DISCUSSION PAPER
February 2010

No.40

Is this Time Different for Asia?
Evidence from Stock Markets

Yushi Yoshida
Faculty of Economics
Kyushu Sangyo University

Is this time different for Asia?

Evidence from stock markets

February 2010

Yushi Yoshida*

Kyushu Sangyo University

Abstract:

The recent sub-prime financial crisis initially affected the Asian economy to a degree comparable to that of the downturn in the Asian financial crisis; however, the recovery in Asia took place at a much faster pace than during the Asian financial crisis. We investigate whether the effects of sub-prime financial crisis on 13 Asian economies are similar to those of the previous crisis, by examining stock markets for volatility spillovers and causality directions between the US and Asia as well as for the degree of regional integration. The empirical evidence indicates stark differences between these two crises. First, the decline in volatility spillovers during the period of financial turmoil was more pervasive for the Asian financial crisis. Second, the estimated point of transition in correlation is indicative of market participants' awareness of the upcoming stock market crash in September 2008. Third, the causality from the epicenter of crises is intensified during crisis. Fourth, regional integration was strengthened after the financial turmoil of the recent sub-prime financial crisis but not after the Asian financial crisis.

Keywords: Asia; Contagion; Financial crisis; Spillover; Stock market integration.

JEL classification codes: F31; F36; G15.

* Kyushu Sangyo University, Faculty of Economics, 2-3-1 Matsukadai Higashi-ku, Fukuoka, 813-8503 Japan. e-mail: yushi@ip.kyusan-u.ac.jp

1. Introduction

The financial turmoil that originated from the US housing market caused the market values of listed firms to plummet in stock markets all over the world. The globalization of financial markets enabled risky lending practices in the US, in the form of housing loans to sub-prime borrowers, to be shared world-wide via the securitization of loans as mortgage backed securities, and their collapse consequently affected financial markets everywhere. While the most severely affected countries are in Europe, severe downturns are also being experienced in many of Asian countries. In fact, the initial impact on Asian economies was so severe that output in most of these countries contracted more than in the US.

The negative impact on Asian financial market was also spectacular. For example, in Japan, the Nikkei255 index dropped from 18,269 yen at its recent peak in July of 2007 to 7,059 yen at the bottom in March of 2009. The Shanghai Stock Exchange Composite also plummeted from its peak of 6,036 RMB in October 17, 2007 to 1,706 RMB in November 4, 2008. However, starting in February 2009, Asia’s economy began to revive (IMF, 2009) and stock markets seemed to regain their confidence in the last half of 2009.

Asia’s quick rebound from the recession can be attributed to three factors (IMF, 2009). First, one of the largest economies in the region demonstrated the fastest recovery. China’s growth indicator was shown to surpass its own long-term trend rate. Second, external factors for Asia were quick to come back to pre-crisis levels well before overall economic activity stabilized in the West. Asia began to recover because trade and finance started to normalize in February 2009. Third, the region’s aggressive countercyclical response helped its economy to move back onto its pre-crisis track.

Preliminary evidence seems to suggest that the recovery of Asian economies from this crisis may proceed faster than that of the rest of the world and than their own experience in the 1997 Asian financial crisis. The effects of the current sub-prime financial crisis on Asia may be different because Asia went through structural changes during the recovery from the Asian financial crisis. This process might have also changed the transmission structure between Asian economies and the US. Simultaneously, regional linkages may have been strengthened in the past decade, thus limiting Asia's external dependence. In this paper, we focus on measuring the degree of financial linkage of Asian markets with the US and within the region, including the sample after the sub-prime financial crisis, to provide a partial explanation for the observed resiliency of the Asian economy during this crisis.

For the analysis of the financial linkage between the US and Asia, in particular, we investigate the change in information flow structure between Asian stock markets and US stock markets by estimating the time-varying correlation of innovations in two markets using a multivariate GARCH model and a Granger-causality in VAR model. To measure the integration of stock markets in Asia, we apply a vector error-correction model to 13 Asian economies. We pay particular attention to the changes in the pre-crisis and post-crisis periods. More importantly, we apply the same methodology in both the Asian crisis in 1997 and the sub-prime financial crisis in 2008.

The empirical evidence indicates stark differences between these two crises. First, the decline in volatility spillovers during the period of financial turmoil was more pervasive for the Asian financial crisis. Second, the estimated point of transition in correlation is indicative of market participants' awareness of the upcoming stock market crash in September 2008. Third, the causality from the epicenter of crises is intensified during crisis. Fourth, regional integration was strengthened after the financial turmoil of the recent sub-prime financial crisis but not after the Asian financial crisis.

The structure of this paper is as follows. The next section summarizes two relevant empirical hypotheses to be investigated in Asian stock markets: spillover effects from the US and market integration within the region. Section 3 describes three econometric approaches: tests for constancy of correlation and smooth-transition correlation, the Granger-causality model, and the vector error-correction model. Section 4 provides empirical evidence for striking differences between the two crises, and Section 5 concludes the paper.

2. Financial linkage of Asian stock markets

This section reviews the literature investigating the financial linkage of Asian stock markets with external markets as well as with other markets within the region. In the followings, we group empirical studies into two categories and discuss their relevance to this paper; spillover effects from the US and stock market integration in Asia.

2-1. Spillover effects from the US

There exist many empirical studies examining the spillover effect from the US market to other stock markets. It is important to examine the US effect simply because it is natural for any national market to be strongly associated with the world's largest stock market. In some studies, indeed, the US stock market is treated as the world factor. Many studies can be related to one of the following two models: the incomplete information model of King and Wadhwani (1990) and the world factor model of Bekeart and Harvey (1997).

King and Wadhwani (1990) specify an incomplete information model for two stock markets in which agents in one market learn about unobservable common shocks through price changes in the other stock market. For stock markets with non-overlapping trading hours, the reduced model includes, as an explanatory variable, the preceding return in the other stock market, and this coefficient is called the contagion coefficient. Applying this model in the context of Asia-Pacific stock markets, Kim (2005) examines empirical evidence for information flow from the US and Japan to Australia, Hong Kong and Singapore. Kim finds that dynamic information spillover effects are significant from the US but less so from Japan. Examining the change in information flow during the Asian currency crisis, Cheung et al. (2007) split the sample into pre-crisis, crisis, and post-crisis periods. They find the US market is Granger-caused by the Asian markets only during the crisis period, while the US market leads the Asian markets in all three periods.

Extending the world factor model of Bekeart and Harvey (1997) to a two-factor model, Ng (2000) examines the effect of US as a global shock and Japan as a regional shock on Asian markets. In contrast with Kim (2005), she finds significant spillovers from the region to many of the Pacific Basin countries. Yi and Tan (2009) find that the level of integration for Singapore and Malaysia with external markets is even higher when the MSCI global and regional indices are used instead of the US and Japanese national stock market indices. Applying a band spectrum approach, Chan et al. (2008) find that the US market effect on Hong Kong comes from the higher frequency of cycles during the post-crisis period.

The mere existence of high correlations of stock market returns between an emerging country and developed countries may only indicate that the fluctuations in the Dow Jones ripple around the world. Interestingly, nevertheless, Cuadro-Saez et al. (2009) show that shocks in emerging market have significant impacts on global equity markets, by examining 14 emerging countries.

From our review of the existing studies, we can summarize the main findings in three points. First, the US stock market has a significant effect on Asian stock markets. Second, the US spillover effect may change during or after the crisis periods. Third, reverse causality may occur only during the crisis period. Reflecting the last two points, in the next subsection, we further discuss the issues on the financial linkages of Asian economies among themselves, especially in the Asian financial crisis.

2-2. Stock market integration in Asia

Studies using stock market returns to investigate the contagion effect among Asian economies include those of Majid et al. (2008), Awokuse et al. (2009), Baur and Fry (2009) and Khan and Park (2009), among others[1]. Khan and Park (2009) investigate bilateral time-varying correlations among Thailand, Malaysia, Indonesia, Korea and Philippines by using Kalman Filter. Evidence is provided for an increase in correlation among Asian economies during crisis periods in contrast with tranquil periods. By introducing a common time dummy for 11 Asian economies, Baur and Fry (2009) provide evidence that interdependencies were substantially more important than contagion during the Asian crisis.

A cointegration approach is applied to Asian economies in Ng (2002), Mukherjee and Bose (2008), Majid et al. (2008) and Awokuse et al. (2009). Ng (2002) applies Johansen’s approach to five Asian economies (Indonesia, Malaysia, Philippines, Singapore, and Thailand) for the pre-Asian crisis period between 1988 and 1997 and does not find a cointegration relationship. Majid et al. (2008) find long-run relationships for five ASEAN countries with the US and Japan only in the post-crisis period, while Awokuse et al. (2009) also show evidence that the number of cointegrating vectors increases in the post-crisis period among 11 Asian economies. Mukherjee and Bose (2008) also apply Johansen's approach to seven Asian economies (India, Japan, Hong Kong, Korea, Malaysia, Singapore and Taiwan) and the US for the post-crisis period between 1999 and 2005. They find more than one cointegration vector among these countries when the daily data are smoothed by a moving average.

Despite the differences in econometric approaches, the majority of the studies indicate that the degree of market integration among Asian economies increased either during or after the Asian crisis period. The evidence for the regional integration and the result for the US spillover effect in the previous sub-section jointly support the claim that a financial crisis significantly alters the country's stock market relationship with external markets as well as within the region's markets.

3. Empirical approach

In this section, we investigate the correlations between movements of Asian stock markets with those of external markets and other markets within the region. To measure the linkage between Asian markets and the US market, we apply time-varying correlation model via a bilateral GARCH model, a bivariate cointegration model, and a Granger-causality approach. To measure the integration within the Asian region, we adopt a vector error correction model.

Let P_t^i be the log of the stock index in one of Asian markets and P_t^U be the log of the US stock index. We define the returns on Asian markets and the US market as the log difference of the stock indices multiplied by 100, and denote them by R_t^i and R_t^U, respectively.

3-1. Time-varying correlation models

Each return is assumed to possess a mean, an autoregressive term, a cross-market effect term and a disturbance term as in the following equation.

$$\begin{bmatrix} R_t^i \\ R_t^U \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} R_{t-1}^i \\ R_{t-1}^U \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{1}$$

We call the specification in Equation (1) the VAR-specification, and the alternative specification obtained by setting all $\beta_{ij} = 0$ the mean-specification.

The variances of disturbance terms are modeled with a GARCH(1,1) structure in which the variances and covariances of the disturbance terms follow ARMA structures (Bollerslev, 1988).

$$\begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix} \sim \mathbf{N}(0, H_t), \qquad \text{where } H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix}. \tag{2}$$

The symmetric covariance can be simplified in the vector representation (Vech) form, restricting the off-diagonal components of the matrix to be zero, following Bollerslev et al. (1988).

$$\begin{bmatrix} h_{11,t} \\ h_{21,t} \\ h_{22,t} \end{bmatrix} = \begin{bmatrix} w_{11} \\ w_{22} \\ w_{33} \end{bmatrix} + \begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t-1}\varepsilon_{1t-1} \\ \varepsilon_{2t-1}\varepsilon_{1t-1} \\ \varepsilon_{2t-1}\varepsilon_{2t-1} \end{bmatrix} + \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix} \begin{bmatrix} h_{11,t-1} \\ h_{21,t-1} \\ h_{22,t-1} \end{bmatrix} \tag{3}$$

We first obtain consistent estimators for $\hat{\alpha}_i$ and $\hat{\beta}_{ij}$ by estimating Equation (1) via the ordinary least squares method. Then using these estimators as initial values, we obtain maximum likelihood estimators for the set of parameters as a whole, including the GARCH part of the stochastic variances.

After we obtain the time-varying variances and covariance, we can calculate the time-varying correlation between the US and the Asian stock market innovations.

$$\rho_t = \frac{h_{12,t}}{\sqrt{h_{11,t} h_{22,t}}} \tag{4}$$

The estimated time-varying correlations for each Asian economy and the US are depicted in Figures 1-1 through 1-12[2]. Given the degree of fluctuations in these figures, it is not clear in many cases whether the correlations are increasing, stabilizing or decreasing. To overcome this ambiguity, we propose to proceed by the following two steps. As the first step, we apply a test for constancy of the correlation. If the constant correlation assumption is rejected, then, as the second step, we specify two correlation regimes and investigate how the correlation evolves between the two regimes.

[Take in Figures (1-1 through 1-12)]

3-1-a. Constant correlation model and tests for constancy of correlation

To impose the conditions for the positive definiteness of the covariance matrix with a simpler parameterization, Bollerslev (1990) introduces a constant correlation assumption in a GARCH model. Each variance term follows a GARCH process in Equation (5). The covariance term is restricted using constant correlation parameters and variance terms in Equation (6).

$$\begin{aligned} h_{11,t} &= w_1 + a_1 \varepsilon_{1,t-1} \varepsilon_{1,t-1} + b_1 h_{11,t-1} \\ h_{22,t} &= w_2 + a_2 \varepsilon_{2,t-1} \varepsilon_{2,t-1} + b_2 h_{22,t-1} \end{aligned} \tag{5}$$

$$h_{21,t} = \rho(h_{11,t} h_{22,t})^{1/2} \tag{6}$$

To simplify the presentation of the test statistics, the scaled residuals are denoted as $\hat{\varepsilon}^*_{i,t} = \hat{\varepsilon}_{i,t} \big/ \sqrt{h_{i,t}}$ and the scaled residual pre-multiplied by the inverse of correlation matrix as

$$\left(\hat{v}^*_{1t}, \quad \hat{v}^*_{2t}\right)' = \left(\frac{\hat{\varepsilon}^*_{1,t} - \hat{\rho}\hat{\varepsilon}^*_{2,t}}{\sqrt{1-\rho^2}}, \quad \frac{\hat{\varepsilon}^*_{2,t} - \hat{\rho}\hat{\varepsilon}^*_{1,t}}{\sqrt{1-\rho^2}} \right). \tag{7}$$

Bera and Kim (2002) propose two versions of IM tests:

$$IM_e = \frac{\left[\sum_{t=1}^{T}(\eta_t)\right]^2}{4T\left(1+4\hat{\rho}^2+\hat{\rho}^4\right)}, \quad \text{where } \eta_t = \hat{v}^{*2}_{1t}\hat{v}^{*2}_{2t} - 1 - 2\hat{\rho}^2, \tag{8}$$

$$IM_s = \frac{\left[\sum_{t=1}^{T}\eta_t\right]^2}{\sum_{t=1}^{T}(\eta_t - \overline{\eta})^2}. \tag{9}$$

Berben and Jansen (2005) apply Tse's (2000) Lagrange multiplier test for a smooth-transition GARCH model.

$$\frac{\partial l_t}{\partial \hat{\gamma}} = \left[\left(\hat{v}^*_{1t}\hat{v}^*_{2t} \Big/ 1-\rho^2\right) + \left(\rho \Big/ 1-\rho^2\right)\right] \tag{10}$$

$$LMC = \frac{\left(\sum_{t=1}^{T}\frac{\partial l_t}{\partial \hat{\gamma}}\right)\left(\sum_{t=1}^{T}\frac{\partial l_t}{\partial \hat{\gamma}}\right)}{\sum_{t=1}^{T}\left(\frac{\partial l_t}{\partial \hat{\gamma}}\frac{\partial l_t}{\partial \hat{\gamma}}\right)} \tag{11}$$

The limiting distributions of all three test statistics are $\chi^2(1)$. Small sample properties via Monte Carlo simulation indicate that the *IMs* test performs better than the *IMe* test in terms of power when the disturbance term follows the t-distribution (Bera and Kim, 2002). The power of the *LMC* test declines when the transition is linear and the location of the transition is closer to either end of the sample period (Berben and Jansen, 2005).

3-1-b. Smooth-transition correlation GARCH(1,1) model

Following Lin and Terasvirta (1994), we can model the correlation between the US and Asian stock markets to follow a smooth transition over the sample period. We follow the specifications of Berben and Jansen (2005)[3]. Variance terms follow a GARCH process in Equation (12) and covariance term is defined as time-varying in Equation (13) with parameter restrictions given in (14) and (15).

$$\begin{aligned} h_{11,t} &= w_1 + a_1 \varepsilon_{1,t-1} \varepsilon_{1,t-1} + b_1 h_{11,t-1} \\ h_{22,t} &= w_2 + a_2 \varepsilon_{2,t-1} \varepsilon_{2,t-1} + b_2 h_{22,t-1} \end{aligned} \tag{12}$$

$$h_{21,t} = \rho_t (h_{11,t} h_{22,t})^{1/2} \tag{13}$$

$$\rho_t = \rho_0 (1 - G(s_t;\gamma,c)) + \rho_1 G(s_t;\gamma,c) \tag{14}$$

$$G(s_t;\gamma,c) = \frac{1}{1+\exp(-\gamma(s_t - c))}, \qquad \gamma > 0 \tag{15}$$

The correlations in the first regime and second regime are denoted by ρ_0 and ρ_1, respectively. The time-varying correlation is therefore a weighted average of these two correlations, as in Equation (14). The weighting function, $G(s_t;\gamma,c)$, follows the logistic specification, and γ and c denote the 'speed' of transition and the (mid) 'point' of transition, respectively. The transition variable s_t is defined as t divided by the number of observations; therefore, $t \in (0,1]$. Then the weight becomes a monotonic function of the transition variable.

We first obtain consistent estimators for $\hat{\alpha}_i$ and $\hat{\beta}_{ij}$ by estimating Equation (1) using ordinary least squares. Then using these estimators as initial values, we obtain maximum likelihood estimators for the parameters in Equation (1) as well as the GARCH component of stochastic variances in Equations (12) through (15). After we obtain estimated coefficients for $\rho_0, \rho_{1,} \gamma,$ and c, we can calculate the time-varying correlation between US and the Asian stock market innovations.

3-2. Granger-causality relationship

The time-varying correlation analysis in the preceding section can reveal a possible shift in the correlations between the movement of stock returns between Asia and the US. The analysis, however, cannot uncover the underlying structure how these markets interact each other. One possible structure is to assume that the US stock market, being the largest in the world, influence the Asian markets uni-directionally as in the world-region component model in Bekeart and Harvey (1997), Ng (2000), Yi and Tan (2009), and Chan et al. (2008). A more general structure is to allow for a possible bi-directional causality between the Asian markets and the US market as in Cheung et al. (2007).

To test the hypothesis that the stock index *i* of an Asian economy does not Granger-cause and the US stock index, we use the test of the joint significance of all β_j in the following regressions,

$$P_t^U = C + \sum_{j=1,\ldots k} \alpha_t P_{t-j}^U + \sum_{j=1,\ldots k} \beta_t P_{t-j}^i + \varepsilon_t, \qquad (16)$$

where *k* is the number of lags. For the test of the reverse causality pattern, the two stock indices are exchanged.

3-3. Vector error correction approach

We now turn to the analysis of the integration of stock markets within Asia, while previous subsections focused on the bilateral relationship of each Asian market with the US market. For N Asian stock indices, consider a vector autoregressive regression (VAR) with k lags,

$$\mathbf{P_t} = \mathbf{C} + \mathbf{A_1}\mathbf{P_{t-1}} + \mathbf{A_2}\mathbf{P_{t-2}} + \cdots + \mathbf{A}_k\mathbf{P_{t-k}} + \boldsymbol{\varepsilon}_t , \tag{17}$$

where $\mathbf{P_t}$ is a $N \times 1$ vector of stock indices, $\mathbf{C}$ is a $N \times 1$ vector of constants, $\mathbf{A_i}, i = 1, \cdots k$, are $N \times N$ matrices of parameters, and $\boldsymbol{\varepsilon}_\mathbf{t}$ is a $N \times 1$ vector of disturbances with mean **0**, covariance matrix $\boldsymbol{\Sigma}$, and is i.i.d. normal over time. We can rewrite the VAR model of (17) in a vector error-correction (VEC) model.

$$\Delta\mathbf{P_t} = \mathbf{C} + \mathbf{\Pi}\mathbf{P_{t-1}} + \sum_{i=1}^{k-1} \mathbf{\Gamma_i}\Delta\mathbf{P}_{\mathbf{t}-i} + \boldsymbol{\varepsilon}_t \tag{18}$$

If stock indices are **I(1)** and there exist r linearly independent cointegrating vectors, the matrix $\mathbf{\Pi}$ in (18) has rank r, Engle and Granger (1987). $\mathbf{\Pi}$ can be expressed as $\mathbf{\Pi} = \alpha\beta'$, where α and β are both $N \times r$ matrices of rank r. Each column in β represents a unique cointegrating vector or error correction term and the effect of the error correction terms for each Asian market is represented by the corresponding row vector in the adjustment coefficients α .

In the following empirical section, we pay particular attention to which markets contribute to the long-run relationship in Asia by scrutinizing the statistical significance of each market in β. We also determine whether each Asian market is correlated with the region in general by testing the joint significance of the corresponding row in α and $\mathbf{\Gamma_i}$.

4. Empirical Results for Asian financial crisis and sub-prime loan crisis

This section presents the empirical results of (1) testing the constant correlation during crisis periods and evidence for changes in the correlation between the US and 12 Asian stock markets, (2) changes in Granger-causality between pre-crisis and post-crisis periods, (3) changes in regional integration by applying the vector error-correction model[4].

4-1. Data

Daily stock market returns are calculated as the log difference between the current and previous-day stock market index. For Asian stock market indices, we use SSEC for China, HIS for Hong Kong, JKSE for Indonesia, KS11 for Korea, BSESN for India, KLSE for Malaysia, KSE for Pakistan, PSI for Philippines, FTSTI for Singapore, CSE for Sri Lanka, TWII for Taiwan and SETI for Thailand. For Japanese and US stock market indices, we use the Nikkei255 and Dow Jones Industrial Average. These data are retrieved in terms of the national currency from *Thomson Reuter 3000Xtra*. The sample period covers from March 26, 1994 to December 21, 2009. To maintain balanced panel data, we limited our sample to days for which all indices are available. This leaves us 2,376 observations for each series. For the most of the following analysis, we use two sub-sample periods with equal length of 33 months: Asian financial crisis period from April 1996 to October 1998 and sub-prime financial crisis from June 2007 to December 2009.

4-2. Measuring changes in volatility spillover during crisis

Focusing on the changes in volatility spillovers between Asian economies and the US during sub-prime loan crisis, this sample is restricted from June 2007 to

December 2009, extending 16 months both before and after September 2008. Applying three tests for constancy of correlation to 12 Asian economies with the US for the sub-prime loan crisis period, Table 1 summarizes the test results. The IMe tests overwhelmingly indicate rejection of the null hypothesis of constant correlations while LMC and IMs test do not reject the null hypothesis for most of the cases. More specifically, IMe rejects the null hypothesis for 10 countries at the one percent significance level. The null hypothesis of constant correlation between Hong Kong and the US cannot be rejected at any traditional significance level. On the other hand, LMC test indicates rejection for constant correlation only for Hong Kong while IMs test only rejects the constant correlation for the case of Thailand.

Table 2 also provides test statistics for the Asian crisis, with the sample also extending 16 months both before and after July 1997, in which the Thai baht was pressured to depreciate after depletion of foreign reserves. The evidence for a change in correlation is stronger in the Asian crisis. IMs also rejects the null hypothesis for five countries with the significance level of ten percent while the IM test rejects the null hypothesis of constant correlation for all countries. LMC, on the other hand, cannot reject the null hypothesis for any countries.

Given the mixed result of these tests, we proceed to investigate a possible change in volatility spillover by applying Berben and Jansen's (2005) smooth-transition correlation GARCH(1,1) model to all 12 Asian countries. Table 3 provides correlation at the beginning, the end, and the change during the period. In addition, the midpoint of the transition for a smooth transition is provided. Figure 2 and 3 provides the full dynamics of time-varying correlations for the sub-prime financial crisis and the Asian financial crisis, respectively.

[Take in Figure 2 and 3]

Comparing smooth-transition specification for correlation dynamics for Asian crisis and sub-prime financial crisis, we find following two striking features. First, volatility spillovers in terms of correlation declined during financial turmoil for some countries in both crises. This decline in correlation is more pervasive for Asian crisis period. This result adds new interesting evidence to the contagion literature, see Edwards (2000) and Forbes and Rigobon (2001) for the survey. Suggesting a bias-correction measure for contagion, Forbes and Rigobon (2002) argue that there is a high degree of interdependence but no contagion, i.e., shift in transmission parameters, during the Asian financial crisis[5]. The debate in the literature strictly focuses on the increase in transmission but we find for some economies that there are decreasing cases in the transmission channel during the Asian financial crisis.

Second, a transition in correlation took place well in advance of the largest impact of September 2008 in the sub-prime financial crisis, while it occurred after July 1997 in the Asian crisis. This result is indicative of market participants' awareness of the upcoming stock market crash well before the collapse of government sponsored enterprises and investment banks.

4-3. Causality during crises

As a preliminary analysis, we tested the stationarity of the log of the stock index at level and confirmed that they are all I(1); see Table 4. For tests of a possible cointegration relationship, we applied the Engle-Granger test and Johansen's trace test to all US-Asia pairs. Table 4 provides test statistics for the Engle-Granger approach of testing the presence of unit root in the residual. Table 5 provides test results for

Johansen's trace test. We find a cointegration relationship for six pairs, namely, Korea-US, Pakistan-US, Singapore-US, Sri Lanka-US, Taiwan-US and Thailand-US in the sub-prime loan crisis while there was a cointegration relationship for four pairs, namely, China-US, Hong Kong-US, Malaysia-US, and Singapore-US in Asian financial crisis.

We further investigated that causality direction between the returns of the stock index during two crises. During the Asian financial crisis, the US returns significantly influenced the markets in Hong Kong, the Philippines and Singapore, while there is no causality in the reverse direction except for weak evidence of Taiwan returns Granger-causing the US market. Additionally, during the sub-prime loan crisis, we have very strong evidence that the US return Granger-caused the Asian market returns, except in Pakistan and China. From the Asian markets to the US market, we also obtained supporting evidence of Granger-causality for many Asian countries.

The striking difference between two crises found in Granger-causality among the US and Asian markets may seem to suggest that the location of the crisis-originating region may affect the contagion process.

4-4. Integration among the Asian stock markets

The analysis in the previous subsections focused on measuring the degree of spillover for Asian markets from (and to) the world largest stock market. In this subsection we turn to measuring the financial link within the region. We apply a vector autoregressive error correction model to the 13 Asian stock markets including Japan. First, we implemented a Johansen trace-test to determine whether there is a cointegration relationship among Asian stock markets[6]. Then, we apply a vector error correction model to investigate the long-run relationship in terms of cointegrating vector and whether price changes in each market can be explained by vector autoregressive framework. We split samples into pre- and post-crisis samples to account for the change in the vector error correction mechanism. Therefore, we have four distinct sub-samples: Pre-Asian crisis; post-Asian crisis; pre-sub-prime loan crisis; and post-sub-prime loan crisis.

Table 8 provides the chi-squared statistics for the null hypothesis that all regressors are not significant for each market equations in sub-periods. Both before and after the Asian crisis, the lagged price changes in other Asian markets and error correction term combined have explanatory power for two markets (Sri Lanka and Indonesia). For Taiwan, the price movements in the region had significant effects on the Taiwanese stock market before the Asian crisis, but no longer in the post-crisis period. For Japan, Malaysia and the Philippines, conversely, the importance of the regional stock price movements increased after the crisis.

In contrast with Asian crisis, the regional factor was not important for most of Asian markets prior to the collapse of Lehman Brothers. The Philippines and Taiwan are only two markets that are affected by the regional error correction term and past price movements in the other countries in the region. However, regional factors became significant for nine other countries. India and Singapore are only two countries that are not affected by either a long-run relationship or past movements in other markets in Asia.

Table 9 provides estimates of the parameters in the cointegrating vector for each sub-sample. We have evidence that the regional long-run relationship is more stable in terms of the number of contributing countries in the recent crisis than the Asian financial crisis. Nine markets, although they have some changes in members, contribute to the long-run relationship within Asia both prior to and after the sub-prime loan crisis, while only six markets are statistically significant for the post-crisis period in the Asian financial crisis.

Table 10 summarizes the estimated adjustment coefficients for each sub-sample. These coefficients determine the degree of effect of the error correction term in each country's equation. Similar to the results from Table 8, we have strong evidence that the regional factor began to affect more Asian countries after the collapse of Lehman Brothers. In summary, we find evidence that the long-run integration in the region is more stable in the recent sub-prime financial crisis and the effect of the regional factor on each Asian market increased, especially after the sub-prime financial crisis.

5. Conclusions

The recent sub-prime financial crisis initially affected the Asian economy to a degree comparable to that of the 1997 Asian crisis, although the epicenters of the two crises were different. Reinhart and Rogoff (2008, 2009a, 2009b) show that all past financial crises share striking similarities in the run-up of asset prices, debt accumulation, growth patterns, and current account deficits although each crisis is distinctively different. While the current crisis may follow the same old pattern for the US, the contagion effect on Asia may not be the same as in the past experience.

We investigate whether the effects of the sub-prime financial crisis on 13 Asian economies are similar to those of the previous crisis, by examining the volatility spillovers and causality directions between the US and Asian economies as well as the degree of regional integration. Regarding the relationship of Asian economies with the

US, the empirical evidence indicates three stark differences between these two crises. First, volatility spillovers in terms of correlation declined during the financial turmoil for some countries in both crises. This decline in correlation was more pervasive for the Asian crisis period. Second, a transition in correlation took place well in advance of the largest impact of September 2008 in the sub-prime financial crisis, while it occurred after July 1997 in Asian crisis. This result is indicative of market participants' awareness of the upcoming stock market crash well before the collapse of government sponsored enterprises and investment banks. Third, the causality direction is influenced by the epicenter of the crisis. Significant effects of US Granger-causality are found for most of the Asian economies during the recent sub-prime financial crisis, while there are only a few cases in the Asian financial crisis.

In addition, empirical evidence shows that regional integration was strengthened after the financial turmoil in the recent crisis. According to the evidence in this paper, subject to limitations due to the preliminary nature of the result, the spillover or contagion effect on Asian markets of the sub-prime financial crisis originating in the US shows a striking difference from the past experience in the Asian financial crisis in 1997. This difference may come from the fact that Asia learned the lesson from its past experience to adopt faster, larger, and more effective policy measures than other regions in the world. The increased integration of anti-crisis measures in the region, such as a multilateral currency swap arrangement under the Chiang Mai Initiatives, may have helped Asian markets be better prepared for the second crisis.

---

[1] There are also empirical studies that examine real components of the economy in the Asian region. By applying a dynamic factor model to macroeconomic variables for ten Asian economies, Moneta and Rüffer (2009) find that the degree of synchronization

increased in Asia.
[2] In general, VAR-specifications are used for the estimation of time-varying correlation in Equation (1). Mean-specification is used when convergence is not achieved with given initial parameter conditions ($a_{ij} = b_{ij} = 0.01$) in the VAR-specification. We altered the initial conditions for parameters if convergence cannot be achieved in either specification.
[3] Yoshida (2009) also applies this approach to investigate the shift in correlations between the US and Japanese stock markets.
[4] The first two analyses do not include Japan because our focus is on emerging economies in Asia. However, we include Japan in the third analysis to investigate the integration of stock markets in Asia with the widest coverage.
[5] Rigobon (2003) and Corsetti et al. (2005) use a different approach to show that there is contagion as well as interdependence.
[6] The table for trace test is only available up to N-r = 12 in Osterwald-Lenum (1992) and Johansen (1995). We calculated a p-value for N-r=13 from Gamma distribution approximation proposed in Doornik (1998). Trace statistics are 428.93, 404.73, 384.37 and 457.57 and corresponding p-values are 0.062, 0.282, 0.604, and 0.004 for pre-Asian crisis, post-Asian crisis, pre-sub-prime crisis, and post-sub-prime crisis. Nevertheless, in the vector error-correction model, we proceed assuming that there is one cointegrating vector for each case.

References:

1. Awokuse, T. O., Chopra, A., and Bessler, D.A. (2009), "Structural change and international stock market interdependence: Evidence from Asian emerging markets", *Economic Modeling*, 26, 549-559.
2. Baur, D. G. and Fry R.A. (2009), "Multivariate contagion and interdependence", *Journal of Asian Economics*, 20, 353-366.
3. Bera, A.K. and Kim, S. (2002), "Testing constancy of correlation and other specifications of the BGARCH model with an application to international equity returns", *Journal of Empirical Finance*, 9, 171-195.
4. Berben, R.P. and Jansen, W.J. (2005), "Comovement in international equity markets: A sectoral view", *Journal of International Money and Finance*, 24, 832-857.
5. Bollerslev, T. (1988), "On the correlation structure for the generalized autoregressive conditional heteroskesastic process", *Journal of Time Series Analysis*, 9, 121-131.
6. Bollerslev, T. (1990), "Modeling the coherence in short-run nominal exchange rates: A multivariate generalized ARCH model", *Review of Economics and Statistics*, 72, 498-505.
7. Bollerslev, T., Engle, R.F., and Wooldridge, J.M. (1988), "A capital asset pricing model with time-varying covariances", *Journal of Political Economy*, 96(1), 116-131.
8. Chan, L., Lien D., and Weng, W. (2008), "Financial interdependence between Hong Kong and the US: A band spectrum approach", *International Review of Economics and Finance*, 17, 507-516.
9. Cheung, Y.L., Cheung Y.W., and Ng, C.C. (2007), "East Asian equity markets, financial crises, and the Japanese currency", *Journal of the Japanese and International Economics*, 21, 138-152.
10. Corsetti, G., Pericoli, M., and Sbracia, M. (2005), "'Some contagion, some interdependence': More pitfalls in tests of financial contagion", *Journal of International Economics*, 24, 1177-1199.
11. Cuadro-Sáez, L., Fratzscher, M., and Thimann, C. (2009), "The transmission of emerging market shocks to global equity markets", *Journal of Empirical Finance*, 16, 2-17.
12. Doornik, J.A. (1998), "Approximations to the asymptotic distributions of cointegration tests", *Journal of Economic Surveys*, 12(5), 573-593.
13. Edwards, S. (2000), "Contagion", *World Economy*, 873-900.

14. Engle, R.F. and Granger, C.W.J. (1987), “Co-integration and error correction: Representation, estimation, and testing”, *Econometrica*, 55, 251-276.
15. Forbes, K.J. and Rigobon, R. (2001), “Measuring contagion: Conceptual and empirical issues”, in *International Financial Contagion: How It Spreads and How It Can be Stopped*, World Bank.
16. Forbes, K.J. and Rigobon, R. (2002), “No contagion, only interdependence: Measuring stock market comovements”, *Journal of Finance*, 57(5), 2223-2261.
17. International Monetary Fund (2009), *Regional Economic Outlook (Asia and Pacific)*, October.
18. Johansen, S. (1995), *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford, Oxford University Press.
19. Khan, S. and Park, K.W. (2009), “Contagion in the stock markets: The Asain Financial crisis revisited”, *Journal of Asian Economics*, 20, 561-569.
20. Kim, S.J. (2005), “Information leadership in the advanced Asia-Pacific stock markets: Return, volatility and volume information spillovers from the US and Japan”, *Journal of the Japanese and International Economics*, 19, 338-365.
21. King, M.A. and Wadhwani, S. (1990), “Transmission of volatility between stock markets”, *The Review of Financial Studies*, 3(1), 5-33.
22. Lin, C.F.J. and Terasvirta, T. (1994), Testing the constancy of regression parameters against continuous structural change, *Journal of Econometrics*, 62, 211-228.
23. Moneta, F. and Rüffer, R. (2009), “Business cycle synchronization in East Asia”, *Journal of Asian Economics*, 20, 1-12.
24. Majid, M.S.A., Meera A.K.M., and Omar, M.A. (2008), “Interdependence of ASEAN-5 stock markets from the US and Japan”, *Global Economic Review*, 37(2), 201-225.
25. Mukherjee, P. and Bose, S. (2008), “Does the stock market in India move with Asia? A multivariate cointegration-vector autoregression approach”, *Emerging Markets Finance & Trade*, 44(5), 5-22.
26. Ng, A. (2000), “Volatility spillover effects from Japan and the US to the Pacific-Basin”, *Journal of International Money and Finance*, 19, 207-233.
27. Ng, T.H. (2002), “Stock market linkages in South-East Asia”, *Asian Economic Journal*, 16(4), 353-377.
28. Osterwald-Lenum, M. (1992), “A note with quantiles of the asymptotic distribution of the ML cointegration rank test statistics”, *Oxford Bulletin of Economics and Statistics*, 54, 461-472.
29. Reinhart, C.M. and Rogoff, K.S. (2008), “Is the 2007 US sub-prime financial crisis

so different? An international historical comparison", *American Economic Review*, 98(2), 339-344.

30. Reinhart, C.M. and Rogoff, K.S. (2009a), "The aftermath of financial crisis", *American Economic Review*, 99(2), 466-472.
31. Reinhart, C.M. and Rogoff, K.S. (2009b), *This time is different: eight centuries of financial folly*, Princeton: Princeton University Press.
32. Tse, Y.K. (2000), "A test for constant correlations in a multivariate GARCH model", *Journal of Econometrics*, 107-127.
33. Yi, Z. and Tan, S.L. (2009), "An empirical analysis of stock market integration: Comparison study of Singapore and Malaysia", *The Singapore Economic Review*, 54(2), 217-232.
34. Yoshida, Y. (2009), "Financial crisis, exchange rate and stock market integration", Kyushu Sangyo University Discussion Paper No.38,.

Figure legends

Figures 1-1 through 1-12.Estimated time-varying correlation between Asia and the US

Figure 2. Smooth Correlation June2007 – December 2009 (Mean-specification)

Figure 3. Smooth Correlation April1996 – October1998 (Mean-specification)

Table 1. Test for the constancy of correlation (June 2007 - December 2009)

	VAR specification			Mean specification		
	LMC	IMe	IMs	LMC	IMe	IMs
India	0.37	125.13	2.07	0.96	23.53	1.25
Sri Lanka	0.05	27.88	2.49	0.13	29.17	2.57
Hong Kong	24.43	1.87	0.11	16.10	3.50	0.32
Indonesia	1.75	20.27	2.10	1.98	13.91	1.83
Malaysia	0.96	50.18	1.51	1.35	35.61	1.73
Korea	0.04	58.73	1.87	0.16	30.24	2.03
Pakistan	0.53	46.19	1.04	0.55	47.72	1.09
Philippines	0.19	33.58	0.81	0.10	24.80	1.27
Thailand	0.33	40.60	2.96	0.27	26.11	2.11
China	0.87	11.41	1.12	0.13	9.78	1.46
Taiwan	0.05	13.58	1.70	0.42	41.32	2.27
Singapore	0.97	3.38	0.42	0.47	104.86	1.99

Note: All test statistics follow $\chi^2(1)$. The critical values are 2.71, 3.84, and 6.63 for significance levels of ten, five, and one percent, respectively.

Table 2. Test for the constancy of correlation (April 1996 - October 1998)

	VAR specification			Mean specification		
	LMC	IMe	IMs	LMC	IMe	IMs
India	0.43	47.20	2.85	0.52	45.33	2.87
Sri Lanka	0.27	144.00	3.08	0.21	139.31	2.95
Hong Kong	0.21	43.62	3.16	0.10	57.57	3.14
Indonesia	0.20	3.03	0.41	0.14	7.41	0.73
Malaysia	0.70	12.22	1.08	0.68	9.12	0.90
Korea	0.07	8.08	2.01	0.06	8.28	1.98
Pakistan	0.32	21.97	1.70	0.26	21.91	1.69
Philippines	1.58	60.11	2.51	1.35	52.24	2.39
Thailand	1.39	58.15	0.97	1.41	65.10	1.01
China	0.02	120.44	2.38	0.04	113.61	2.49
Taiwan	0.11	34.60	3.29	0.16	41.45	3.49
Singapore	0.03	55.42	1.91	0.03	49.59	2.08

Note: All test statistics follow $\chi^2(1)$. The critical values are 2.71, 3.84, and 6.63 for significance levels of ten, five, and one percent, respectively.

Table 3. Change in correlation and transition date

	Asian Crisis				Sub-prime financial crisis			
	initial	end	change	trans. date	initial	end	change	trans. date
India	-0.08	0.19	0.27	97/08/28	0.23	0.63	0.40	08/11/14
Sri Lanka	0.64	0.16	-0.48	96/11/13	-0.32	0.12	0.44	-
Hong Kong	0.67	0.30	-0.37	96/12/17	-0.33	0.42	0.75	08/07/23
Indonesia	0.40	0.11	-0.30	97/04/28	0.13	0.58	0.45	-
Malaysia	0.57	0.13	-0.44	96/07/09	0.21	0.78	0.58	09/06/10
Korea	0.15	0.25	0.10	97/09/12	-0.14	0.20	0.33	08/07/16
Pakistan	0.22	0.04	-0.18	97/08/22	0.32	-0.03	-0.34	08/04/02
Philippines	-0.01	0.40	0.40	97/11/07	0.47	0.21	-0.26	-
Thailand	-0.12	0.32	0.44	97/12/08	0.41	0.49	0.08	09/03/05
China	-0.08	0.00	0.07	97/05/15	-0.10	0.35	0.45	07/11/28
Taiwan	0.05	0.27	0.21	97/10/21	0.45	0.36	-0.09	-
Singapore	0.31	0.60	0.29	97/03/17	0.03	0.73	0.69	07/08/10

Note: Convergence was not achieved for Pakistan in the Asian crisis and Taiwan for the sub-prime financial crisis. ‘-‘ indicates that the transition started at the first period.

Table 4. Unit root test and cointegration test

	Asian financial crisis			Sub-prime loan crisis		
	WS	ADF	EG	WS	ADF	EG
India	-1.95	-1.73	-3.07	-1.49	-1.2	-1.93
Sri Lanka	-1.48	-1.08	-2.98	-0.62	-0.12	-3.96*
Hong Kong	-1.60	-1.88	-1.74	-1.45	-1.33	-2.45
Indonesia	-2.40	-2.47	-2.48	-1.5	-1.16	-2.22
Malaysia	-1.69	-2.22	-3.08	-1.03	-0.59	-2.83
Korea	-2.51	-2.43	-2.41	-1.46	-1.14	-1.85
Pakistan	-1.54	-1.43	-1.96	-1.67	-1.54	-4.05*
Philippines	-1.71	-2.28	-2.33	-0.93	-0.53	-1.8
Thailand	-2.31	-2.08	-3.24	-1.14	-0.79	-2.91
China	-1.34	-3.17	-4.10*	-1.25	-0.97	-1.77
Taiwan	-0.79	-1.43	-3.59	-1.41	-1.01	-1.94
Singapore	-1.96	-2.01	-2.44	-1.09	-0.67	-2.56
US	-1.77	-1.75		-1.17	-0.84	

Note: WS and ADF are the weighted symmetric and augmented Dicky-Fuller test statistics for the null of unit-root, and EG is the Engle-Granger cointegration test statistic for the null of no-cointegration. Statistical significance at the one and five percent levels are indicated by ** and *, respectively.

Table 5. Johansen cointegration test

	Asian financial crisis		Sub-prime loan crisis	
	r=0	$r \leq 1$	r=0	$r \leq 1$
India	14.81	1.66	13.80	3.67
Sri Lanka	11.91	1.37	19.19*	0.01
Hong Kong	18.89*	4.48*	15.92	5.16*
Indonesia	12.21	2.44	13.32	5.88*
Malaysia	21.17*	5.73*	12.11	0.89
Korea	11.29	4.40*	23.31**	8.70**
Pakistan	8.56	0.88	14.64	0.48
Philippines	14.66	4.75*	10.16	0.95
Thailand	9.45	3.11	18.70*	4.60*
China	20.92*	3.33	10.30	2.18
Taiwan	12.14	1.69	22.21*	5.85*
Singapore	18.22*	6.16**	22.83*	8.04**

Note: Statistical significance at the one and five percent levels are indicated by ** and *, respectively.

Table 6. Granger causality test, Apr1996-Oct1998

	US Granger-cause			Asia Granger-cause		
	5-lags	10-lags	20-lags	5-lags	10-lags	20-lags
India	0.19	0.77	0.82	0.51	0.69	0.96
Sri Lanka	1.88	1.18	0.78	0.36	1.44	0.92
Hong Kong	2.93	2.58*	1.63	0.69	0.42	1.10
Indonesia	1.41	1.18	1.03	0.87	0.91	0.74
Malaysia	2.75	1.53	1.23	0.30	0.23	1.19
Korea	2.36	1.78	1.55	1.45	1.58	1.11
Pakistan	0.10	0.42	0.30	0.64	0.90	0.75
Philippines	6.44*	3.54*	2.37*	0.18	0.20	1.25
Thailand	0.18	0.50	0.65	0.29	0.27	0.46
China	0.18	0.42	0.49	0.33	0.51	0.49
Taiwan	2.22	1.19	0.99	1.32	2.75*	1.63
Singapore	4.03*	2.74*	1.90	0.37	0.51	0.89

Note: Statistical significance at the one and five percent levels are indicated by ** and *, respectively.

Table 7. Granger causality test, Jun2007-Dec2009

	US Granger-cause			Asia Granger-cause		
	5-lags	10-lags	20-lags	5-lags	10-lags	20-lags
India	6.26*	6.23*	4.04*	0.38	1.54	1.34
Sri Lanka	4.17*	4.32*	3.81*	1.72	0.97	0.75
Hong Kong	9.30*	8.22*	5.11*	0.97	2.45*	2.49*
Indonesia	3.58*	5.93*	3.55*	1.28	1.26	2.61*
Malaysia	6.60*	5.38*	3.44*	1.96	2.14	1.67
Korea	10.41*	11.18*	6.05*	2.22	2.29	2.51*
Pakistan	1.11	1.28	1.24	1.01	1.07	1.28
Philippines	14.28*	9.11*	4.91*	3.31*	2.72*	2.45*
Thailand	4.73*	4.45*	3.21*	2.48	2.01	2.35*
China	1.90	1.44	1.20	1.64	2.52*	1.66
Taiwan	6.27*	5.46*	3.05*	1.17	3.24*	2.84*
Singapore	6.97*	8.47*	5.78*	0.47	1.28	1.87

Note: Statistical significance at the one and five percent levels are indicated by ** and *, respectively.

Table 8. The fits of the country equations

	Pre-Asian crisis		Post-Asian crisis		Pre-SPL crisis		Post-SPL crisis	
	χ^2	p-value	χ^2	p-value	χ^2	p-value	χ^2	p-value
Korea	19.0	0.22	21.1	0.13	13.3	0.58	36.6	0.00
India	12.8	0.62	17.9	0.27	15.2	0.43	17.0	0.32
Sri Lanka	28.7	0.02	57.9	0.00	15.3	0.43	23.2	0.08
Hong Kong	17.0	0.32	17.2	0.30	11.7	0.70	23.7	0.07
Indonesia	31.8	0.01	25.2	0.05	9.8	0.83	45.9	0.00
Malaysia	8.6	0.90	22.7	0.09	8.9	0.88	49.3	0.00
Pakistan	7.7	0.94	13.9	0.54	6.8	0.96	34.4	0.00
Philippines	16.3	0.36	40.8	0.00	24.2	0.06	99.1	0.00
Thailand	21.8	0.11	21.5	0.12	16.8	0.33	51.9	0.00
China	18.7	0.23	20.9	0.14	19.4	0.19	27.5	0.02
Taiwan	102.7	0.00	21.9	0.11	22.9	0.09	34.3	0.00
Japan	6.9	0.96	24.1	0.06	13.7	0.55	54.7	0.00
Singapore	15.1	0.44	18.2	0.25	11.4	0.72	20.6	0.15
NOB	163		219		215		205	

Note: The chi-squared statistic is a test for the null of all regressors to be insignificant for a given market equation.

Table 9. Cointegrating vectors

	Pre-Asian crisis		Post-Asian crisis		Pre-SPL crisis		Post-SPL crisis	
	Coef.	Std	Coef.	Std	Coef.	Std	Coef.	Std
Korea	1.000		1.000		1.000		1.000	
India	-0.191	0.341	-0.101	0.333	-0.922**	0.129	1.746**	0.539
Sri Lanka	-3.267**	0.561	-2.147**	0.376	0.332	0.173	-0.834*	0.414
Hong Kong	2.443**	0.630	-0.164	0.192	0.857**	0.175	-1.800*	0.784
Indonesia	2.364**	0.858	-0.002	0.187	-0.448**	0.119	-4.179**	0.675
Malaysia	-1.598*	0.725	0.101	0.208	0.850**	0.179	-0.218	1.071
Pakistan	-0.152	0.351	0.802**	0.160	0.040	0.070	0.118	0.200
Philippines	-2.592**	0.640	1.463**	0.242	0.507**	0.081	5.348**	0.710
Thailand	2.432**	0.354	-1.763**	0.205	0.541**	0.189	2.402**	0.760
China	-1.072**	0.266	1.430**	0.377	-0.061*	0.029	1.006**	0.323
Taiwan	5.091**	0.562	-0.528	0.299	-0.796**	0.155	-0.065	0.399
Japan	-0.325	0.415	0.585	0.431	0.071	0.166	1.226*	0.525
Singapore	-3.453**	1.084	0.739**	0.259	-1.630**	0.272	-3.322**	0.841

Note: Statistical significance at the one and five percent levels are indicated by ** and *, respectively. Constants are suppressed.

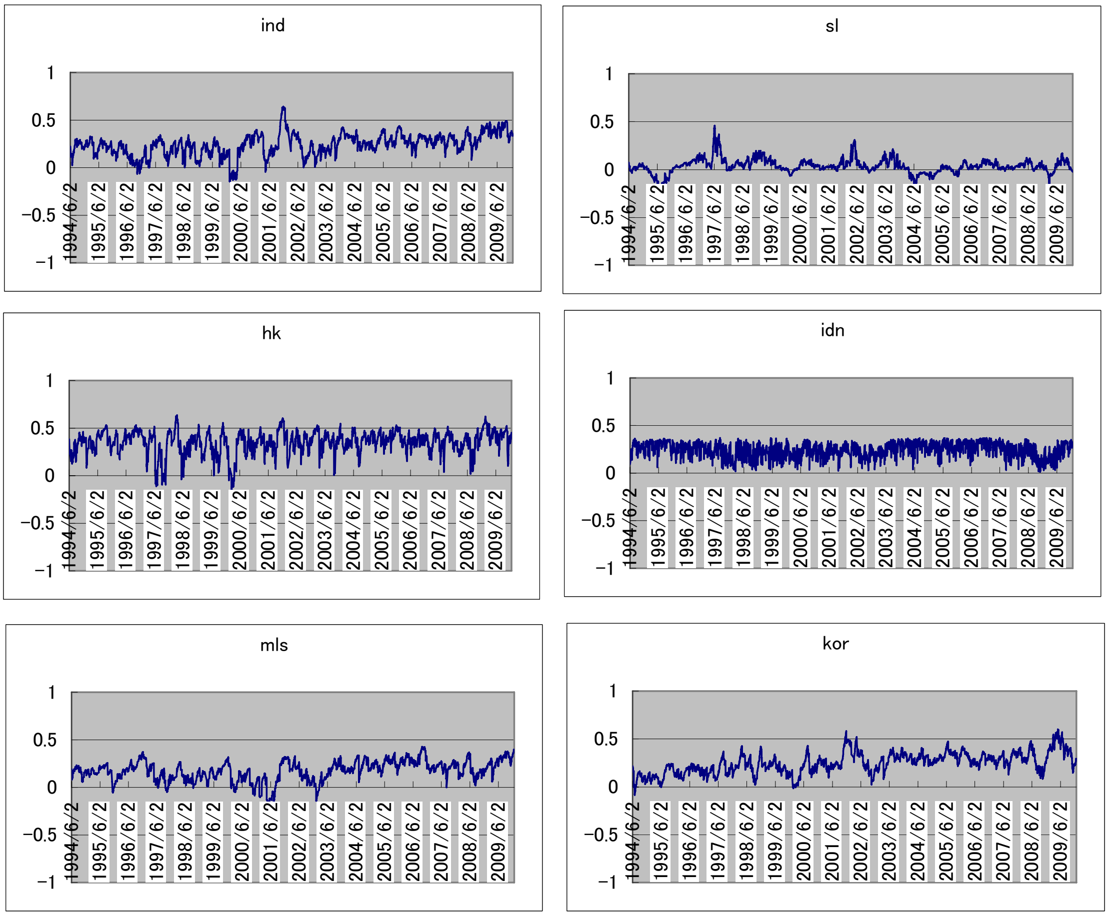
Table 10. Adjustment coefficients

	Pre-Asian crisis		Post-Asian crisis		Pre-SPL crisis		Post-SPL crisis	
	Coef	Std	Coef	Std	Coef	Std	Coef	Std
Korea	-0.011	0.012	-0.063**	0.024	0.015	0.044	-0.036*	0.015
India	-0.008	0.013	0.023	0.013	0.135*	0.060	-0.045**	0.017
Sri Lanka	0.023**	0.007	0.031**	0.008	-0.063**	0.021	-0.015	0.010
Hong Kong	-0.002	0.008	-0.035	0.020	0.000	0.054	-0.031	0.017
Indonesia	-0.008	0.007	-0.033	0.024	0.007	0.050	-0.021	0.015
Malaysia	0.000	0.006	-0.020	0.025	-0.040	0.034	-0.025**	0.006
Pakistan	-0.011	0.013	0.019	0.020	-0.016	0.048	0.010	0.011
Philippines	-0.019*	0.009	-0.067**	0.019	-0.141**	0.043	-0.065**	0.011
Thailand	-0.028	0.015	0.017	0.022	-0.034	0.042	-0.045**	0.013
China	0.047*	0.021	-0.036**	0.012	0.106	0.067	-0.052**	0.014
Taiwan	-0.063**	0.009	0.023	0.012	0.077	0.045	-0.025	0.013
Japan	0.005	0.009	-0.011	0.013	0.028	0.042	-0.045**	0.014
Singapore	-0.009	0.006	-0.017	0.018	0.065	0.041	-0.027	0.015

Note: Statistical significance at the one and five percent levels are indicated by ** and *, respectively. Constants are suppressed.

Figures 1-1 through 1-6.

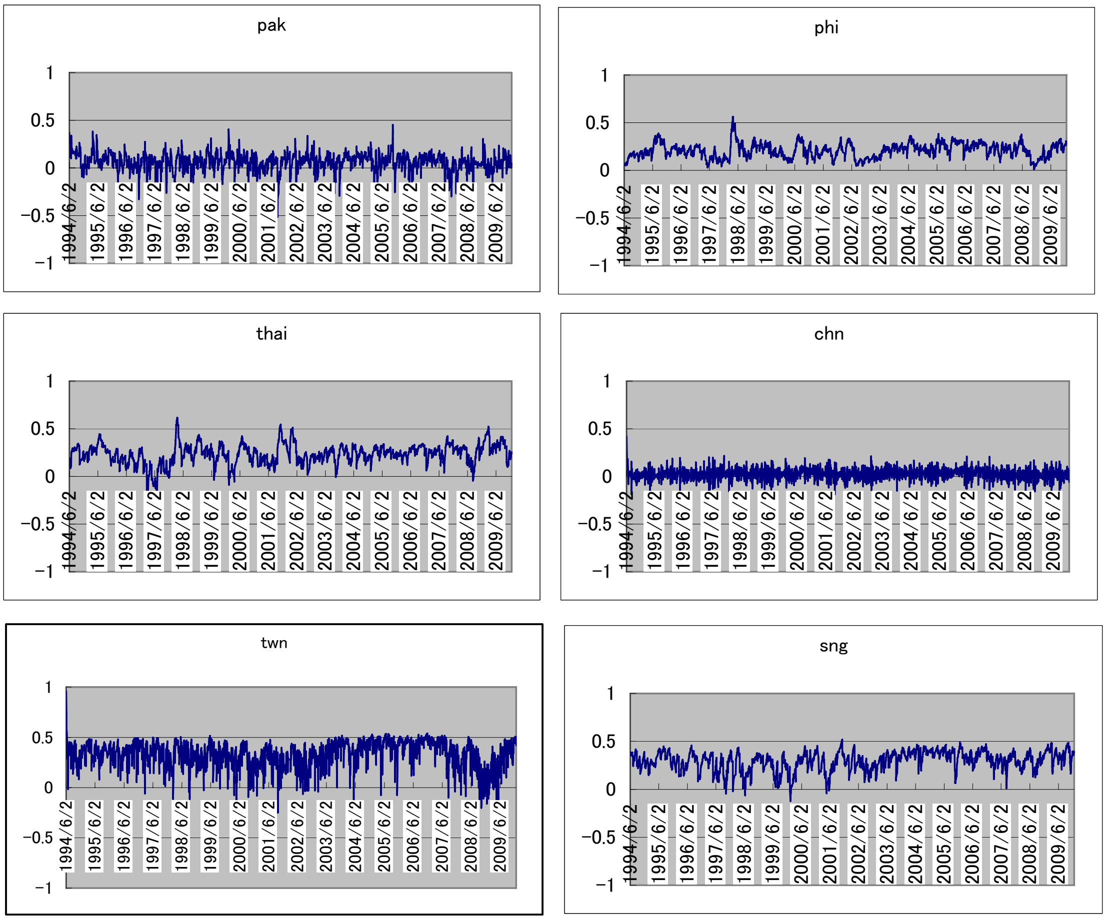
Estimated time-varying correlations between Asia and the US



Note: In general, VAR-specifications are used for the estimation of the time-varying correlation in Equation (1). The mean-specification is used when convergence is not achieved with the given initial parameter conditions ($a_{ij} = b_{ij} = 0.01$) in the VAR-specification. This applies only for the case of Korea. For Sri Lanka, the mean-specification is also used for a better representation of the correlation dynamics.

Figures 1-7 through 1-12.

Estimated time-varying correlation between Asia and the US



Note: In general, the VAR-specifications are used for the estimation of the time-varying correlation in Equation (1). The mean-specification is used when convergence is not achieved with the given initial parameter conditions ($a_{ij} = b_{ij} = 0.01$) in the VAR-specification. This applies for the case of Singapore. For Taiwan, convergence is not achieved for either specifications, so the mean-specification is applied with a different set of initial parameters ($a_{ij} = b_{ij} = 0.1$) to achieve convergence.

Figure 2. Smooth Correlation June2007 – December 2009 (Mean-specification)

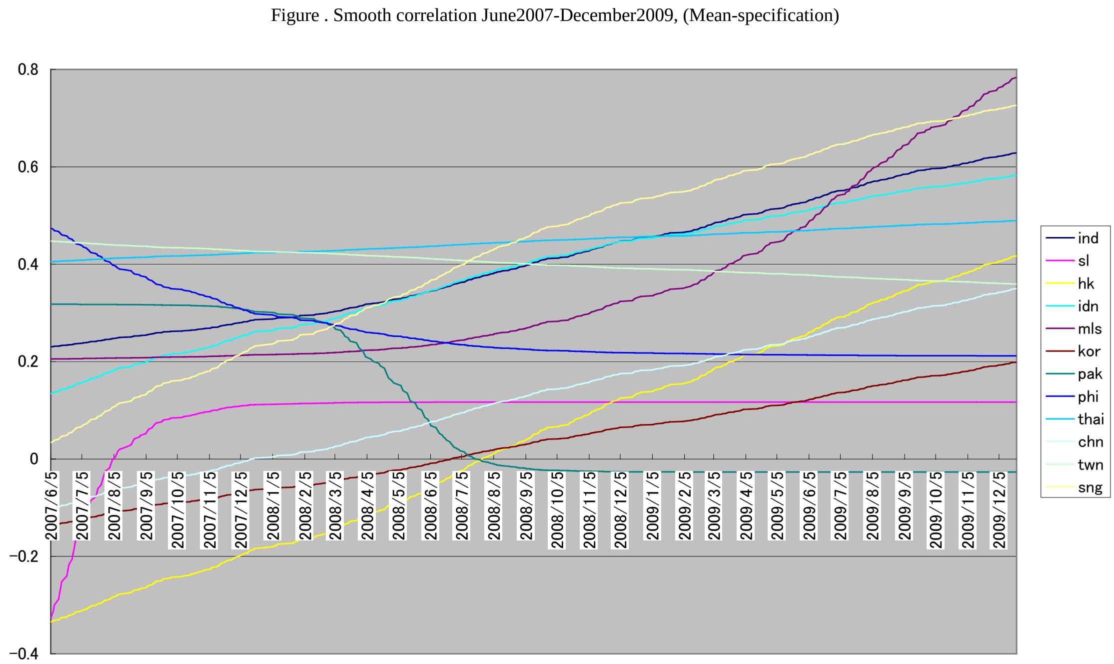


Figure 3. Smooth Correlation April1996 – October1998 (Mean-specification)