				F=2.68***

Notes: ***, **, *significant at 1, 5 and 10 percent levels.

Table 4b
VAR model with error correction

	Dependent variable (Δ (ln Index) * 100)			
	FI		Malay	
Constant	0.18*	(1.77)	0.16*	(1.68)
FI (t-1)	0.13***	(5.35)	0.00	(0.05)
FI (t-2)	-0.06***	(-2.33)	0.01	(0.53)
FI (t-3)	0.01	(0.22)	-0.01	(-0.31)
FI (t-4)	0.04	(1.63)	0.03	(1.36)
FI (t-5)	-0.00	(-0.11)	0.02	(0.93)
FI (t-6)	-0.02	(-0.76)	0.04**	(2.05)
Malay (t-1)	0.02	(0.62)	0.13***	(5.26)
Malay (t-2)	0.02	(0.71)	-0.06***	(-2.48)
Malay (t-3)	-0.00	(-0.02)	0.06**	(2.24)
Malay (t-4)	-0.01	(-0.36)	0.046*	(1.86)
Malay (t-5)	-0.06**	(-2.01)	-0.04*	(-1.76)
Malay (t-6)	-0.07***	(-2.41)	-0.00	(-0.01)
lnF-lnM	0.30*	(1.88)	0.21	(1.49)
Q(24)	20.48		23.41	
Regional Financial index does not cause Malaysia index				F=1.42
Malaysia index does not cause the Regional Financial index				F=1.97**

Table 4c
VAR model with error correction

	Dependent variable (Δ (ln Index) * 100)			
	FI		Thai	
Constant	0.12*	(1.65)	-0.04	(-0.45)
FI (t-1)	0.13***	(5.31)	-0.03	(-0.90)
FI (t-2)	-0.06***	(-2.64)	0.04	(1.39)
FI (t-3)	0.00	(0.10)	-0.05*	(-1.74)
FI (t-4)	0.04*	(1.81)	0.016	(0.55)
FI (t-5)	-0.01	(-0.56)	-0.02	(-0.66)
FI (t-6)	-0.02	(-0.87)	0.018	(0.64)
FI (t-7)	-0.03	(-1.21)	-0.00	(-0.16)
FI (t-8)	-0.02	(-0.87)	-0.01	(-0.45)
Thai (t-1)	0.00	(0.14)	0.13***	(5.56)
Thai (t-2)	0.01	(0.70)	-0.00	(-0.19)
Thai (t-3)	-0.00	(-0.03)	0.07***	(2.89)
Thai (t-4)	-0.04*	(-1.86)	0.01	(0.27)
Thai (t-5)	-0.01	(-0.59)	0.00	(0.03)
Thai (t-6)	-0.02	(-1.03)	0.02	(0.79)
Thai (t-7)	-0.02	(-0.78)	-0.02	(-0.94)
Thai (t-8)	-0.04**	(-2.06)	-0.01	(-0.30)
lnF-lnM	0.279*	(1.87)	-0.07	(-0.41)
Q(24)	17.40		25.50	
Regional Financial index does not cause Thailand index				F=0.73
Thailand index does not cause the Regional Financial index				F=1.66*

Notes: ***, **, *significant at 1, 5 and 10 percent levels, respectively.

The significant positive coefficient of the lagged spread in the financial index equation, coupled with the insignificant coefficients in the national index equation reported in Tables 4(a-c), suggest that once the two indices diverge, there is more pressure for the indices to diverge in the three emerging markets under study. Therefore, regardless of initial causes of financial turmoil, regional financial problems would instigate further instability and may not be corrected by the endogenous forces. Thus, external intervention by the World Bank or the IMF may be called upon to initiate the momentum necessary to reestablish the equilibrium in financial markets of the region. The coefficient of the spread variable (lnF-lnM) in each market indicates the speed of adjustment toward or away from the starting equilibrium. It is noteworthy that the speed with which equity markets move toward chaos and disequilibrium is similar in all of the equity markets under consideration and the order of magnitude is fairly sizable. Thus, in order to curb the spread of the financial turmoil in the region and beyond, intervention by international organizations should be implemented rapidly.

To further investigate the spillover of the financial instability in the region we estimate the bivariate GARCH model discussed above. Table 5 (a through c) reports results from the joint estimation of (1)-(5). For the sake of brevity, we only present the results from the variance and covariance equations. It should be noted, however, that the nonlinear estimations of mean equations (1) and (2) continued to support the evidence of uni-directional causality between the two indices, and the evidence that the convergence between the two indices does not occur.

The coefficients for the lagged variances in the variance equations suggest considerable volatility persistence for indices in all markets. Thus, these results further reinforce our finding that the forces endogenous to the region are not sufficient to resolve the problems of financial disequilibrium in the region. There is strong evidence of volatility spillover from the equity markets of Malaysia to the financial sectors of the region. The coefficient on the intermarket lagged shocks is significant at the one percent level in the regional financial market equation but not in the national market equation. According to Ross (1989), such evidence would be consistent with information arriving first in the national market. However, in Thailand and Indonesia, volatility spillover occurs in both directions, perhaps indicating a simultaneous information arrival. Furthermore, this finding may be related to the size of equity markets under consideration. For example, Malaysia boasts the largest capitalization equity market of the markets under study. It is conceivable that it affects the regional financial conditions significantly. There is evidence of persistence in the covariance of the two returns as indicated by the coefficient on $\square_{FMt-1.}$ Finally, the diagnostics support the specification of the model. The Q(24) and $Q^2(24)$ statistics for autocorrelation in the standardized residuals are mostly insignificant at the 0.01 level and the sign bias statistic suggest that the standardized residuals are independent and identically distributed (see Engle and Ng, 1993).

Table 5a
Bivariate Garch model with volatility spillovers

Variance Equation	Financial	Indonesia
Intercept	0.56***	0.59***
	(5.76)	(7.50)
Lagged Conditional Variance	0.71***	0.61***
	(16.30)	(11.90)
Lagged Own Shocks	0.12***	0.11***
	(6.37)	(4.39)
Intermarket Lagged Shock	0.017***	0.012***
	(13.8)	(8.28)
Ho: intermarket lagged shocks are equal	χ^2 (1) = 5.52***	
Conditional Covariance Equation		
Intercept	0.06	
	(0.89)	
Lagged Conditional Covariance	0.62**	
	(2.04)	
Product of Lagged Residuals	0.078	
	(1.49)	
Diagnostics on Standardized residuals		
Q(24)	21.77	25.52
Q^2 (24)	29.40	25.60
Sign Bias t-Statistic	0.09	0.83
System Log Likelihood	-2217.22	

Notes: Returns and conditional variance equations are estimated in a system assuming variance correlations are constant. Q(24) and Q^2 (24) are the Ljung-Box statistics of the autocorrelation in the standardized residuals ($\varepsilon_{it} / \sqrt{\sigma_{it}}$) and square of standardized residuals. The sign bias test shows whether positive and negative innovations affect future volatility differently from the model prediction (see Engle and Ng, 1993).

*, **, ***, represent significant at 10, 5, and 1 percent levels, respectively.

Table 5b
Bivariate Garch model with volatility spillovers

Variance Equation	Financial	Malaysia
Intercept	0.34***	0.088***
	(9.00)	(5.54)
Lagged Conditional Variance	0.70***	0.87***
	(28.35)	(49.70)
Lagged Own Shocks	0.17***	0.07***
	(9.70)	(8.04)
Intermarket Lagged Shock	0.012***	0.0003
	(11.87)	(0.15)
Ho: intermarket lagged shocks are equal	χ^2 (1) = 18.98***	
Conditional Covariance Equation		
Intercept	0.17***	
	(10.01)	
Lagged Conditional Covariance	0.23	
	(1.58)	
Product of Lagged Residuals	0.04	
	(1.22)	
Diagnostics on Standardized residuals		
Q(24)	21.05	22.45
Q^2 (24)	26.52	18.80
Sign Bias t-Statistic	0.60	1.34
System Log Likelihood	-2112.18	

Notes: Returns and conditional variance equations are estimated in a system assuming variance correlations are constant. Q(24) and Q^2 (24) are the Ljung-Box statistics of the autocorrelation in the standardized residuals ($\varepsilon_{it} / \sqrt{\sigma_{it}}$) and square of standardized residuals. The sign bias test shows whether positive and negative innovations affect future volatility differently from the model prediction (see Engle and Ng, 1993).
*, **, ***, represent significant at 10, 5, and 1 percent levels, respectively.

Table 5c
Bivariate Garch model with volatility spillovers

Variance Equation	Financial	Thailand
Intercept	0.12***	0.09***
	(13.39)	(9.64)
Lagged Conditional Variance	0.76***	0.87***
	(61.30)	(88.87)
Lagged Own Shocks	0.17***	0.09***
	(13.67)	(10.03)
Intermarket Lagged Shock	0.006***	0.0008***
	(3.06)	(8.34)
Ho: intermarket lagged shocks are equal	$\chi^2(1)=2.60^*$	
Conditional Covariance Equation		
Intercept	0.0007	
	(1.36)	
Lagged Conditional Covariance	0.99***	
	(32.20)	
Product of Lagged Residuals	0.004**	
	(1.98)	
Diagnostics on Standardized residuals		
Q(24)	29.88	30.19
$Q^2(24)$	12.41	15.40
Sign Bias t-Statistic	0.79	-1.15
System Log Likelihood	-2526.28	

Notes: Returns and conditional variance equations are estimated in a system assuming variance correlations are constant. Q(24) and $Q^2(24)$ are the Ljung-Box statistics of the autocorrelation in the standardized residuals ($\varepsilon_{it} / \sqrt{\sigma_{it}}$) and square of standardized residuals. The sign bias test shows whether positive and negative innovations affect future volatility differently from the model prediction (see Engle and Ng, 1993).

*, **, ***, represent significant at 10, 5, and 1 percent levels, respectively.

The findings reported in Table 5(a-c) reinforce our empirical evidence shown in previous Tables. Our findings in Table 5 (a-c) verify that in two out of three cases, regional and market spasms indeed spillover to national equity markets and subsequently feedback into the process of disequilibrium. The disequilibrium seems to persist as shown by the magnitude of the coefficients of the lagged conditional variance, lagged own shocks, and the lagged conditional covariance in all panels of Table 5. These findings one more time highlight the urgency with which IMF or central banks of the region should act in order to prevent the spread of financial instability to the rest of the region and the world.

V. CONCLUSIONS

The origins of the Asian financial crisis are found in the crash of Thailand's baht in July, 1997. Oddly, initially the Thai stock market soared by a 7.9 percent in one day after the crash. Investors believed that the Thai Central Bank and other economic authorities were accepting the realities of the free market and allowing the baht settle at its market value. However, in the following months the ripple effects from the baht depreciation caused bank failures and corporate bankruptcies around the region. In addition, the U.S. believed this to be an isolated economic downturn in Thailand. The U.S.-backed IMF plan was to provide funds to Thailand while imposing stringent austerity plans, high interest rates, and banking system regulations. Once the banking system in Thailand began to fail, investor confidence in the economy was lost. The baht fell even lower against the dollar. The Central bank was forced to raise interest rates to bolster the baht. However, higher interest rates slowed the economy further, caused other businesses to fail, and Thailand's economy experienced a serious downward spiral. Investor nervousness spread to Malaysia, Indonesia and others in the region creating the contagion effect. The western capital that had poured into the region in the early and mid-1990s began to flood out in 1997 further weakening domestic currencies and the banking systems.

In this paper we investigate the relationship between regional financial turmoil and three major emerging equity markets. Thus, we focus on the contagion of the regional banking and financial difficulties to the security markets of three emerging economies, Indonesia, Malaysia, and Thailand. Our results show that the crises in the regional financial sector lead the equity market crises in the economies of the region. However, once the turmoil spreads to the entire market, the equity markets decline and exacerbate the crisis in the regional financial sector. The speed with which equity markets respond to the regional liquidity and financial turmoil is quite similar despite the varying sizes of equity markets and regional economies. The volatility becomes persistent and the equity market and financial sector volatility appear to fuel further volatility in one another. These findings are plausible because it is shown that there is a long-run equilibrium relationship (cointegration) between the equity markets and financial sectors of these emerging markets.

The results have implications for financial market participants, local regulators, and international governing bodies. First, for international investors in equity markets of these emerging Asian nations, examining the health and stability of the regional financial

intermediaries is a wise prerequisite for investing in the region's equity markets. This is especially true since our results show that the financial sector is a leader of equity market prices. Next, for the financial intermediaries themselves, the development and maintenance of sound lending policies before accepting foreign capital is warranted. This would include the delineation of acceptable lending risks and limits on extensions of credit. Intermediaries must also recognize the liquidity risks posed when accepting foreign capital that is subject to "flight" as higher returns can be obtained in other regions of the world.

International financial organizations such as the International Monetary Fund also have responsibilities in regard to regional financial turmoil. The IMF appropriately demands that countries in need of funds impose sound fiscal and monetary policies so that additional funds do not perpetuate chronic economic problems. However, as events in Thailand and subsequently in Malaysia and Indonesia showed, these reforms should be implemented over time. The period of capital flight and sever economic instability requires prompt action to stem the spread of economic and financial problems from one market to the rest of the markets of the region.

As for local regulators of financial intermediaries whose primary job is to prevent failures, placing reasonable limitations on the lending/investing choices made by intermediary managers is necessary, along with judicious enforcement of these limitations. This helps prevent a nation's financial system from deteriorating due to imprudent employment of capital in increasingly risky projects. This problem is especially acute in emerging markets where the financial system is young and regulatory experience is limited. International governing bodies such as the IMF and the World Bank should take actions to correct problems in emerging market financial systems at the first signs of economic difficulties. This could include persuasion of local banking systems to take corrective actions such as curtailing questionable lending practices, nepotism in the financial sector, and stabilizing local currency. Such actions should help avoid regional financial sector difficulties from becoming international economic catastrophes.

Two main conclusions of this paper may be the following. First, as the international economies and financial systems become more integrated and efficient, the vulnerability to financial shocks at the regional and international level also increases. Similar to capital flows, market jitters can move across nations and regions instantaneously. The Asian financial crisis demonstrated the perils of globalization without the implementation of the financial and regulatory infrastructures. Secondly, it is absolutely essential that emerging markets who rely mainly on foreign capital for investment projects plan and put in place the necessary laws and regulations and infrastructures such as modern accounting systems, banking regulations, and rigorous financial reporting free of corruption and manipulations.

NOTES

1. By mid 1997, short-term external debt relative to liquid foreign assets (foreign exchange reserves) was as much as 1.7 and 1.5 in Indonesia and Thailand, respectively.
2. Montgomery (1997) shows that in Indonesia, for example, loans to the real estate sector grew at an annual rate of thirty seven per cent during 1992-5, compared with

twenty two per cent for total bank credit; and in Thailand, the growth of lending by finance companies to the property sector averaged forty one per cent per annum, compared with total lending growth of thirty three per cent per annum during 1990-95.

3. Malaysia has a market capitalization of over $106 billion or 5.7 percent of the total emerging market capitalization, Indonesia $20.5 billion or 1.1 percent , and Thailand $35 billion 1.9 percent at the end of 1998, according to the Emerging Stock Markets Factbook, 1999, International Finance Corporation.
4. The financial sector includes banks, insurance, real estate, savings and loans, and brokerage firms.
5. The Regional Financial Index is mainly based on share prices of the financial sector, which includes Banking, insurance sectors, real estate, and brokerage firms of the region.
6. We choose Bollerslev's (1986) GARCH (1, 1) model over higher order ARCH or GARCH models due to the strong support found for this model in recent work. Moreover, the GARCH (1, 1) model, with its fewer parameters, is more viable a multivariate setting (Baillie and Bollerslev, 1990).
7. Note that the conditional correlation coefficient is equal to the conditional covariance divided by the square root of the product of two conditional variances.

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