



East Asian equity markets, financial crises, and the Japanese currency

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The paper studies the interactions between the US and four East Asian equity markets. The focus is on the change in the information structure/flow between these markets triggered by the 1997 Asian financial crisis. It is shown that the information structure during the crisis period is different from that in the non-crisis periods. While the US market leads the four East Asian markets before, during, and after the crisis, it is Granger-caused by these markets during the financial crisis period but not in the post-crisis sample. 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. *J. Japanese Int. Economies* 21 (1) (2007) 138–152. Department of Economics and Finance, City University of Hong Kong, Hong Kong; Economics Department, University of California, Santa Cruz, CA, USA; School of Economics and Finance, the University of Hong Kong, Hong Kong.

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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, [Granger and Morgenstern \(1970\)](#), [Grubel and Fadner \(1971\)](#), 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 et al. \(1990\)](#), for instance, examine the interactions between the US, Japan, and UK stock markets and infer that information flow is unidirectional from New York to the other two markets. The leading role of the US in transmitting information to both developed and emerging markets is documented in numerous studies, which usually consider both returns and volatility interactions.¹ To the extent that information flow and market dominance have implications for market stability and real economic activity, policymakers are interested in the patterns of equity market interactions.

The recurrence of financial crises has spurred a literature on contagion in international markets. Volatility spillover is commonly used to capture the contagion effect ([King and Wadhvani, 1990](#); [King et al., 1994](#)).² Some recent studies on contagion include [Bae et al. \(2003\)](#) and [Forbes and Rigobon \(2002\)](#). It is noted that the unusual volatility observed during crisis periods can affect the measurement of the intensity of markets interactions and, when is used properly, help identify the transmission mechanism.³

During the 1980s the gradual liberalization of financial markets in Asia, including Korea, Taiwan and other emerging markets, has fostered considerable investment interests in the East Asian equity markets. The creation of various mutual funds that have an investment focus on individual East Asian equity markets and on the region is an evidence of the growing popularity of investing in these markets. For international investors, apart from sharing the growth prospect of the region, diversification is another reason for investing in these East Asian equity markets. Even though these East Asian equity markets suffered a major setback during the recent Asian financial crisis, these markets have come back quite strongly and still represent good investment opportunities for international investors.

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 that may signal a different information transmission mechanism between financial markets during a crisis. 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 Wadhvani \(1990\)](#) suggest that contagion effects lead to shock transmission during financial crises. On the other hand, [Malliaris and Urrutia \(1992\)](#) assert that there is no lead-lag relationship among the major national equity indexes during the October 1987 crash period.

¹ For example, see [Eun and Shim \(1989\)](#), [Ng et al. \(1991\)](#), [Cha and Cheung \(1998\)](#), and [Cheung and Ng \(1996\)](#). [Worthington and Higgs \(2004\)](#), on the other hand, focus on the transmission among Asian markets.

² [Hashimoto and Ito \(2004\)](#) and [Ito and Hashimoto \(2002\)](#) propose an alternative measure of contagion between high frequency exchange rate and stock price data.

³ See [Rigobon \(1999, 2003\)](#). [Ehrmann et al. \(2005\)](#), for example, use the identification through heteroskedasticity to examine the transmission between markets for money, bond, equity, and foreign exchange within and between the US and the euro area.

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 1987 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 the interaction between stock indexes, the current study also investigates the impact of Japanese currency movements on these markets. McKinnon and Schnabl (2003) show that fluctuations in the dollar–yen exchange rate have significant repercussion effects on other East Asian economies.⁴ It is argued that the dollar–yen exchange rate variation impacts other East Asian economies through, for example, changes in export competitiveness, and foreign direct investment flows. To the extent that Japanese currency movements affect the East Asian economies, these movements can affect the East Asian equity markets.

One predominant feature of the Asian crisis is its rippling effects on economies both within and outside the region. Given its economic dominance and trade and financial ties in the region, Japan was closely scrutinized during the crisis period. 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.⁵

The market’s acute concern about the Japanese currency suggests a possible change of the fundamental information structure in equity markets during the crisis period. International investment risk has two components—the price risk in the local market movement and the exchange rate risk. Under normal circumstances, investors concern only the market movement because they can hedge the exchange rate risk in the currency market by taking a short position in the forward market. During the Asian crisis, the Japanese yen exchange rate variability represented not only the usual standard exchange rate risk but also the likelihood that it could trigger another wave of financial disturbances in the region. Thus, the Japanese currency variation can assume a different role for the East Asian equity markets during the crisis. 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 pre-crisis period. The crisis period extends from July 1997 to June 2000. The post-crisis period is from July 2000 to July 2001. 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 but have 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

⁴ Hashimoto and Ito (2004) examine the interaction between exchange rates and stock prices during the crisis from a contagion perspective. Recent studies on spillovers across various financial markets include Forbes and Chinn (2004) and Hartmann et al. (2004).

⁵ 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 Renminbi (the Chinese currency) was mounting as the Yen/US exchange rate was weakening. Such devaluation was seen to be a substantial threat to the stability and recovery in the region.

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 from 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 Hong Kong Hang Seng Index, the Korea Composite Index, the Singapore Strait Times Index, the Taiwan Weighted Index, and the US Dow Jones Industrial Average Index. 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 sample from July 2000 to July 2001. The end of the crisis period is set to 2000 to accommodate the total and lingering effects of the 1997 and 1999 crises. Also, a general recovery from the financial crises began in 2000.⁶

Before analyzing the interactions between these stock indexes, we apply the standard unit root and cointegration tests to the data.⁷ 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 augmented Dickey–Fuller regression. Together, results for stock indexes in log levels (panel A) and in first log differences (panel B) suggest that the stock indexes are $I(1)$ processes—a result in accordance with similar studies in the literature. One observation is in order. For each stock index series, the lag parameter is not the same across sample periods. The observed parameter instability is indicative of shifting of dynamics across the samples and casts doubt on the use of the combined sample to infer interactions between these 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 pair-wise cointegrated during the pre-crisis period. The result is consistent with some earlier studies on 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 results, an error correction term will be included in specifications for the pre-crisis analysis.

⁶ Varying the starting and ending points of the three sample periods by a few months does not have any material implications for results reported in the text. The additional results are available upon request.

⁷ 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 Johansen (1991) for a detailed description of these procedures.

Table 1
Unit root test results

| | Pre-crisis | | During crisis | | Post-crisis | | Combined | |
|---|------------|----------|---------------|----------|-------------|----------|----------|----------|
| | Lag | ADF | Lag | ADF | Lag | ADF | Lag | ADF |
| <i>A. Levels of the logarithmic stock indexes series</i> | | | | | | | | |
| HK | 7 | -3.0296 | 4 | -2.9352 | 0 | -2.8051 | 4 | -2.2591 |
| SG | 1 | -2.0625 | 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 |
| <i>B. First-differences of the logarithmic stock indexes series</i> | | | | | | | | |
| 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 2001. The “Combined” column contains results from January 1995 to July 2001. 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 | | During crisis | | Post-crisis | | Combined | |
|-------|------------|---------|---------------|---------|-------------|---------|----------|---------|
| | C.E.(s) | L.R. | C.E.(s) | L.R. | C.E.(s) | L.R. | C.E.(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 only in the pre-crisis sample but not in the crisis or post-crisis samples.

3. Causality patterns

Following the literature, we adopt the causality test as the tool to determine the lead–lag relationship between stock indexes.⁸ Essentially, the test examines whether one series contains

⁸ We focus on return causality that offers a relative easy to follow analysis to highlight the main issue of varying interaction patterns between these markets. The reported results are not affected by the possibility of varying heteroskedasticity because (a) its effect is explicitly controlled for in the analysis, and (b) prior information is used to split the sample into crisis and non-crisis periods.

useful information about the evolution of another series. Let X_t be the return on one of the East Asian market indexes at time t , as measured by the first log difference, and Y_t be the return on the US stock index. To test the hypothesis that the US market does not Granger-cause the East Asian market, we first consider the regression

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

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

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

and use the joint significance of β_j 's to test the causality hypothesis. Specifically, the null hypothesis that the US market does not Granger-cause the East Asian market is not rejected if β_j 's are jointly insignificant. In other words, 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 controlling for X_t 's own history. In estimating (2), we consider $n = 1, \dots, 10$ and report the statistic based on the value of n determined by the Akaike information criterion.⁹

To test the hypothesis that the US market is not Granger-caused by the East Asian market, we consider the regression equations

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

and

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

which are analogous to (1) and (2). 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. On 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. If X_t is excluded from (4), the test will tend to understate the influence of East Asian markets. Further, as mentioned in the previous section, an error correction term 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 known that monthly equity returns display substantial conditional heteroskedasticity, which is commonly modeled as a GARCH process. In fact, for our data set, preliminary analyses of Eqs. (2) and (4) confirm the presence of GARCH effects in the error term ε_t .¹⁰ The presence of GARCH implies the error term and lagged dependent variables are not independent. The dependence between explanatory variables and error terms invalidates one of the assumptions underlying the standard F -test. Thus, the standard F -test statistic for causality can yield spurious results in the presence of GARCH effects. To circumvent the adverse effect of conditional heteroskedasticity on testing for causality, we adopt a maximum likelihood procedure that allows for GARCH effects

⁹ In general the results reported in the text are quite insensitive to the choice of n .

¹⁰ The estimated GARCH effects for all the specifications are available upon request.

Table 3
Causality test results

| | | 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 |
| <i>A. The US Granger-causes the East Asian economies</i> | | | | | | |
| HK | LR | 142.23 | 15.64 | 117.52 | 83.32 | 355.42 |
| | <i>p</i> -value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SG | LR | 62.13 | 4.78 | 123.34 | 35.60 | 193.27 |
| | <i>p</i> -value | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| TW | LR | 4.33 | 14.01 | 50.89 | 10.38 | 61.46 |
| | <i>p</i> -value | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 |
| KW | LR | 0.93 | 6.64 | 53.46 | 37.39 | 52.91 |
| | <i>p</i> -value | 0.33 | 0.01 | 0.00 | 0.00 | 0.00 |
| <i>B. The East Asian economies Granger-cause the US</i> | | | | | | |
| HK | LR | 9.54 | 3.00 | 39.24 | 0.90 | 33.83 |
| | <i>p</i> -value | 0.02 | 0.08 | 0.00 | 0.64 | 0.00 |
| SG | LR | 3.73 | 1.87 | 19.76 | 2.57 | 23.58 |
| | <i>p</i> -value | 0.05 | 0.17 | 0.00 | 0.11 | 0.00 |
| TW | LR | 0.12 | 0.33 | 15.07 | 0.44 | 8.22 |
| | <i>p</i> -value | 0.73 | 0.56 | 0.04 | 0.51 | 0.08 |
| KW | LR | 9.50 | 1.29 | 8.78 | 4.11 | 7.40 |
| | <i>p</i> -value | 0.02 | 0.26 | 0.00 | 0.53 | 0.01 |

The table reports the causality test results based on Eqs. (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 statistics and the “*p*-value” row gives the corresponding *p*-values. The column “ β_j 's = 0” lists the statistic that tests the joint significance of the β_j 's in Eqs. (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 Granger-cause the individual East Asian markets. Panel B contains the results of testing the hypothesis of an East Asian market does not Granger-cause the US. See the note to Table 1 for definitions of notation.

and construct the likelihood ratio statistic to test the hypothesis of β_j 's are jointly insignificant. 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 joint significance of β_j 's is usually considered as evidence of causation relationship. We also test 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 their *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 Granger-cause the individual East Asian markets. During the pre-crisis period, the movement in the US stock index significantly affects only Hong Kong and Singapore. Apparently, the Taiwan and the South Korea market do 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 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 that the US is not Granger-caused by an East Asian market. The evidence is quite intriguing. While the US market responds to movements

in Hong Kong, Singapore and South Korea during the pre-crisis period, it significantly reacts to all the four East Asian markets during the crisis. The same set of markets, however, appears to have no effect on the US stock market after the crisis. In panel B the error correction term is not significant at the 5% level. Since the error correction term measures the deviation from the empirical long-run relationship, its significance patterns in Table 3 indicate that it is the East Asian market, and not the US, that responds to the deviation from the empirical long-run relationship. When the combined sample is considered, these East Asian markets exhibit significant effects on the US.

Thus far the analysis shows that the interaction between stock indexes can change quite substantially across a financial crisis. While feedback is detected among some index pairs in the pre-crisis sample and in all index pairs during the crisis, only unidirectional 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 Asian and world markets. Some envisage the wild fluctuation of the yen value before 1997 is one of the culprits of the recent Asian finance crisis.¹¹ During the crisis, both officials of the East Asian governments and market practitioners were critical of the yen exchange rate movement. Yen depreciation is deemed to be harmful to the recovery of East Asian markets. For instance, the Japanese economy is sought as the growth engine to lead the region out of the slump. A weak yen is considered a sign that the Japanese economy is still far from recovery. Further, a weak yen is a threat to other Asian economies because it can shrink the market share of Asian exporters or force them to compress profit margins. Thus a weak Japanese currency is an adverse 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?¹²

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

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

and

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

where S_t is the daily dollar–yen exchange rate in first log differences. The lag parameter m is again selected using the Akaike information criterion from the set $m = 1, \dots, 10$. The results are quite robust to the choice of m . Table 4 presents only the likelihood ratio statistics and their

¹¹ See, for example, Corsetti et al. (1998), Ito et al. (1998), Radelet and Sachs (1998) for some discussion on the causes of the Asian financial crisis.

¹² There is a related, but different literature on the effect of a country's exchange rate 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 Bartove and Bodnar (1994).

Table 4
The Japanese currency effect

| | | Prior crisis | | | During crisis | | Post-crisis | | Entire period | |
|--|-----------------|------------------|-------------------|---------|------------------|-------------------|------------------|-------------------|------------------|-------------------|
| | | 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 |
| <i>A. The US Granger-causes the East Asian economies</i> | | | | | | | | | | |
| HK | LR | 138.72 | 7.47 | 15.20 | 129.28 | 16.42 | 84.20 | 0.96 | 353.71 | 0.09 |
| | <i>p</i> -value | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.76 |
| SG | LR | 59.86 | 2.31 | 4.82 | 129.89 | 9.05 | 34.94 | 0.01 | 192.08 | 0.06 |
| | <i>p</i> -value | 0.00 | 0.13 | 0.03 | 0.00 | 0.01 | 0.00 | 0.90 | 0.00 | 0.81 |
| TW | LR | 4.45 | 6.14 | 14.11 | 55.83 | 12.70 | 8.19 | 2.77 | 63.16 | 3.41 |
| | <i>p</i> -value | 0.11 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.06 |
| KW | LR | 0.91 | 0.01 | 6.65 | 63.14 | 31.24 | 37.41 | 0.10 | 56.46 | 13.80 |
| | <i>p</i> -value | 0.34 | 0.92 | 0.01 | 0.00 | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 |
| <i>B. The East Asian economies Granger-cause the US</i> | | | | | | | | | | |
| HK | LR | 10.90 | 4.30 | 2.90 | 40.88 | 3.53 | 1.19 | 2.94 | 36.23 | 20.51 |
| | <i>p</i> -value | 0.01 | 0.04 | 0.09 | 0.00 | 0.06 | 0.55 | 0.40 | 0.00 | 0.00 |
| SG | LR | 4.39 | 3.62 | 1.81 | 19.91 | 3.39 | 2.34 | 2.71 | 25.08 | 20.12 |
| | <i>p</i> -value | 0.04 | 0.06 | 0.18 | 0.00 | 0.07 | 0.13 | 0.44 | 0.00 | 0.00 |
| TW | LR | 0.21 | 2.89 | 0.17 | 22.47 | 5.35 | 0.03 | 2.81 | 8.70 | 19.71 |
| | <i>p</i> -value | 0.65 | 0.09 | 0.68 | 0.00 | 0.07 | 0.87 | 0.42 | 0.07 | 0.00 |
| KW | LR | 9.08 | 2.67 | 1.12 | 8.63 | 3.25 | 4.61 | 4.31 | 8.25 | 19.32 |
| | <i>p</i> -value | 0.03 | 0.10 | 0.29 | 0.00 | 0.07 | 0.47 | 0.23 | 0.00 | 0.00 |

The table reports the test for the Japanese currency effect based on Eqs. (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 Eqs. (5) and (6). See the notes to the previous tables for additional definitions of notation.

p-values for the respective tests of the (joint) significance of β_j 's, the error correction term, and γ_j 's for brevity. Comparing Table 3 and Table 4, it is revealed that the presence of S_{t-j} 's does not have any discernible 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 number of significance cases increases to 5 if a 10% level is considered. In general, the Japanese yen effect on these stock markets is quite limited before the financial crisis.

There is a noticeable change in the role of the Japanese currency during the crisis period. For all the bivariate causation equations in panel A, the added exchange rate term is highly significant. The dollar–yen exchange rate term has almost uniformly a positive coefficient estimate; implying that a yen depreciation leads to a lower stock index. The results are in accordance with the perception that, during the financial turmoil, a weak yen raises the concern of a weak Japanese economy and an erosion of export competitiveness among East Asian economies, which, in turns, exert pressure on these stock markets. 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. In addition to the usual lagged stock price factor commonly investigated in the literature, the equity return is affected by the Japanese currency movement.

Compared with its effects on East Asian economies, the impact of yen on the US market is weaker; the exchange rate terms are only significant at the 10% but not the 5% level. The economic repercussion of a weak yen for the US is smaller than for the East Asian economies. Thus, the lesser US response is consistent with the Japanese currency effect during the crisis described above.

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 any one of the four East Asian markets. Similarly, the post-crisis US market is not affected by the yen exchange rate. 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, then the combined sample results are spurious and offer erroneous information on market interactions for investment and portfolio management analyses.

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 yen effect for these markets differs 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 US dollar and redo 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

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

and

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

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

The use of dollar return data has limited implications for the general inference of yen effects 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 slightly stronger during the crisis period. An exception is the Singapore case in panel A. Nonetheless, the currency effect is mostly observed during the crisis period and is evaporated in the post-crisis sample. The coefficient estimates (which are available upon request), again, suggest that a yen depreciation tends to lower these equity markets during the crisis period. Overall, data on both local currency and US dollar returns yield similar inferences on the variation of information flows across these samples. Thus, currency conversion is not likely to be the cause of the reported Japanese yen effect.

As argued above, a weak yen may impact the East Asian equity markets because it connotes a weak Japanese economy and represents a threat to exports of the East Asian economies during the crisis period. Is it possible that the reported Japanese currency effect captures the markets' responses to implied developments in the Japanese economy rather than some effects specific to the crisis experience? To investigate this possibility, we include the return on the Nikkei 225 index in the exercise and check if the Japanese currency variable is crowded out by the stock return variable. The Japanese stock index is used as an indicator of the well-being of the Japanese economy because the stock market is commonly perceived to be a barometer of the economy.

Table 5
The Japanese currency effect—dollar return data

| | | Prior crisis | | | During crisis | | Post-crisis | | Entire period | |
|--|-----------------|------------------|-------------------|---------|------------------|-------------------|------------------|-------------------|------------------|-------------------|
| | | 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 |
| <i>A. The US Granger-causes the East Asian economies</i> | | | | | | | | | | |
| HK | LR | 135.73 | 13.02 | 15.15 | 129.36 | 16.98 | 84.35 | 0.97 | 353.56 | 0.04 |
| | <i>p</i> -value | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | 0.84 |
| SG | LR | 43.21 | 11.53 | 3.14 | 108.85 | 2.45 | 31.74 | 0.13 | 170.63 | 0.67 |
| | <i>p</i> -value | 0.00 | 0.02 | 0.08 | 0.00 | 0.12 | 0.00 | 0.72 | 0.00 | 0.41 |
| TW | LR | 4.13 | 3.33 | 11.91 | 53.92 | 27.71 | 8.84 | 4.48 | 57.35 | 12.44 |
| | <i>p</i> -value | 0.13 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| KW | LR | 1.14 | 3.28 | 2.81 | 75.29 | 42.80 | 29.98 | 0.39 | 58.31 | 19.27 |
| | <i>p</i> -value | 0.57 | 0.19 | 0.09 | 0.00 | 0.00 | 0.00 | 0.53 | 0.00 | 0.00 |
| <i>B. The East Asian economies Granger-cause the US</i> | | | | | | | | | | |
| HK | LR | 10.74 | 4.25 | 2.89 | 41.14 | 3.49 | 1.17 | 2.93 | 35.81 | 20.40 |
| | <i>p</i> -value | 0.01 | 0.04 | 0.09 | 0.00 | 0.06 | 0.56 | 0.40 | 0.00 | 0.00 |
| SG | LR | 12.97 | 2.49 | 1.45 | 16.47 | 3.75 | 2.57 | 3.29 | 28.52 | 16.51 |
| | <i>p</i> -value | 0.07 | 0.11 | 0.23 | 0.00 | 0.05 | 0.11 | 0.35 | 0.00 | 0.01 |
| TW | LR | 0.16 | 2.88 | 0.10 | 23.85 | 14.49 | 0.00 | 2.85 | 6.71 | 19.39 |
| | <i>p</i> -value | 0.69 | 0.09 | 0.76 | 0.00 | 0.00 | 0.95 | 0.41 | 0.03 | 0.00 |
| KW | LR | 22.71 | 2.80 | 1.62 | 8.43 | 6.43 | 2.44 | 3.91 | 7.80 | 19.03 |
| | <i>p</i> -value | 0.02 | 0.09 | 0.20 | 0.00 | 0.00 | 0.12 | 0.27 | 0.01 | 0.00 |

The table reports the test for the Japanese currency effect based on Eqs. (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 Eqs. (7) and (8). Dollar return data are used to generate the statistics. See the notes to the previous tables for additional definitions of notation.

If the yen exchange rate variable is a proxy for economic conditions that are captured by the stock market, then the presence of the Japanese stock variable will render the yen variable insignificant. We consider the following regression equations

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

and

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

where JP_t is the return on the Japanese Nikkei 225 index. Since the dollar return data give a stronger Japanese yen currency effect, using Eqs. (9) and (10) will not overstate the importance of the currency effect.¹³

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 some cases during the crisis period—a result that can be ascribed to contagion effects commonly documented during a crisis (King and Wadhvani, 1990). The effects of lagged Y_t 's (X_t 's) on X_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 qualitatively change the significance of the Japanese currency variable. The yen effect, again, shows up mainly during

¹³ Dollar return data gave results similar to those reported in Table 6. In fact, the use of dollar return data does not qualitatively change the results reported in the text.

Table 6
Tests for the Japanese currency effect in the presence of Japanese stock returns

| | | 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 |
| <i>A. The US Granger-causes the East Asian economies</i> | | | | | | | | | | | | | | |
| HK | LR | 137.47 | 8.60 | 1.92 | 16.17 | 132.93 | 18.45 | 5.65 | 86.09 | 0.76 | 2.98 | 356.17 | 0.11 | 3.06 |
| | <i>p</i> -value | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.38 | 0.23 | 0.00 | 0.74 | 0.22 |
| SG | LR | 60.97 | 1.75 | 1.76 | 4.68 | 130.86 | 9.44 | 1.05 | 35.03 | 0.01 | 0.11 | 191.60 | 0.08 | 0.62 |
| | <i>p</i> -value | 0.00 | 0.19 | 0.19 | 0.03 | 0.00 | 0.01 | 0.30 | 0.00 | 0.94 | 0.74 | 0.00 | 0.78 | 0.43 |
| TW | LR | 4.30 | 6.16 | 0.01 | 14.08 | 43.26 | 10.26 | 7.53 | 8.03 | 2.10 | 1.73 | 60.06 | 2.87 | 6.58 |
| | <i>p</i> -value | 0.12 | 0.05 | 0.91 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.15 | 0.19 | 0.00 | 0.09 | 0.01 |
| KW | LR | 0.83 | 0.01 | 1.36 | 7.08 | 62.29 | 30.81 | 0.04 | 37.85 | 0.27 | 0.82 | 55.84 | 7.96 | 0.20 |
| | <i>p</i> -value | 0.36 | 0.94 | 0.24 | 0.01 | 0.00 | 0.00 | 0.83 | 0.00 | 0.61 | 0.36 | 0.00 | 0.02 | 0.65 |
| <i>B. Focal economies Granger-cause the US</i> | | | | | | | | | | | | | | |
| HK | LR | 12.27 | 5.33 | 3.45 | 3.26 | 35.39 | 3.37 | 1.11 | 0.31 | 3.06 | 1.11 | 31.88 | 20.53 | 0.32 |
| | <i>p</i> -value | 0.01 | 0.02 | 0.18 | 0.07 | 0.00 | 0.07 | 0.29 | 0.86 | 0.38 | 0.29 | 0.00 | 0.00 | 0.57 |
| SG | LR | 4.39 | 3.45 | 0.06 | 1.83 | 15.82 | 3.93 | 3.63 | 1.21 | 2.86 | 0.87 | 21.77 | 20.17 | 1.36 |
| | <i>p</i> -value | 0.04 | 0.06 | 0.80 | 0.18 | 0.00 | 0.05 | 0.06 | 0.27 | 0.41 | 0.35 | 0.00 | 0.00 | 0.24 |
| TW | LR | 0.10 | 3.61 | 1.96 | 0.24 | 20.83 | 6.81 | 7.02 | 0.07 | 2.94 | 2.03 | 8.00 | 19.81 | 3.98 |
| | <i>p</i> -value | 0.75 | 0.06 | 0.37 | 0.62 | 0.00 | 0.03 | 0.01 | 0.80 | 0.40 | 0.15 | 0.09 | 0.00 | 0.05 |
| KW | LR | 8.58 | 3.32 | 1.79 | 1.33 | 7.72 | 3.68 | 8.59 | 4.72 | 4.66 | 2.00 | 7.01 | 19.48 | 3.43 |
| | <i>p</i> -value | 0.04 | 0.07 | 0.41 | 0.25 | 0.01 | 0.06 | 0.01 | 0.45 | 0.20 | 0.16 | 0.01 | 0.00 | 0.06 |

The table reports the test for the Japanese currency effect in the presence of returns on Nikkei 225 index; see Eqs. (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 Eqs. (9) and (10). See the notes to the previous tables for the additional definitions of notation.

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 economy captured by the stock market variable.

6. Concluding remarks

The paper presents an empirical study on the interactions between the US and four East Asian markets. The main empirical insights are the changes in the information structure/flow and in the role of the Japanese yen around the 1997 Asian financial crisis. The results are not contaminated by conditional heteroskedasticity because our testing procedure explicitly accounts for GARCH effects in the data. Our results document that the information structure during the crisis period is different from the non-crisis periods. The empirical evidence confirms the dominant role of the US market—the US index leads these East Asian markets before, during, and after the crisis. The influence of these East Asian markets on the US, however, is mainly found during the crisis. Specifically, in the post-crisis sample these markets do not affect the US market.

An interesting result is the effect of the Japanese currency. While the reported yen effect on equity markets corroborates with the finding that fluctuations in dollar–yen affect the East Asian economies (McKinnon and Schnabl, 2003), we find that the yen effect is subsample specific. Consistent with concerns reported in the market, the Japanese currency is found to affect these equity markets only during the crisis period but not in the post-crisis sample.

The Japanese yen effect does not appear spurious. The same currency effect is uncovered from both local currency and US dollar return data and is detected in the presence of the Japanese stock return variable. The results are suggestive of exchange rate risk is not overwhelmingly important under normal market conditions possibly because the risk can be hedged in the forward market. On the other hand, Japanese yen volatility appears a risk factor during the Asian crisis that is priced in the equity market. The findings corroborate the contention that financial crises endure extreme market conditions. These extreme market conditions can lead to changes in the channel via which information is incorporated and transmitted across markets.

Policymakers, practitioners and researchers are aware of the interaction between equity markets. However, the nature and extent of market interaction are not very well understood. Our results on the change in information flows have some interesting implications. For policymakers, our results suggest that measures to stabilize and insulate the domestic market for external influences have to account for possible changes in the pattern and strengthen of market interdependence. Specifically, a measure that is effective during the tranquil market condition may not deliver the expected results in a turmoil and crisis period.

For practitioners, information on market interactions helps improve hedging and managing portfolios that contain foreign equities. The documented changes in the causal relationship 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.

For researchers, the reported varying causation pattern warrants a detailed study on information flow and propagation mechanisms under different market conditions. The upsurge and disappearance of the Japanese yen effect is an intriguing phenomenon. In addition to the usual question of what are the economic variables that help us understand the interactions between equity markets, one has to ask: “What are the factors that trigger the currency effect and through what channels the currency affects the equity market interdependence?” The channel and trans-

mission mechanism with which the yen exchange rate affects the East Asian economies is an interesting future research area.

References

- Bae, K.-H., Karolyi, A., Stulz, R., 2003. A new approach to measuring financial contagion. *Rev. Finan. Stud.* 16, 717–763.
- Bartove, E., Bodnar, G.M., 1994. Firm valuation, earning expectations, and the exchange-rate exposure effect. *J. Finance* 49, 1755–1786.
- Cha, B., Cheung, Y.-L., 1998. The impact of the US and the Japanese equity markets on the emerging Asia-Pacific equity markets. *Asia Pacific Finan. Markets* 5, 191–209.
- Cheung, Y.-W., Fujii, E., 2001. A note on the power of money-output causality test. *Oxford Bull. Econ. Statist.* 63, 247–261.
- Cheung, Y.-W., Ng, L.K., 1996. A causality-in-variance test and its application to financial market prices. *J. Econometrics* 72, 33–48.
- Corsetti, G., Pesenti, P., Roubini, N., 1998. What caused the Asian currency and financial crisis. Part I: A macroeconomic overview. *Japan World Economy* 11, 305–373.
- Dickey, D.A., Fuller, N.A., 1979. Distribution of the estimators for autoregressive time series with a unit root. *J. Amer. Statist. Assoc.* 74, 427–431.
- The Economist, 1998. Asia trembles again. *The Economist* 8073 (20 June) (347), 85–86.
- Ehrmann, M., Fratzscher, M., Rigobon, R., 2005. Stocks, bonds, money markets and exchange rates: Measuring international financial transmission. Working paper No. 11166. NBER.
- Eun, C., Shim, S., 1989. International transmission of stock market movements. *J. Finan. Quant. Anal.* 24, 241–256.
- Forbes, K.J., Chinn, M.D., 2004. A decomposition of global linkages in financial markets over time. *Rev. Econ. Statist.* 86.
- Forbes, K.J., Rigobon, R., 2002. No contagion, only interdependence: Measuring stock market co-movement. *J. Finance* 57, 2223–2261.
- Granger, C.W.J., Morgenstern, O., 1970. *Predictability of Stock Market Prices*. Heath, Lexington, MA.
- Grubel, H., 1968. Internationally diversified portfolio: Welfare gains and capital flows. *Amer. Econ. Rev.* 58, 1299–1314.
- Grubel, H., Fadner, K., 1971. The interdependence of international equity markets. *J. Finance* 26, 89–94.
- Hamao, Y., Masulis, R., Ng, V., 1990. Correlation in price changes and volatility across international stock markets. *Rev. Finan. Stud.* 3, 281–307.
- Hartmann, P., Straetmans, S., de Vries, C., 2004. Asset market linkages in crisis periods. *Rev. Econ. Statist.* 86, 313–326.
- Hashimoto, Y., Ito, T., 2004. High-frequency contagion between and the exchange rates and stock prices. Working paper No. 10448. NBER.
- Ito, T., Hashimoto, Y., 2002. High-frequency contagion of currency crisis in Asia. Working paper No. 9376. NBER.
- Ito, T., Ogawa, E., Sasaki, N., 1998. How did the dollar peg fail in Asia? *J. Japanese Int. Economies* 12, 256–304.
- Jeon, N.N., von Furstenberg, G.M., 1990. Growing international comovement in stock price indexes. *Quart. Rev. Econ. Bus.* 30, 15–30.
- Johansen, S., 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregression models. *Econometrica* 59, 1551–1580.
- Jorion, P., 1990. The exchange-rate exposure of US multinationals. *J. Bus.* 63, 331–345.
- King, M., Wadhvani, S., 1990. Transmission of volatility between stock markets. *Rev. Financial Stud.* 3, 5–33.
- King, M., Sentana, E., Wadhvani, S., 1994. Volatility and links between national stock markets. *Econometrica* 62, 901–934.
- Leachman, L.L., Francis, B., 1995. Long-run relations among G-5 and G-7 equity markets: Evidence on the Plaza and Louvre Accords. *J. Macroecon.* 17, 551–577.
- Levy, H., Sarnat, M., 1970. International diversification of investment portfolios. *Amer. Econ. Rev.* 60, 668–675.
- Malliaris, A.G., Urrutia, J.L., 1992. The international crash of October 1987: Causality tests. *J. Finan. Quant. Anal.* 27, 353–364.
- Masih, R., Masih, M.M., 2001. Long and short term dynamic causal transmission among international stock markets. *J. Int. Money Finance* 20, 563–587.
- McKinnon, R., Schnabl, G., 2003. Synchronized business cycle in East Asia and fluctuations in the yen/dollar exchange rate. *World Economy* 26, 1067–1088.
- Ng, V., Chang, R., Chou, R., 1991. An examination of the behavior of international stock market volatility. *Pacific-Basin Capital Market Res.* II, 245–259.

- Radelet, S., Sachs, J., 1998. The East Asian financial crisis: Diagnosis, remedies, prospects. *Brookings Pap. Econ. Act.* 28, 1–74.
- Rigobon, R., 1999. On the measurement of the international propagation of shocks: Is the transmission stable? Working paper No. 7354. NBER.
- Rigobon, R., 2003. Identification through heteroskedasticity. *Rev. Econ. Statist.* 85, 777–792.
- Ripley, D.M., 1973. Elements in the linkage of national stock market indices. *Rev. Econ. Statist.* 55, 356–361.
- Solnik, B.H., 1974. Why not diversify internationally rather than domestically? *Finan. Analysts J.* 30, 48–54.
- Tuluca, S.A., Zwick, B., 2001. The effects of the Asian crisis on global equity markets. *Finan. Rev.* 36, 125–142.
- Worthington, A., Higgs, H., 2004. Transmission of equity returns and volatility in Asian developed and emerging markets: A multivariate GARCH analysis. *Int. J. Finance Econ.* 9, 71–80.