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VOLATILITY STATES AND SPILLOVER EFFECTS FOR ASIAN EMERGING MARKETS: MARKOV REGIME SWITCHING MODEL

In this paper, we investigate volatility in stock returns and analyze spillovers for Asian emerging markets using the Markov regime switching model. This article utilizes 8 emerging stock markets data for its empirical analysis. The empirical results show the following: (1) Asian emerging markets mostly conform to 3 volatility states; (2) During the financial crisis, the stock markets were mostly in the high volatility state; (3) The Markov switching vector autoregressive response model can clearly capture 8 stock markets in crisis and non-crisis states of transfer.

Keywords: financial crisis; Markov regime switching model; spillover effect; stock return volatility.

JEL: F01; F15; G01.

Чі-Мінг Хо, Дзюнь-Ю Ші

НЕСТАБІЛЬНІ СТАНИ ТА СУПУТНІ ЕФЕКТИ НА АЗІЙСЬКИХ РИНКАХ, ЩО РОЗВИВАЮТЬСЯ: МАРКІВСЬКА МОДЕЛЬ ЗМІНИ РЕЖИМУ

У статті досліджено нестабільність прибутковості акцій та супутні ефекти на азійських ринках, що розвиваються, за марківською моделлю зміни режиму. Для емпіричного аналізу застосовано дані щодо 8 ринків цінних паперів, що розвиваються. Результати демонструють, що (1) азійські ринки, які розвиваються, в основному схильні до 3 моделей нестабільності; (2) під час фінансової кризи ринки цінних паперів в основному перебували у стані крайньої нестабільності; (3) марківська модель авторегресійної реакції зі зміною вектора здатна описати 8 ринків цінних паперів у кризовому та некризовому перехідних станах.

Ключові слова: фінансова криза; марківська модель зміни режиму; супутній ефект; нестабільність прибутковості акцій.

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НЕСТАБИЛЬНЫЕ СОСТОЯНИЯ И СОПУТСТВУЮЩИЕ ЭФФЕКТЫ НА АЗИАТСКИХ РАЗВИВАЮЩИХСЯ РЫНКАХ: МАРКОВСКАЯ МОДЕЛЬ ИЗМЕНЕНИЯ РЕЖИМА

В статье исследована нестабильность прибыльности акций и сопутствующие эффекты на азиатских развивающихся рынках по марковской модели изменения режима. Для эмпирического анализа применены данные по 8 развивающимся рынкам ценных бумаг. Результаты демонстрируют, что (1) азиатские развивающиеся рынки в основном склонны к 3 моделям нестабильности; (2) во время финансового кризиса рынки ценных бумаг в основном находились в состоянии крайней нестабильности; (3) марковская модель авторегрессионной реакции с изменением вектора способна описать 8 рынков ценных бумаг в кризисном и некризисном переходных состояниях.

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Ключевые слова: финансовый кризис; марковская модель изменения режима; сопутствующий эффект; нестабильность прибыльности акций.

1. Introduction. The Asian financial crisis in 1997 and the Subprime mortgage crisis in the United States in 2009 both dramatically ended the serenity of global stock and exchange markets, indirectly causing firm bankruptcies and difficulties in financing. The ways to predict volatility and crises on crisis contagion and stock and exchange markets are the core issues for practitioners and academia. The primary value of a nation's stock and exchange markets is to theoretically respond to economic fundamentals and industrial structures. However, the impact of volatility on stock and exchange markets is still relevant to other factors such as dividend rate, rate level and estimation of crisis spillover (Campbell and Shiller, 1988; Campbell and Ammer, 1993). The foresaid variable predictions are lagging indices, which cannot demonstrate the volatilities on stock and exchange markets nor the volatility relationship among adjacent nations.

Theodossiou and Lee (1993) initially employed the GARCH model to test volatility on the stock price index in the United States, Canada, Germany, the United Kingdom and Japan. Edwards and Susmel (2001) used the regime switching model to inspect the rate volatility among emerging markets. As indicated in this study, the standard GARCH model is inappropriate for explaining emerging markets. In other words, use of a t-distribution GARCH tackles the fat tail on stock returns, whereas it is found that the model may fail over predicted information. Morana and Beltratti (2002) applied the Markov regime switching model along with the theory proposed by Edwards and Susmel (2000) to explore the impact of economic integration in Europe and the introduction of the Euro on volatility of European stock markets. Moore and Wang (2007) also adapted the study and used the Markov regime switching model proposed by Hamilton (1989) to investigate the degree of volatility on stock markets in the European Union's newly affiliated nations. 2-3 regimes are found to exist at the European Union's emerging stock markets, demonstrating a correlation as emerging markets move from high volatility to low volatility with their affiliations to the EU. Nevertheless, the two above mentioned studies do not obviously illustrate whether these factors have impacted return volatility. Mandilaras and Bird (2007) conducted an empirical analysis of the exchange markets in South-Eastern Asia and investigated the spillover effect of financial crises among these nations. Their findings confirmed there is a significant correlation among nations in crisis. Though recent studies have demonstrated these results, the relationship between states of crisis and non-crisis and crisis transmission should also be examined.

Financial crises may foster regional interaction. This study indicates that volatility of emerging markets may be affected by several crucial elements. During financial crises, the systematic alteration of exchange markets may cause stock markets to crash, exhibiting high volatility at stock markets. As a result, the present study redefines crisis and non-crisis in terms of return and volatility degree, and applies the Markov switching vector autoregression model proposed by Krolzig (1997) to explore the relationship between crisis and non-crisis at Asian emerging markets. The purpose of this study is to use the Markov regime switching model to capture volatility at different stock markets. The dynamic movement

between markets is scrutinized using the Markov regime switching process. Section 1 of this paper illustrates the aims and motivation of this study. Section 2 provides a literature review describing relevant results in early researches and reasons for applying the Markov switching model. Section 3 presents the application of data, the model and experimental designs. Section 4 reviews the models used to analyze the data for empirical results. The last section presents the conclusions and suggestions.

2. Literature Review. In financial time series, fluctuations of stock prices and exchange rates are closely monitored. Distinctive characteristics and behaviors indirectly emerge in time series, which helps us to understand the past and the future of capital markets. However, characteristics and behaviors cannot be simulated by a linear time-series model because it contains a number of switching and systematic alterations. Quandt and Ramsey (1978) proposed a non-linear time series model known as the switching regression model. Goldfeld and Quandt (1973) then added the Markov chain to broaden the switching regression model, resulting in the Markov switching regression model. Hamilton (1989) further adapted characteristics of regime-dependent transferring to develop the Markov switching autoregression model. This model is mainly used to control systematic alterations activated by financial data. It handles the dynamic alteration of data and can be merged with two or more distributions. The advantage of Markov regime switching is that it allows for corresponding characteristics of financial data, transferring from one regime to another. Take Markov switching in regime 2, for example; time series enables an alteration within two distributions; one is steadier and less volatile, whereas the other is less steady and more volatile.

Turner, Startz and Nelson (1989) compared the diverse characteristics in the Markov switching model and pointed out that means and variations in this model completely corresponded to the traits of the data. Chu, Santoni and Liu (1994) applied MS-AR to explore the relationship between stock returns and the volatility of stock markets and found that non-linear and non-symmetric correlations existed between return and volatility. Schaller and Norden (1997) expanded the study by Turner et al. (1989) and furthered its significant regime switching in stock returns. Nishiyima (1998) also extended this research and discussed the regimes of 5 industrialized nations, finding dissimilar regime volatilities among them. Maheu and McCurdy (2000) employed Markov switching to define American stock returns as high returns in a steady regime and low returns in an unsteady regime. Separately, they investigated bull markets and bear markets in two regimes. Guidolin and Timmermann (2006) utilized a multi-variation MS-AR model to scrutinize the correlation between American stock and fund returns. Some findings confirmed that MS-VAR in regime 4 significantly explains the relationship between stock and fund returns. As indicated by the above mentioned researchers, this study aims to use the Markov regime switching model to methodically investigate the spillover effect at Asian emerging markets, especially examining volatility among these nations during outbursts of financial crises.

3. Methodology

3.1. Markov Regime Switching Model. This study is founded on the Markov regime switching model by Moore and Wang (2007) and allows for means and varia-

tions to be cross-transferred. y_t in (1) is a time series, which produces a p -order autoregressive process and employs an expectation maximization algorithm. The model is as follows:

$$\Phi(L)y_t = \alpha + \sigma(s_t)\varepsilon_t, \quad (1)$$

$\Phi(L)$ in it represents the lag operator, α is the intercept, σ is the standard deviation under t time regime, s_t is a scattered unobservable variable and ε_t is a random variable following the standard normal distribution $iid \sim N(0, 1)$. Moreover, s_t is assumed to have m regimes and adheres to the first-order Markov process. The switching rate matrix P is presented in formula 2:

$$p_{ij} = \Pr(s_{t+1} = j | s_t = i) = \sum_{j=1}^m p_{ij} = 1, \forall i, j \in \{1, \dots, m\} \quad (2)$$

Formula 2 represents the transferring rate and fixed constants, and time t is independent and changeable.

3.2. Markov Switching Vector Autoregressive Model (MS-VAR). The Markov switching vector autoregressive model (MS-VAR) proposed by Krolzig in 1997 embodies Hamilton's (1989) model, involving characteristics of the Markov chain in a vector autoregressive model. Intercept terms, coefficients of explanatory variables and residual variations all vary over regimes. One p -order Markov switching vector autoregressive model [MS - VAR(p)] is shown in Formula 3.

$$Y_t = \mu(s_t) + A_1(s_t)Y_{t-1} + \dots + A_p(s_t)Y_{t-p} + \sigma(s_t)u_t, \quad u_t | s_t \sim NID(0, \Sigma(s_t)) \quad (3)$$

In Formula 3, y_t refers to a $T \times 1$ vector and a stationary time series. $Y_t = (y_{1t}, \dots, y_{kt})$, $t = 1, \dots, T$ represents a time-series vector of K dimensions, $u_t = (\varepsilon_{1t}, \varepsilon_{2t}, \dots, \varepsilon_{kt})$ is the residual vector and $s_t = (1, 2, \dots, m)$ is a scattered unobservable variable. Alterations of regimes transform the average $\mu(s_t)$, coefficient matrix $A_1(s_t), \dots, A_p(s_t)$ and residual covariance matrix $\Sigma(s_t)$. These parameter vectors can be seen in Formula 4 according to descriptions in Formula 3.

$$Y_t = \begin{cases} \mu_1 + A_{11}Y_{t-1} + \dots + A_{p1}Y_{t-p} + \sigma_1 u_t, & \text{if } s_t = 1 \\ \vdots & \\ \mu_m + A_{1m}Y_{t-1} + \dots + A_{pm}Y_{t-p} + \sigma_m u_t, & \text{if } s_t = m \end{cases}, \quad u_t \sim N(0, I_K) \quad (4)$$

u_t in Formula 4 is defined as the distracting vector of K dimension and assumes a normal distribution, which is unrelated to superior and inferior residual distractions. A_{ij} is the regime-dependent matrix $i = 1, 2, \dots, p$ $j = 1, 2, \dots, m$, and s_t is a scattered unobservable variable, following the first-order Markov chain. Thus, the residual covariance matrix $\Sigma(s_t)$ of $\sigma(s_t)u_t$ has the regime-dependent characteristics shown in Formula 5.

$$\Sigma(s_t) = E(\sigma(s_t)u_t u_t' \sigma'(s_t)) = \sigma(s_t)E(u_t u_t')\sigma'(s_t) = \sigma(s_t) \Sigma_K \sigma'(s_t) = \sigma(s_t) \sigma'(s_t) \quad (5)$$

This study utilizes formula 3 to evaluate an interaction between multinational markets and assumes that autoregressive coefficients do not alter over regimes in favor of the empirical analysis. Formula 6 illustrates the modified model.

$$Y_t - \mu(s_t) = \sum_{j=1}^p A_j Y_{t-j} + \sigma(s_t) u_t, u_t | s_t \sim NID(0, \Sigma(s_t)) \quad (6)$$

Reversion of formula 6 also adheres to the first-order Markov process; that is implementation of a hypothetical regime relies on the previous regimes. Due to scattered regime variables, this study uses two heterogeneity settings according to Mandilar and Bird (2007), assuming 1 in crisis with low-averaged high volatility and 2 in non-crisis with high-averaged low volatility.

4. Data Analysis

4.1. Description. The subjects of this study are 8 emerging stock markets, including Taiwan, South Korea, Thailand, Malaysia, the Philippines, Indonesia, Mainland China and India. This study scrutinizes the path to financial crisis in Asia. Because the subprime mortgage crisis in the United States drastically smashed the global economy in 2009, we excluded the data from the period of 2008 to 2009 and only included the data from December 30, 1994 to December 28, 2007. The data all originate from the Global Financial Database. The hypothetical weekly return in this study is half of the stock price executing first difference and surplus 100. This study uses weekly data because daily data would make it more difficult to capture the periodical changes in the statistics. As for the time-series stationary test, an ADF test was performed for the analysis. Before executing differences, each variable cannot reject the null hypothesis of the unit root. There is, however, no unit root with the examination of the first difference.

4.2. Markov switching. In consideration of serial correlation, AR (2) is the estimated foundation for evaluating univariate Markov switching model. This study centers on transferring the variation to capture the volatility state because it does not achieve any significance in the mean transferring coefficient in Moore and Wang's (2007) model. To explore which states conformed to each market variation, this study estimates regimes 1, 2 and 3 in Markov switching model and executes a likelihood ratio test to analyze estimates. Consequently, the P-value is utilized to select the most appropriate volatility state for investigation.

As shown in Tables 1 and 3, Asian emerging stock markets in the hypothesis of regime 1 were strongly negative, and most of the markets conformed to regimes 2 and 3 in the Markov switching.

Table 1. Markov Switching in Emerging Stock Markets

	Taiwan	Korea	Thailand	Malaysia	Philippines	Indonesia	China	India
α	0.0398 (0.2958)	0.1040 (0.6147)	-0.0423 (-0.2771)	0.0650 (0.5090)	0.0499 (0.3690)	0.2593** (1.6656)	0.3286** (2.1966)	0.2418* (1.8142)
ϕ_1	-0.0257 (-0.6680)	-0.0641* (-1.6656)	0.0507* (1.3303)	0.0254 (0.6624)	0.0388 (1.0229)	-0.0659** (-1.7211)	0.0096 (0.2487)	0.0633* (1.6435)
ϕ_2	0.0346 (0.9000)	0.0188 (0.4888)	0.1318*** (3.4587)	0.0777** (2.0271)	0.1335*** (3.5192)	0.1079*** (2.8262)	-0.0293 (-0.7628)	-0.0054 (-0.1402)
σ	3.4964	4.3895	3.9578	3.3151	3.5101	4.0242	3.8604	3.4446
L' value	-1800.036	-1953.355	-1883.571	-1764.142	-1802.663	-1894.784	-1866.778	-1789.968
Note: () = t value, * P<0.1, ** P<.05, ***<.01, L' value = Likelihood ratio of regime 1. Estimation model = $\Phi(L)y_t = \alpha + \sigma(s_t)\varepsilon_t$; $\Phi(L)$ = Lag Operator, α = Intercept Term, σ = Standard Deviation in state								

Tables 2 and 3 revealed that the Philippines in regime 2 are superior to that in regime 3, whereas Taiwan, South Korea, Thailand, Malaysia, Indonesia, Mainland China and India are inclined to regime 3. Moreover, regime 2 in this study is categorized as low and high volatility states, whereas regime 3 refers to low, medium and high volatility states.

Table 2. The Second State Markov Switching in Emerging Stock Markets

	Taiwan	Korea	Thailand	Malaysia	Philippines	Indonesia	China	India
α	0.3007*** (2.6912)	0.1838** (1.3522)	0.0865 (0.6936)	0.2056*** (2.4705)	0.0554 (0.4844)	0.4231*** (3.2416)	0.1544 (1.2850)	0.2907*** (2.3304)
ϕ_1	0.0033 (0.0826)	-0.0501* (-1.2895)	0.0322 (0.8263)	0.0459 (1.1865)	0.0815** (2.0868)	-0.0114 (-0.2795)	0.0745** (1.8382)	0.0816** (2.0319)
ϕ_2	0.0358 (0.9185)	0.0190 (0.4782)	0.1246*** (3.1671)	0.0723** (1.9272)	0.0926*** (2.4163)	0.0902*** (2.3681)	0.0583* (1.5721)	0.0199 (0.5071)
σ_1	1.9280	2.7528	2.6275	1.7051	2.7189	2.5738	2.7775	2.7223
σ_2	4.2419	5.8643	5.3983	5.3078	6.7515	7.0356	8.3463	5.5926
P_{11}	0.9741	0.9889	0.9903	0.9827	0.9858	0.9666	0.9726	0.9338
P_{12}	0.9849	0.9869	0.9851	0.9603	0.9034	0.8845	0.7947	0.7126
L'value	-1745.47	-1881.76	-1818.61	-1601.28	-1739.38	-1797.94	-1777.08	-1766.47
LR	109.12***	143.19***	129.93***	325.72***	126.56***	193.68***	179.39***	47.00***

Note: () = t value, [] = P value, * $P < 0.1$, ** $P < 0.05$, *** < 0.01 , L' value = Likelihood ratio of regime 2. Estimation model = $\Phi(L)y_t = \alpha + \sigma(s_t)\epsilon_t$; $\Phi(L)$ = Lag Operator, α = Intercept Term, σ = Standard Deviation in regimes

Table 3. The Third State Markov Switching Concerning Emerging Stock Markets

	Taiwan	Korea	Thailand	Malaysia	Philippines	Indonesia	China	India
α	0.2742*** (2.5048)	0.2202* (1.6126)	0.0670 (0.5427)	0.1626** (1.9872)	0.0760 (0.6653)	0.4239*** (3.6039)	0.1250 (1.0856)	0.3282*** (2.7339)
ϕ_1	0.0129 (0.3250)	-0.0610* (-1.5656)	0.0218 (0.5650)	0.0565* (1.4370)	0.0780** (1.9557)	0.0016 (0.0397)	0.0860** (2.0733)	0.0835** (2.1492)
ϕ_2	0.0431 (1.0597)	0.0195 (0.4859)	0.1211*** (3.1010)	0.0700** (1.7860)	0.0881** (2.2179)	0.0839** (2.1701)	0.0694** (1.8024)	0.0236 (0.6271)
σ_1	1.8872	2.4595	2.5224	1.3960	2.1840	2.1254	2.0972	2.3550
σ_2	3.4106	4.0941	4.1568	2.9253	3.2273	3.7439	4.0967	3.0633
σ_3	6.3002	6.6154	6.5021	6.3266	7.0919	7.7407	14.3710	5.9042
P_{11}	0.9754	0.9867	0.9868	0.9722	0.8070	0.9488	0.9434	0.9742
P_{12}	0.0143	0.0133	0.0131	0.0278	0.1919	0.0428	0.0565	0.0245
P_{21}	0.0145	0.0107	0.0225	0.0345	0.1802	0.0605	0.0614	0.0095
P_{22}	0.9184	0.9827	0.9714	0.9601	0.7947	0.9394	0.9241	0.7865
P_{32}	0.2914	0.0098	0.0121	0.0117	0.1035	0.0268	0.2725	0.5564
P_{33}	0.7032	0.9902	0.9879	0.9882	0.8905	0.9730	0.7152	0.4082
L'value	-1737.50	-1873.93	-1810.45	-1577.59	-1737.46	-1783.07	-1755.42	-1759.93
LR	15.95**	15.66**	16.31**	47.37***	3.85	29.74***	43.33***	13.07**

Note: () = t value, [] = P value, * $P < 0.1$, ** $P < 0.05$, *** < 0.01 , L' value = Likelihood ratio of regime 3. Estimation model = $\Phi(L)y_t = \alpha + \sigma(s_t)\epsilon_t$; $\Phi(L)$ = Lag Operator, α = Intercept Term, σ = Standard Deviation in state

To determine whether the transferring variation exists in regimes 2 and 3, this study employs ARCH to test standard residuals. As shown in Table 4, stock markets in Taiwan, Malaysia, Mainland China and India were all influenced by ARCH. Q statistics in Ljung-Box demonstrated that stock returns of most of the nations did not

present serial correlation. The aforementioned characteristics suggest that regimes 2 and 3 in Markov switching can capture and describe the heteroskedasticity of weekly national returns.

Table 4. Diagnostic Checking of Model Residuals

	Taiwan	Korea	Thailand	Malaysia	Philippines	Indonesia	China	India
J-B	8.014**	6.055**	2.094	12.425***	0.537	2.456	5.198*	13.291***
	[0.018]	[0.048]	[0.351]	[0.002]	[0.765]	[0.293]	[0.074]	[0.001]
Q(5)	3.801	6.756	3.911	2.359	3.180	11.193*	6.062	2.407
	[0.578]	[0.239]	[0.562]	[0.798]	[0.672]	[0.048]	[0.300]	[0.790]
Q(10)	6.392	7.675	7.453	5.005	7.546	15.497	9.880	18.959**
	[0.781]	[0.661]	[0.682]	[0.891]	[0.673]	[0.115]	[0.451]	[0.041]
Q(20)	12.913	10.261	15.548	13.417	11.772	24.952	19.666	23.405
	[0.881]	[0.963]	[0.744]	[0.859]	[0.924]	[0.203]	[0.479]	[0.269]
ARCH(2)	3.891**	0.207	0.179	2.607*	0.262	2.174	2.909*	0.803
	[0.021]	[0.813]	[0.836]	[0.075]	[0.770]	[0.115]	[0.055]	[0.448]
ARCH(4)	2.497**	0.227	0.841	2.157*	0.468	1.136	1.617	2.408**
	[0.042]	[0.923]	[0.500]	[0.072]	[0.759]	[0.339]	[0.168]	[0.048]
ARCH(12)	1.518	0.375	0.922	0.906	0.887	1.080	1.036	1.775**
	[0.113]	[0.972]	[0.524]	[0.541]	[0.560]	[0.374]	[0.414]	[0.049]

Note: J-B Estimation = Normality Test of Residuals, Q(i) = Q i-order autocorrelation test; ARCH(q) = q-order ARCH-LM. [] = P value, * P<0.1, ** P<.05, ***<.01.

This study examines the smoothed plots concerning the high volatility states of stock markets. From the plots of the high volatility states, we find South Korea, Thailand, Malaysia, the Philippines and Indonesia are in high volatility states during the period from 1997 to 2000, when the Asian financial meltdown took place. The Asian financial meltdown originated in Thailand. Structural transformation of the exchange market in Thailand at the beginning of 1997 caused the financial crisis, which affected its stock market. Other stock markets transitioned into high volatility states several months later.

To attract foreign capital, most Asian emerging markets adopted fixed rates. Thailand, for example, utilized a fixed rate, which pinned down the USD. Currency policy in Thailand could not be independently implemented after its market opening in 1993. However, to avert inflation and stabilize the fixed rate, Thailand did not reduce its rate at the time of the downfall in the U.S. Such a reduction might have prevented a crisis in Thailand and encouraged foreign capital to flow into Thailand. Asian emerging stock markets were in a low volatility state during 1995. Because of the rate fixed, the real foreign exchange rate continuously elevated, causing currency values in South Korea, Thailand, Malaysia and Indonesia to be overestimated, which gradually affected competition. Deterioration of international revenue and expenditures among nations gradually influenced the steadiness of the exchange markets. Most stock markets moved into a medium volatility state in 1996.

As a whole, the nations gradually returned to medium volatility states as soon as the financial crisis ended. Though the financial crisis ended in 1999 and emerging market nations implemented new policies, financial markets still took much time to settle with respect to the steadiness of volatility states. Nations experienced steadier growth of their stock markets after 2004.

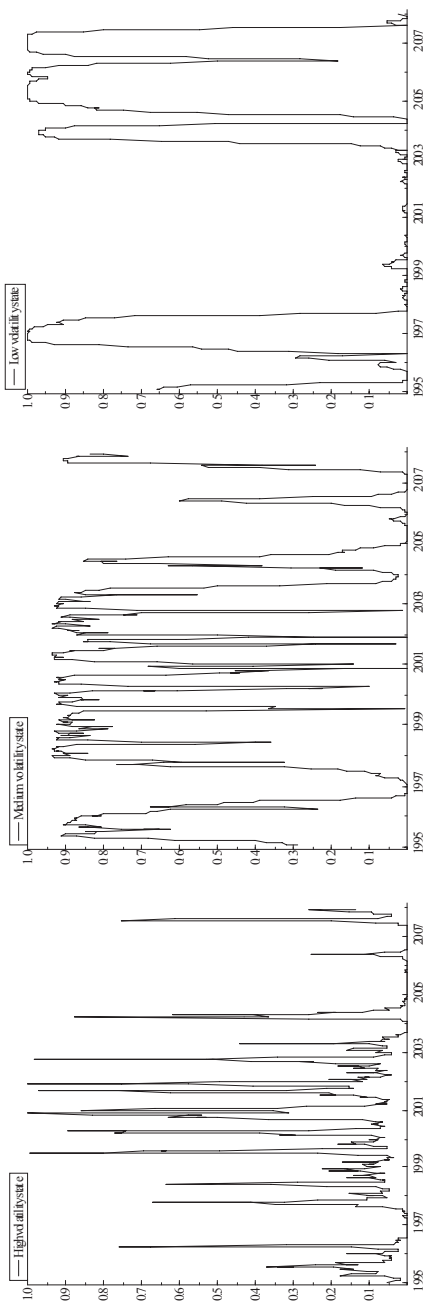


Chart 1. Volatility State at Taiwanese Stock Market (High, Medium, Low)

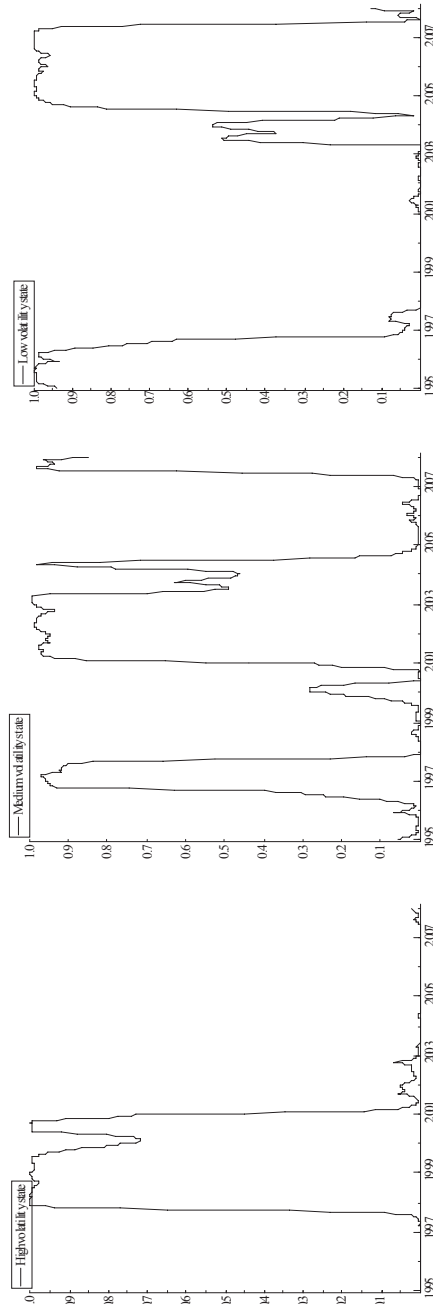


Chart 2. Volatility State at South Korean Stock Market (High, Medium, Low)

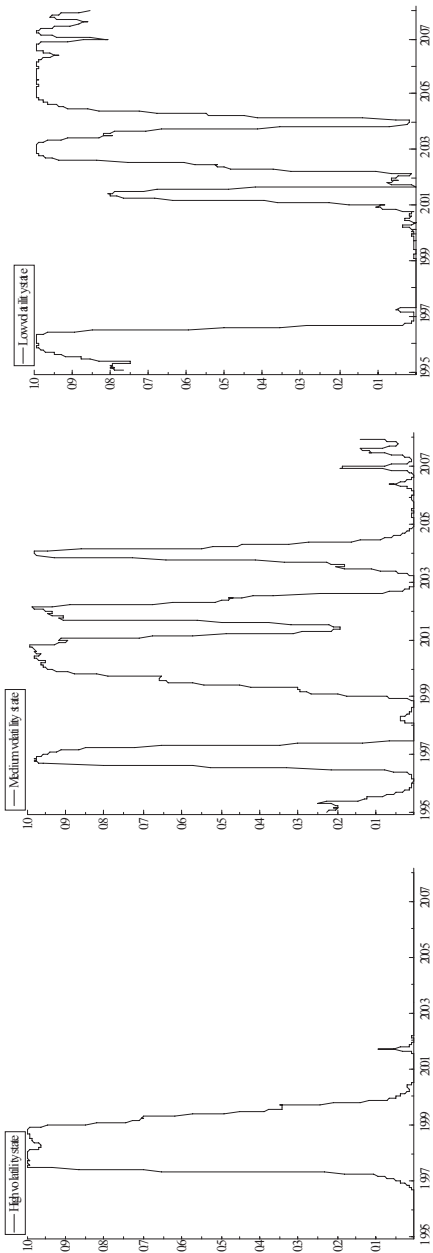


Chart 3. Volatility State at Thailand's Stock Market (High, Medium, Low)

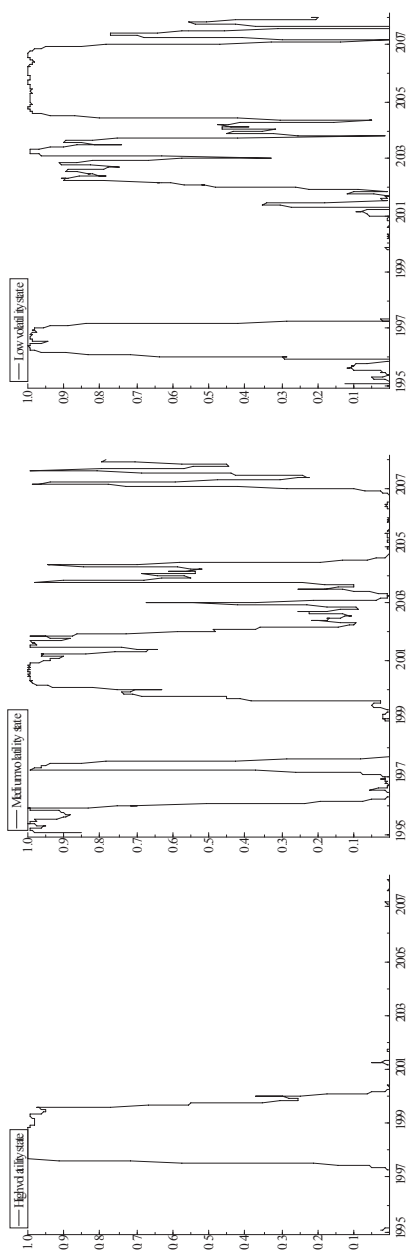


Chart 4. Volatility State at Malaysian Stock Market (High, Medium, Low)

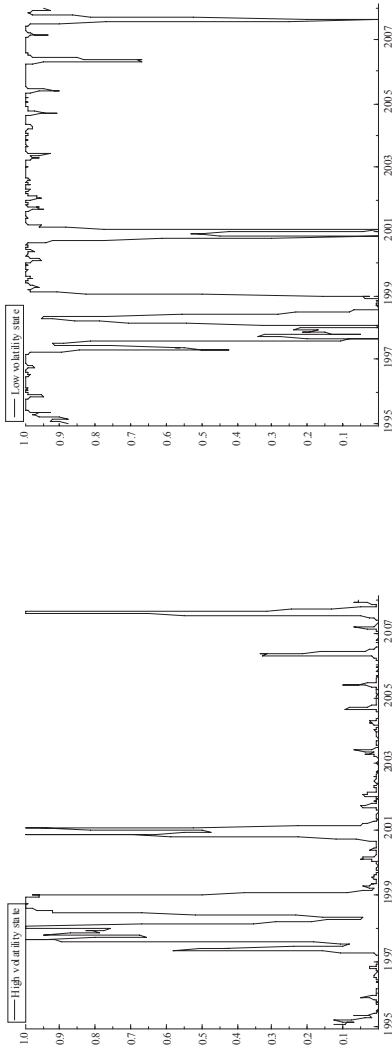


Chart 5. Volatility State at the Philippines Stock Market (High, Medium, Low)

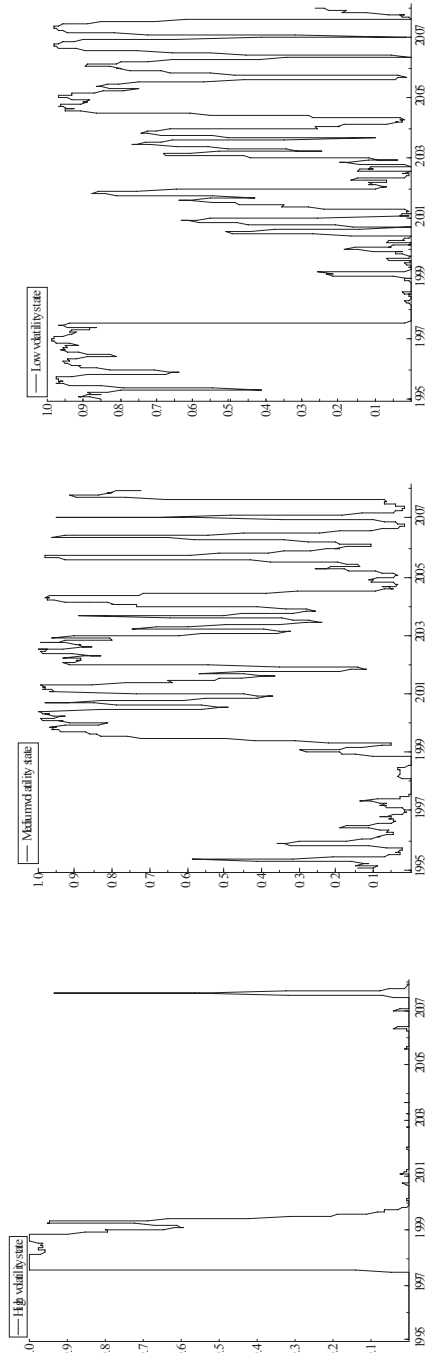


Chart 6. Volatility State at Indonesian Stock Market (High, Medium, Low)

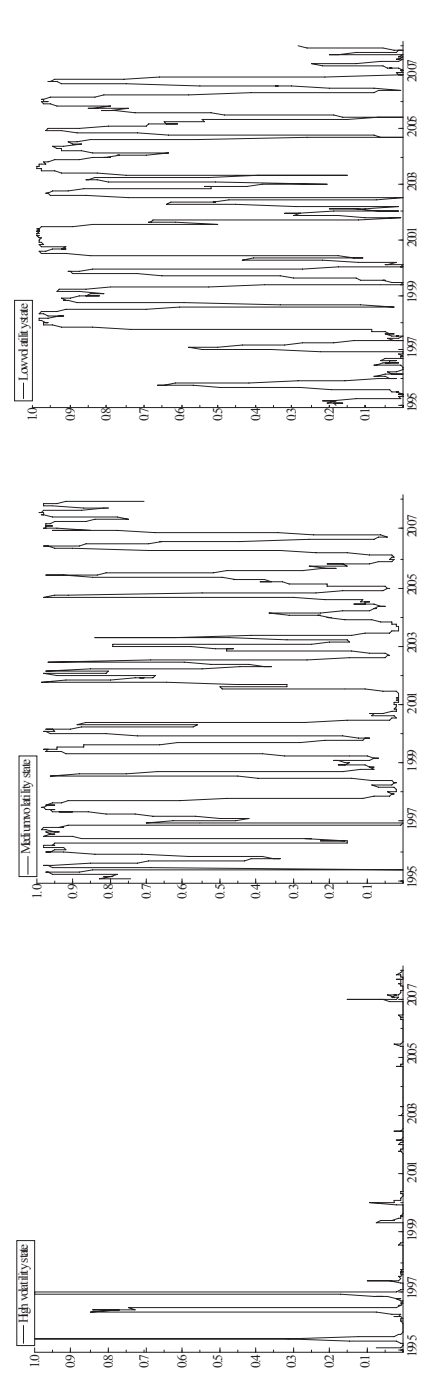


Chart 7. Volatility State at Chinese Stock Market (High, Medium, Low)

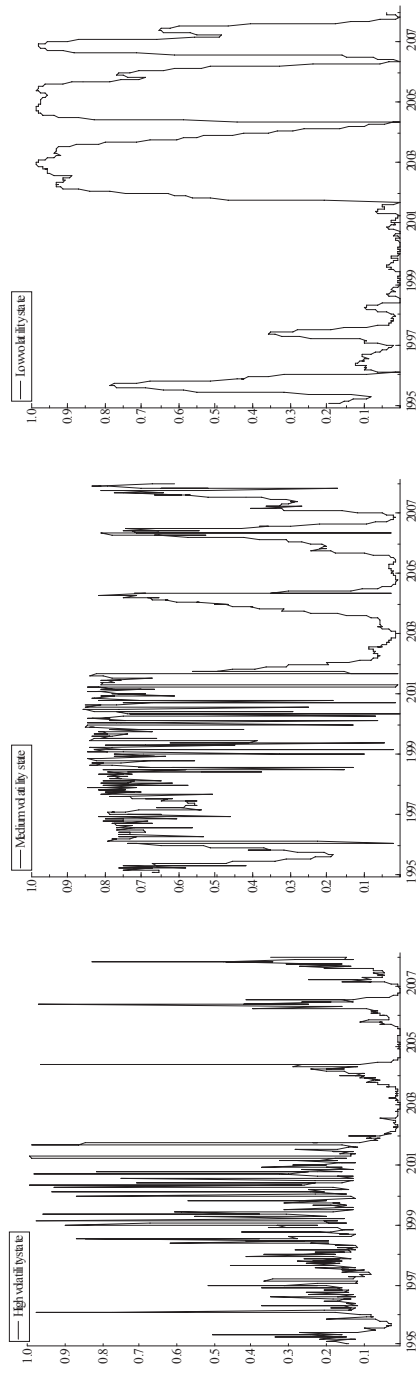


Chart 8. Volatility State at Indian Stock Market (High, Medium, Low)

4.3. Vector Autoregressive Model. To examine whether contagion and spillover effects existed among the markets during the financial crisis, this study employs multivariate MS-VAR to further analyze the parameters of 8 emerging Asian stock markets as shown in Table 5.

Table 5. Estimation of Multivariate MS-VAR

	Taiwan	Korea	Thailand	Malaysia	Philippines	Indonesia	China	India
μ_1	-0.246	-0.106	-0.415	-0.334	-0.314	-0.361	0.045	-0.184
	(-0.718)	(-0.236)	(-0.981)	(-0.906)	(-0.890)	(-0.839)	(0.182)	(-0.560)
μ_2	0.141	0.180	0.055	0.171**	0.154	0.543***	0.405	0.410***
	(0.996)	(1.249)	(0.403)	(2.059)	(1.255)	(4.116)	(2.061)	(3.022)
Taiwan_1	-0.045	0.264***	0.086**	0.136***	0.111***	0.018	0.049	0.108***
	(-1.135)	(6.200)	(2.119)	(5.190)	(3.130)	(0.469)	(1.172)	(2.862)
Korea_1	0.014	-0.140***	0.013	-0.008	-0.018	0.055*	-0.044	-0.001
	(0.395)	(-3.455)	(0.346)	(-0.316)	(-0.545)	(1.457)	(-1.299)	(-0.036)
Thailand_1	0.048	0.160***	-0.052	0.029	0.108***	0.109***	0.038	0.043
	(1.184)	(3.528)	(-1.190)	(1.029)	(2.823)	(2.616)	(0.995)	(1.107)
Malaysia_1	0.069*	-0.071	0.090*	-0.006	0.054	0.089*	0.034	0.068*
	(1.320)	(-1.162)	(1.583)	(-0.164)	(1.096)	(1.546)	(0.791)	(1.379)
Philippines_1	0.019	-0.036	0.029	-0.013	-0.049	-0.026	0.008	0.078**
	(0.416)	(-0.725)	(0.605)	(-0.438)	(-1.174)	(-0.565)	(0.178)	(1.811)
Indonesia_1	-0.036	0.121***	0.110**	0.166***	0.136***	-0.071**	0.027	0.045
	(-0.909)	(2.723)	(2.569)	(5.994)	(3.678)	(-1.744)	(0.754)	(1.200)
China_1	-0.010	-0.035	-0.075**	0.001	-0.047**	-0.028	0.008	-0.043*
	(-0.312)	(-1.066)	(-2.380)	(0.030)	(-1.696)	(-0.952)	(0.194)	(-1.424)
India_1	0.048	-0.012	-0.012	-0.021	0.035	0.036	0.023	0.014
	(1.175)	(-0.258)	(-0.275)	(-0.717)	(0.931)	(0.864)	(0.552)	(0.357)
σ_1	4.624	6.150	5.842	5.136	4.860	5.945	3.102	4.445
σ_2	2.853	2.910	2.800	1.659	2.504	2.662	4.110	2.755
Observed in R1	200.1000							
Observed in R2	475.9000							
P ₁₁	0.8948							
P ₁₂	0.1052							
P ₂₁	0.0427							
P ₂₂	0.9573							
Note: This study adopts MS(2)-VAR(1) to precede the analysis. ()=t value, P<0.1, ** P<.05, ***<.01. Estimation model:								
$Y_t - \mu(s_t) = \sum_{i=1}^p A_i Y_{t-i} + u_t, u_t \sim NID(0, \Sigma(s_t))$								

Table 5 shows that using the methodology of the first-order VAR is appropriate. State means of nations, except for Mainland China, are negative. As for volatility level, only Mainland China shows lesser-estimated variation; however, other nations all had higher return volatility. Moreover, the means of the nations in regime 2 were all positive and displayed minor return volatility. Even though the estimated *t*-value was not significant, it was consistent with the regime hypothesis previously defined in this study. Namely, as the crisis took place, the stock markets of the nations had greater volatility and lower return rates. During a non-crisis period, conversely, stock markets were all in a sturdy state, having lesser volatility and better geometric mean return. As a result, we can find that most μ_2 is superior to μ_1 , and σ_1 is greater than σ_2 as shown in Table 5.

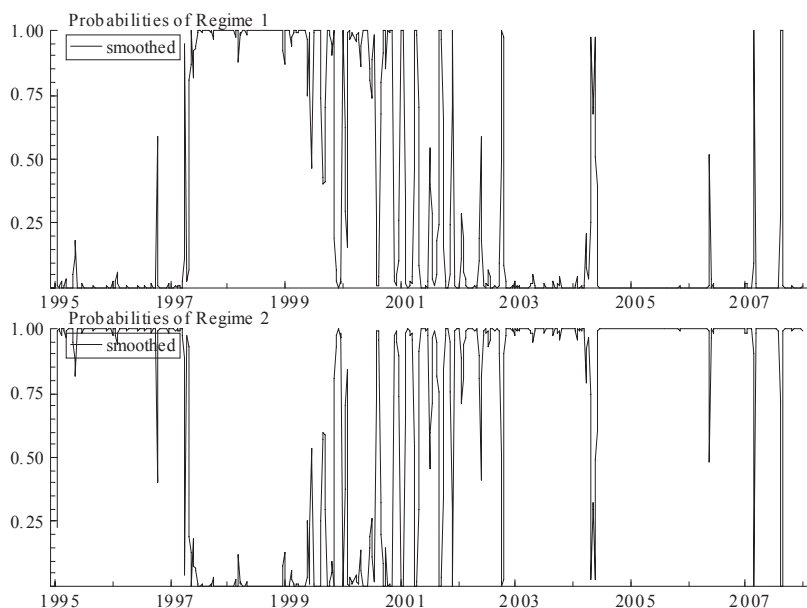


Chart 9. MS(2) VAR(1) Smoothed Plot at Asian Emerging Stock Markets

From Chart 9, we understand that Asian emerging stock markets were in low return and high volatility states (Regime 1) from July 1997 to 1999, after the outbreak of the financial crisis. As soon as these Asian nations implemented economic and financial reforms, this situation improved. Nations took time to adjust to a steady state, moving between regimes 1 and 2, after the crisis. The results in the chart indicate that use of MS-VAR can explicitly differentiate the states of crisis and non-crisis at Asian emerging stock markets. Compared with most nations in single probabilities of regime, stock markets in crisis may portray apparent volatility spillover and contagion. A correlation matrix of nations' states regarding the MSVAR was used to ascertain whether markets in crisis or non-crisis presented obvious spillover effects.

Table 6. Correlation Matrix among nations in Crisis and Non-Crisis

	Taiwan	Korea	Thailand	Malaysia	Philippines	Indonesia	China	India
Taiwan	1.0000	0.0658	0.1981	0.1186	0.1044	0.0763	0.1751 ⁺⁺	0.1263
Korea	0.2469	1.0000	0.3458 ⁺⁺	0.2119 ⁺⁺	0.2050	0.2400 ⁺⁺	-0.0017	0.1925
Thailand	0.2112	0.2650	1.0000	0.1846	0.2855	0.3670 ⁺⁺	0.0239 ⁺⁺	0.1538 ⁺⁺
Malaysia	0.1493	0.1111	0.2924	1.0000	0.3921 ⁺⁺	0.0263	0.0421 ⁺⁺	0.1597 ⁺⁺
Philippines	0.1545	0.2123	0.3321	0.2819	1.0000	0.2313 ⁺⁺	-0.0074	0.1105 ⁺⁺
Indonesia	0.1816	0.1595	0.2481	0.1995	0.2128	1.0000	-0.0248 ⁺⁺	-0.0209
China	0.0776	0.0607	-0.0289	-0.0158	0.0602	-0.0548	1.0000	0.1414 ⁺⁺
India	0.1557	0.2974	0.1305	0.0539	0.0909	0.1870	0.1102	1.0000

Note: ++ represent the spillover in crisis between the nations.

The outbreak of a financial crisis may upgrade a systematic crisis, which accompanies upheavals in the correlation matrix between the nations with significant correlation. The statistics in Table 6 signify that the correlation matrix for Thailand in finan-

cial crisis towards stock markets in Indonesia, Mainland China and India obviously increased. As for the Korean stock market, it achieved significant correlation with Thailand, Malaysia and Indonesia. Malaysia significantly correlated with the Philippines, Mainland China and India. The results demonstrate there was a regional volatility spillover effect during the financial crisis among the above mentioned nations. Further, Taiwan significantly correlated with Mainland China, which positively related to the Taiwanese investors in Mainland China. Hence, the impact of the Asian financial crisis on Taiwan was lower.

Extrapolation may show (Table 6) Korean investors in financial crisis declined the investment ratio in Thailand, Malaysia, and Indonesia and further decreased variation in investment portfolio. Malaysian investors should have reduced their investment ratios in Korea, the Philippines, Mainland China and India as a means of debasing an investment crisis. Therefore, Table 6 offers investors in global assets allocation referrals regarding investment policies.

5. Conclusions and Suggestions. Studies from the 1980s demonstrate that economic growth of Asian emerging nations has, on average, been greater than in other industrial nations due to comparatively low labor costs, high productivity, competitive strengths and multinational joint ventures in these nations. The Asian financial meltdown in 1997 triggered contagion effects throughout exchange markets in Asian nations, acutely impacting the Southeastern region. This study adopts the Markov regime switching model to investigate the volatilities of return at 8 Asian emerging stock markets and to compare the spillover effects between Asian markets involved in this financial crisis. In addition, we further apply the latest calculation developed by Mandilaras and Bird (2007) to increase the validity of this study. The results reveal that most of the Asian emerging markets are in regime 3, except for the Philippines, which is in regime 2. During the financial crisis, a majority of the 8 nations were in high volatility states, showing that alteration of the exchange markets significantly correlates with stock markets. Further, steadiness of economic fundamentals correlates with the volatility of emerging markets, along with significant interaction in markets and mutual transformation in volatility. Fourth, we capture the regime switching of the 8 markets in crisis and non-crisis by means of Markov switching vector autoregressive model. High volatility may influence adjacent nations, especially concerning volatility spillover effects during crises. In crisis, the economic constitution of an individual nation may influence the intensity of spillover effects. Nations with a weak constitution may experience a greater impact.

To conclude, the findings in this study mostly correspond with the "tequila effect" discussed in international financial management, indicating that spillover and contagion effects were mutually exhibited during the Asian financial crisis. As multinational investors lose their confidence in a certain market, they may rapidly withdraw from it. This phenomenon may spread to other nations with identical economic constitutions and foster a crisis in regional economies, conforming to the key points emphasized by the IMF on the contagious paths of financial crises. This study does not apply factor analysis to explain the above-mentioned volatility and spillover effects, thus suggesting that future researches further discuss the cause of volatility and spillover effects at markets for all the institutions concerned.

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