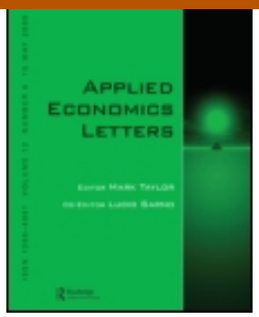

Applied Economics Letters

ISSN: 1350-4851 (Print) 1466-4291 (Online) Journal homepage: http://www.tandfonline.com/loi/rael20

Who has more influence on Asian stock markets around the subprime mortgage crisis – the US or China?

Chien-Chung Nieh , Chao-Hsiang Yang & Yu-Sheng Kao

To cite this article: Chien-Chung Nieh , Chao-Hsiang Yang & Yu-Sheng Kao (2012) Who has more influence on Asian stock markets around the subprime mortgage crisis – the US or China?, Applied Economics Letters, 19:4, 329-335, DOI: 10.1080/13504851.2011.577001

To link to this article: http://dx.doi.org/10.1080/13504851.2011.577001

Published online: 13 Jun 2011.

Applied Economics Letters, 2012, **19**, 329–335

Routledge
Taylor & Francis Group

Who has more influence on Asian stock markets around the subprime mortgage crisis – the US or China?

Chien-Chung Nieh, Chao-Hsiang Yang and Yu-Sheng Kao*

Department of Banking and Finance, Tamkang University, No. 151, Yingzhuan Road, Danshui District, New Taipei City 251, Taiwan

This article employed the Momentum Threshold Autoregressive (M-TAR) model to investigate the changes in the asymmetric co-integration relationship between the US and China's stock markets and Asian stock markets of Taiwan, Hong Kong, Singapore, Japan, Korea and India around the subprime mortgage crisis. The main empirical findings demonstrated that with the application of traditional symmetric co-integration tests, the subprime mortgage crisis did not reinforce the co-movement trends between the US and China's markets and Asian markets. However, with the application of the M-TAR model for the threshold co-integration test, there was significant increase in these asymmetric co-integration relationships between them during the period of the subprime mortgage crisis, and our empirical results show evidence that the linkage between the US and China's stock markets is low, and investors can somewhat diversify risks by investing in the United States and China simultaneously.

Keywords: M-TAR model; asymmetric co-integration; stock markets; subprime mortgage crisis

JEL Classification: C32; G11; G15

I. Introduction

The United States is the largest economic entity and importer of goods in the world. The impact of an economic shock in the United States would affect a broader region. On the other hand, China is a major trading partner to the Pacific Basin countries and has political influence on them. This study aims to examine which country has more influence on the Asian stock markets by testing the transmission effect between the US and Asian markets and between China and Asian markets.

The recent subprime mortgage crisis in the United States, which seems to have had a perceived structural change to the influences of stock markets in the United States and China, has had a great effect upon the financial markets of the whole world. Therefore, we use this crisis as the breaking point to investigate the influence of the US and China's stock markets on the Asian stock markets.

In empirical literature, four different approaches have been utilized to measure how shocks are transmitted internationally: cross-market correlation coefficients, Autoregressive Conditional Heteroscedasticity

*Corresponding author. E-mail: cia60kimo@yahoo.com.tw

(ARCH) or Generalized Autoregressive Conditional Heteroscedasticity (GARCH) frameworks, co-integration techniques and direct estimation of specific transmission mechanisms by using the probit model.

King and Wadhwani (1990) and Lee and Kim (1993) both used the correlation approach and found that international stock markets had become more interrelated after the US stock market collapse in October 1987. Cha and Oh (2000) also showed evidence that the links between the developed markets and the Asian emerging markets began to increase after the US stock market collapse in 1987. Hamao *et al.* (1990) utilized the GARCH model and pointed out the volatility spillovers of the stock indices from New York to Tokyo, London to Tokyo and New York to London after the US stock market collapse in 1987. Many researchers considered that significant increases of correlation or co-movement of the stock markets were the indicators of a contagion effect. Ghosh *et al.* (1999) utilized the co-integration method to investigate which Asian developing markets were moved by the markets of Japan and the United States. Sheng and Tu (2000) found that co-integration did not exist in the 11 Asian stock markets and US stock markets before the 1997 Asian financial crisis, but it did during the financial crisis, which demonstrated a contagion effect.

However, the problems of 'nonlinear' or 'asymmetric' characteristics are seldom considered in the traditional co-integration method. Li and Lam (1995), Koutmos (1998) and Chiang (2001) pointed out that a co-integration relationship between stock markets was asymmetric. Wang and Lin (2005), Shen *et al.* (2007) and Chang (2008, 2010) further employed the asymmetric co-integration test for their empirical studies. To investigate how the asymmetric phenomenon influenced the transmission effect, we apply the asymmetric threshold co-integration method to compare the transmission effects of the US and China stock markets on the Asian stock markets, pre- and during the subprime mortgage crisis.

The traditional symmetric co-integration tests by Engle and Granger (1987) and the Momentum Threshold Autoregressive (M-TAR) model by Enders and Siklos (2001) are both employed to investigate the transmission effect. Section II discusses the M-TAR model. Section III describes the data and empirical results. Section IV concludes our study.

II. The M-TAR Model

We employed the Enders and Siklos (2001) M-TAR model to examine the 'asymmetric transmission effect' from the US to Asian markets and China to Asian markets around the subprime mortgage crisis. The long-term equilibrium relationship is as follows:

$$Y_{i,t} = \eta_0 + \eta_1 X_{t^*} + \varepsilon_{i,t} \quad i = 1, 2, \ldots, 6 \qquad (1)$$

where $Y_{i,t}$ is the logarithm of the Asian stock index for country i on period t and $i = 1, 2, \ldots, 6$ represents six Asian countries, respectively. X_{t^*} implies the logarithm of the US or China stock index, while t^* represents period t for China but period $t-1$ for the United States with the time lag of the trading day which must be considered (Eun and Shim, 1989; Liu *et al.*, 1998). η_0 and η_1 are the regression coefficients. $\varepsilon_{i,t}$ measures the estimated residuals. Enders and Siklos (2001) modified ε_t to allow for two types of asymmetric error corrections based on a co-integrating relationship as depicted in Equation 1.

$$\Delta\varepsilon_t = M_t\rho_1\varepsilon_{t-1} + (1 - M_t)\rho_2\varepsilon_{t-1} + \sum_{i=1}^{p-1}\beta_i\Delta\varepsilon_{t-i} + \zeta_t \qquad (2)$$

$$M_t = \begin{cases} 1 & \text{if } \Delta\varepsilon_{t-1} \geq r \\ 0 & \text{if } \Delta\varepsilon_{t-1} < r \end{cases} \qquad (3)$$

where M_t is the Heaviside indicator function, ρ_1 and ρ_2 are the adjustment coefficients of asymmetric error corrections term based on a co-integrating relationship as depicted in Equation 1, β are the regression coefficients of the lagged value of different error terms in Equation 2, ζ is the residual of the white-noise disturbance in Equation 2 and r denotes the unknown threshold values. Equations 2 and 3 represent the M-TAR model.[1]

In the M-TAR model, the adjustment is modelled by $\rho_1\varepsilon_{t-1}$ that $M_t = 1$ when $\Delta\varepsilon_{t-1}$ is above the threshold value r and by $\rho_2\varepsilon_{t-1}$ that $M_t = 0$ when $\Delta\varepsilon_{t-1}$ is below the threshold value. The no co-integration hypothesis (H_0: $\rho_1 = \rho_2 = 0$) was tested using specifically derived critical values provided by Enders and Siklos (2001). If the null of no co-integration was rejected, the null of symmetric (H_0: $\rho_1 = \rho_2$) can be tested using a standard F-test.

[1] Enders and Granger (1998) pointed out the M-TAR model was especially valuable when adjustment was asymmetric such that the series exhibited more 'momentum' in one direction than the other.

III. Data and Empirical Results

This research is conducted using the US, China and six other Asian stock indices. The S&P 500 and the Shanghai Stock Exchange (SSE) Composite are selected to represent the stock indices for the United States and China, respectively. The other six Asian stock indices are from Taiwan, Hong Kong, Singapore, Japan, Korea and India.[2] We have analysed the data of synchronized trading days in all stock markets. The entire daily sample period was from 2 January 2004 to 31 March 2010.

Since there is still no consensus on the start date for the subprime mortgage crisis, it is not easy to determine an exact date. In general, some scholars (Gorton, 2008) consider the outburst of the financial crisis of the New Century Financial Corp. as the beginning of the crisis. Therefore, we used the date on which the trading of stocks of New Century Financial Corp. was terminated in New York Stock Exchange (NYSE), that is, 13 March 2007, as the cutting point. Thus, the period of 'the pre-subprime mortgage crisis' was defined as the period from 2 January 2004 to 13 March 2007 and the period of 'during the subprime mortgage crisis' was defined as the period from 14 March 2007 to 31 March 2010.

Table 1 represents the summary statistics for all the series, and Table 2 shows that there are no symmetric co-integration and asymmetric co-integration relationships between the US and China's markets, the results of which show evidence that the linkage between the US and China's stock market is low. The results of the three unit root tests, Augmented Dickey and Fuller (ADF; 1984), Phillips and Perron (PP; 1988) and Kwiatkowski *et al*. (KPSS; 1992), are summarized in Table 3. All the variables are the $I(1)$ type series at the 1% significance level.

Table 4 represents the results of the Engle–Granger test for symmetric co-integration between the US and Asian markets and between China and the Asian markets in the entire period (Panels A and B of Column 1 in Table 4), the period of the pre-subprime mortgage crisis (Panels A and B of Column 2 in Table 4) and the period of during the subprime mortgage crisis (Panels A and B of Column 3 in Table 4). Column 1 in Table 4 shows that there are no co-integration relationships between the US and each of the Asian markets and between China and each of the Asian markets in the

Table 1. Summary statistics for return on stock indices

	United States	Taiwan	Hong Kong	Singapore	Japan	Korea	India	China
Mean	3.31E-03	0.0206	0.0394	0.0367	1.94E-03	0.0578	0.0855	0.0549
Maximum	10.4083	16.0768	16.8007	21.4742	9.9854	13.8635	15.9900	9.3262
Minimum	–13.7989	–12.1069	–15.9720	–10.6280	–12.7154	–13.1533	–19.2130	–14.1681
SD	1.5156	1.7185	1.9983	1.5923	1.7784	1.8193	2.1300	2.1692
Skewness	–0.7240**	0.0257	–0.0228	1.5855***	–1.1015***	–0.7309**	–0.6339**	–0.1946*
Kurtosis	16.2262***	14.4769***	15.9793***	34.8464***	11.6264***	12.0342***	13.5844***	6.6046***
Jarque–Bera	9190.74***	6838.53***	8746.04***	53175.6***	4115.33***	4348.18***	5899.60***	682.442***
L-B Q(24)	86.073***	37.036**	36.113*	38.554**	33.163	43.312***	49.997***	59.056***
	(0.000)	(0.043)	(0.053)	(0.030)	(0.101)	(0.009)	(0.001)	(0.000)

Notes: Jarque–Bera is the statistic of the normal test. L-B Q is the statistics of Ljung-Box Q.
*, ** and ***Significant at 10%, 5% and 1% levels, respectively.

[2] There are restricted fluctuation ranges, 7% for Taiwan and 10% for China, respectively, in the Taiwanese and Chinese stock markets, but there are no such restrictions in the US and Hong Kong stock markets. A reviewer in the sixth China Financial Association Anniversary Conference (CFAAC) questioned whether the restrictions would affect researchers' evaluation results. In our study, there were only 23 days on which the Taiwan Stock Exchange Corporation (TSEC) Weighted Index exceeded the 7% limit and 17 days on which the SSE Composite Index exceeded the 10% limit in our research period, which accounted for less than 3% of the entire samples. Shen and Wang (1998) pointed out that when the samples with restricted ranges were less than 5% of the entire samples, their impact on the evaluation results could be considered insignificant.

Table 2. Relationships between the United States and China

	(1) Entire period (2/1/2004 to 31/3/2010; N = 1247			(2) Pre-subprime mortgage crisis (2/1/2004 to 13/3/2007; N = 638)			(3) During subprime mortgage crisis (14/3/2007 to 31/3/2010; N = 609)		
Engle–Granger co-integration	–0.704, AIC = –849.229			–22.03, AIC = –818.087			–0.319, AIC = –891.759		
Ender–Siklos threshold co-integration	AIC = –1157.756			AIC = –1126.614			AIC = –1209.304		
	Fc	*Fa*	*R*	*Fc*	*Fa*	*R*	*Fc*	*Fa*	*R*
	4.058	1.589	–0.01868	4.346	1.776	0.01324	3.636	1.121	–0.02459

Notes: The critical values of the Engle–Granger co-integration are taken from Engle and Yoo (1987). The lag length of difference *k*s is selected by minimizing AIC; *r* is the estimated threshold value. F_C and F_A denote the *F*-statistics for the null hypothesis of no co-integration and symmetric adjustment, respectively. Critical values are taken from Enders and Siklos (2001). The threshold value is endogenously determined by using the Chan's (1993) grid search method to find the consistent estimate of the threshold. This method arranges the values, $\{\Delta\varepsilon_t\}$, in an ascending order and excludes the smallest and largest 15%, and the consistent estimate of the threshold is the parameter that yields the smallest Residual Sum of Squares (RSS) over the remaining 70%.

Table 3. Results of various unit root tests

	Level			First difference		
	ADF	PP	KPSS	ADF	PP	KPSS
United States	–1.4368(1)	–1.5009	5.2397***	–17.2314(5)***	–36.6190***	0.0793
Taiwan	–1.4696(7)	–1.5822	3.7241***	–16.4603(6)***	–34.5620***	0.0902
Hong Kong	–1.4424(9)	–1.5345	2.0340***	–17.2314(8)***	–36.6190***	0.0793
Singapore	–1.4692(8)	–1.4990	6.4723***	–16.1312(7)***	–35.5446***	0.1602
Japan	–1.2754(9)	–1.3547	6.2189***	–17.4413(9)***	–35.6042***	0.1961
Korea	–1.4837(5)	–1.5486	5.2359***	–16.4166(4)***	–35.1614***	0.1012
India	–1.0253(6)	–1.0409	8.0021***	–16.6577(5)***	–34.2104***	0.1018
China	–0.7695(8)	–0.7561	4.4687***	–16.4727(9)***	–35.8116***	0.2256

Notes: The numbers in the parentheses are the appropriate lag lengths selected by minimizing AIC. The critical values for the 10%, 5% and 1% significance levels of ADF, PP and KPSS are (–2.567948, –2.863659, –3.435402), (–2.567944, –2.863651, –3.435385) and (0.3470, 0.4630, 0.7390), respectively. The null hypothesis of ADF and PP is nonstationary (unit root); the null hypothesis of KPSS is stationary (non-unit root).
***Significant at 1% level.

entire period. The results of Column 2 in Table 4 show that only the US and Hong Kong markets are co-integrated at the 5% significance level, whereas there are no co-integration relationships for all the other pairs in the pre-subprime mortgage crisis period. Column 3 in Table 4 shows that the only co-integration relationship exists between China and Korea markets at the 10% significance level; all the other pairs show no co-integration relationships during the subprime mortgage crisis period. Since the results in Table 4 show that the significant long-term relationship increase only happened between China and Korea markets around the subprime mortgage crisis, this result does not support the transmission effect from the US or China to the Asian markets caused by the subprime mortgage crisis.

Table 5 represents the results of the threshold co-integration test with the null of no co-integration (F_C) and symmetric adjustment (F_A). In Panel A of Column 1 in Table 5, the F_C statistics rejected the null at the 1% significant level and the F_A statistics rejected the null at least at the 10% level for United States–Taiwan, United States–Hong Kong, United States–Japan, United States–Korea and United States–India relationships in the entire period. The rejection of both nulls implies an asymmetric co-integration relationship for each of the above pairs of countries. We also found in Panel B of Column 1 in Table 5 that the asymmetric co-integration exists between China and Hong Kong and China and Korea since both nulls were rejected at least at the 5% significant level for these two pairs of countries in the entire period.

Furthermore, Columns 2 and 3 in Table 5 represent the results of the threshold co-integration relationship tests around the subprime mortgage crisis. Column 2 in Table 5 shows that, with the exception that the

Table 4. Results of the Engle–Granger test for co-integration

	(1) Entire period	(2) Pre-subprime mortgage crisis	(3) During subprime mortgage crisis	
	Engle–Granger ADF statistic	Engle–Granger ADF statistic	Engle–Granger ADF statistic	Co-integration statistics
Panel A – United States				
Taiwan	–1.458	–2.587	–1.443	Decrease
Hong Kong	–1.061	–3.728**	–2.104	Decrease
Singapore	–1.292	–2.801	–1.727	Decrease
Japan	–2.032	–1.908	–2.376	Increase
Korea	–1.232	–1.850	–2.527	Increase
India	–0.689	–2.999	–1.429	Decrease
Panel B – China				
Taiwan	–2.105	–2.488	–2.379	Decrease
Hong Kong	–2.632	–1.393	–2.521	Increase
Singapore	–1.953	–1.341	–2.575	Increase
Japan	–1.235	–1.557	–2.705	Increase
Korea	–2.352	–1.272	–3.144*	Increase
India	–1.912	–1.187	–1.959	Increase

Note: * and **Significant at 10% and 5% levels, respectively.

pair of United States–Japan is asymmetrically co-integrated at the 10% level, all the other pairs of countries, regardless of whether they were compared with the US or China market, show no co-integration relationships in the pre-subprime mortgage crisis period. Moreover, in Column 3 of Table 5, we found that both F_C and F_A reject the two nulls at least at the 5% level regardless of whether it is the US case or the China case, which implies that all the pairs of the countries investigated are asymmetrically co-integrated during the subprime mortgage crisis period.

By further comparisons of F_C and F_A statistics in Columns 2 and 3 of Table 5, we found that the co-integration relationships have significantly increased after the shock of the crisis for all the pairs of the countries considered, which confirms a 'transmission effect' caused by the subprime mortgage crisis on our investigated samples. The asymmetry in the co-integration relationships has also significantly increased after the shock for all the pairs of the countries considered.

Moreover, based on Column 3 in Table 5, we see that, during the subprime mortgage crisis period, the strengths of the co-integration relationships between the US and the Asian markets considered are ordered as follows: United States–Singapore, United States–Japan, United States–Hong Kong, United States–Taiwan, United States–Korea and United States–India, whereas the co-integrated strengths between China and the Asian markets considered are ordered as China–Hong Kong, China–Korea, China–Japan, China–Singapore, China–India and China–Taiwan. This can be explained with the fact that the security markets of Singapore, Japan and Hong Kong are relatively advanced. They thus had more linkage with the US markets and showed stronger transmission effects in their relationships. On the other hand, viewed as emerging markets, Taiwan, Korea and India security markets had less linkage with the US market. In addition, being part of China since 1997, Hong Kong had the strongest transmission effect with China in their security markets during the subprime mortgage crisis period.

IV. Conclusions

The co-integration relationship between stock markets represents market co-movement. In this study, we examine which country has more influence on the Asian stock markets by co-integration test for testing the transmission effect between the US and Asian markets and between China and Asian markets.

Two major findings are summarized in our study. Firstly, the result of the symmetric Engle–Granger co-integration tests showed less co-integration between either the United States or China and each of the six Asian markets considered, which does not support the transmission effect from the US or China to Asian markets. However, the results of the Enders–Siklos asymmetric threshold co-integration test showed that, for both cases of the United States and China, the co-integration relationships with the six Asian markets increased due to the subprime mortgage crisis. With further analyses, we see that the asymmetric co-integration relationships between the US and Asian markets exist in both periods of pre- and during the subprime mortgage crisis, while the

Table 5. Results of the Enders–Siklos test for threshold co-integration

	(1) Entire period			(2) Pre-subprime mortgage crisis			(3) During subprime mortgage crisis			Co-integration statistics	Asymmetric statistics
	F_C	F_A	r	F_C	F_A	r	F_C	F_A	r		
Panel A – United States											
Taiwan	37.302***	3.310*	0.01349	9.943***	1.057	−0.00860	50.027***	6.267***	0.01537	Increase	Increase
Hong Kong	48.536***	3.837**	−0.01121	19.888***	1.336	−0.00934	76.026***	8.633***	−0.01410	Increase	Increase
Singapore	76.547***	1.983	−0.01307	16.869***	0.773	−0.01182	132.028***	11.643***	−0.01577	Increase	Increase
Japan	74.756***	3.053*	0.01475	16.519***	2.756*	−0.01238	106.267***	7.262***	−0.01730	Increase	Increase
Korea	34.294***	7.987***	−0.00581	22.702***	1.479	0.01745	46.861***	8.981***	−0.00564	Increase	Increase
India	23.808***	2.792*	−0.01604	13.264***	1.598	0.02396	34.992***	6.262***	−0.01863	Increase	Increase
Panel B – China											
Taiwan	4.305	2.042	−0.00784	0.906	1.728	0.01183	8.833**	4.818**	0.01184	Increase	Increase
Hong Kong	20.340***	5.154**	0.00379	3.830	0.913	−0.00612	27.475***	5.887**	0.01932	Increase	Increase
Singapore	10.648***	0.561	−0.01112	4.300	0.389	0.00520	10.787***	5.643**	0.01606	Increase	Increase
Japan	4.887	5.387**	0.01390	1.130	0.391	0.01402	10.807***	7.792***	0.00751	Increase	Increase
Korea	12.569***	4.871**	−0.00867	0.995	1.778	0.01406	15.028***	6.746***	−0.00564	Increase	Increase
India	6.850**	0.617	−0.01734	1.153	2.312	0.01641	9.331***	4.237**	−0.02235	Increase	Increase

Note: *, ** and ***Significant at 10%, 5% and 1% levels, respectively.

relationships between China and the Asian markets changed from not being co-integrated in the pre-crisis period to showing significant co-integration relationships in the during-crisis period. Therefore, it can be concluded that China showed more influence on those Asian markets during the recent subprime mortgage crisis; however, its influence is less than that of the United States.

Secondly, this study finds that the relative advanced Asian markets, for example, Singapore, Japan and Hong Kong markets, showed stronger transmission effects in their relationships with the US market. The emerging markets, Korea, Taiwan and India markets, had less linkage with the US market. Moreover, the transmission effect was the strongest between China and Hong Kong in their security markets during the subprime mortgage crisis period.

The increases of the co-integration relationships caused by the subprime mortgage crisis had some implications, which demonstrated that the financial crisis had weakened the effectiveness of international portfolio diversification. However, because the linkage between the US and China's stock market is low, international investors can somehow diversify risks by investing in the US and China markets simultaneously.

References

Cha, B. and Oh, S. (2000) The relationship between developed equity markets and the Pacific Basin's emerging equity markets, *International Review of Economics and Finance*, **9**, 299–322.

Chan, K. S. (1993) Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model, *The Annals of Statistics*, **21**, 520–33.

Chang, S. (2008) Asymmetric cointegration relationship among Asian exchange rates, *Economic Change and Restructuring*, **41**, 125–41.

Chang, S. (2010) Effects of asymmetric adjustment among labor productivity, labor demand, and exchange rate using threshold cointegration test, *Emerging Markets Finance and Trade*, **46**, 55–68.

Chiang, M. H. (2001) The asymmetric behavior and spillover effects on stock index returns: evidence on Hong Kong and China, *Pan Pacific Management Review*, **4**, 1–21.

Enders, W. and Granger, C. W. (1998) Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates, *Journal of Business and Economic Statistics*, **16**, 304–11.

Enders, W. and Siklos, P. L. (2001) Cointegration and threshold adjustment, *Journal of Business and Economic Statistics*, **29**, 166–76.

Engle, R. and Granger, C. W. (1987) Cointegration and error correction: representation, estimation, and testing, *Econometrica*, **55**, 251–76.

Engle, R. and Yoo, S. (1987) Forecasting and testing in co-integration systems, *Journal of Econometrics*, **35**, 143–59.

Eun, C. S. and Shim, S. (1989) International transmission of stock market movements, *Journal of Financial and Quantitative Analysis*, **24**, 241–56.

Ghosh, A., Saidi, R. and Johnson, K. H. (1999) Who moves the Asia-Pacific stock markets – US or Japan? Empirical evidence based on the theory of cointegration, *The Financial Review*, **34**, 159–70.

Gorton, G. B. (2008) The subprime panic, NBER Working Paper No. w14398, National Bureau of Economic Research (NBER). Available at http://www.nber.org/papers/w14398 (accessed 14 May 2011).

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

King, M. and Wadhwani, S. (1990) Transmission of volatility between stock markets, *The Review of Financial Studies*, **3**, 5–33.

Koutmos, G. (1998) Asymmetries in the conditional mean and the conditional variance: evidence from nine stock markets, *Journal of Economics and Business*, **50**, 277–90.

Lee, S. B. and Kim, K. J. (1993) Does the October 1987 crash strengthen the co-movements among national stock markets?, *Review of Financial Economics*, **3**, 89–102.

Li, W. K. and Lam, K. (1995) Modelling asymmetry in stock returns by a threshold autoregressive conditional heteroscedastic model, *The Statistician*, **44**, 333–41.

Liu, Y. A., Pan, M. and Shieh, J. (1998) International transmission of stock price movements: evidence from the US and five Asian-Pacific markets, *Journal of Economics and Finance*, **22**, 59–69.

Shen, C. H., Chen, C. and Chen, L. (2007) An empirical study of the asymmetric cointegration relationships among the Chinese stock markets, *Applied Economics*, **39**, 1433–45.

Shen, C. H. and Wang, L. R. (1998) Daily serial correlation, trading volume, and price limit, *Pacific-Basin Finance Journal*, **6**, 251–74.

Sheng, H. C. and Tu, A. H. (2000) A study of cointegration and variance decomposition among equity indices before and during the period of the Asian financial crisis, *Journal of Multinational Financial Management*, **10**, 345–65.

Wang, C. and Lin, C. A. (2005) Using threshold cointegration to examine asymmetric price adjustments between ADR's and their underlying securities – the case of Taiwan, *South African Journal of Economics*, **73**, 449–61.