10. A STUDY OF THE NONLINEAR RELATIONSHIPS AMONG THE U.S. AND ASIAN STOCK MARKETS DURING FINANCIAL CRISES[1]

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Abstract

This study employs the nonlinear Panel TAR (Threshold Autoregressive) model to examine the relationships among the U.S. and Asian stock markets. The aims are to distinguish the impacts of the U.S. stock market on the Asian stock markets, both in normal periods and financial crises periods, and develop an early-warning system for such markets. Our results show that during periods of financial crises the Asian stock markets are profoundly influenced by the U.S. stock market, and less affected by the returns of their own stock markets. In contrast, during non-financial crisis periods the performance of the Asian stock markets has a positive correlation with their own returns in the previous period, and a negative correlation with the U.S. stock market.

Keywords: panel TAR, nonlinear, early-warning system, financial crises, correlation
JEL Classification: F2, F3, G1

1. Introduction

There are two main streams in past research about economic integration: one discusses the correlations among the business cycles of various countries, while the other focuses on financial market integration, including stock markets and foreign exchange rate markets. Based on the results of theoretical analyses, the linkages among markets mainly come from two channels, international trade and the liquidity of international capital. With regard to the former, Forbes (2002) found that when one country encounters a foreign exchange crisis, it will affect other countries via the

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relative price effect of exports and the wealth effect, and then affect their stock markets. The Asian countries in particular have a high level of trade dependence with the U.S., and a large amount of export income that they need to convert to foreign assets. Some of this foreign currency is transferred to the U.S. stock market, thus making a link between the two countries' stock markets, and causing greater integration, as one may see in countries with a large amount of exports, such as Malaysia, Singapore and Taiwan. With regard to the liquidity of international capital, the relaxation of capital regulations, increasing volumes of international exchanges, and the growth of internet trade, have all lead to a significant rise in cross-border trade. Moreover, many investors now hold many countries' securities, which also increase the strength of the links among the international stock markets. Boyer, Kumagai and Yuan (2006) divided the stock markets into two groups, those that allow foreigners to hold stocks, and those that do not, and found that the former has stronger links with the international markets during periods of international financial crises. Kodres and Pritsker (2002) also noted that when certain stock markets are undergoing periods of great change, then international investors will move to reallocate their assets, thus leading to concurrent changes in other markets. Kyle and Xiong (2001) and Yuan (2005) also found that investors will carry out cross-border asset reallocations when facing significant losses in certain stock markets, and thus that falls in one market will affect others.

Most Asian countries depend on exports for their economic growth. No matter whether during economic booms or recessions, most Asian countries have the direct relations with more developed countries, such as the U.S. and those in the E.U. The IMF(2009) found that the linkages between Asian countries and the U.S. are stronger than those among the Asian countries and any other developed economies. Hong, Lee and Tang (2009) examined the strength of the links among the economic cycles and financial markets of Asian and OECD countries using three indicators of GDP, credit loans and stock prices, and found that the correlations among these financial indicators is stronger during periods of financial crises. In addition, some studies also find asymmetric relationships among stock markets, such as Longin and Solnik (2001), Connolly and Wang (2003), Ang and Bekaert (2002), Ang and Chen (2002) and Boyer, Kumagai and Yuan (2006), all of whom show that there is a greater correlation among markets during crises periods.

After the global stock market crash of 1987, the economic links among countries became stronger, due to greater interdependence with regard to economic development and more integration of financial markets. Many empirical articles have examine these links among developed countries (e.g., Arshanapalli and Doukas, 1993; Rapach, Strauss and Zhou, 2009), or developed and developing ones (e.g., Arshanapalli, Doukas and Lang, 1995; Theodore Syriopoulos, 2007; Huyghebert and Wang, 2009; Wongswan, 2006). Fung, Leung and Xu (2001) indicated that the extent to which one country's financial market is influenced by international markets depends on the degree to which their financial situations are linked. For example, during the 1997 Asian financial crisis the Thai baht depreciated significantly, leading to a fall in domestic production that affected nearly all Thai companies. This affected many Japanese banks, which, as lenders, where faced with a huge rise in non-performing loans. As a result, the stock markets in both Thailand and Japan fell dramatically. The links between economies are stronger in times of recession than times of growth. Earlier research about the relationships among the U.S. and Asian stock markets mostly employ correlation analysis, regression analysis or co-integration (Abidin Ozdemir, Hasan Olgun, Bedriye Saracoglu, 2009; Arshanapalli, Doukas and Lang, 1995) to investigate the degree of integration, but few studies attempt to examine the causal relations among them using an out-of-sample prediction method, and this is one gap in the current literature that this study addresses.

Most studies that attempt to predict stock prices focus on the U.S. and other developed countries, and consider various economic variables and financial ratios. The empirical results of these works show that the indicators examined have a significant lag period with regard to actual stock prices (Baker and Wurgler, 2000; Hong, Torous, and Valkanov, 2007). For example, Rapach, Wohar and Rangvid (2005) examined 12 industrialized countries using the macroeconomic indicators of interest rate, inflation rate, index of industrial production, money stock and unemployment rate to predict stock prices, and showed that only the interest rate achieved consistently good results for every country in both in-sample and out-of-sample predictions. Similarly, Ang and Bekaert (2007) investigated using dividend yields to predict stock prices, and found that if the short-term interest rate was also considered then the short-run stock return could be predicted, but not the long-run stock return. They found the same results for the U.S., the U.K., France and Germany. Based on the correlations among international stock markets, it is reasonable to consider international factors when carrying out stock price forecasts. Rapach, Strauss and Zhou (2009) undertook out-of-sample predictions for stock markets in the U.S. and other 11 industrialized countries, and obtained the conclusion that using U.S. macroeconomic variables to predict the stock prices of other countries can lead to better results. This result reveals that the U.S. stock price leads the international stock prices.

At the annual conference of IMF and World Bank in October 2009, the main issues that were discussed included the possibilities of future international financial crises, and the likely effects on individual countries. One of the key issues is how to build a crisis early-warning system, which would assess the vulnerabilities of the financial systems in each country to uncover the key factors that could trigger a financial crisis, thus making it easier to foresee and respond to such events. The main purpose of this paper is thus to use the leading characteristics of the U.S. stock market to predict crises among the Asian stock markets. Some studies indicate that the U.S. financial crises intensify the links between the Asian and U.S. stock markets. Recently, many studies investigate whether the stock price movements follow non-linear dynamic and conclude that the P/E ratio, interest rate, production and stock returns are better suited to non-linear rather than linear models (Guidolin, Hyde, McMillan and Ono, 2009; Kim, Mollick and Nam, 2008), although these works obtained inconclusive results with regard to out-of-sample predictions. This paper adopts the model of Rapach, Strauss and Zhou (2009) to build a non-linear Panel TAR (threshold autoregressive) model with changes in the U.S. financial market (i.e., the financial pressure index) as the threshold variable to explain that during crisis and non-crisis periods there is likely to be a different linear relationship between the U.S. and Asian stock prices. For instance, when the U.S. stock market falls significantly, it is likely to have a more different relationship with the Asian stock markets. By using the method presented in this work, we can understand how much the threshold value changes from the regular to financial crisis periods, and also build an early-warning system based on abnormal changes in the U.S. stock prices. A similar approach was employed by Chong, He and Hinich (2008) to predict foreign exchange market crises.

The main methodology used in the present paper is to use a non-linear model to construct the relationships among the U.S. and Asian stock markets. Our aims are to distinguish the different impacts of the U.S. stock market on the Asian stock markets in both normal and financial-crisis periods, and then infer the possibility of crises occurring in Asia based on significant changes in the U.S. financial market pressure index. Moreover, the model presented in this work can also predict the start of Asian stock market crises and carry out out-of-sample predictions of stock prices. The results of the non-linear model's out-of-sample prediction are then compared with those of the random walk models. This paper thus complements the work of Rapach, Strauss and Zhou (2009), which only used a linear model to examine whether the U.S. stock prices can be used to predict other countries' stock prices via out-of-sample data. With regard to the threshold value, this paper employs the CMAX indicator developed by Patel and Sarkar (1998) to classify the crisis and regular periods.

In this paper, panel data is used to estimate the influence of the U.S. stock market on nine Asian stock markets, including those in Taiwan, Korea, Hong Kong, Japan, Singapore, Indonesia, Thailand, the Philippines and China. All data come from the Global Financial Database. Symmetrical data must be used in the Panel model. Since the earliest data for China is from 1990:12, the period covered in this paper is from 1990:12 to 2009:12.

The rest of this paper is organized as follows: Section 2 presents the methodology used in this work, including a brief discussion of the financial pressure index proposed by Patel and Sarkar (1998), predictions using a non-linear model, a test of the coefficients, as well as a test of the predictive ability of out-of-sample data. Section 3 presents the empirical results, while Section 4 summarizes the conclusions of this work and discusses some economic and policy implications of our empirical findings.

2. Methodology

This section contains four parts, as follows: (1) the definition of the financial pressure index, (2) the estimation of the non-linear model, (3) the testing of the coefficients, and (4) the testing of the out-of-sample predictive ability of the non-linear model.

(1) The Financial Pressure Index

The financial pressure index proposed by Patel and Sarkar (1998) is used to develop the CMAX indicator, and it describes when a financial crisis is likely to occur. The CMAX is defined as follows:

$$CMAX_t = \log(\frac{x_t}{\max[x \in (x_{t-j} \mid j = 0,1...T)]})$$

where: X_t is the stock index at the end of the month at time *t* and *T* = 12.

CMAX thus compares the present stock index with the highest of the previous one-year stock indices. Vila (2000) suggested that if the value of CMAX falls to 1.5 or 2 standard deviations below the average, it can be recognized as the start of a financial crisis, and also to identify how long a crisis will last. This paper calculates the CMAX value of the U.S. and estimates the threshold value λ, and in this way it is possible to define the financial crisis period endogenously.

(2) Estimation of Nonlinear Model

The previous literature found that when the U.S. financial market is in crisis, it has stronger links with other stock markets. Therefore, we can build a Panel Threshold Autoregressive model (hereafter Panel TAR) to separate the crisis and non-crisis periods. Based on the estimations from Panel TAR, we can examine the degree to which an Asian stock market is affected by its own market or by the U.S. stock market in different periods. The model is as follows:

$$\begin{aligned} r_{i,t} = \alpha_i &+ (\beta_1 * r_{i,t-1} + \beta_2 * r_{us,t-1}) * I(CMAX_{us,t-1} <= \gamma) \\ &+ (\beta_3 * r_{i,t-1} + \beta_4 * r_{us,t-1}) * I(CMAX_{us,t-1} > \gamma) + \varepsilon_{i,t} \end{aligned} \quad (1)$$

where: *i*=1, 2,…, 9 represent Taiwan, Korea, Hong Kong, Japan, Singapore, the Philippines, Indonesia, Thailand and China, respectively, $r_{i,t} = \log(p_{i,t}) - \log(p_{i,t-1})$, $p_{i,t}$ represents the stock index at time *t* in country *i*, $r_{i,t}$ is the monthly return of stock market at time t in country i, $r_{us,t-1}$ is the monthly return of stock market at time t-1 in the U.S., and $CMAX_{us,t-1}$ represents the financial crisis index, a larger negative value meaning that a crisis is more likely to occur. (β_1, β_2) represents the estimated coefficients during the crisis period, while (β_3, β_4) represents the estimated coefficients during the non-crisis period.

We are interested in the estimation of the threshold value λ, because this can be regarded as an index for differentiating the crisis and non-crisis periods. When $CMAX_{us,t-1}$ is lower than or equal to λ, it can be taken as a signal of an impending financial crisis, and if not, then it represents a regular, non-crisis period. The advantage of using a panel method is that there is a significant correlation among the Asian stock markets, and these also have similar relationships with the U.S. stock market. Using the data from these countries to estimate these coefficients is thus an appropriate approach and also provides a common standard to judge periods of U.S. financial crisis. Previous papers found that there are different correlations among markets in crisis and non-crisis periods. When the US stock market has been falling sharply over several months, it may be a signal for an upcoming financial crisis. The estimation in this model is carried out using the sequential conditional least squares method in Hansen (1999), which uses stepwise searching, from small to large, in order to find λ with minimum sum of squared error. In equation (1), based on the individual-specific fixed effect, the stock market in each country is allowed to have the individual long-run return α_i. The estimation steps are as follows:

(a) Eliminating the long-run average return in each country, α_i

To calculate the average value of equation (1) in each individual country from period 1 to period *t*, the following equation is used:

$$\bar{r}_i = \alpha_i + (\beta_1 * \bar{r}_i + \beta_2 * \bar{r}_{us}) * I(CMAX_{us,t-1} <= \gamma) + (\beta_3 * \bar{r}_i + \beta_4 * \bar{r}_{us}) * I(CMAX_{us,t-1} > \gamma) + \bar{\varepsilon}_i \quad (2)$$

(1) minus (2) can be rewritten as

$$r^*_{i,t} = (\beta_1 * r^*_{i,t-1} + \beta_2 * r^{US}_{t-1}) * I(CMAX_{us,t-1} <= \gamma) + (\beta_3 * r^*_{i,t-1} + \beta_4 * r^{US}_{t-1}) * I(CMAX_{us,t-1} > \gamma) + \varepsilon^*_{i,t}$$

where: $r^*_{i,t} = (r_{i,t} - \bar{r}_i)$, $r^*_{i,t-1} = (r_{t-1} - \bar{r}_i)$, $r^*_{us,t-1} = (r_{us,t-1} - \bar{r}_{us})$, $\varepsilon^*_{i,t} = (\varepsilon_{i,t} - \bar{\varepsilon}_i)$

(b) Panel estimation

The following panel equation can be used to estimate the related coefficients via the least squares method:

$$\begin{bmatrix} r^*_{1,2} \\ \vdots \\ r^*_{1,t} \\ \vdots \\ r^*_{n,2} \\ \vdots \\ r^*_{n.t} \end{bmatrix} = (\beta_1 * \begin{bmatrix} r^*_{1,1} \\ \vdots \\ r^*_{1,t-1} \\ \vdots \\ r^*_{n,1} \\ \vdots \\ r^*_{n.t-1} \end{bmatrix} + \beta_2 * \begin{bmatrix} r^*_{us,1} \\ \vdots \\ r^*_{us,t-1} \\ \vdots \\ r^*_{us,1} \\ \vdots \\ r^*_{us.t-1} \end{bmatrix}) * I(CMAX_{us,t-1} <= \gamma) + (\beta_3 * \begin{bmatrix} r^*_{1,1} \\ \vdots \\ r^*_{1,t-1} \\ \vdots \\ r^*_{n,1} \\ \vdots \\ r^*_{n.t-1} \end{bmatrix} + \beta_4 * \begin{bmatrix} r^*_{us,1} \\ \vdots \\ r^*_{us,t} \\ \vdots \\ r^*_{us,1} \\ \vdots \\ r^*_{us.t} \end{bmatrix}) * I(CMAX_{us,t-1} > \gamma) + \begin{bmatrix} \varepsilon^*_{1,2} \\ \vdots \\ \varepsilon^*_{1,t} \\ \vdots \\ \varepsilon^*_{n,2} \\ \vdots \\ \varepsilon^*_{n.t} \end{bmatrix} \quad (3)$$

Using this equation we can estimate the coefficients of (β_1, β_2) and (β_3, β_4), which represent coefficients of the financial crisis and the non-crisis periods, respectively. Following the methodology in Hansen (1999), we choose the optimal γ^* to minimize sum of squared error (S_1).

(3) Testing coefficients

Testing whether the threshold effect exists, the null hypothesis is as follows: $H_0 : \beta_1 = \beta_3, \beta_2 = \beta_4$

If the threshold effect does not exist, after eliminating the fixed effect the equation changes as:

$$r^*_{i,t} = (\beta_{01} * r^*_{i,t-1} + \beta_{02} * r_{us,t-1}) + \varepsilon^*_{i,t} \quad (4)$$

Panel estimation is then carried out using all countries' data and the sum of squared error (S_0) is calculated. The statistic F is as follows:

$$F = \frac{(S_0 - S_1)}{\hat{\sigma}^2}, \text{ where } \hat{\sigma}^2 = \frac{1}{n(t-1)} S_1 \quad (5)$$

Because the asymptotic distribution of the F value is not a standard statistic, by using the bootstrap process in Hansen (1999), we build the critical value under null hypothesis, H_0.

(4) The out-sample predictive ability of the non-linear model

After the estimation of the non-linear model, the results of the early-warning effect for upcoming financial crises can be compared with the results of a random walk model with regard to out-of-sample predictions. First, the whole period (1990:12-2009:12) is divided into two parts: in-sample (1990:12-2002:12) and out-of-sample (2003:1-2009:12) period, and in-sample data can be used to estimate the parameters of the following models: (model 1) – a random walk model, which indicates that stock prices are unpredictable; (model 2) - the non-linear model developed in the paper.

Model 1: $r^*_{i,t} = \varepsilon^{*1}_{i,t}$

Model 2: $r^*_{i,t} = (\beta_1 * r^*_{i,t-1} + \beta_2 * r_{us,t-1}) * I(CMAX_{us,t-1} <= \gamma)$
$+ (\beta_3 * r^*_{i,t-1} + \beta_4 * r_{us,t-1}) * I(CMAX_{us,t-1} > \gamma) + \varepsilon^{*2}_{i,t}$

where: $\hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3, \hat{\beta}_4, \hat{\gamma}$ are the estimated coefficients from period 1 to period t.

The predictive ability when using out-of-sample data is evaluated in the following two ways: the ratio of Theil U and CW test in Clark and West (2006, 2007). The ratio of Theil U (hereafter TU) is the root mean square error of the out-of-sample forecast in model 1 divided by that in model 2, and if the ratio is greater than 1, this means that the predictive ability of model 1 is worse than that of model 2. Clark and West (2007) stated that in addition to being used to finding the difference between both models, it should be noted that although these two statistics do not have asymptotic normal distributions, with a large sample they seem to have normal distributions, and thus their critical values can be used to make predictions. The CW test in Clark and West (2006, 2007) is as follows: H_0: Both models have the same predictive ability.

H_1: The predictive ability of model 2 is better than model 1.

The CW statistic is developed as follows:

(a) Calculate $D_{i,t+1} = [(\hat{\varepsilon}^{*1}_{i,t+1})^2 - (\hat{\varepsilon}^{*2}_{i,t+1})^2] + (\hat{\varepsilon}^{*1}_{i,t+1} - \hat{\varepsilon}^{*2}_{i,t+1})^2$,

(b) Generate new series D_i, and then this undergoes regression analysis with the intercept, and the *t* value of the intercept is the CW statistic.

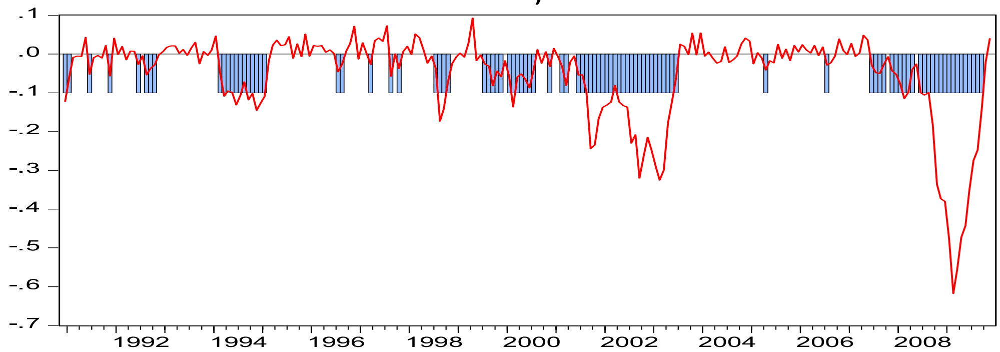
Because this statistic is asymptotic and has a standard normal distribution, it can be used to check directly tables and carry out one-sided tests (Clark and West, 2006, 2007). The results can reveal the predictive ability of the model with regard to the Asian stock prices. If an Asian country rejects the null hypothesis, this means that it is appropriate to use the model to forecast stock prices.

3. Empirical Results

(1) The index of financial pressure (CMAX): The CMAX index of the U.S. stock market over the period 1990:12-2009:12 is shown in Figure 1.

Figure 1.

The CMAX index of the U.S. stock market and financial crises period (shaded areas)



The CMAX index of the U.S. stock market shows significant abnormal phenomena for the periods 1994-1995, 2000-2002 and 2007-2009, which can be explained by the downturn that occurred after the bullish market in 2000, and the financial tsunami crises that started in 2007.

(2) The estimation results:

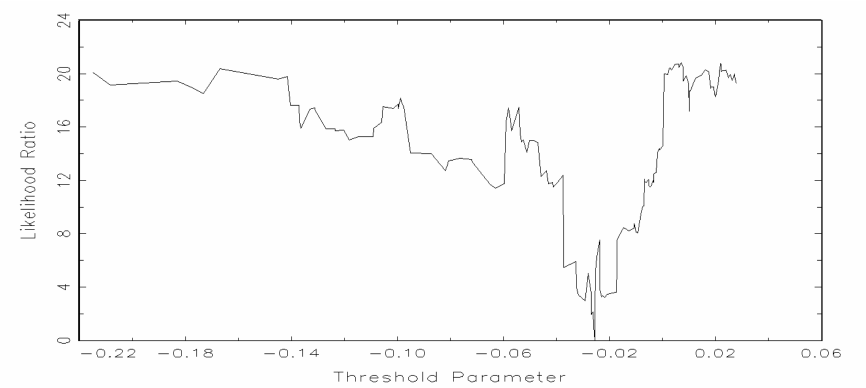
The results based on equation (3) are shown in Table 1. When estimated by the linear model the sum of squared error is 16.176, while the result calculated by the non-linear model is 15.998, which shows that the latter is better than the former. The threshold value of the Panel TAR model is -0.025, with a confidence interval ranging from -0.037 to -0.017, as shown in Figure 2, representing that when the U.S. stock index fell by more 2.5% from the highest level of the previous year's stock index, then this can be defined as a period of financial crisis. The coefficient β_2, which represents the impact of the U.S. stock market on the Asian markets, is 0.378, at a level of statistical significance, and this also means that during a period of financial crisis the earlier period's U.S. stock returns will have a more positive influence on the later period stock returns in the Asian stock markets. However, the coefficient β_1, which means that an Asian stock market was influenced by its own previous returns, is only -0.007, without statistical significance. When CMAX is greater than -2.5%, the coefficient β_4, which shows how Asian stock markets are affected by the U.S., is -0.214, with significance but showing a negative relationship. To test $H_0: \beta_1 = \beta_3, \beta_2 = \beta_4$, we use the bootstrap method to obtain the distribution by running 1,000 simulations, and the results show that the threshold effect (LR test) is 43.657, with a P-value of 0.085, and thus the threshold effect exists.

Table 1

The Results of the Non-Linear Model (1990:12-2009:12)

The Linear Model				
(SSE, Sum of squared errors of estimation)			16.176	
The Threshold Model				
(λ) the estimated threshold value		-0.025		
(SSE)		15.998		
The estimated coefficients of the threshold model				
		coefficients	standard deviation	t value
$CMAX_{us,t-1} <= \gamma$	β_1	-0.007	0.037	-0.185
	β_2	0.378	0.070	5.409
$CMAX_{us,t-1} > \gamma$	β_3	0.043	0.032	1.323
	β_4	-0.214	0.101	-2.118
(LR test) the test of threshold effect(LR test)				43.657
P value (bootstrap test)				0.085

Figure 2. The Likelihood Ratio of Threshold Parameter



In addition, Figure 1 shows that periods smaller than -0.025 can be approximately divided into four periods (1993-1994, 1998, 2000-2002 and 2007-2009), in which 1998 is the period of the Asian financial crisis, 2000-2002 is the start of the downturn from the highest point of the US stock market, and 2007-2009 is the period of the most recent global financial crisis.

(3) The forecasting results:

As for the out-sample forecasts, this paper uses the Panel TAR model to estimate the coefficients and then uses each individual country's return, $r_{i,t,}$ to forecast $r_{i,t+1}$. The results are shown in Table 2. With regard to the TU values, only Taiwan and China have values smaller than 1, and those of all the other countries are greater than 1, meaning that, apart from Taiwan and China, the non-linear model has good forecasting ability for the other seven Asian countries. Moreover, with regard to the CW statistics, these also show that the forecasting ability of the non-linear model in the same seven countries (Korea, Hong Kong, Japan, Singapore, Indonesia, Thailand, and the Philippines) is significantly better than that of the random walk model.

(4) The robustness test:

In the cases of Taiwan and China, the out-of-sample forecasts made by the Panel TAR method do not have good predictive ability. It should be noted that some studies, like Huyghebaert and Wang (2009), stated that in recent years the performance of the stock market in China has seen better growth rates than other markets, reflecting the fact that it is less influenced by the U.S. stock market. We thus exclude Taiwan and China and re-estimate the results for the stock markets of the other seven Asian countries, as shown in Tables 3 and 4. The results in Table 3 are similar to those in Table 2, and show that the threshold CMAX value is -2.5%. In more detail, Tables 1 and 3 show that in periods of financial crisis these Asian stock markets were profoundly influenced by the U.S. stock market, and less influenced by their own previous period return. In contrast, in non-crisis periods, the returns of these markets had positive correlations with their own previous period returns, and negative correlations with the U.S. stock market, and this may reflect meaningful hedging strategy to international capital investors. In addition, the forecasting results, excluding the data for Taiwan and China, still indicate that the out-of-sample data has good predictive ability, as shown in Table 4.

Table 2

The Predictions Using Out-of-sample Data (2003:-2009:12)

		TU	CW(A)
Hong Kong	Statistic value	1.0186	1.6453
	P value		***0.0519***
Korea	Statistic value	1.0237	1.5101
	P value		***0.0675***
Taiwan	Statistic value	0.9985	0.6348
	P value		0.2637
Singapore	Statistic value	1.0466	1.9738
	P value		***0.0259***
Thailand	Statistic value	1.0390	1.9567
	P value		***0.0269***
Philippine	Statistic value	1.0183	1.4801
	P value		***0.0714***
Indonesia	Statistic value	1.0218	1.5812
	P value		***0.0589***
China	Statistic value	0.9731	-0.7324
	P value		0.7670
Japan	Statistic value	1.0364	2.0468
	P value		***0.0220***

Table 3

The Results Estimated by the Non-Linear Model for the Period 1990:12-2009:12 (Excluding the Data for Taiwan and China)

The Linear Model					
(SSE, Sum of squared errors of estimation)				10.05	
The Threshold Model					
The threshold value estimated (λ)		-0.025			
(SSE)		9.838			
The estimated coefficients of the threshold model					
		coefficients	standard deviation	t value	
$CMAX_{us,t-1} <= \gamma$	β_1	0.046	0.042	1.101	
	β_2	0.373	0.075	4.992	
$CMAX_{us,t-1} > \gamma$	β_3	0.078	0.039	2.003	
	β_4	-0.356	0.104	-3.430	
The test of threshold effect (LR test)					66.287
	P value (bootstrap test)			0.001	

Table 4

The Predictions Using Out-of-sample Data (2003:-2009:12) (Excluding the Data for Taiwan and China)

		TU	CW(A)
Hong Kong	Statistic value	1.0128	1.4217
	P value		***0.0795***
Korea	Statistic value	1.0182	1.5421
	P value		***0.0635***
Singapore	Statistic value	1.0478	1.8858
	P value		***0.0315***
Thailand	Statistic value	1.0411	1.8645
	P value		***0.0329***
Philippine	Statistic value	1.0172	1.5834
	P value		***0.0586***
Indonesia	Statistic value	1.0209	1.4051
	P value		***0.0819***
Japan	Statistic value	1.0249	1.7552
	P value		***0.0415***

4. Conclusions

The aims of this work are to investigate the relationships between the Asian stock markets, namely Honk Kong, Korea, Taiwan, Singapore, Thailand, Philippine, Indonesia, China, Japan, and the US stock market based on monthly returns. A nonlinear Panel TAR (Threshold Autoregressive) model has been applied and the results show that there are significant effects between the US and Asian markets. By comparing the estimated coefficients, this work examines the asymmetric correlations among the international stock markets that have been proposed in the past literature.

Our results show that during periods of financial crises the Asian stock markets are influenced by the U.S. stock market, and less affected by the returns of their own stock markets. In contrast, during non-financial crisis periods the performance of the Asian stock markets has a positive correlation with their own returns in the previous period, and a negative correlation with the U.S. stock market. Finally, we employ out-of-sample predictions and find that the model produced better results than the random walk model in most Asian countries. We conclude the Asian stock markets can be forecasted by the previous period of US stock market, especially in financial crisis time. These meaningful results can offer the policy maker means to build the effective early-warning system to avoid the future financial crisis and also help the international investors making hedging strategy to adverse financial crisis risk.

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