East Asian Equity Markets, Financial Crises, and the Japanese Currency

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ABSTRACT

The paper studies the interactions between the US and four East Asian markets. The new empirical insight is on the change in the information structure/flow between these markets triggered by the 1997 Asian financial crisis. The likelihood ratio test allowing for GARCH effects is used to alleviate the problem of using a standard F-test in the presence of conditional heteroskedasticity. It is shown that the information structure during the crisis period is different from the non-crisis periods. While the US market leads these East markets before, during, and after the crisis, it is Granger-caused by these markets during the financial crisis period. Further, in accordance with concerns reported in the market, the Japanese currency is found to affect these equity markets during the crisis period. The Japanese yen effect, however, disappears in the post-crisis sample. The Japanese currency effect is quite robust as it is found from both local currency and US dollar return data and in the presence of Japanese stock returns.

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1. Introduction

The interaction of national equity markets is an active research area. Early studies usually focus on the comovement of national equity indexes; see, for example, Graneger and Morgenstern (1970), Grubel and Fadler (1971), and Ripley (1973). Some of these studies are motivated by the benefits of international portfolio diversification (Grubel, 1968; Levy and Sarnat, 1970; Solnik, 1974). In addition to portfolio diversification, the pattern of interactions provides evidence on information flows between national markets and the relative dominance of individual markets. Hamao, Masulis and Ng (1990), for instance, study the interactions between the US, Japan, and UK stock markets and infer that information flow is uni-directional from New York to the other markets. Apparently, the US market plays a leading role in transmitting information to other equity markets – including both developed and emerging markets (Eun and Shim, 1989; Ng, Chang and Chow, 1990; Cha and Cheung, 1998; Cheung and Ng, 1996). Obviously the pattern of market comovements has important implications for portfolio management and hedging activity.

The current study investigates the interactions between the equity markets in the US and four East Asian economies. Specifically, the study compares the interaction patterns before, during, and after the 1997 Asian financial crisis. Financial crises are characterized by extreme market conditions. Thus, during a crisis, a different information transmission mechanism between financial markets can prevail. Even after the financial crisis, informational linkages between markets can assume a different pattern depending on how the crisis is resolved. For instance, King and Wadhwani (1990) suggest that the presence of contagion effects, which lead to shock transmission, during financial crises. On the other hand, Malliaris and Urrutia (1990) assert that there is no lead-lag relationship among the major national equity indexes during the

October 1987 crash period. Jeon and Von Furstenberg (1990) report that the comovement between international equity indexes is stronger after October 1987 while Cha and Cheung (1998) show that the US exerts a more pronounced effect on Asian markets after the crash. Tuluca and Zwick (2001) investigate 13 Asian and non-Asian equity markets before and after the 1997 Asian financial crisis and find that these markets experience a stronger comovement after the crisis.

Besides examining of the interaction between stock indexes, the current study also investigates the impact of Japanese currency movements on these markets. One predominant feature of the Asian crisis was its rippling effects on economies both within and without the region. Given its dominance and trade and financial ties in the region, Japan was closely scrutinized during the crisis. Specifically, a weak yen was conceived as a threat to the recovery in the troubled region and the turnaround of the depressed stock markets. During that time, officials from various East Asian economies were quite vocal about the possibility that a sharp yen depreciation might lead to a new round of 'competitive depreciation' and trigger another wave of financial crises. Equity market traders were looking to the yen exchange rate for clues on the stock market movements.[1] The market's acute concern about the Japanese currency suggests there may be a change in the information structure between equity markets during the crisis period. To empirically document such a phenomenon, the Japanese yen exchange rate will be explicitly included in our analysis of stock market interactions.

Daily equity returns on Hong Kong, Korea, Singapore, Taiwan and the US markets from three sample periods are considered. The sample from January 1995 to June 1997 constitutes the

[1] See, for example, The Economist (1998). On June 16, 1998, the China finance minister, Xiang Huaicheng, said that the pressure for a devaluation of the yuan (the Chinese currency) was mounting as the Yen/US exchange rate was weakening. Such devaluation was seen to be a

pre-crisis period. The crisis period extends from July 1997 to June 2000. The post-crisis period is from July 2000 to February 2002. The causality test confirms the prominent role of the US in the international equity market. It is found that the US index leads the East Asian market indexes in all the sample periods under consideration. The East Asian market indexes, on the other hand, have the strongest effect on the US market during the crisis period and no effect after the crisis. Most interestingly, our empirical results attest the effect of the Japanese currency on equity markets. The Japanese currency effect is widely felt during the crisis period but is not found in the post-crisis sample – even after controlling for the returns on the Japanese Nikkei 225 index and the currency conversion effect. As conceived by market participants, yen depreciation is found to induce a downward drift in these equity markets during the crisis.

The remainder of the paper is organized as follows. Section 2 presents the basic data analysis. The causal relationships between the stock markets are examined in Section 3. Section 4 considers the Japanese yen effects. Additional analyses including the regression results based on dollar-based return data are reported in Section 5. Section 6 offers some concluding remarks.

2. Data and Preliminary Analyses

Daily stock indexes for Hong Kong, Korea, Singapore, Taiwan, and the US were retrieved from Datastream. These indexes are the Hang Seng Index for Hong Kong, the Korea Composite Index for South Korea, the Strait Times Index for Singapore, the Weighted Index for Taiwan, and the Dow Jones Industrial Average Index for the US. All data were transformed to the logarithmic form. Three sample periods are considered. The pre-crisis sample is from January 1995 to June 1997, the crisis sample from July 1997 to June 2000 and the post-crisis

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substantial threat to the stability and recovery in the region.

sample from July 2000 to July 2002. The end of the crisis period is set to 2000 to accommodate the total and lingering effect of the 1997 and 1999 crises. The year 2000 also witnessed a general recovery from the financial crisis.[2]

Before analyzing the interactions between these stock indexes, we apply the standard unit root and cointegration tests to the data.[3] Table 1 reports the results of the augmented Dickey-Fuller unit root test that allows for a trend and an intercept. The combined sample is also included for comparison purposes. The Akaike information criterion and residual correlation are used to determine the lag parameter used in the Dickey-Fuller regression. Results for stock indexes in log levels (Panel A) and in first log differences (Panel B) together suggest that the stock indexes are I(1) processes - a result in accordance with other studies in the literature. One observation is in order. For each stock index series, the lag structure parameters are not the same across sample period. The observed parameter instability is indicative of shifting of dynamics across the samples and raises the concern of using the combined sample to make inferences about the interaction of these equity markets.

Since the stock indexes are individually I(1), the appropriate first-difference specification depends on whether the indexes are cointegrated or not. The Johansen procedure is employed to test for the cointegration property of country pairs that consist of the US and one respective East Asian economy. In Table 2, these country pairs display different cointegration results across samples. The Johansen statistic shows that the US index and the East Asian market indexes are pairwise cointegrated during the pre-crisis period. The result is consistent with some earlier on

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[2] Modifying the three sample periods by change the starting and end points by a few months does not have any material implications for results reported in the subsequent sections. The additional results are available upon request.

[3] Since both the augmented Dickey-Fuller and Johansen tests are standard procedures, they were not discussed in the text for brevity. See, for example, Dickey and Fuller (1979) and

the cointegration of national equity markets (Leachman and Francis, 1995; Masih and Masih 2001). Nonetheless, there is no evidence of cointegration from the crisis and post-crisis samples. The results in the crisis and post-crisis periods are likely to be the reason of finding no-cointegration in the combined sample. Given these test results, an error correction term will be included in specifications used for the pre-crisis period.

3. Causality Patterns

Following the literature, we adopt the causality test as the tool to determine the lead-lag relationship between a pair of stock indexes. Essentially, the test examines whether one series contains useful information about the evolution of another series. Let X_t be the return on one of East Asian market indexes at time t, as measured by first log differences, and Y_t be the return on the US stock index. To test the hypothesis of the US market does not Granger cause the East Asian market, we first consider the regression

$$X_t = C + \sum_{j=1,\ldots,k} \alpha_j X_{t-j} + \varepsilon_t, \qquad (1)$$

where the lag parameter k is selected to make ε_t a white noise process. That is, (1) represents the specification in which X_t is best explained by its own history. Then, we consider

$$X_t = C + \sum_{j=1,\ldots,k} \alpha_j X_{t-j} + \sum_{j=1,\ldots,n} \beta_j Y_{t-j} + \varepsilon_t \qquad (2)$$

and use the joint significance of β_j's to test the causality hypothesis. Specifically, the null hypothesis of the US market does not Granger cause the East Asian market is rejected if β_j's are not jointly insignificantly different from zero. In other word, the US market is said to cause the East Asian market if the lagged values of Y_t provide additional explanatory power for X_t after

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Johansen (1991) for an excellent description of these procedures.

controlling for X_t's own history. In estimating (2), we consider n = 1, …, 10 and report the statistic based on the value of n determined by the Akaike information criterion.[4]

The regression equations analogous to (1) and (2), which are given by

$$Y_t = C + \sum_{j=1,\ldots,k} \alpha_j Y_{t-j} + \varepsilon_t, \qquad (3)$$

and

$$Y_t = C + \sum_{j=1,\ldots,k} \alpha_j Y_{t-j} + \sum_{j=0,\ldots,n} \beta_j X_{t-j} + \varepsilon_t, \qquad (4)$$

are used to test the hypothesis of the US market is not Granger caused by the East Asian market. Note that in (4) the second summation index j starts from 0 instead of 1. It is because the US and East Asian markets operate in different time zones. For a given business day, the US market opens after the close of these East Asian equity markets. Thus, X_t is predetermined relative to Y_t and can be legitimately used to test the causality hypothesis. The exclusion of X_t from (4) tends to under-state the influence of East Asian markets. Further, as mentioned in the previous section, an error correction is added to (2) and (4) for the pre-crisis sample.

There is a technical issue of testing for causality in the current setting. It is well conceived that monthly equity returns display substantial conditional heteroskedasticity, which is commonly modeled as an GARCH process. In fact, for our dataset, preliminary analyses of equations (2) and (4) confirm the presence of GRACH effects in the error terms ε_t.[5] The presence of GARCH implies the error term and lagged dependent variables are not independent. Hence, the standard F-test for causality yields spurious results in the presence of GARCH effects. To circumvent the adverse conditional heteroskedasticity effect on testing for causality, we adopt the maximum likelihood procedure that allows for GARCH effects and construct the

[4] In general the results reported are quite insensitive to the choice of n.

corresponding likelihood ratio statistic to test the hypothesis of β_j's are zero. Cheung and Fujii (2001), for example, illustrate that the explicit treatment of GARCH effects can considerably improve the test performance.

The causality test results are summarized in Table 3. The hypothesis on the joint significance of β_j's is usually considered as evidence of causation relationship. We also tested for the significance of the error correction term in regressions considered in the pre-crisis period. Since the error correction term represents the deviation from the (empirical) long-run relationship, its significance can be interpreted as a causal response to deviation from the long-run equilibrium relationship. To conserve space, only the likelihood statistics and theirs p-values are presented. Other estimation results and diagnostics are available upon request. Panel A of Table 3 contains results for testing the hypothesis that the US does not cause the individual East Asian markets. During the pre-crisis period, the movement in the US stock index significantly affects three of the four East Asian markets. Apparently, the Taiwan market does not respond to developments in the US. For the pre-crisis period in which an error correction term is included, the error correction term is significant in all the four regression equations – that is, these East Asian markets do respond to deviations from the cointegrating relationships. During both the crisis and post-crisis periods, there is strong evidence that the US market leads the other markets. The evidence on the US influences is largely consistent with other studies in the literature.

Panel B presents the results of testing the hypothesis of that the US is not caused by an East Asian market. The evidence is quite intriguing. While the US market responses only to market movements in Hong Kong and Korea during the pre-crisis period, it significantly reacts to all the four East Asian markets during the crisis. Interestingly, the same set of markets appears

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[5] The estimated GARCH effects for all the specifications are available upon request.

to have no effect on the US stock market after the crisis. The error correction term is not significant in Panel B. Thus, when there is a cointegration relationship, it is the East Asian market, and not the US, that responds to the deviation from the empirical long-run relationship. One way to interpret the result is that the East Asian markets are caused by the US market, but not *vice versa*, in the long run. If we look at the combined sample, we tend to conclude that these East Asian markets have significant effects on the US.

Thus far the analysis shows that the interaction between stock indexes can change quite substantially across a financial crisis. Panels A and B indicate that feedback is detected among some index pairs in the pre-crisis sample and in all index pairs during the crisis, but only uni-directional causality pattern is revealed in the post-crisis period. On the other hand, the causality inferences based on the combined sample are quite different from those based on individual samples. Thus, a study of the interaction between equity markets should recognize the possible change in the comovement pattern around a crisis period.

4. Effects of the Japanese Currency

As one of the major economies, Japan plays an important role in both the Asian region and the world economy. Some envisage the wild fluctuation of the yen value before 1997 is one of the culprits of the recent Asian finance crisis.[6] During the crisis, both officials of the East Asian governments and market practitioners were vocal about the role of the yen exchange rate. On the one hand, the Japanese economy is sought as the growth engine to lead the region out of the slump. On the other hand, a weak yen is seen as a threat and will shrink the market share of Asian exporters or force them to compress profit margins. If it is the case, then a weak yen is a

[6] See, for example, Corsetti , Pesenti and Roubini (1999), Ito, Ogawa and Sasaki (1998),

negative factor for these stock markets. In this section, we attempt to determine whether the East Asian stock markets respond to the Japanese currency. If they do, do they react differently before and after the crisis?[7]

To investigate the effect of the Japanese currency on the causal relationship between the stock indexes, we augment (2) and (4) with an exchange rate term and estimate

$$X_t = C + \sum_{j=1,\ldots,k} \alpha_j X_{t-j} + \sum_{j=1,\ldots,n} \beta_j Y_{t-j} + \sum_{j=1,\ldots,m} \gamma_j S_{t-j} + \varepsilon_t, \qquad (5)$$

and

$$Y_t = C + \sum_{j=1,\ldots,k} \alpha_j Y_{t-j} + \sum_{j=0,\ldots,n} \beta_j X_{t-j} + \sum_{j=1,\ldots,m} \gamma_j S_{t-j} + \varepsilon_t, \qquad (6)$$

where S_{t-j} is the daily dollar-yen exchange rate in first log differences. Similar to the determination of n, the lag parameter m is selected using the Akaike information criterion from the set m = 1, …, 10. The results are quite robust to the choice of m. Again, for brevity, Table 4 presents only the likelihood ratio statistics and their p-values for the respective tests of the (joint) significance of β_j's, the error correction term, and γ_j's. Comparing Table 3 and Table 4, it is revealed that the presence of S_{t-j}'s does not have any material effects on the significance of β_j's and the error correction term.

The role of the Japanese currency in (5) and (6) depends on the sample period. During the pre-crisis period, the dollar-yen exchange rate, at the 5% significance level, provides some incremental explanatory power for two cases in Table 4. The Japanese yen effect on these stock markets appears quite limited before the financial crisis.

Radelet and Sachs (1998) for some discussion on the causes of the Asian financial crisis.

[7] There is a related, but different literature on a country's exchange rate effects on its own stock market. The empirical results documented in these studies are quite mixed - positive, negative and zero exchange rate effects are reported. See, for example, Jorion (1990) and Bartov and Badnar (1994)

There is a noticeable change in the role of the Japanese currency during the crisis period. For all the bivariate causation equations, the added exchange rate term is highly significant. It is interesting to observe that the inclusion of S_{t-j}'s does not alter the previous causality results based the significance of β_j's. Thus, the Japanese currency effect is in addition to the usual market interaction mechanism investigated in the literature. The coefficient estimates of the dollar-yen exchange rate term are mostly positive; implying that a yen depreciation leads to a lower stock index. For the East Asian equity markets, the results are in accordance with the perception that, during the financial economic turmoil, a weak yen raises the concerns of a weak Japanese economy and an erosion of export competitiveness among East Asian economies, which, in turns, exert pressure on these stock markets. The effect of yen on the US market can be ascribed to the contagion effect commonly found during the crisis (King and Wadhwani, 1990).

The yen exchange rate effect on these stock markets after the crisis is quite different from the other two periods. Essentially, in the presence of the lagged US stock index, the Japanese currency has no significant explanatory power for the four East Asian markets. Similarly, the post-crisis US market is not affected by the yen exchange rate. Note that the US index is affected by the value of yen in some of the specifications considered in the pre-crisis period. The results from the combined sample indicate that some of these markets are influenced by the yen exchange rate. If the focus is on the market behavior in the post-crisis period, the combined sample results will yield spurious inferences about market interactions and provide erroneous information for making investment and portfolio management decisions.

In sum, the empirical results corroborate the contention that the Japanese currency is a factor affecting the East Asian stock markets during the crisis. Further, the impact of the yen on these markets is likely to change across the samples.

5. Additional Analyses

In this section, we investigate the robustness of the yen effect reported in the previous section. First we consider whether the results are sensitive to the use of return data expressed in the US dollar unit. Specifically, we transform the equity return data from local currency units to returns in the US dollar and re-do the exercise. One interpretation is that we consider the stock market interaction from the perspective of a US investor. The results from the regression equations

$$X_{US,t} = C + \sum_{j=1,\ldots,k} \alpha_j X_{US,t-j} + \sum_{j=1,\ldots,n} \beta_j Y_{t-j} + \sum_{j=1,\ldots,m} \gamma_j S_{t-j} + \varepsilon_t \qquad (7)$$

and

$$Y_t = C + \sum_{j=1,\ldots,k} \alpha_j Y_{t-j} + \sum_{j=0,\ldots,n} \beta_j X_{US,t-j} + \sum_{j=1,\ldots,m} \gamma_j S_{t-j} + \varepsilon_t \qquad (8)$$

are reported in Table 5. $X_{US,t}$ is the return on an East Asian stock market index expressed in the US term. The lag parameters k, n, and m are determined using the approach discussed in the previous sections.

The use of dollar return data appears to have limited impacts on the results reported in the previous section. The patterns of significance of β_j's and the error correction term in Table 5 are essentially the same as those in Table 4. With the dollar-based returns, the Japanese yen currency effect appears to be slightly weakened. Nonetheless, the currency effect is mostly observed during the crisis period and evaporated in the post-crisis sample. The coefficient estimates (which are available upon request), again, suggest that a yen depreciation during the crisis tends to lower these equity markets. Overall speaking, from data on both local-currency and US dollar returns, the implied variations in the information flow structure across these samples are quite

similar. Thus, the reported Japanese yen effect is not likely to be the consequence of currency conversion.

The stock market is commonly perceived as a barometer of the economy. Thus, the reaction of the East Asian equity markets to the Japanese stock market can be viewed as their reactions to the development in the Japanese economy. Since exchange rate movements are influenced by the economy, it is possible that the reported Japanese currency effect captures the markets' responses to developments in the Japanese economy rather than some effects specific to the crisis experience. If the yen exchange rate variable is a proxy for economic conditions that are represented by the stock market, then the presence of the Japanese stock variable will render the yen variable insignificant. To investigate such a possibility, we consider the following regression equations

$$X_{US,t} = C + \sum_{j=1,\ldots,k} \alpha_j X_{US,t-j} + \sum_{j=1,\ldots,n} \beta_j Y_{t-j} + \sum_{j=1,\ldots,m} \gamma_j S_{t-j} + \sum_{j=1,\ldots,p} \phi_j JP_{t-j} + \varepsilon_t, \qquad (9)$$

and

$$Y_t = C + \sum_{j=1,\ldots,k} \alpha_j Y_{t-j} + \sum_{j=0,\ldots,n} \beta_j X_{US,t-j} + \sum_{j=1,\ldots,m} \gamma_j S_{t-j} + \sum_{j=1,\ldots,p} \phi_j JP_{t-j} + \varepsilon_t, \qquad (10)$$

where JP_t is the return on the Japanese Nikkei 225 index. Since the dollar return data give a weaker Japanese yen currency effect, the use of equations (9) and (10) will not over-state the importance of the currency effect.[8]

The likelihood ratio test results are presented in Table 6. In general, conditional on other variables, these equity markets do not exhibit much response to the Japanese stock market. The JP_t variable is significant in only a few cases. The effects of lagged Y_t's ($X_{US,t}$'s) on $X_{US,t}$ (Y_t) across the samples are essentially the same as those reported in the previous tables. The presence of lagged Japanese equity returns does not have any discernable impacts on the significance of

the Japanese currency variable. The yen effect, again, shows up mainly during the crisis period and does not exist in the post-crisis sample. Thus, the reported Japanese currency effect is not just a reflection of market concerns about the Japanese stock market variable, which can be interpreted as a proxy for the Japanese economy.

6. Concluding Remarks

The paper presents an empirical study on the interactions between the US and four East Asian markets. The empirical evidence confirms the dominant role of the US market in these equity markets. The new empirical insight is on the change in the information structure/flow between these markets triggered by the 1997 Asian financial crisis. Our results document that the information structure during the crisis period is different from the non-crisis periods. While the US market leads these East markets before, during, and after the crisis, it is Granger-caused by these markets during the financial crisis period. Further, consistent with concerns reported in the market, the Japanese currency is found to affect these equity markets during the crisis period. The Japanese yen effect, however, disappears in the post-crisis sample.

The analysis employs the maximum likelihood approach and the likelihood ratio test to account for GARCH effects in the data. Thus, the results on the change of information structure/flow are not attributable to erroneous inferences generated by the standard F-test in the presence of conditional heteroskedasticity. The Japanese yen effect does not appear spurious. The same currency effect is uncovered from both local currency and US dollar return data and detected in the presence of the Japanese stock return variable. The findings corroborate the

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[8] In fact, local currency return data gave results similar to those reported in Table 6.

contention that financial crises endure extreme market conditions, which can lead to changes in the way information is transmitted across markets.

The results on the change in information flows have substantial implications for both the academia and the investment community. The changing causal relationship and the come and go of the Japanese yen effect warrant a detailed study on information flow and propagation mechanisms under different market conditions. The channel and transmission mechanism through which the yen exchange rate affects the East Asian economies is an interesting future research area. For practitioners, information on market interactions helps improve hedging and managing portfolios containing foreign equities. The documented changes in market behavior suggest that different investment strategies should be pursued under different market conditions. Further, if changes are not allowed for, the use of long sample data may yield obscure and even erroneous information on market interactions.

References

Bartove, E. and Bodnar, G.M. (1994) Firm Valuation, Earning Expectations, and the Exchange-Rate Exposure Effect, Journal of Finance **49**, 1755-1786.

Cha, B. and Cheung, Y.L. (1998), The Impact of the U.S. and the Japanese Equity Markets on the Emerging Asia-Pacific Equity Markets, *Asia Pacific Financial Markets* **5**, 191-209.

Cheung, Y.L. and Mak, S.C. (1992), The International Transmission of Stock Market Fluctuation Between the Developed Markets and the Asian-Pacific Markets, *Appl. Financ. Econom.* **2**, 43-47.

Cheung, Y.-W. and Fujii, E., (2001) A Note on the Power of Money-Output Causality Test, *Oxford Bulletin of Economics and Statistics* **63**, 247-261.

Cheung, Y.-W. and Ng, L.K. (1996), A Causality-In-Variance Test and Its Application to Financial Market Prices, *Journal of Econometrics* **72**, 33-48.

Corsetti G., Pesenti, P. and Roubini, N., (1998), What Caused the Asian Currency and Financial Crisis - Part I: A Macroeconomic Overview, *Japan and the World Economy* **11**, 305-373.

Dickey, D.A. and Fuller, N.A. (1979), Distribution of the estimators for autoregressive time series with a united root, *J. Am. Stat. Assoc.* **74**, 427-431.

The Economist, 1998, Asia Trembles Again, *The Economist* (20 June) **347**, Issue 8073, 85-86.

Eun, C. and Shim, S. (1989), International Transmission of Stock Market Movements. *Journal of Financial and Quantitative Analysis* **24**, 241-256.

Errunza, V.R. (1997), Gains from portfolio error of a coefficient of correlation into less-developed country's securities, *J. Int. Busin. Stud.* **8** (Fall), 83-89.

Ghosh, A., Saidi, R., and Johnson, K.H. (1999), Who moves the Asia-Pacific stock markets – US or Japan? Empirical evidence based on the theory of cointegration, *The Financial Review* **34**, 159-169.

Granger, C.W.J. and Morgenstern, O. (1970), *Predictability of Stock Market Prices*, Health-Lexington, Massachusetts.

Grubel, H. (1968), Internationally diversified portfolio: Welfare gains and capital flows, *Amer. Econom. Rev.* **58** (December), 1299-1314.

Grubel, H. and Fadner, K. (1971), The interdependence of international equity markets, *J. Finance* **26** (March), 89-94.

Hamao, Y., Masulis, R., and Ng, V. (1990), Correlation in price changes and volatility across international stock markets, *Review of Financial Studies* **3**, 281-307.

Ito, T., Ogawa, E. and Sasaki, N. (1998), How Did the Dollar Peg Fail in Asia? *Journal of Japanese and International Economics* **12**, 256-304.

Jeon, N.N. and von Furstenberg, G.M. (1990), Growing International Comovement in Stock Price Indexes, *Quarterly Review of Economics and Business* **30**, 15-30.

Johansen, S. (1991), Estimation and hypothesis testing of cointegration vectors in guassian vector autoregression models, *Econometrica* **59**, 1551-1580.

Jorion, P. (1990), The Exchange-Rate Exposure of U.S. Multinatinals, *Journal of Business* **63**, 331-345.

King, M. and Wadhwani, S. (1990), Transmission of Volatility between Stock Markets, *Review of Financial Studies* **3**, 5-33.

Leachman, L.L. and Francis, B. (1995), Lon run relations among G-5 and G-7 equity markets: evidence on the Plaza and Louvre accords, *J. of Macroeconomic* **17**, 551-577.

Lessard, D. (1973), International portfolio diversification: A multivariate analysis for a group of Latin American countries, *J. Finance* **28** (June), 619-633.

Levy, H. and Sarnat, M. (1970), International diversification of investment portfolios, *Amer. Econom. Rev.* **60** (September), 668-675.

Lin, W., Engle, R., and Ito, T. (1991), Do bull and bears move across borders? International transmission of stock return and volatility as the world turn, Working Paper, University of Wisconsin at Madison.

Makridakis, S.G. and Wheelwright, S.C. (1974), An analysis of the interrelationships among the major world stock exchanges, *J. Busin. Finance Account.* **1** (2), 195-215.

Maldonado, R. and Saunders, A. (1981), International portfolio diversification and the intertemporal stability of international stock market relationships, 1957-78, *Financ. Managt.* **10** (Autumn), 54-63.

Malliaris, A.G. and Urrutia, J.L. (1992), The international crash of October 1987: Causality tests, *J. Financ. Quantitat. Anal.* **27**, 353-364.

Masih, R. and Masih, M.M. (2001) Long and short term dynamic causal tranamission among international stock markets, *Journal of International Money and Finance* **20**, 563-587.

Ng, V., Chang, R., and Chou, R. (1990), An examination of the behavior of international stock market volatility, *Pacific-Basin Capital Market Research*, Vol. II.

Panton, D.B., Lessiq, V.P., and Joy, O.M. (1976), Comovement of international equity markets: A taxonomic approach, *J. Financ. Quantitat. Anal.* **11** (September), 425-431.

Philippatos, G.C., Christofi, A., and Christofi, P. (1983), The intertemporal stability of international stock market relationships: Another view, *Financ. Managt.* **12** (Winter), 63-39.

Radelet, S. and Sachs J. (1998), The East Asian Financial Crisis: Diagnosis, Remedies, Prospects, Brooking Papers On Economic Activity **28**, 1-74.

Ripley, D.M. (1973), Elements in the linkage of national stock market indices, *Rev. Econom. Statist.* **55** (August), 356-361.

Solnik, B.H. (1974), Why not diversify internationally rather that domestically? *Financ. Anal. J.* **30** (July/August), 48-54.

Tuluca, S.A. and Zwick, B. (2001), The effects of the Asian crisis on global equity markets, *The Financial Review* **36**, 125-142.

Table 1. Unit Root Test Results

Panel A: Log Levels								
	Pre-Crisis		Crisis		Post-Crisis		Combined	
	lag	ADF	lag	ADF	lag	ADF	lag	ADF
HK	7	-3.0296	4	-2.9352	0	-2.8051	4	-2.2591
SG	1	-2.6254	1	-2.1503	0	-2.6153	1	-1.7609
TW	0	-1.8843	0	-2.3897	4	-1.7241	4	-0.8041
KW	1	-2.5819	1	-2.2745	0	-2.3225	1	-1.8177
US	0	-2.5008	0	-2.7434	0	-2.7275	0	-1.7650

Panel B: First Log Differences								
	Pre-Crisis		Crisis		Post-Crisis		Combined	
	lag	ADF	lag	ADF	lag	ADF	lag	ADF
HK	9	-8.8700	3	-13.9441	4	-7.5727	3	-20.4037
SG	9	-7.9221	0	-23.2547	0	-16.9971	0	-35.5687
TW	0	-26.5235	0	-26.7071	3	-9.4552	3	-21.8195
KW	0	-22.4551	0	-24.9709	1	-12.4212	4	-19.9654
US	0	-24.7743	9	-9.0355	1	-12.6816	2	-25.5043

The augmented Dickey-Fuller unit root test results are reported. The lag parameter is given under the column "lag" and the statistics are given under "ADF." The stock indexes are HK – Hong Kong Hang Seng Index, SG - the Singapore Strait Times Index, TW- the Taiwan Weighted Index for Taiwan, KW- the Korea Composite Index, and US – the US Dow Jones Industrial Average Index. All data were transformed to the logarithmic form. The pre-crisis sample is from January 1995 to June 1997, the crisis sample from July 1997 to June 2000 and the post-crisis sample from July 2000 to July 2002. The "Combined" column contains results from January 1995 to July 2002. All the statistics in Panel A do not reject the unit root null hypothesis. The same null hypothesis is rejected by first log differenced data (Panel B).

Table 2. Cointegration Test Results

	Pre-Crisis		Crisis		Post-Crisis		Combined	
	CE(s)	L.R.	CE(s)	L.R.	CE(s)	L.R.	CE(s)	L.R.
US/HK	0	40.6611	0	11.1884	0	10.0627	0	16.1210
	1	14.2568	1	1.6758	1	2.1765	1	5.0031
US/SG	0	24.4054	0	8.0678	0	12.5974	0	17.1445
	1	7.2632	1	1.2358	1	1.7776	1	2.9841
US/TW	0	30.7747	0	11.7817	0	12.1283	0	13.4981
	1	13.2000	1	4.5866	1	4.2069	1	1.5199
US/KW	0	22.4716	0	8.5591	0	19.5428	0	15.6297
	1	6.4538	1	1.0620	1	4.3707	1	3.2613

The Johansen trace statistics are reported. The maximum eigenvalue statistic gives similar results. See the note to Table 1 for the definitions of notation. Cointegration is found in the pre-crisis period but not in the crisis and post-crisis samples.

Table 3. Causality Test Results

PANAL A: The US Causes the East Asian Economies

		Prior Crisis		During Crisis	Post Crisis	Entire Period
		β_j's = 0	ECT=0	β_j's = 0	β_j's = 0	β_j's = 0
HK	LR	140.55	13.42	117.57	83.32	346.88
	p-value	0.00	0.00	0.00	0.00	0.00
SG	LR	59.14	3.92	123.34	35.60	196.29
	p-value	0.00	0.05	0.00	0.00	0.00
TW	LR	2.41	14.71	51.89	8.41	61.66
	p-value	0.12	0.00	0.00	0.00	0.00
KW	LR	7.07	6.64	53.94	32.33	67.03
	p-value	0.01	0.01	0.00	0.00	0.00

PANAL B: The East Asian Economies Cause the US

		β_i's = 0	ECT=0	β_i's = 0	β_i's = 0	β_i's = 0
HK	LR	8.82	1.89	40.70	0.90	39.89
	p-value	0.01	0.17	0.00	0.64	0.00
SG	LR	5.78	2.09	19.36	2.60	28.23
	p-value	0.06	0.15	0.00	0.27	0.00
TW	LR	1.69	0.43	7.78	0.80	8.21
	p-value	0.43	0.51	0.25	0.67	0.08
KW	LR	12.47	0.00	9.91	0.55	9.46
	p-value	0.01	1.00	0.01	0.76	0.01

The table reports the causality test results based on equations (1) to (4) in the text. Likelihood ratio statistics allowing for GARCH in error terms are used to conduct the test. The "LR" row gives the likelihood ratio statistic and the "p-value" row gives the corresponding o-value. The column "β_j's = 0" lists the statistic that tests the joint significance of the β_j's in equations (2) and (4). The column "ECT=0" lists the statistic that tests the significance of the error correction term included in regressions considered in the pre-crisis sample. Panel A contains the results of testing the hypothesis of the US does not cause the individual East Asian markets. Panel B contains the results of testing the hypothesis of an East Asian market does not cause the US. See the note to Table 1 for the definitions of notation.

Table 4. The Japanese Currency Effect

PANAL A: The US Causes the East Asian Economies

		Prior Crisis			During Crisis		Post Crisis		Entire Period	
		β_i's = 0	γ_i's = 0	ECT=0	β_i's = 0	γ_i's = 0	β_i's = 0	γ_i's = 0	β_i's = 0	γ_i's = 0
HK	LR	134.95	23.19	13.26	129.54	16.87	84.22	0.96	345.27	1.55
	p-value	0.00	0.01	0.00	0.00	0.00	0.00	0.33	0.00	0.46
SG	LR	57.36	2.16	3.90	129.89	9.05	34.94	0.01	195.17	0.12
	p-value	0.00	0.14	0.05	0.00	0.01	0.00	0.91	0.00	0.94
TW	LR	1.84	2.96	13.72	59.21	10.96	6.88	2.61	63.40	3.48
	p-value	0.17	0.09	0.00	0.00	0.00	0.01	0.11	0.00	0.06
KW	LR	0.78	2.47	6.36	63.16	31.24	32.57	0.24	63.57	8.90
	p-value	0.38	0.29	0.01	0.00	0.00	0.00	0.62	0.00	0.03

PANAL B: The East Asian Economies Cause the US

		β_j's = 0	γ_j's = 0	ECT=0	β_j's = 0	γ_j's = 0	β_j's = 0	γ_j's = 0	β_j's = 0	γ_j's = 0
HK	LR	10.67	3.94	1.80	39.42	14.29	1.16	1.05	42.76	9.18
	p-value	0.00	0.05	0.18	0.00	0.16	0.56	0.59	0.00	0.03
SG	LR	6.65	3.25	2.06	20.80	16.39	2.78	1.05	29.22	7.43
	p-value	0.04	0.07	0.15	0.00	0.09	0.25	0.59	0.00	0.06
TW	LR	1.67	2.16	0.37	22.82	25.54	0.28	0.99	8.39	6.93
	p-value	0.43	0.14	0.54	0.00	0.00	0.87	0.61	0.08	0.07
KW	LR	2*	9.13	0*	11.23	16.64	0.83	1.25	9.25	6.14
	p-value	0*	0.00	1*	0.00	0.08	0.66	0.54	0.01	0.10

The table reports the test for the Japanese currency effect based on equations (5) and (6) in the text. The column "γ_j's = 0" gives the likelihood ratio statistic that tests the joint significance of the γ_j's = 0 in equations (5) and (6). See the notes to the previous Tables for the additional definitions of notation.

Table 5. The Japanese Currency Effect - Dollar Return Data

PANAL A: The US Causes the East Asian Economies

		Prior Crisis			During Crisis		Entire Period			
		β_i's = 0	γ_i's = 0	ECT=0	β_i's = 0	γ_i's = 0	β_i's = 0	γ_i's = 0	β_i's = 0	γ_i's = 0
HK	LR	133.63	23.02	13.26	129.57	17.40	84.36	0.97	345.07	1.48
	p-value	0.00	0.01	0.00	0.00	0.00	0.00	0.32	0.00	0.48
SG	LR	46.10	3.85	3.55	112.44	2.49	31.74	0.13	171.15	1.52
	p-value	0.00	0.05	0.06	0.00	0.29	0.00	0.72	0.00	0.47
TW	LR	1.11	0.19	11.50	54.59	19.72	7.80	4.44	54.68	12.98
	p-value	0.29	0.67	0.00	0.00	0.00	0.01	0.04	0.00	0.00
KW	LR	0.84	3.35	2.54	76.59	32.57	32.78	0.09	68.54	20.39
	p-value	0.36	0.19	0.11	0.00	0.00	0.00	0.77	0.00	0.00

PANAL B: The East Asian Economies Cause the US

		β_i's = 0	γ_i's = 0	ECT=0	β_i's = 0	γ_i's = 0	β_i's = 0	γ_i's = 0	β_i's = 0	γ_i's = 0
HK	LR	10.30	3.88	1.78	39.69	14.19	1.14	1.05	42.28	9.09
	p-value	0.01	0.05	0.18	0.00	0.16	0.57	0.59	0.00	0.03
SG	LR	4.49	2.62	1.59	19.22	17.33	4.34	1.17	26.37	7.16
	p-value	0.11	0.11	0.21	0.00	0.07	0.11	0.56	0.00	0.07
TW	LR	2.71	2.17	0.37	17.54	21.18	0.49	0.95	7.68	6.81
	p-value	0.26	0.14	0.54	0.01	0.02	0.78	0.62	0.26	0.08
KW	LR	14.10	4.14	0*	12.06	17.34	2.45	1.96	8.73	6.03
	p-value	0.00	0.04	1*	0.00	0.07	0.29	0.38	0.01	0.11

The table reports the test for the Japanese currency effect based on equations (7) and (8) in the text. The column "γ_j's = 0" gives the likelihood ratio statistic that tests the joint significance of the γ_j's = 0 in equations (7) and (8). Dollar return data are used to generate the statistics. See the notes to the previous Tables for the additional definitions of notation.

Table 6. Tests for the Japanese Currency Effect in the presence of Japanese Stock Returns

PANAL A: The US Causes the East Asian Economies

		Prior Crisis				During Crisis			Post Crisis			Entire Period		
		β_j's = 0	γ_j's = 0	ϕ_j's = 0	ECT=0	β_j's = 0	γ_j's = 0	ϕ_j's = 0	β_j's = 0	γ_j's = 0	ϕ_j's = 0	β_j's = 0	γ_j's = 0	ϕ_j's = 0
HK	LR	131.15	19.39	2.00	14.15	133.21	22.66	5.55	85.68	1.13	2.13	345.43	1.31	0.80
	p-value	0.00	0.04	0.16	0.00	0.00	0.00	0.02	0.00	0.29	0.35	0.00	0.52	0.37
SG	LR	44.58	6.05	13.14	3.30	114.16	5.41	3.80	31.85	0.02	0.14	171.71	2.03	2.16
	p-value	0.00	0.01	0.01	0.07	0.00	0.07	0.15	0.00	0.90	0.71	0.00	0.36	0.34
TW	LR	1.10	0.13	0.00	11.52	50.82	6.51	2.09	7.16	1.18	2.60	51.91	3.76	4.28
	p-value	0.29	0.72	0.97	0.00	0.00	0.01	0.15	0.01	0.28	0.11	0.00	0.05	0.04
KW	LR	0.68	3.80	1.03	2.49	75.05	22.00	0.70	43.38	10.85	10.89	67.92	16.04	2.98
	p-value	0.41	0.15	0.31	0.11	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.08

PANAL B: FOCAL ECONOMIES CAUSE THE US

		β_j's = 0	γ_j's = 0	ϕ_j's = 0	ECT=0	β_j's = 0	γ_j's = 0	ϕ_j's = 0	β_j's = 0	γ_j's = 0	ϕ_j's = 0	β_j's = 0	γ_j's = 0	ϕ_j's = 0
HK	LR	14.93	0.57	7.38	1.81	36.33	11.34	0.84	0.32	0.97	2.80	45.08	7.65	3.25
	p-value	0.00	0.45	0.02	0.18	0.00	0.33	0.84	0.85	0.62	0.25	0.00	0.05	0.20
SG	LR	6.50	0.58	10.03	1.73	16.75	16.60	1.21	2.74	1.12	2.01	27.27	6.58	1.34
	p-value	0.04	0.45	0.04	0.19	0.00	0.08	0.55	0.25	0.57	0.37	0.00	0.09	0.51
TW	LR	2.72	0.20	3.85	0.22	16.40	17.16	4.59	0.57	0.77	3.69	7.72	5.65	0.17
	p-value	0.26	0.65	0.15	0.64	0.01	0.07	0.10	0.75	0.68	0.16	0.26	0.13	0.92
KW	LR	15.52	0*	0*	0*	12.50	16.75	4.12	1.10	1.47	2.65	8.31	5.64	0.02
	p-value	0.00	1*	1*	1*	0.00	0.08	0.13	0.58	0.48	0.27	0.02	0.13	0.99

The table reports the test for the Japanese currency effect in the presence of returns on Nikkei 225 index; see equations (9) and (10) in the text. The column "ϕ_j's = 0" gives the likelihood ratio statistic that tests the joint significance of the Japanese stock variable (i.e. γ_j's = 0) in equations (9) and (10). See the notes to the previous Tables for the additional definitions of notation.