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Volatility and Mean Spillover from US and China to ASEAN

May 2007

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Abstract

This paper investigates volatility and mean spillover effects from the US and the Chinese stock markets into individual ASEAN stock markets using a GARCH spillover model. I find strong statistical evidence for both the mean-spillover and the volatility-spillover effects from the US into the individual ASEAN markets. The Chinese volatility-spillover effects are less essential to the individual ASEAN markets, but appear to generally increase over time. The Chinese volatility-spillover intensity is found to be strengthened after China entered WTO. The Chinese mean-spillover effects appear to be almost negligible. Pure local volatility effects are substantial, especially for the emerging markets. Subsequently, the evidence is found for the existence of asymmetric responses of ASEAN markets to upturns and downturns as well as positive shocks and negative shocks in the US and the Chinese stock markets. Finally, all the spillover effects are not necessarily dependent on the economic variables, i.e. exchange rate changes and the ratio of trade to GDP, but the exchange rate changes are able to explain the Chinese volatility-spillover intensities in the majority of the ASEAN markets.

Key words: stock markets; China; ASEAN; volatility; mean; spillover; asymmetries; exchange rate; trade

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1. Introduction

International stock markets have experienced ever-increasing interaction with one another during the past decade. Volatility and returns have been closely synchronized across national stock markets as a result of economic integration, development of stock markets, financial deregulation and liberalization, and the reduction of information and transaction cost. Shocks in one stock market or in one region are very likely to transmit to other markets and regions (for example, the East Asian crisis that started from Thailand and spread out in the whole region rapidly and pervasively). Therefore, it is very critical for the investors to understand the behavior of the volatility and mean spillover so as to efficiently implement international hedging strategies with global diversified portfolios. International diversification is often considered as the best instrument to improve portfolio performance. Because correlations between asset returns from different markets are usually lower than correlations within the same market, international diversification enable the investors to shift to investments of high risk and expected return without altering the overall risks of their portfolios. This benefit would be reduced if international stock markets tend to move together and volatility transmits across borders. Moreover, to understand the volatility and mean spillover also helps the policy makers better evaluate the regulatory proposals, supervising and restricting the international cash flows and hence protecting national markets and national economy from the international shocks. This is especially vital to the emerging stock markets that are in the process of liberalization and deregulation.

This paper deals with the volatility and return transmissions from the Chinese stock market (regional effect) and the US stock market (global effect) to various individual stock markets in ASEAN. I also examine whether the individual ASEAN stock markets respond asymmetrically to lagged returns and shocks in the US and the Chinese stock markets.

The spillover model was initiated by Engle, Ito and Lin (1990). They investigate the YEN/USD exchange rate and find the intra-day volatility spillovers between the US and Japanese foreign exchange markets. Bekaert and Harvey (1997), Ng (2002), Baele (2002), Christiansen (2003), and Worthington and Higgs (2004) investigate spillover effects on various capital markets using similar spillover models. Bekaert and Harvey (1997) analyze the volatilities of emerging equity markets. They find that the volatility is strongly influenced by global factors in the fully integrated markets but is more likely to be influenced by local factors in the segmented markets. Ng (2000) examines the magnitude and the variation of volatility spillovers from Japan and the US to pacific-basin stock markets. Baele (2002) quantifies the magnitude and the time-varying nature of the volatility-spillover effects from the US (global effects) and the aggregate European stock markets (regional effects) into individual European stock markets. Christiansen (2003) examines mean and volatility spillover effects from both the US and Europe into the individual European bond markets. She finds mean-spillover effects to be almost negligible, whereas volatility-spillover effects to be substantial. Worthington and Higgs (2004) find the presence of large and predominantly positive mean and volatility spillovers among nine Asian stock markets.

Previous literature has also used a number of alternative frameworks to analyze the interdependence of international equity markets. Ratanapakorn and Sharma Rivas (2002) use cointegration analysis and a VAR model to examine the long-term and short term relationships among stock indices of the US, Europe, Asia, Latin America, and Eastern Europe–Middle East. Gerard, Thanyalakpark and Batten (2003) look into the integration of Eastern Asian stock markets with the International Capital Asset Pricing Model. Rodríguez and Albuquerque (2006) use a linear regression model to capture the effect of European stock markets on Latin American stock markets.

Some literatures offer the evidence of the asymmetric effects between equity markets. Bahng and Shin (2003) find the asymmetric responses among the stock price indices among China, Japan and South Korea. Verma R. and Verma P. (2005) find the existence of asymmetries in Latin American equity markets to upturns and downturns in the US stock market.

The research on the international linkages of the Chinese stock market is very limited. Although some researches have investigated how the volatility and return of Chinese stock exchange is influenced by global markets (eg.US) and regional markets (eg. Japan, Hong Kong), cf. Li (2007), few studies have shed light on the causation of the other direction: possible spillover effect from China to overseas. As the Chinese economy has much stronger impact on the other Asian emerging economies than ever before through international trade and foreign direct investment, it would be significative to investigate the magnitude of the Chinese stock market's effect on the other Asian stock markets. In this paper, I investigate the volatility and mean spillover from the Shanghai equity market (as the representative of the mainland Chinese stock market) to five main ASEAN countries: Indonesia, Malaysia, Philippines, Singapore and Thailand. I introduce the US stock market into the study in order to investigate the possibility that the ASEAN stock markets are indirectly integrated with the Chinese market through the global developed market (US). Different from previous spillover studies, I introduce an asymmetric effect analysis into the spillover model to examine whether the returns of the individual ASEAN stock markets react asymmetrically to upturns and downturns as well as positive shocks and negative shocks in the Chinese and the US stock markets.

The empirical analysis makes use of indices extracted from Datastream. The spillover models are based on the models specified by Ng(2000) and Christiansen(2003) et al. Their models work on volatility and mean spillover with both global and regional effects. The estimation is conducted in three steps. In the first two steps, the returns of the US and the Shanghai indices are modeled respectively. In the third step, the returns of the individual ASEAN country indices follow AR-GARCH processes. The one-period lagged US and Shanghai returns and the contemporary US and Shanghai residuals are added to the mean specification. Including the lagged US and Shanghai returns in the mean equation enable mean-spillover effects, while including the US, Shanghai and Shenzhen residuals enable volatility-spillover effects. The conditional volatility of the unexpected return of the individual country index is hence dependent on the variance of its own idiosyncratic shocks and the contemporary US and Shanghai shocks. The conditional variance of the unexpected return is thus divided into the proportions caused by US effect, Shanghai effect and the local effect.

To start, it is assumed that spillover parameters are constant over time. I find strong indications of both mean-spillover and volatility-spillover effects from the US to the individual ASEAN markets. Chinese volatility-spillover effect is generally significant, but the evidence for the Chinese mean-spillover effect is very weak. The importance of the Chinese volatility is less essential than the US volatility, but it is generally increasing over time. Pure local effect is generally substantial in ASEAN, especially in the emerging markets.

Then, the spillover effects are allowed to be different before and after China entered WTO. Great changes in spillover effects are found for all ASEAN markets from the first sub-period to the second. The significance of Chinese volatility-spillover effects arise considerably in all individual ASEAN markets after China joined WTO.

Subsequently, I investigate whether the ASEAN countries respond asymmetrically to the upturns and downturns, and positive shocks and negative shocks in the US and the Chinese markets. Greater reactions to the US downturns and negative shocks are commonly found in all ASEAN markets. Strong evidence of asymmetric response to negative Chinese shocks is found in Philippines, Singapore, and Thailand, whereas investors in Malaysia are good-news-chasing, reacting more sharply to the positive shocks in Chinese market.

Moreover, based on the Ng (2002)'s time-varying spillover model, information instruments (i.e. exchange rate changes and trade/GDP ratio) are introduced to explain the time-varying spillover intensities. The Chinese spillover effects are found to be driven by the two instruments more significantly than the US spillover effects.

The remaining part of the paper is structured as follows. Section 2 briefly introduces the development of Chinese stock market. Section 3 describes the data on China, USA and five ASEAN countries. Subsequently, the empirical models of volatility spillover are set forth in Section 4. Empirical findings are discussed in

Section 5. Finally, Section 6 concludes the paper.

2. Development of Chinese stock markets

In this section, I describe the historical background of the Chinese stock markets, which includes the processes of the liberalization and the opening of the Chinese stock markets.

There are two stock markets in mainland China: Shanghai stock exchange and Shenzhen stock exchange. The Shanghai stock market was open in 1990, and Shenzhen stock market in 1991. Both markets are linked via the national stock exchange automated quotation system. The characteristics of companies listed in these two stock exchanges are different. While most companies listed on the Shanghai Stock Exchange are large and state-owned, those on the Shenzhen Stock Exchange tend to be relatively small, joint ventures, and export-oriented, cf. Xu (2000). The stock markets were initially set up in China mainly for the sake of supplying capital to state owned enterprises (SOEs), therefore, Chinese stock market was developed as a tool of industrial policy throughout 1990s and was not representative of the economy in mainland China. The Chinese stock market was characterized by frequent government intervention, poor regulation, extreme volatilities, poor liquidity, market segregation, and limited access for foreign investors. Regarding market segregation, stocks in both Shanghai and Shenzhen markets are traded in two types: ‘A share’ and ‘B share’. A shares are restricted to Chinese (People’s Republic of China) citizens(before Dec 2002) and denominated in Chinese currency yuan (CNY), while B shares can be sold and bought by international investors only (before February 2002), and are denominated in CNY but traded in foreign currencies (US dollars for Shanghai stock exchange, Hong Kong dollars for Shenzhen stock exchange). Therefore, the Chinese stock market is mildly segregated and the access for foreign investors is limited. As to liquidity, Chinese stock market had a split-share structure featuring that only one-third of the stocks could be freely traded and the other two-thirds were non-tradable state owned shares (before 2000).

Chinese stock markets have evolved rapidly with legal improvement and liberalization since the end of 1990s. The securities law of P.R.C. was put into effect on July 1, 1999, which established the basic regulations of China's securities market. The Chinese government has implemented many commissions to liberalize and open the stock market since China entered WTO in the end of December 2001. First, the B share market has been open to domestic investors since February 22, 2002. Second, foreign investors began to have easier access to the China's stock market: the QFII Act was commenced giving the qualified foreign institutional investors the access to China's A-share market in December 2002. The QFII rules were relaxed in August 2006 to attract more non-speculative overseas investment. Third, circulation of China's market has been improved. The Chinese government started to reduce non-tradable state-shares in 2000. Subsequently a new plan for state share reform was issued by the China Securities Regulatory Commission in April 2005. As a result, more than 1,100 Chinese firms listed domestically, which account for over 80 percent of the total, have completed or are in the process of state-shareholding reform in July 2006.[1] Given these reforms and the rapid growth of China's economy, the Chinese stock markets are becoming more developed, less volatile and more reflective of the underlying economy. And the investors are getting more broad and diverse and more sophisticated. Despite of some inevitable twists and turns in the process of its development, Chinese stock market's development and its increasing integration with the global capital market has generated much interest among investors, researchers and regulators.

3. Data and Preliminary Analysis

3.1. Data

In this paper, the raw data are the price indices of the stock markets in U.S., Shanghai,

[1] Chinese Government's Official Web Portal, 'State-Share Reform Brings Huge Wealth to Private Investors', July 19, 2006, http://english.gov.cn/2006-07/19/content_340582.htm

Shenzhen and five ASEAN countries (Indonesia, Malaysia, Philippines, Singapore and Thailand) which have relatively large economic scale compared to the rest of the countries in ASEAN. The sample period for all data is from December 23, 1998 to December 27, 2006. This period is recent and avoids any abnormal behavior caused by the underdevelopment of China's stock market in early 1990s and the Asian Financial crisis starting in 1997. The stock market indices used are as follows: Dow-Jones Industrials Price Index for the US, Shanghai SE Composite and Shenzhen SE composite for China, Jakarta SE Composite for Indonesia, Kuala Lumpur Composite for Malaysia, Philippines Composite for Philippines, Singapore Straits Times (New) for Singapore, and Bangkok S.E.T for Thailand. Close-to-close weekly data is used for the indices instead of daily returns. Using weekly data partially overcomes the potential problem of daily returns, cf. Burns and Engle (1998). Close-to-close daily returns on international stock markets tend to underestimate correlations, cf. Martens and Poon (2001), so the use of daily returns in volatility spillover model might suggest that the hypothesis of no spillover effects is not rejected too often. As all the indices are in local currencies, I adjust them into terms of US dollars by multiplying the indices with the close-to-close weekly exchange rates between USD and the local currencies: USD/CNY, USD/IDR, USD/MYR, USD/PHP, USD/SGD, and USD/THP. The returns are calculated as the difference between the log of the indices and the log of their own one-period lag. The data of trade between China, the US and the five ASEAN countries, the GDP of each ASEAN countries are employed quarterly. The data of the indices, the exchange rates are extracted from Datastream; and the data of the trade and the GDP from Ecowin Graphics.

3.2. Preliminary Analysis

Table 1 presents the descriptive statistics for the returns of the price indices. During the sample period, the performance across the eight stock markets has positive returns, the weekly index of Jakarta SE Composite increasing most quickly on average and that of Philippines Composite most slowly. The volatilities of Shanghai and Shenzhen markets are similar with the standard deviations 0.128% and 0.137% respectively. The Indonesian stock market is the most volatile among the eight markets, while the US is the least, which is consistent with the common perspective that the more developed the market is, the less volatile it is.

Table 1: sample statistics of the return series

	US	Shanghai	Shenzhen	Indonesia	Malaysia	Philippines	Singapore	Thailand
Mean	0.0003	0.0009	0.0005	0.0014	0.0008	0.0002	0.0009	0.0007
Median	0.0004	0.0008	0.0000	0.0030	0.0010	-0.0001	0.0010	0.0009
Maximum	0.0425	0.0554	0.0565	0.0962	0.0438	0.0995	0.0570	0.0838
Minimum	-0.0401	-0.0326	-0.0363	-0.1027	-0.0456	-0.0485	-0.0460	-0.0589
Std. Dev.	0.0098	0.0128	0.0137	0.0212	0.0113	0.0156	0.0123	0.0174
Skewness	0.1514	0.4174	0.3461	-0.2139	-0.0056	0.6044	-0.0359	0.1084
Kurtosis	4.9395	4.0438	4.0416	6.8359	5.1492	7.7275	4.5513	4.3130
Jarque-Bera	67.1105	31.1130	27.2426	259.4583	80.4532	414.7072	42.0057	30.8438
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Seen from Figure A1 and Figure A2, the indices and the returns of Shanghai and Shenzhen follow almost the same path. The two markets are highly correlated (correlation 0.96). Therefore, this paper takes Shanghai market as the representative as the mainland Chinese market for the sake of its larger market capitalization.

The returns of the price indices have the features of volatility clustering and heteroskedasticity (see Figure A2). The nonzero skewness statistics of the returns suggest an ARCH order higher than one in the conditional variance equation. Subsequently, a GARCH(1,1) model should be preferred to an ARCH(p) model due to parsimony. Therefore, GARCH models are capable of dealing with the data.

4. Empirical Models

The empirical volatility and mean spillover model in this paper is based on the models specified by Ng (2000) and Christiansen (2003).

Ng (2000), who works on volatility and price spillover effect from the US and Japan to Pacific-Basin countries, structures a two step model. In the first step, a bivariate GARCH model for the US (global effect), Japanese (regional effect) returns is estimated. There are no spillover effects between the US and Japan. In the second step, the one-period lagged US and Japanese returns and the contemporary US and Japanese residuals from the first-step regression are used as explanatory variables in the mean specifications of the individual Pacific-Basin countries (local). In this way, the model captures two sources of spillover effects (global and regional). Finally, Ng utilizes a time-varying spillover model measuring the economic instruments as the driving forces for the spillover intensities.

Christiansen (2003) applies a similar model of three steps investigating the spillover effects in European Bond Market. In the first step, a univariate AR-GARCH model is estimated for the return of the US bond market (global effect). In the second step, an extended univariate AR-GARCH model is estimated for the aggregate European return (regional effect). The one-period lagged US return and the contemporary US idiosyncratic shock are used as an explanatory variable. In the third step finally, a univariate extended AR-GARCH model for the return of the individual European bond markets is estimated. Both the one-period lagged returns and the contemporary residuals of the US and Europe are included as explanatory variables.

The subsequent analysis relies on using one-period returns and idiosyncratic shocks of the US stock markets and the Shanghai stock market as explanatory variables. I use the three-step univariate AR-GARCH to avoid orthogonalization between the idiosyncratic shocks of the US and Shanghai stock markets, having the causality go from the US to Shanghai stock markets. Subsequently, an asymmetric spillover model is applied so as to examine the existence of asymmetric responses. Finally, I utilize a conditional spillover model to investigate the time-varying spillover intensities.

Unconditional Spillover Model

The return on the US index, $R_{US,t}$, is assumed to evolve according to an AR(1) process:

$$R_{US,t} = c_{0,US} + c_{1,US} R_{US,t-1} + e_{US,t} \tag{1}$$

The idiosyncratic shock, $e_{US,t}$, is normally distributed with mean 0 and the conditional variance follows a symmetric GARCH(1,1) specification, cf. Engle (1982) and Bollerslev (1986):

$$\sigma^2_{US,t} = \omega_{US} + \alpha_{US} e^2_{US,t-1} + \beta_{US} \sigma^2_{US,t-1} \tag{2}$$

The return on the Shanghai index, $R_{SH,t}$, is described by the following extended AR(1) specification:

$$R_{SH,t} = c_{0,SH} + c_{1,SH} R_{SH,t-1} + \gamma_{SH} R_{US,t-1} + \phi_{SH} e_{US,t} + e_{SH,t} \tag{3}$$

The return of Shanghai index depends on its own lagged return as well as the lagged US return and the contemporary US residual. The mean spillover effects are introduced by the lagged US return, $R_{US,t-1}$. The volatility spillover from the US to Shanghai stock markets takes place via the US idiosyncratic shock, $e_{US,t}$. The idiosyncratic shocks $e_{SH,t}$ has mean 0 and the conditional variance $\sigma^2_{SH,t}$ evolves according to the GARCH (1,1):

$$\sigma^2_{SH,t} = \omega_{SH} + \alpha_{SH} e^2_{SH,t-1} + \beta_{SH} \sigma^2_{SH,t-1} \tag{4}$$

The last steps consist in providing a model for the individual ASEAN country returns. The mean specification for country *i* (i = 1, …, N) is:

$$R_{i,t} = c_{0,i} + c_{1,i} R_{i,t-1} + \gamma_i R_{US,t-1} + \delta_i R_{SH,t-1} + \phi_i e_{US,t} + \psi_i e_{SH,t} + e_{i,t} \tag{5}$$

The US and Shanghai stock markets returns have mean spillover effects to the individual country *i* by the lagged returns $R_{US,t-1}$ and $R_{SH,t-1}$. Volatility-spillover effects from the US and China to the individual countries are introduced by the variables $e_{US,t}$ and $e_{SH,t}$. The idiosyncratic shock of country i, $e_{i,t}$, is subject to the same distributional assumptions as the US and the Shanghai idiosyncratic shocks; they have mean 0 and the following conditional variance specification:

$$\sigma^2_i = \omega_i + \alpha_i e^2_{i,t-1} + \beta_i \sigma^2_{i,t-1} \tag{6}$$

The unexpected returns ε_t are described by equations (7)-(9) as follows:

$$\varepsilon_{US,t} = e_{US,t} \tag{7}$$

$$\varepsilon_{SH,t} = \phi_{SH} e_{US,t} + e_{SH,t} \tag{8}$$

$$\varepsilon_{i,t} = \phi_i e_{US,t} + \psi_i e_{SH,t} + e_{i,t} \tag{9}$$

The idiosyncratic shocks $e_{US,t}$, $e_{SH,t}$ and $e_{i,t}$ (for I = 1, … N) are assumed to be independent. The conditional variance $h_{i,t}$ of the unexpected return of country *i* based on the information available at time t-1 (I_{t-1}) is given as follows:

$$h_{i,t} = E(\varepsilon_{i,t}^2 \mid I_{t-1}) = \phi_i^2 \sigma_{US,t}^2 + \psi_i^2 \sigma_{SH,t}^2 + \sigma_{i,t}^2 \tag{10}$$

The conditional variance of the unexpected return for country *i* depends on the variance of the contemporary US, Shanghai and own idiosyncratic shocks. The sign and significance of the parameters ϕ_i and ψ_i determine whether volatility-spillover effects from the US and Shanghai are present in country *i* respectively. The conditional variance of Shanghai unexpected return depends only on the US and its own idiosyncratic volatility. The conditional variance of the US unexpected return is equal to the variance of the US idiosyncratic shock.

I measure the proportion of the variance of the unexpected return of country *i*, cf. equation (10), that is caused by the US and Chinese volatility-spillover effects. The variance ratios are defined as follows:

$$VR_{i,t}^{US} = \frac{\phi_{i,t-1}^2 \sigma_{US,t}^2}{h_{i,t}} \tag{11}$$

$$VR_{i,t}^{SH} = \frac{\psi_{i,t-1}^2 \sigma_{SH,t}^2}{h_{i,t}} \tag{12}$$

The remaining part of the variance of the unexpected return for country *i* is caused by pure local effects:

$$VR_{i,t}^{i} = 1 - VR_{i,t}^{US} - VR_{i,t}^{SH} = \frac{\sigma_{i,t}^2}{h_{i,t}} \tag{13}$$

Asymmetric Spillover Model

Asymmetric mean equations are introduced to examine whether the returns of individual ASEAN countries respond asymmetrically to the upturns and downturns as well as positive and negative shocks in the US and Chinese markets.

$$R_{i,t} = c_{0,i} + c_{1,i} R_{i,t-1} + \gamma_{1,i} R^{+}_{US,t-1} + \gamma_{2,i} R^{-}_{US,t-1} + \delta_{1,i} R^{+}_{SH,t-1} + \delta_{2,i} R^{-}_{SH,t-1} + \phi_{1,i} e^{+}_{US,t} + \phi_{2,i} e^{-}_{US,t} + \psi_{1,i} e^{+}_{SH,t} + \psi_{2,i} e^{-}_{SH,t} + e_{i,t} \quad (14)$$

where $R^{+}_{t-1} = R_{t-1}$ if $R_{t-1} > 0$ and 0 otherwise;

$R^{-}_{t-1} = R_{t-1}$ if $R_{t-1} < 0$ and 0 otherwise;

$e^{+}_{t} = e_t$ if $e_t > 0$ and 0 otherwise;

$e^{-}_{t} = e_t$ if $e_t < 0$ and 0 otherwise.

Conditional Spillover Model

This section is based on the time-varying spillover model specified by Ng (2000), which relaxes the assumption of constant spillover parameters. As the degree of international linkage is changing over time, it is more appropriate to introduce some information variables in order to capture the time variation in the spillover intensity parameters $\gamma_{i,t-1}$, $\delta_{i,t-1}$, $\phi_{i.t-1}$ and $\psi_{i,t-1}$.

$$\begin{aligned} \gamma_{i,t-1} &= v' X^{US}_{i,t-1} \\ \phi_{i,t-1} &= w' X^{US}_{i,t-1} \\ \delta_{i,t-1} &= p' X^{SH}_{i,t-1} \\ \psi_{\mathrm{i,t\text{-}1}} &= q' X^{SH}_{i,t-1} \end{aligned} \quad (15)$$

where v and w are (3*1) vectors of parameters which measure the impact of economic variables on the spillover effects from the US; p and q are (3*1) vectors of parameters measuring the effects of economic instruments on spillovers from the Chinese stock market. The economic variables in $X^{US}_{i,t-1}$ include a constant, change of exchange rate (currency of country *i* against US dollars) and trade with the US as a ratio to country *i*'s GDP; the variables in $X^{SH}_{i,t-1}$ include a constant, change of exchange rate (currency of country *i* against Chinese Yuan) and trade with China as a ratio to country *i*'s GDP. Previous studies show the importance of currency effects on the volatility and correlation of stock markets, cf. Karolyi and Stulz (1996) and Mun (2007). Large exchange rate shocks (for example, the Asian currency crisis in the late 1990s) usually transmit to the equity markets. The ratios of trade of country *i* with the US and China to GDP are proxies for economic integration. The more economies are linked, the more they will be exposed to common shocks, and the more the stock markets are correlated, cf. Baele (2002).

5. Empirical Results

In the first part of this section, I estimate the unconditional spillover model. Firstly, the model is estimated for the full sample period (from Dec 1998 to Dec 2006). Secondly, spillover effects are allowed to be different before and after China entered WTO in the end of 2001. Subsequently, the asymmetric spillover model is estimated. The second part deals with the conditional spillover models, in which spillover coefficients are allowed to vary over time.

5.1. Unconditional Spillover Model

5.1.1. Full Sample Period Model

I estimate the unconditional spillover model specified by the equations (1)-(6) for the full sample period (from Dec 1998 to Dec 2006). The results for the estimated coefficients are reported in Table 2. Table 3 provides the robust Wald tests for four different joint hypotheses regarding spillover effects: no US spillover effects, no Chinese spillover effects, no mean spillover effects, and no volatility spillover effects.

In the first step, the univariate model for the US return is estimated, cf. the first row of Table 2. The AR(1) parameter is small, negative and insignificant, which implies no or weak negative first-order autocorrelation. Variance of the US return is stationary, as $\alpha_{US} + \beta_{US} \leq 1$.

The second row of Table 2 reports the results for the return of the Shanghai index, which is the second step in the unconditional spillover model. Own lagged and US lagged returns are not important to the return of Shanghai index: $c_{1,SH}$ and γ_{SH} are positive and insignificant. The coefficient of the contemporary US residual is also insignificant. Therefore, there is no evidence of either mean-spillover or volatility-spillover from the US to Shanghai market. The joint Wald test leads to the same result that the null hypothesis of no US-spillover effects at all: $H_0 : \gamma_{SH} = \phi_{SH} = 0$ is not rejected. The volatility process is found to be stationary: $\alpha_{SH} + \beta_{SH} \le 1$.

Table 2: Estimated coefficients for the symmetric unconditional spillover model with the whole sample period (from Dec 1998 to Dec 2006)

	c_0	c_1	γ	δ	ϕ	ψ	ω	α	β
US	0.001&	-0.074					0.000	0.097*	0.899*
	(0.053)	(0.118)					(0.389)	(0.001)	(0.000)
SH	0.001	0.030	0.110&		0.049		0.000	0.113&	0.714*
	(0.371)	(0.609)	(0.093)		(0.510)		(0.156)	(0.070)	(0.000)
IN	0.002#	0.088&	0.430*	-0.057	0.260*	0.199*	0.000&	0.033*	0.956*
	(0.037)	(0.088)	(0.000)	(0.324)	(0.000)	(0.002)	(0.089)	(0.000)	(0.000)
ML	0.001&	0.119#	0.156*	0.057&	0.282*	0.100*	0.000&	0.015	0.976*
	(0.082)	(0.010)	(0.001)	(0.067)	(0.000)	(0.001)	(0.091)	(0.131)	(0.000)
PH	0.000	-0.017	0.220*	0.086	0.383*	0.053	0.000*	0.299*	0.296#
	(0.576)	(0.813)	(0.000)	(0.142)	(0.000)	(0.237)	(0.000)	(0.000)	(0.027)
SG	0.001*	0.018	0.257*	-0.002	0.536*	0.127*	0.000*	-0.021*	1.005*
	(0.009)	(0.659)	(0.000)	(0.967)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TH	0.001	0.044	0.330*	0.044	0.430*	0.162*	0.000*	-0.019#	1.008*
	(0.232)	(0.385)	(0.000)	(0.405)	(0.000)	(0.003)	(0.000)	(0.025)	(0.000)

Note: P-values are in parentheses. *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

In the last step, I apply the models for the individual ASEAN countries. The models include one-period lagged returns and contemporary residuals of the US and Shanghai markets, thus allow the mean and volatility-spillover from both the US and Shanghai to individual ASEAN countries. The results are provided in the bottom rows of Table2.

I find no significant first-order autocorrelation except in Malaysia. The conditional volatility processes are stationary for all ASEAN countries: $\alpha_i + \beta_i \le 1$.

Table 3: Joint Wald tests for the following null hypotheses regarding the spillover effects in the unconditional spillover model in the full sample period (from Dec 1998 to Dec 2006)

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$
IN	24.926*	10.502*	22.424*	20.440*
	(0.000)	(0.005)	(0.000)	(0.000)
ML	52.670*	13.588*	14.222*	50.368*
	(0.000)	(0.001)	(0.001)	(0.000)
PH	47.564*	3.326	21.368*	37.415*
	(0.000)	(0.190)	(0.000)	(0.000)
SG	126.419*	14.191*	21.614*	116.966*
	(0.000)	(0.001)	(0.000)	(0.000)
TH	48.045*	9.693*	17.494*	42.089*
	(0.000)	(0.008)	(0.000)	(0.000)

Note:

$H_0^1 : \gamma_i = \phi_i = 0$ (no US spillover effects)

$H_0^2 : \delta_i = \psi_i = 0$ (no Chinese spillover effects)

$H_0^3 : \gamma_i = \delta_i = 0$ (no mean spillover)

$H_0^4 : \phi_i = \psi_i = 0$ (no volatility spillover)

Under the null hypotheses $Wald_1$, $Wald_2$, $Wald_3$, and $Wald_4$ are $\chi^2(2)$ distributed. P-values are in parentheses. *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

Strong evidences for both the US mean-spillover and the US volatility-spillover are found for all the individual ASEAN countries: γ_i and ϕ_i are positive and significant at the 1% significance level. The robust joint Wald tests for no US-spillover effects at all, $H_0 : \gamma_i = \phi_i = 0$, is strongly rejected.

There is strong indication for Chinese volatility-spillover effects in all ASEAN countries except in Philippines: ψ_i is positive and significant at the 1% significance level. In contrast, Chinese mean-spillover effect is found significant only in Malaysia (and that only at the 10% level of significance). The robust Wald tests for the joint hypothesis of no Chinese spillover effects, $H_0^2 : \delta_i = \psi_i = 0$ is rejected for all the ASEAN countries except for Philippines again.

For all countries, the robust joint Wald test for no mean-spillover ($H_0^3 : \gamma_i = \delta_i = 0$) and the Wald test for no volatility-spillover ($H_0^4 : \phi_i = \psi_i = 0$) are strongly rejected.

To summarize, there are strong indications of volatility-spillover effects from both the US and Chinese markets and mean-spillover effects effect from the US into the individual ASEAN markets. Very weak signs of Chinese mean-spillover effects are found.

Table 4: Variance Ratios-Unconditional Spillover Model

	VR^{US}		VR^{SH}		VR^{i}	
	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.
IN	0.019	0.014	0.021	0.011	0.961	0.017
ML	0.077	0.045	0.022	0.014	0.901	0.048
PH	0.067	0.049	0.002	0.001	0.931	0.049
SG	0.193	0.102	0.026	0.019	0.781	0.107
TH	0.073	0.053	0.019	0.009	0.907	0.053
Min	0.019	0.014	0.002	0.001	0.781	0.017
Max	0.193	0.102	0.026	0.019	0.961	0.107

So far, only the signs and significance of the spillover parameters have been discussed. To evaluate the quantitative importance of the US and Chinese volatility-spillover effects on the variance of the unexpected return of the individual ASEAN market *i*, the time series of the variance ratios $VR_{i,t}^{US}$, $VR_{i,t}^{SH}$, and $VR_{i,t}^{i}$ from equations (11) to (13) are calculated. Table 4 reports the means and the standard deviations of the variance ratios for each country. On average, the US volatility-spillover effects accounts 1.9%-19.3% of the conditional variance of the unexpected return of country *i*. For majority of the countries, the mean of the US variance ratio is around 7%. The US volatility spillover is considerably strong in Singapore (mean of 19.3%), whereas rather weak in Indonesia (mean of 1.9% only). On average the Chinese volatility-spillover make up between 0.2% and 2.6% for the ASEAN markets, implying much weaker influence than the US volatility-spillover effects. Philippines is the least influenced by the Chinese volatility-spillover: $VR^{SH}_{PH,t}$ =0.2%, while Singapore is the most affected: $VR^{SH}_{SG,t}$ =2.6%.

Finally, the pure local volatility effects are found to be substantial in ASEAN markets. In Singapore is the local variance ratio relatively small (mean of 78.1%). This is probably because Singapore is the only developed market among the five ASEAN countries and therefore is the most integrated with the global markets. In other four emerging markets, the means of the local variance ratios are all above 90%.

Figure A3 presents the time series evolution of the variance ratios for each country *i*. The US variance ratio follows a similar path for every country *i*. It generally arises till the end of Oct. 2002, and decreases afterwards. Consistent with the analysis above, the Chinese variance ratios are much smaller than the US variance ratios. However, the Chinese variance ratio is generally increasing over the sample period for all countries except for Philippines where the Chinese variance ratio appears to be negligible over time. It is remarkable, that the portion of the Chinese spillover effect overtakes the US spillover effect in Indonesia after Oct. 2003.

5.1.2. Two-Sub-Period Model

In this part, the unconditional model is applied for two sub-periods: before and after China entered WTO (end of 2001), thus the estimated coefficients are allowed to be different in the two sub-periods.

Table 5 contains the results from estimating the unconditional spillover model for the first sub-period. Table 6 provides the robust Wald tests for the four different joint hypotheses regarding spillover effects for the first sub-period.

The mean specification for the US return and the Shanghai return in the first-sub period is similar to that of the full sample period. First-order autocorrelation is found for neither the US nor Shanghai. There is no evidence of mean spillover from the US to Shanghai: γ_{SH} is insignificant. The contemporary US residual is not able to explain the return of Shanghai index, therefore US volatility-spillover effect does not exist in Shanghai. The robust joint Wald test for no US-spillover to Shanghai at all: $H_0 : \gamma_{SH} = \phi_{SH} = 0$, is not rejected.

For the returns of the five ASEAN markets, the first-order autocorrelation is found only in Malaysia (again). Different from the strong US spillover effects in all ASEAN countries in the full sample period, there is significant US mean-spillover only in three countries: Philippines, Singapore and Thailand. The US volatility-spillover effect exists in all ASEAN countries with Indonesia as an exception. The null hypothesis of no US spillover effects at all: $H_0^1 : \gamma_i = \phi_i = 0$, is strongly rejected in most of the ASEAN countries but Indonesia.

Table 5: Estimated coefficients for the symmetric unconditional spillover model with the first sub-period (from Dec 1998 to Dec 2001)

	c_0	c_1	γ	δ	ϕ	ψ	ω	α	β
US	0.000	-0.042					0.000&	0.270&	0.176
	(0.766)	(0.645)					(0.052)	(0.054)	(0.572)
SH	0.001	0.011	0.088		-0.012		0.000	0.095	0.712#
	(0.615)	(0.911)	(0.333)		(0.919)		(0.424)	(0.261)	(0.020)
IN	-0.003	-0.035	0.159	-0.042	0.199	0.034	0.000	0.103&	0.853*
	(0.219)	(0.747)	(0.408)	(0.739)	(0.137)	(0.870)	(0.163)	(0.070)	(0.000)
ML	0.001	0.179#	0.136	-0.092	0.290*	-0.037	0.000	-0.027	1.010*
	(0.618)	(0.024)	(0.144)	(0.298)	(0.000)	(0.671)	(0.257)	(0.151)	(0.000)
PH	-0.004*	-0.146	0.298*	0.195#	0.331*	-0.048	0.000*	0.540*	-0.085
	(0.000)	(0.231)	(0.006)	(0.036)	(0.002)	(0.616)	(0.000)	(0.000)	(0.198)
SG	0.000	0.004	0.225#	0.017	0.670*	0.129	0.000#	-0.062*	0.960*
	(0.681)	(0.956)	(0.034)	(0.848)	(0.000)	(0.174)	(0.016)	(0.001)	(0.000)
TH	-0.002	-0.061	0.495*	-0.038	0.582*	0.219#	0.000#	0.305&	-0.164
	(0.204)	(0.511)	(0.001)	(0.736)	(0.000)	(0.036)	(0.012)	(0.051)	(0.502)

Note: P-values are in parentheses. *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

Table 6: Joint Wald tests for the following null hypotheses regarding the spillover effects in the unconditional spillover model in the full sample period (from Dec 1998 to Dec 2001)

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$
IN	2.723	0.138	0.826	2.209
	(0.256)	(0.933)	(0.662)	(0.331)
ML	15.372*	1.175	3.217	12.552*
	(0.001)	(0.556)	(0.200)	(0.002)
PH	18.011*	5.754&	13.030*	9.599*
	(0.000)	(0.056)	(0.002)	(0.008)
SG	37.874*	1.978	4.544	35.236*
	(0.000)	(0.372)	(0.103)	(0.000)
TH	30.122*	4.379	11.107*	17.860*
	(0.000)	(0.112)	(0.004)	(0.000)

Note:

$H_0^1 : \gamma_i = \phi_i = 0$ (no US spillover effects)

$H_0^2 : \delta_i = \psi_i = 0$ (no Chinese spillover effects)

$H_0^3 : \gamma_i = \delta_i = 0$ (no mean spillover)

$H_0^4 : \phi_i = \psi_i = 0$ (no volatility spillover)

Under the null hypotheses $Wald_1$, $Wald_2$, $Wald_3$, and $Wald_4$ are $\chi^2(2)$ distributed. P-values are in parentheses. *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

As for the Shanghai spillover, evidence is found only for the mean-spillover to Philippines and the volatility-spillover to Thailand. There is no Chinese spillover effect to most of the ASEAN countries indicated by the joint Wald test. Only in Philippines do I find significant joint Chinese spillover effect (and that only at the 10% level of significance).

The volatility-spillover effect is more prominent than mean spillover in both the cases of US spillover and Chinese spillover in all the ASEAN markets, indicated by the $\chi^2_{(2)}$ distributed test statistics. The null hypothesis of no volatility-spillover effects at all is rejected in most of the ASEAN countries except in Indonesia, whereas significant joint mean-spillover effects are found only in Philippines and Thailand.

Moreover, the variance appears to be stationary in every market.

To summarize, Indonesia is the least integrated with the both US and the Chinese markets in the first sub-period, as no spillover effect at all is found. Chinese spillover effect is weak in all ASEAN markets, while US spillover effect is prominent in all the markets except in Indonesia. Moreover, volatility-spillover effect tends to be stronger than mean-spillover effect.

The results from estimating the unconditional spillover model for the second sub-period is reported in Table 7. Table 8 provides the robust Wald tests for four different joint hypotheses regarding spillover effects for the second sub-period. Similar to the result in the first sub-period, own lagged and the US lagged returns and the contemporary US residual are of minor importance to the mean of Shanghai: $c_{1,SH}$ and γ_{SH} are positive and insignificant.

Table 7: Estimated coefficients for the symmetric unconditional spillover model with the second sub-period (from Jan 2002 to Dec 2006)

	c_0	c_1	γ	δ	ϕ	ψ	ω	α	β
US	0.001#	-0.126&					0.000	0.113#	0.865*
	(0.038)	(0.057)					(0.260)	(0.032)	(0.000)
SH	0.001	0.050	0.113		0.116		0.000	0.185&	0.675*
	(0.500)	(0.499)	(0.233)		0.252		(0.150)	(0.082)	(0.000)
IN	0.003#	0.093	0.450*	-0.004	0.353*	0.214*	0.000	0.070	-0.189
	(0.011)	(0.241)	(0.000)	(0.955)	(0.000)	(0.002)	(0.255)	(0.262)	(0.846)
ML	0.001	0.071	0.162*	0.134*	0.279*	0.122*	0.000*	0.062#	-0.901*
	(0.117)	(0.245)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.030)	(0.000)
PH	0.002#	0.002	0.213*	0.037	0.425*	0.125#	0.000	0.062	0.598#
	(0.041)	(0.980)	(0.000)	(0.603)	(0.000)	(0.022)	(0.172)	(0.321)	(0.028)
SG	0.002*	-0.019	0.253*	-0.010	0.528*	0.132*	0.000*	-0.024*	1.008*
	(0.001)	(0.752)	(0.000)	(0.748)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
TH	0.001	0.062	0.284*	0.070	0.358*	0.164#	0.000	0.039	0.888*
	(0.112)	(0.380)	(0.004)	(0.285)	(0.000)	(0.012)	(0.627)	(0.431)	(0.000)

Note: p-values are in parentheses. *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

Table 8: Joint Wald tests for the following null hypotheses regarding the spillover effects in the unconditional spillover model in the full sample period (from Jan 2002 to Dec 2006)

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$
IN	20.151*	9.987*	15.868*	21.427*
	(0.000)	(0.007)	(0.000)	(0.000)
ML	61.619*	36.813*	31.555*	56.408*
	(0.000)	(0.000)	(0.000)	(0.000)
PH	42.346*	5.609&	14.807*	26.842*
	(0.000)	(0.061)	(0.001)	(0.000)
SG	102.773*	16.369*	15.521*	86.344*
	(0.000)	(0.000)	(0.000)	(0.000)
TH	18.099*	6.967 *	9.833*	16.906*
	(0.000)	(0.031)	(0.007)	(0.000)

Note:

$H_0^1 : \gamma_i = \phi_i = 0$ (no US spillover effects)

$H_0^2 : \delta_i = \psi_i = 0$ (no Chinese spillover effects)

$H_0^3 : \gamma_i = \delta_i = 0$ (no mean spillover)

$H_0^4 : \phi_i = \psi_i = 0$ (no volatility spillover)

Under the null hypotheses $Wald_1$, $Wald_2$, $Wald_3$, and $Wald_4$ are $\chi^2(2)$ distributed. P-values are in parentheses. *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

In the mean specification of the individual ASEAN countries, the coefficients of both the lagged US return and the contemporary US residual are positive and significant. Thus, there is evidence for both mean-spillover and volatility-spillover from the US to all the ASEAN markets. The robust joint Wald test for no US spillover effects at all: $H_0^1 : \gamma_i = \phi_i = 0$ is strongly rejected.

For most of the ASEAN countries there is no significant mean-spillover effects from Shanghai, however, the mean-spillover parameter δ_i is strongly significant in Malaysia. In contrast, Chinese volatility-spillover effect is found in all the ASEAN countries. The robust joint Wald test for no Chinese spillover effects at all, $H_0^2 : \delta_i = \psi_i = 0$ is rejected, which implies that the Chinese spillover effects are more prominent in the second sub period compared to the first period.

Moreover, the null hypothesis of no mean spillover effect and the one of no volatility spillover effect are all rejected for all the ASEAN countries. All the variances still appear to be stationary.

Summing up, there is strong US volatility-spillover and US mean-spillover into all ASEAN countries in the second-sub period. With the exception in Malaysia, the Chinese mean-spillover is rather weak in ASEAN countries, whereas the Chinese volatility-spillover is essential. Compared to the results in the first sub-period, both the US and Chinese mean and volatility effects tend to be more prominent in the second sub-period.

Figure A4 displays the absolute values of the z-statistics for the spillover parameters in both sub-periods, implying the change of the significance of the US and Chinese spillover to ASEAN countries. As for the US spillover effects, the sizes of the z-statistics for both the mean-spillover intensity γ_i and volatility-spillover intensity ϕ_i arise in all ASEAN countries except in Thailand, implying that the US spillover effects generally tend to become stronger over time. The US volatility-spillover is more substantial than the US mean-spillover. Moreover, I find the sizes of the z-statistics of the US volatility-spillover considerably high in Singapore for both the sub-periods compared to those in other four ASEAN countries. As for the Chinese spillover effects, the mean-spillovers in both the sub-periods are rather insignificant, and there is no prominent rising trend in the significance over time. However, a remarkable increase in the size of z-statistics is found for the Chinese volatility-spillover parameter ψ_i in all the ASEAN countries.

5.1.3. Asymmetric Spillover Model

This part investigates the existence of asymmetries in ASEAN stock markets to upturns (positive one-period lagged returns) and downturns (negative one-period lagged returns) as well as positive shocks (positive contemporary residuals) and negative shocks (negative contemporary residuals) in the US and Chinese markets.

Table 9 reports the regression results using the equation (14) for all the ASEAN countries with the full sample period. The constant and the own lagged return in the mean specification and the variance specifications are not presented in the table, as they are similar with the results of the symmetric model. Table 10 represents the Wald tests for the four hypothesis regarding asymmetric responses.

In the case of Indonesia, I find asymmetric response to the US market. γ_2, namely the coefficient of $R^{-}_{US,t-1}$ and ϕ_2, namely the coefficient of $e^{-}_{US,t}$ are strongly significant. The size of γ_2 is 0.785, which is much greater than the size of γ_2, the coefficient for $R^{+}_{US,t-1}$ (0.044). This suggests that a decrease in the US market has a much greater impact than an increase of the same magnitude on the Indonesian stock market. The size of ϕ_2 is also larger than the size of ϕ_1, namely the coefficient for $e^{+}_{US,t}$, which implies that the investors in Indonesia react more sharply to the negative shocks than the positive shocks in the US market. The Wald tests for null hypotheses of no asymmetries to the US returns and residuals: $H_0^1 : \gamma_1 = \gamma_2$ and $H_0^3 : \phi_1 = \phi_2$ leave the conclusions unaltered: both the null-hypotheses are strongly rejected.

I come to a similar conclusion regarding the impacts of the US lagged returns and shocks on Philippines, Singapore and Thailand. Moreover, there is evidence of asymmetric response to the Shanghai negative shocks from Philippines, Singapore and Thailand: ψ_2, namely the coefficient for is significant and larger than ψ_1. However, the null hypothesis of no asymmetric response to Chinese shocks: $H_0^4 : \psi_1 = \psi_2$ is rejected only for Philippines and Thailand but not for Singapore.

Some interesting results are discovered in Malaysia. Like investors in the other four ASEAN countries, the investors in Malaysia penalize downturns and negative shocks in the US markets more heavily than they reward equivalent upturns and positive shocks: γ_2 is more significant and larger than γ_1; ϕ_2 is more significant and larger than ϕ_1. However, the Malaysian investors respond more sharply to the good news in the Chinese market rather than bad news: the size of δ_1, namely the coefficient for R^+_{SH} is 0.124 (p-value 0.029) is greater than the size of δ_2, which is 0.033 (p-value 0.659); ψ_1, namely the coefficient for e^+_{SH} is also more significant and greater than ψ_2.

Table 9: Estimated coefficients for the asymmetric volatility spillover model with the sample period from Jan 2002 to Dec 2006

	γ_1	γ_2	δ_1	δ_2	ϕ_1	ϕ_2	ψ_1	ψ_2
IN	-0.044	0.785*	-0.185	0.043	-0.223	0.752*	0.115	0.233
	(0.794)	(0.000)	(0.110)	(0.719)	(0.135)	(0.000)	(0.328)	(0.112)
ML	0.080	0.243*	0.124#	-0.033	0.175&	0.392 *	0.098#	0.085
	(0.448)	(0.006)	(0.029)	(0.659)	(0.069)	(0.000)	(0.040)	(0.186)
PH	-0.173&	0.631*	0.063	0.118	0.109	0.628*	-0.098	0.192#
	(0.083)	(0.000)	(0.536)	(0.314)	(0.384)	(0.000)	(0.203)	(0.036)
SG	0.056	0.441*	-0.004	-0.016	0.350*	0.719*	0.053	0.180#
	(0.629)	(0.000)	(0.944)	(0.844)	(0.001)	(0.000)	(0.448)	(0.012)
TH	0.224	0.403*	0.093	-0.034	0.138	0.697*	-0.046	0.363*
	(0.137)	(0.006)	(0.312)	(0.761)	(0.436)	(0.000)	(0.671)	(0.003)

Note: p-values are in the parentheses *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

Except in Malaysia, neither the positive one-period lagged Shanghai return nor the negative one-period lagged Shanghai return is able to explain the returns in the ASEAN countries. The Wald test of the null hypothesis: $H_0^2 : \delta_1 = \delta_2$ leads to the result of no asymmetry to the upturns and downturns in Shanghai.

To summarize, the greater response to the US downturns and negative shocks are common in all the ASEAN countries. The asymmetric reaction to the Chinese stock market exists in most of the ASEAN countries except in Indonesia; however, the prominence of the asymmetric response is not as strong as that to the US market, indicated by the Wald tests. Phlippines, Singapore, and Thailand respond more sharply to the negative shocks in the Chinese market than to the positive ones, whereas investors in Malaysia react more drastically to the upturns and positive shocks in China, which is distinct from the common view that investors are more concerned about bad news rather than good ones.

Table 10: Joint Wald tests for the following null hypotheses regarding the spillover effects in the asymmetric spillover model

	$Wald_1$	$Wald_2$	$Wald_3$	$Wald_4$
IN	8.291*	1.233	16.839*	0.260
	(0.004)	(0.267)	(0.000)	(0.610)
ML	0.946	1.929	1.998	0.019
	(0.331)	(0.165)	(0.158)	(0.889)
PH	19.198*	0.083	7.631*	4.066#
	(0.000)	(0.773)	(0.006)	(0.044)
SG	4.322#	0.010	5.025#	1.096
	(0.038)	(0.921)	(0.025)	(0.295)
TH	0.531	0.549	4.856#	4.340#
	(0.466)	(0.459)	(0.028)	(0.037)

Notes:

$H_0^1 : \gamma_1 = \gamma_2$ (no asymmetries to US lagged returns).

$H_0^2 : \delta_1 = \delta_2$ (no asymmetries to Shanghai lagged returns).

$H_0^3 : \phi_1 = \phi_2$ (no asymmetries to US shocks).

$H_0^4 : \psi_1 = \psi_2$ (no asymmetries to Shanghai shocks).

Under the null hypotheses $Wald_1$, $Wald_2$, $Wald_3$, and $Wald_4$ are $\chi^2(1)$ distributed. P-values are in the parentheses*, # and & represent the levels of significance of 1%, 5% and 10% respectively.

5.2. Conditional spillover Model

As analyzed in the two-sub-period unconditional model, the spillover parameters tend not to remain constant over time. Therefore in this section, I investigate the time variation of the Chinese and US spillover intensities with the conditional model. The model specified by equation (14) is applied with two economic instruments: exchange rate changes and the ratio trade/GDP (see Table 11).

I find that the spillover effect can be partly explained by the exchange rate changes and the ratio trade/GDP. However, none of the parameters of these two instruments is significant for Singapore, indicating that the spillover to Singapore from the US and China are dependent on some other factors rather than exchange rate changes and the size of trade.

In the case of Indonesia, the US mean-spillover effect can be explained by trade/GDP: v_2=-19.516 (p-value 0.015). The Shanghai volatility-spillover is strongly driven by the change of the exchange rate IDR/CNY: q_1=11.484 (p-value 0.014). The US volatility-spillover and Chinese mean-spillover are driven neither by trade/GDP nor the exchange rate fluctuations.

As for Malaysia, the Chinese mean-spillover is found to be driven by the fluctuations of the exchange rate MYR/CNY. And the Chinese volatility-spillover is dependent on both the exchange rate changes and the trade to GDP ratio. There is no strong evidence that the US spillover effects in Malaysia are dependent on the trade between US and Malaysia and the exchange rate changes.

When coming to the result of Philippines, only the Chinese volatility-spillover effects can be explained by the two information instruments. As to Thailand, there is mild evidence that the Chinese mean-spillover effect is dependent on the change of the exchange rate THP/CNY.

Summing up, the spillover parameters are not necessarily dependent on the exchange rate changes and the trade to GDP ratio. However, the conditional model is prior to the unconditional model in dealing with the Chinese volatility-spillover effect,

Table 11: Estimated coefficients for the conditional spillover model with full sample period (from Dec 1998 to Dec 2006)

			IN	ML	PH	SG	TH
US Mean-spillover	constant	v_0	1.629*	0.793	0.355	0.870	1.171
			(0.002)	(0.139)	(0.289)	(0.213)	(0.100)
	exchange rate changes	v_1	-122.803	-3.283	63.862	-21.431	7.149
			(0.799)	(0.511)	(0.456)	(0.170)	(0.744)
	trade/GDP	v_2	-19.516*	-1.841	-0.440	-1.771	-5.137
			(0.015)	(0.226)	(0.753)	(0.378)	(0.258)
SH Mean-spillover	constant	p_0	0.088	0.044	0.162	0.167	0.064
			(0.760)	(0.667)	(0.102)	(0.216)	(0.684)
	exchange rate changes	p_1	8.177	-22.007&	5.151	-3.228	-28.919&
			(0.332)	(0.072)	(0.733)	(0.807)	(0.052)
	trade/GDP	p_2	-3.036	-0.034	-0.808	-0.712	-0.340
			(0.615)	(0.946)	(0.362)	(0.178)	(0.842)
US Volatility-spillover	constant	w_0	0.923#	0.102	0.760&	-0.250	0.487
			(0.030)	(0.851)	(0.051)	(0.701)	(0.494)
	exchange rate changes	w_1	-96.754	4.899	24.475	-14.056	-10.605
			(0.834)	(0.133)	(0.782)	(0.286)	(0.662)
	trade/GDP	w_2	-10.590	0.503	-1.493	2.221	-0.353
			(0.107)	(0.740)	(0.311)	(0.236)	(0.935)
SH Volatility-spillover	constant	q_0	-0.294	-0.169&	-0.103	0.009	0.069
			(0.388)	(0.084)	(0.286)	(0.945)	(0.684)
	exchange rate changes	q_1	11.484#	20.915#	32.574*	8.898	-16.860
			(0.014)	(0.050)	(0.000)	(0.549)	(0.297)
	trade/GDP	q_2	9.690	1.372*	1.928#	0.497	1.017
			(0.171)	(0.004)	(0.021)	(0.328)	(0.572)

Note: p-values are in the parentheses *, # and & represent the levels of significance of 1%, 5% and 10% respectively.

as the Chinese volatility spillover parameters are found to be driven by at least one of the two economic instruments in majority of the cases.

Subsequently, the time series of the Chinese volatility-spillover parameter ψ_i for all ASEAN countries are presented in Figure A5. As can be seen, ψ_i fluctuates over time instead of remaining constant for all the ASEAN countries. The fluctuation of the Chinese volatility-spillover parameter is mainly dependent on the variance of the exchange rate changes, because the trade/GDP ratio, the other independent variable for the volatility-spillover, remains constant during the same quarter and is hence much less volatile. This is especially prominent in the case of Indonesia, Malaysia and Philippines, for which the Chinese volatility-spillovers are strongly driven by the exchange rate changes. For example, the path of ψ_{ML}, namely the Shanghai volatility spillover parameter in Malaysia, is generally smooth till July 2005, and becomes highly volatile afterwards. This can be explained by the minor change of exchange rage MYR/CNY till July 2005 and its drastic fluctuations after that. Furthermore, all the Shanghai volatility spillover parameters except that in Thailand are generally increasing overtime.

To access the importance of the US and Chinese volatility-spillover effects on the ASEAN countries, the variance ratios $VR_{i,t}^{US}$, $VR_{i,t}^{SH}$, and $VR_{i,t}^{i}$ are calculated for the conditional model. Table 12 reports the mean and standard deviation of the variance ratios. Compared to the unconditional spillover model, the means and standard deviations of the US variance ratio have a slight increase in all the ASEAN countries. The Means and standard deviations are 2.5%-19.4% and 2.7%-10.6% respectively compared to 1.9% -19.3% and 1.4%-10.2% in unconditional model. This is consistent with the analysis that in none of the ASEAN countries is the US volatility spillover significantly driven by the two economic instruments. The conditional spillover model is not prior to the unconditional model at explaining the US volatility spillover, thus leaving the results almost unaltered. On average, Indonesia is still the least influenced by the US volatility and Singapore is the most.

In contrast, the mean and standard deviation of the Chinese variance ratio increase remarkably compared to the unconditional model. The mean and standard deviation are 2.2%-4.1% and 2.1%-6.4% respectively compared to 0.2%-2.6% and 0.1%-1.9%. This change is partly due to the fact that the Chinese volatility spillover effect is better explained by the conditional model. The greatest changes take place in Malaysia and Philippines, where the Chinese spillover effects are strongly driven by the change of the exchange rate and the trade as a ratio to GDP. Malaysia is found most influenced by the volatility in the Chinese market (mean of 4.1%) in stead of Singapore; and Thailand, instead of Philippines, is the least influenced by the Chinese spillover in the conditional model (mean of 2.2%).

Similar to the unconditional model, the pure local variance ratio stay substantial (means around 90%), and Singapore is still an exception (mean of 77.3%).

Table 12: Variance Ratios-Conditional Spillover Model

	VR^{US}		VR^{SH}		VR^{i}	
	Mean	Stdev.	Mean	Stdev.	Mean	Stdev.
IN	0.025	0.027	0.023	0.029	0.952	0.039
ML	0.086	0.058	0.041	0.064	0.873	0.077
PH	0.076	0.053	0.030	0.043	0.894	0.061
SG	0.194	0.106	0.032	0.038	0.773	0.094
TH	0.076	0.058	0.022	0.021	0.902	0.059
Min	0.025	0.027	0.022	0.021	0.773	0.039
Max	0.194	0.106	0.041	0.064	0.952	0.094

To investigate how the importance of the US and the Chinese volatility-spillover in the ASEAN country *i* varying over time in the conditional model, the time series of the variance ratios are plotted in Figure A6. The US volatility-spillover effect is still generally greater than the Chinese volatility-spillover in all ASEAN countries. Compared to the unconditional model, the evolutions of the US variance ratios are almost unaltered. The paths of the Chinese variance ratios become more volatile than in the unconditional model, mainly due to the variation of the Chinese spillover effect parameter ψ_i, which is in turn driven by the fluctuation of the exchange rates. The

Chinese variance ratio appears to increase in all countries except in Philippines. This rising trend becomes more remarkable after the year 2002.

6. Conclusion

This paper has investigated how the volatility and mean in the US and the Chinese (Shanghai) stock markets transmit to the five main markets in ASEAN. I have applied a GARCH model that allows mean and volatility spillover from the US and the Chinese markets into the individual ASEAN countries. Both the US mean and volatility spillover effects have appeared to be essential. The Chinese volatility spillover effect has been rather weak in ASEAN before China entered WTO, but has increased remarkably after China entered WTO. In comparison, the Chinese mean spillover has appeared to be almost negligible over time. For all ASEAN countries, own country effects are strong. Only Singaporean market, which is the developed stock market in ASEAN, has appeared to be affected by less pure local effect.

I have found the existence of asymmetries in the returns of the ASEAN stock markets to upturns and downturns as well as positive and negative shocks in the US and the Chinese stock markets. Greater reactions to the US downturns and negative shocks are found in all ASEAN markets. Strong evidence of asymmetric response to negative Chinese shocks is found in most of the ASEAN countries: Philippines, Singapore, and Thailand. However, investors in Malaysia have appeared to be good-news-chasing, reacting more drastically to the positive shocks in Chinese market.

All spillover effects are not necessarily dependent on the economic instruments (i.e. exchange rate changes and the ratio trade/GDP), but regarding the Chinese volatility-spillover effect, conditional model has appeared to be prior to the unconditional model. The variation of the importance of the Chinese volatility spillover effects has been mainly dependent on the fluctuation of exchange rate.

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Appendix

Figure A1: Indices

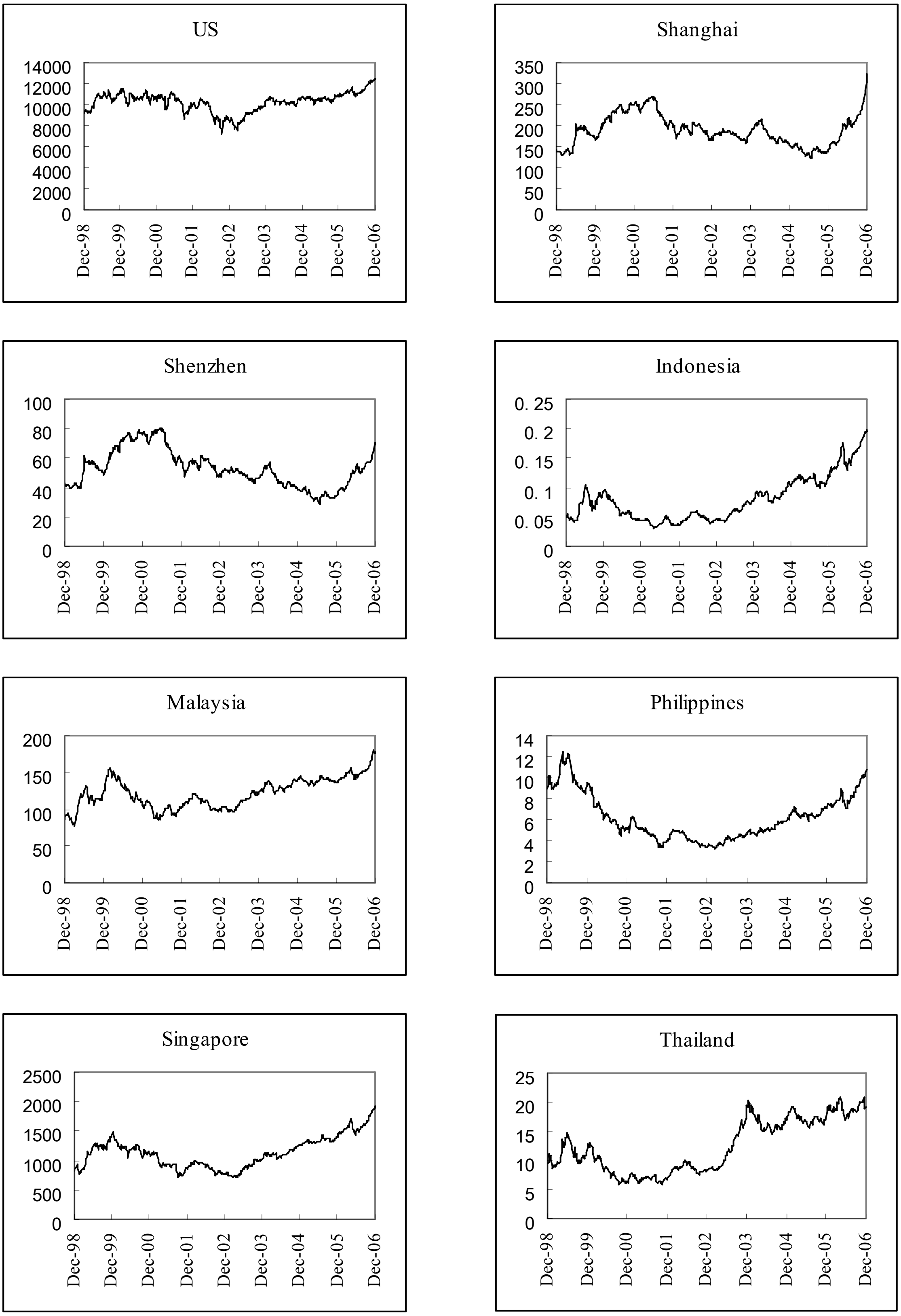


Figure A2: Squared returns

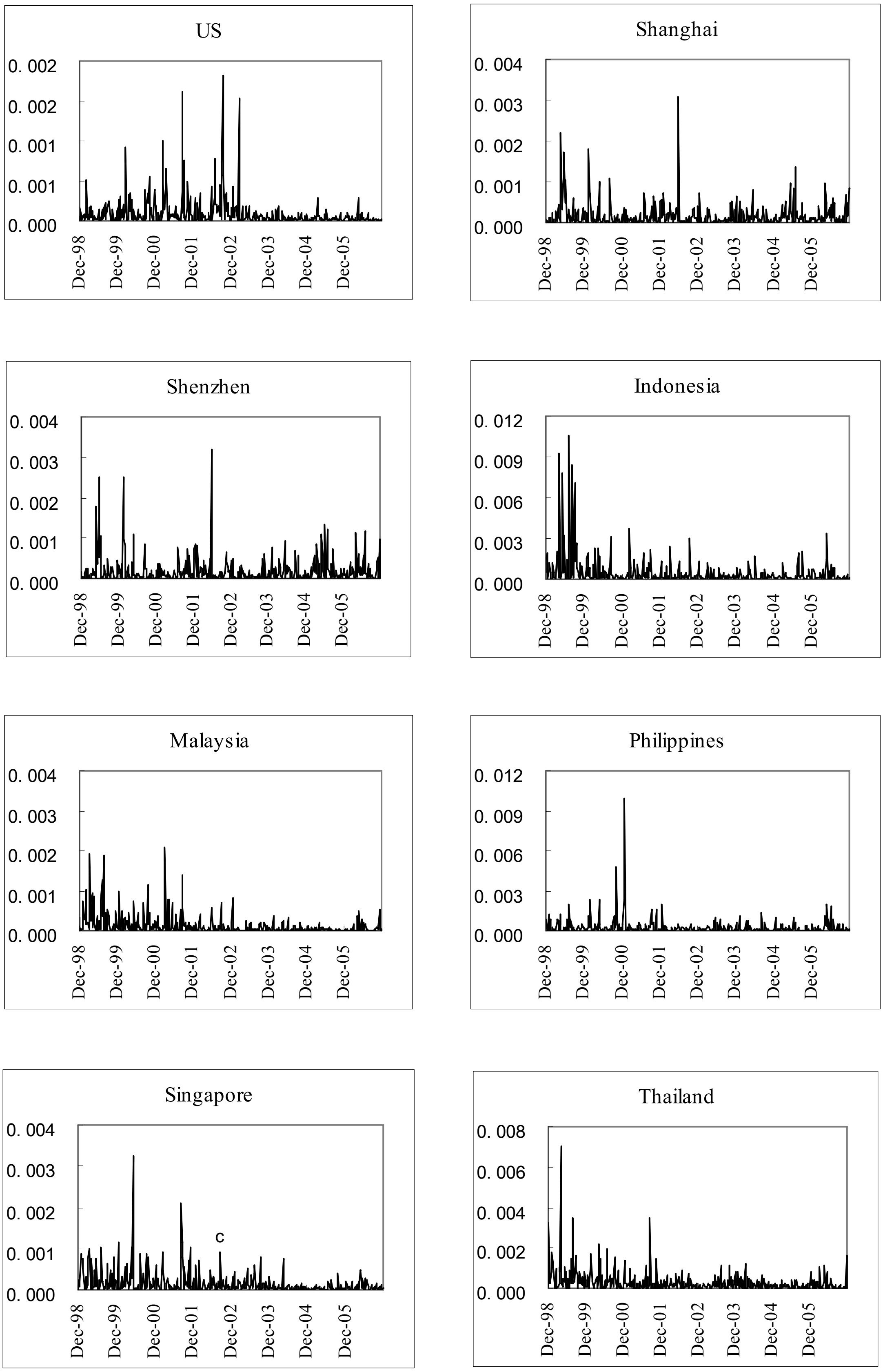
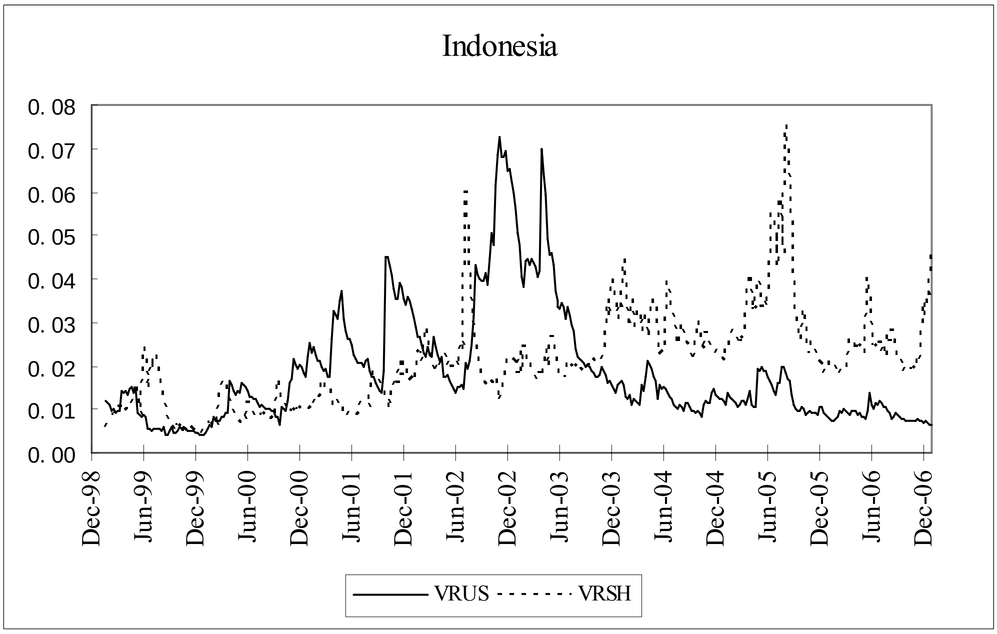
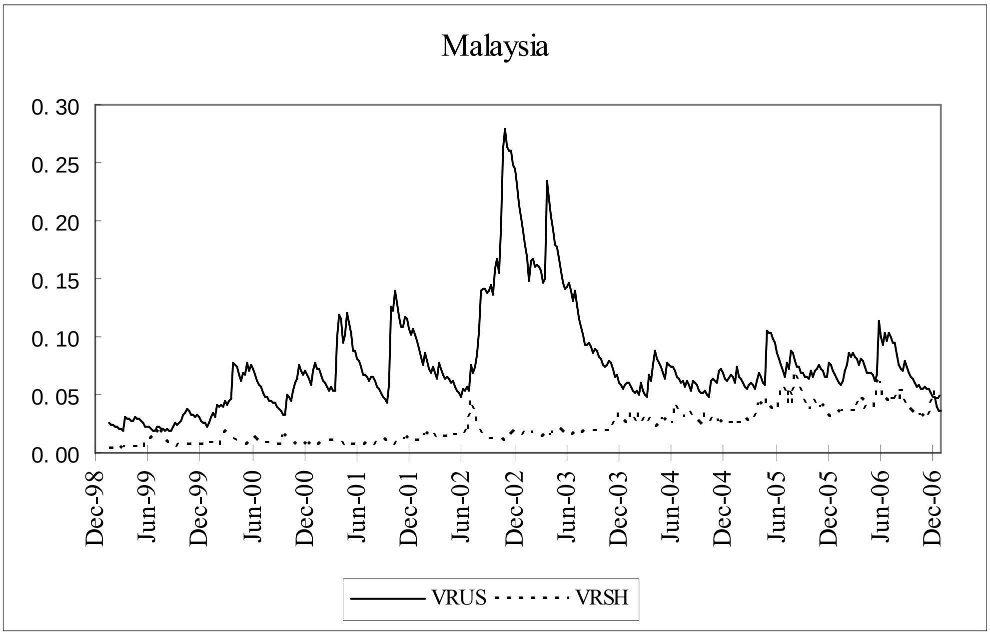
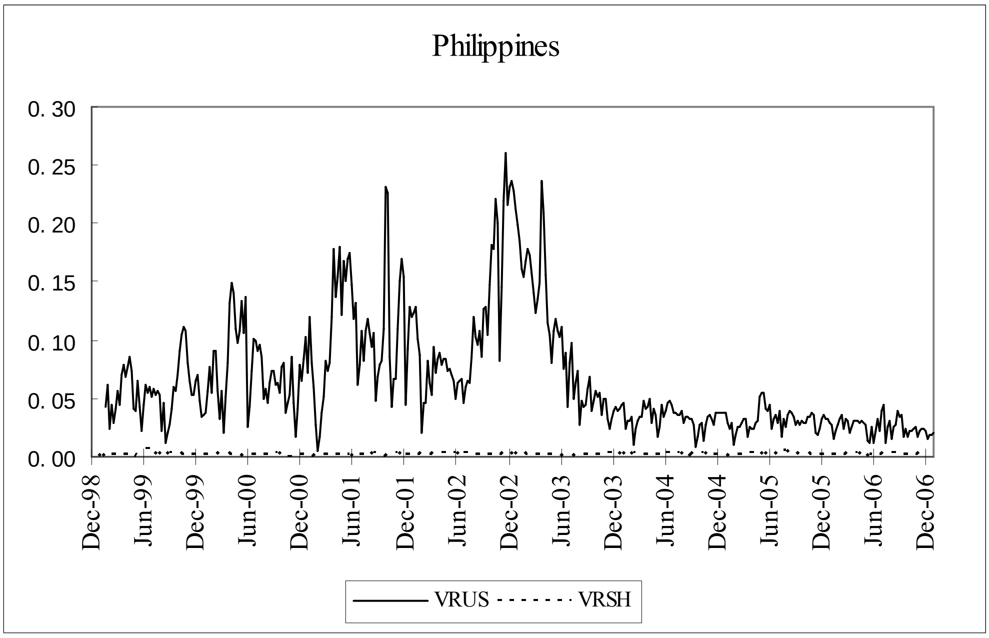


Figure A3: Variance Ratios in the symmetric unconditional spillover model (from Dec 1998 to Dec 2006)



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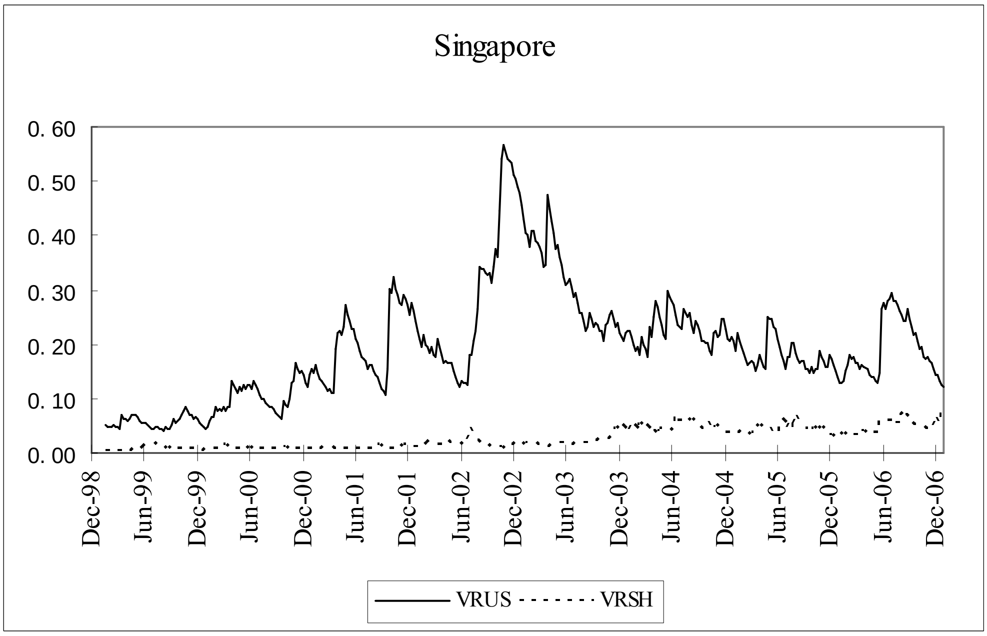
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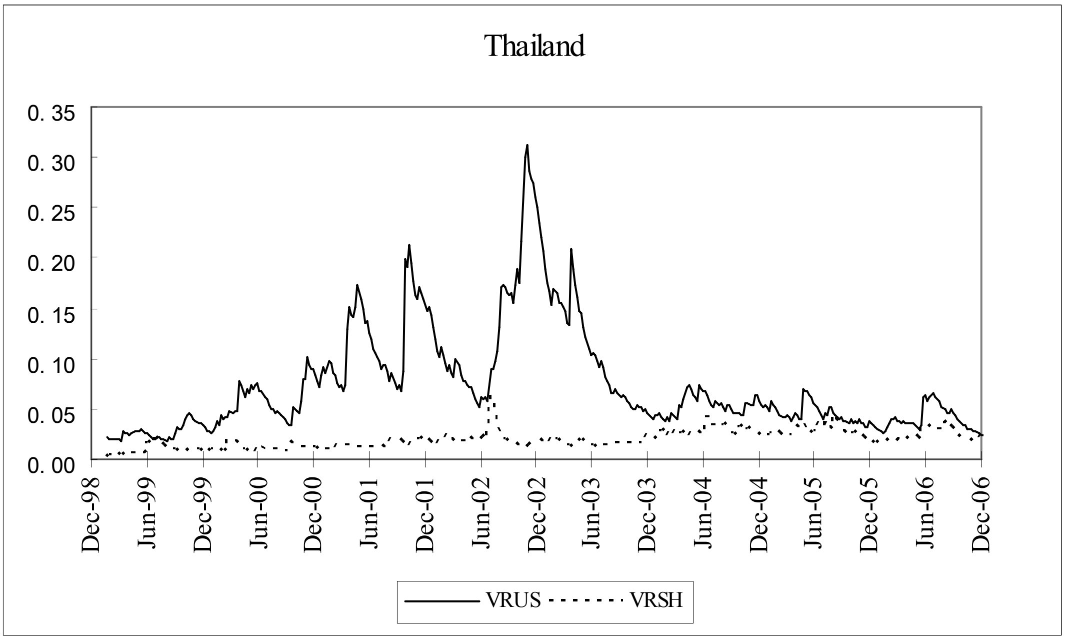
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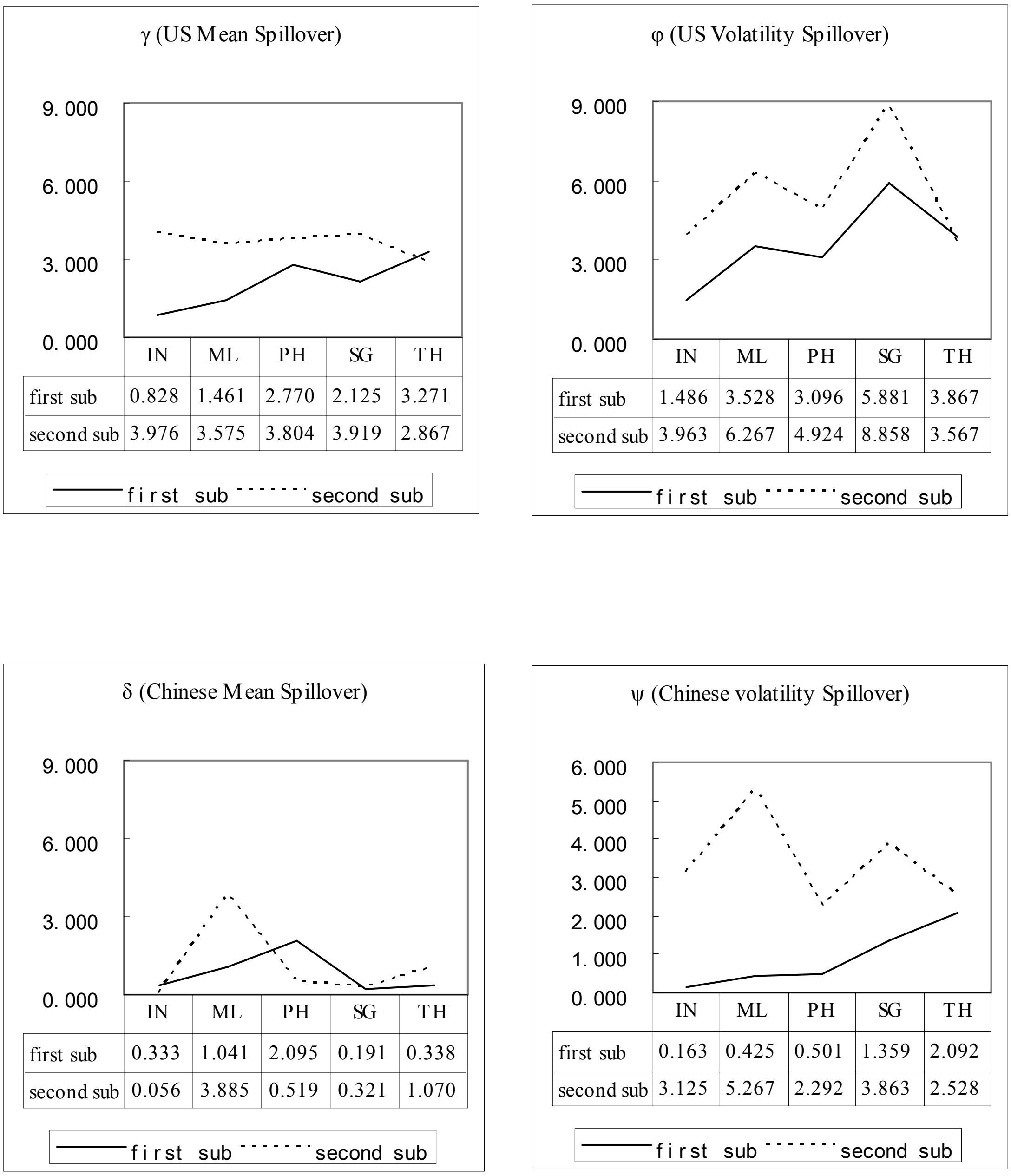
Figure A4: Absolute values of the z-statistics for the spillover parameters



γ (US Mean Spillover)

	IN	ML	PH	SG	TH
first sub	0.828	1.461	2.770	2.125	3.271
second sub	3.976	3.575	3.804	3.919	2.867

φ (US Volatility Spillover)

	IN	ML	PH	SG	TH
first sub	1.486	3.528	3.096	5.881	3.867
second sub	3.963	6.267	4.924	8.858	3.567

δ (Chinese Mean Spillover)

	IN	ML	PH	SG	TH
first sub	0.333	1.041	2.095	0.191	0.338
second sub	0.056	3.885	0.519	0.321	1.070

ψ (Chinese volatility Spillover)

	IN	ML	PH	SG	TH
first sub	0.163	0.425	0.501	1.359	2.092
second sub	3.125	5.267	2.292	3.863	2.528

Figure A5: Time series of volatility spillover effect ψ_i

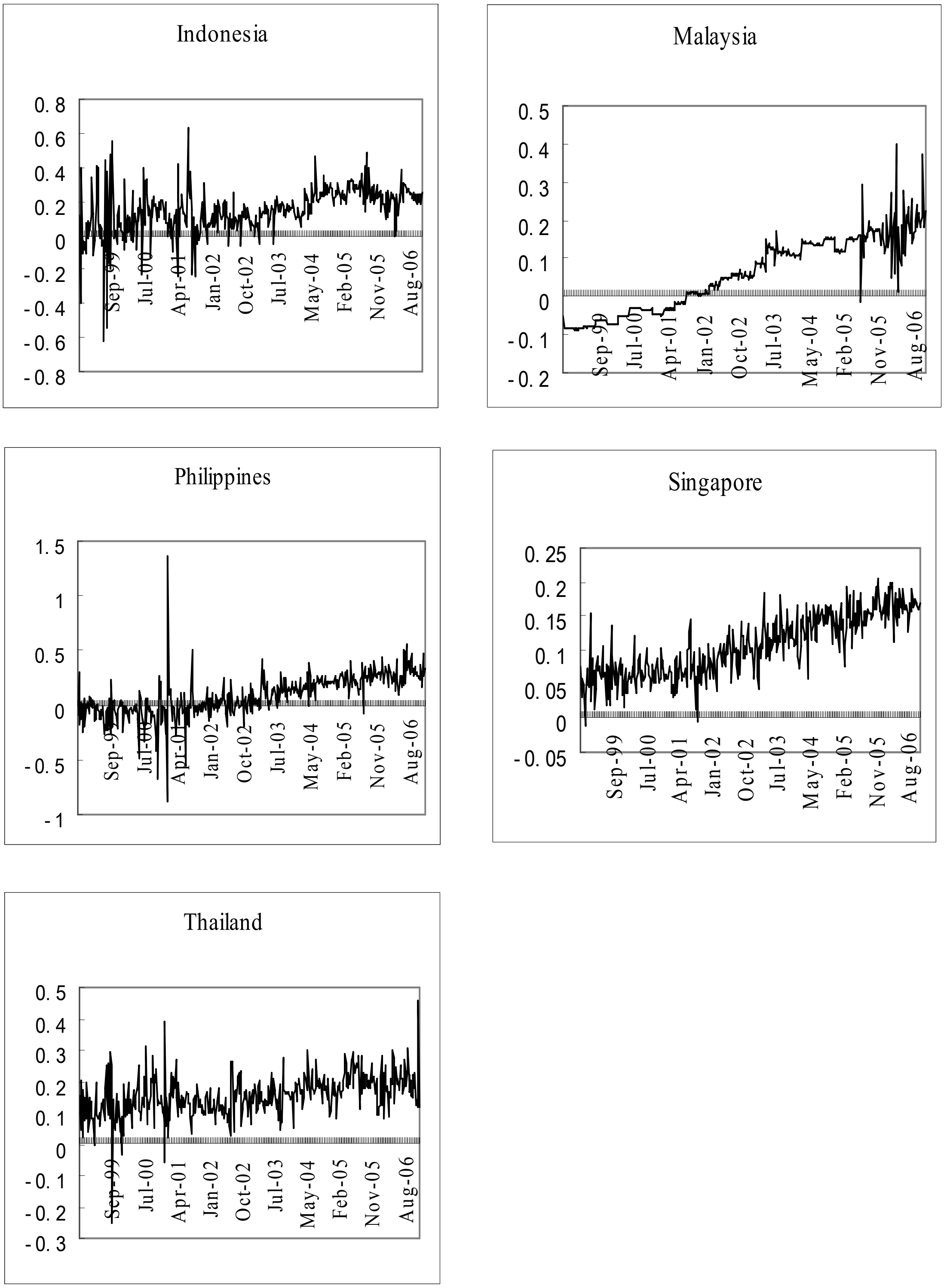
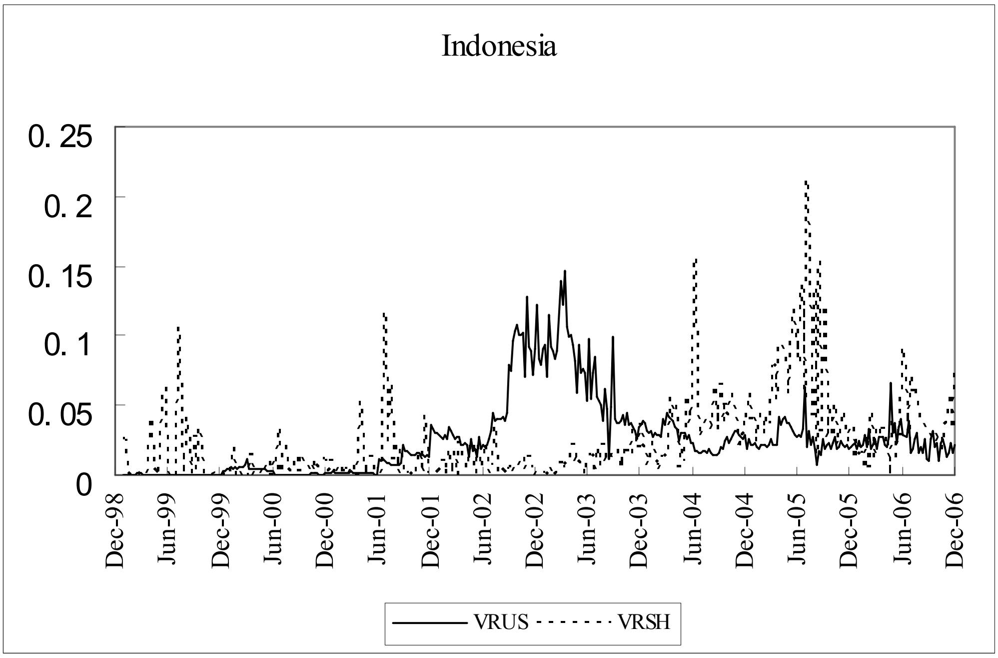
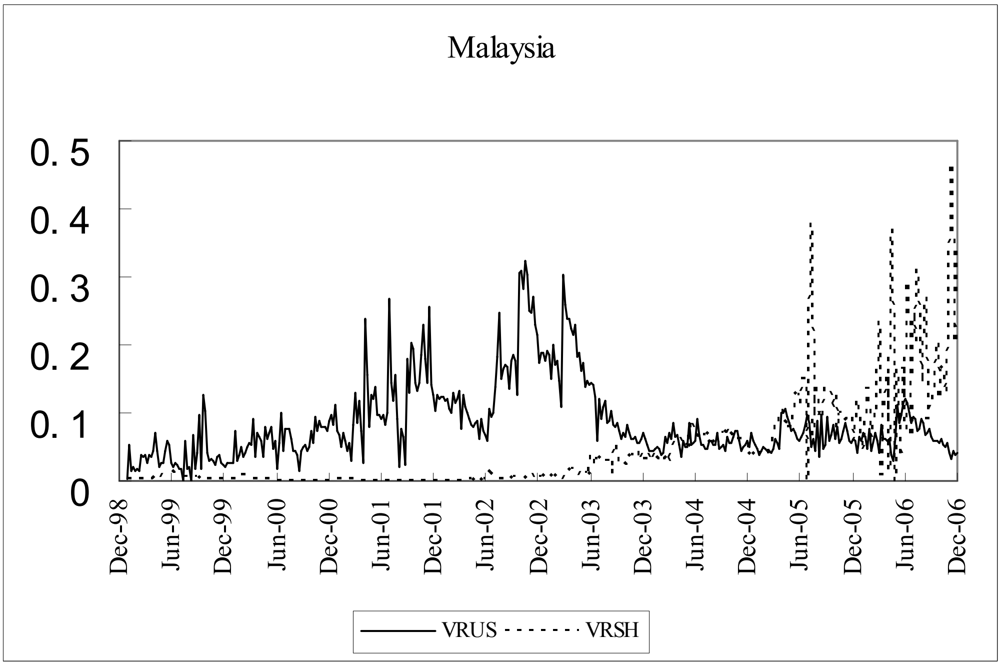
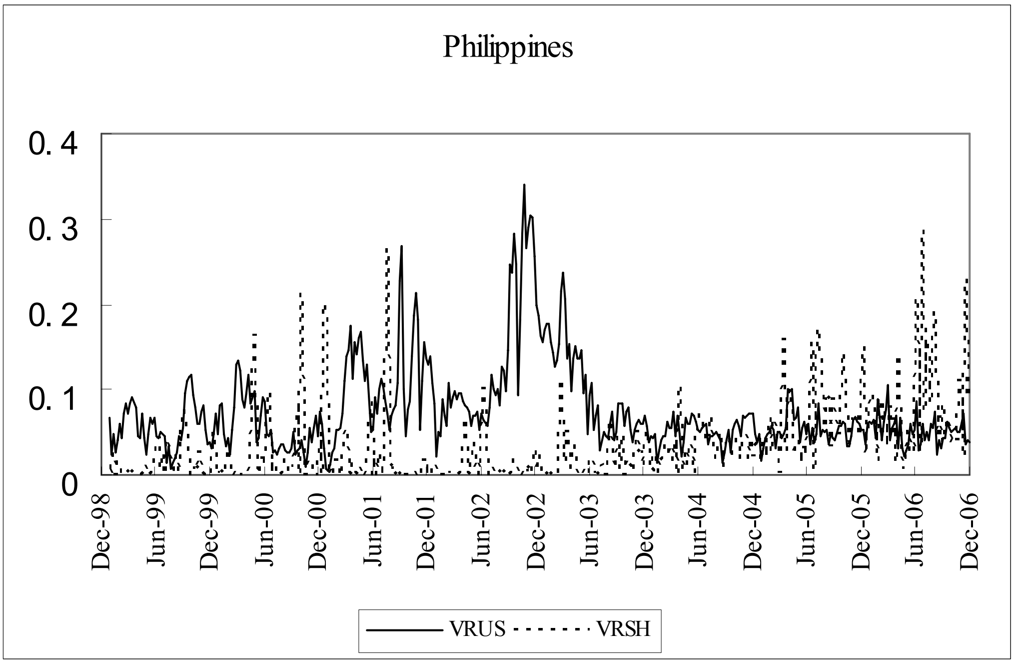


Figure A6: Variance Ratios in the conditional spillover model (from Dec 1998 to Dec 2006)



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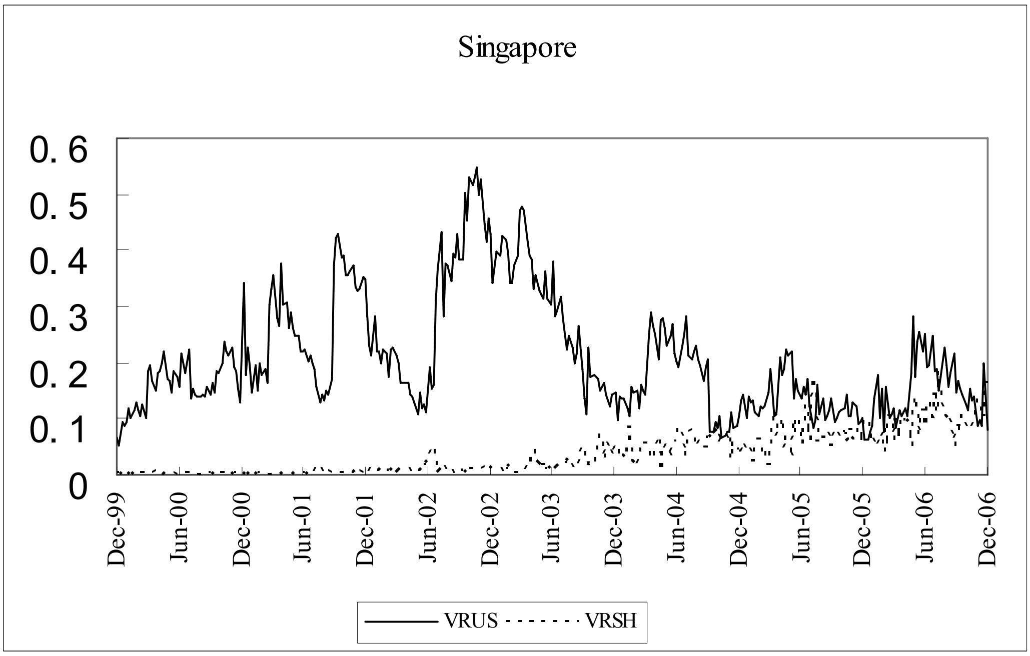
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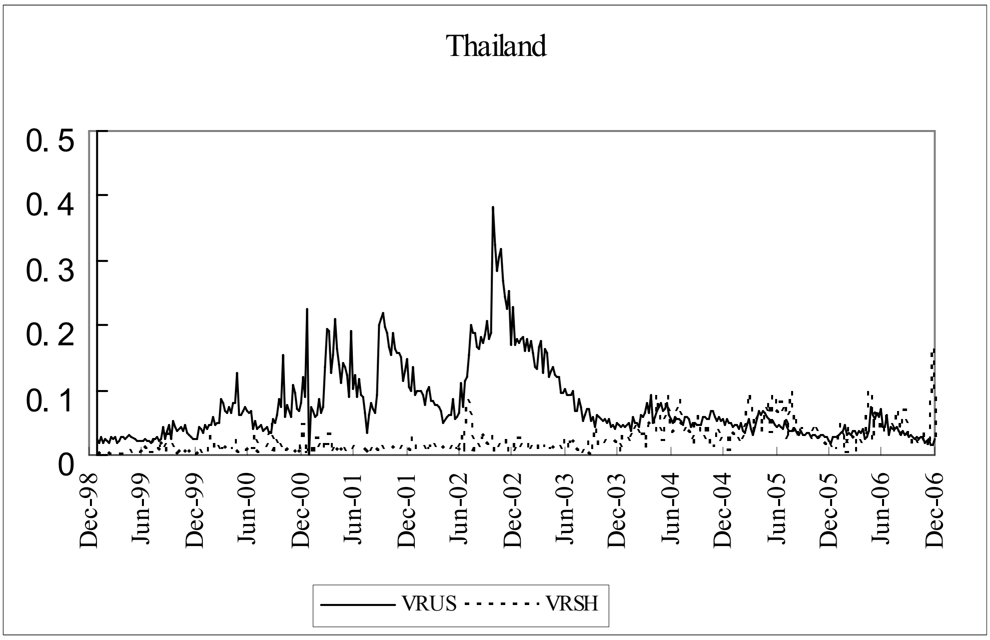
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