Chapter 5

Modeling the volatility spillover and conditional correlations between ASEAN, Europe, and the USA in forecasting Value-at-Risk

This chapter explore the volatility spillover and conditional correlations between ASEAN, Europe, and the USA by using only the VARMA-AGARCH model of McAleer, M., et al. (2009), which have volatility spillover and asymmetric effect and can be used to estimate the covariance matrix. Then test for change in the correlation between ASEAN and Europe and between ASEAN and the USA following the Asian economic crisis. In this chapter focus on five countries in ASEAN, namely, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Moreover, this chapter use the 'rolling windows' approach to examine the time-varying nature of the conditional correlation and use a Value-at-Risk (VaR) threshold for a portfolio, which includes countries in ASEAN, Europe and the USA to examine the effects from the Asian crisis to Value-at-Risk. This chapter is a revised version from the original paper of Kunsuda Ninanussornkul, Chia-Lin Chang, Michael McAleer, and Songsak Sriboonchitta; presented at the Sixth International Conference on Business and Information 2009, Kuala Lumpur, Malaysia in Appendix B in 5 – 6 January 2009.

Abstract

This paper will explore the volatility spillover and conditional correlations between ASEAN, Europe, and the USA by using the VARMA-AGARCH model of McAleer, M., et al. (2009), which can be used to estimate the covariance matrix. It is used to test for change in the correlation between ASEAN and Europe and between ASEAN and the USA following the Asian economic crisis. This paper focuses on five countries in ASEAN, namely, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Moreover, we use the 'rolling windows' approach to examine the time-varying nature of the conditional correlation. We also use a Value-at-Risk (VaR) threshold for a portfolio, which includes countries in ASEAN, Europe and the USA to examine the effects from the Asian crisis to Value-at-Risk. The results show negative volatility spillover from the USA to Indonesia, while evidence of positive volatility spillovers is found from the USA to the Philippines. The calculated conditional correlations between ASEAN countries and Europe after the Asian crisis are significantly higher than before the Asian crisis, except for Malaysia, which after the Asian crisis has significantly lower correlations than before the crisis. The calculated conditional correlations between ASEAN countries and the USA are insignificant. Moreover, we found all the conditional correlations display significant variability. Finally, the results do not appear to be show a direct relationship between the sample size and the number of violations, which suggests that adjusting for the Asian crisis may not be important.

Keywords: volatility spillover, conditional correlation, Value-at-Risk

5.1 Introduction

International stock markets have had increasing interaction with one another during the past decade. Shocks in one stock market or in one region are very likely to transmit disturbances to other market and regions (for example, the Asian crisis in 1997 that started in Thailand and spread out to the entire region). The behavior of the financial economy has produced negative shocks in the real economy. For example, Korea, Indonesia, and Thailand experienced negative GDP growth rates throughout the period 1997-1998. This effect on the real GDP later transferred to the most important Latin American economies. Although European countries and the United States are those that best adjusted to the effects of the Asian crisis, forecasts of their real growth were revised downwards. (see Fernández-Izquierdo, Á. and Lafuente, J. A. (2004))

Another good example is 9 September 2001. The 9-11 terrorist attacks on the USA affected most world stock markets because the USA is the most influential economy in the world, and most countries have some links with the USA.

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 to be 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 enables the investors to shift to investments of high risk and expected returns without altering the overall risks of their portfolios. Moreover, understanding the volatility and mean spillover also helps the policy makers better evaluate the regulatory proposals, and supervise and restrict the international cash flows, thus protecting national markets and economies from international shocks. (see Liu, L. (2007))

Many papers have studied volatility spillover in several regions, so we classify those we have studied by region. The first group is papers that studied volatility spillover among Asia, Europe, and the USA. For example, Theodossiou, P. and Lee, U. (1993) and Ramchand, L. and Susmel, R. (1998) used weekly data of major stock markets. Santis, G. D. and İmrohoroğlu, S. (1997) also used weekly data, but they studied volatility in emerging financial markets. Moreover, Fernández-Izquierdo, Á. and Lafuente, J. A. (2004) and Sharkasi, A., et al (2004) studied international transmission by using daily data from Europe, America, and Asia. Alternately, Fernández-Izquierdo, Á. and Lafuente, J. A. (2004) were also interested in empirical evidence from the Asian crisis.

The second group of papers studied volatility spillover between Pacific-Asia and the USA. For example, Kim, S.W. and Rogers, J.H. (1995), Ng, A. (2000), Miyakoshi, T. (2003), Lee, S.J. (2006) and Liu, L. (2007) used daily data, except for Ng, A. (2000) who used weekly data. All were interested in the differences among countries in Pacific-Asia. Third, Forte, G. and Manera, M. (2004) and Chai, H. and Rhee, Y. (2005) were interested to study volatility spillover between Asia and Europe, but Forte, G. and Manera, M. (2004) used weekly data, while Chai, H. and Rhee, Y. (2005) used daily data.

Fourth, Booth, G.G., et al (1997) and Baur, D. and Jung, R.C. (2006) studied volatility linkages between Europe and the USA, but Booth, G.G., et al (1997) used daily data, while Baur, D. and Jung, R.C. (2006) used intraday data. Finally, In, F., et al (2001) and da Veiga, B., et al. (2008) studied volatility transmission in Asia, and used daily data, but In, F., et al (2001) were interested in effects from the Asian crisis, while da Veiga, B., et al. (2008) were interested in effects from the B share market reform.

This paper would like to find out about volatility spillover and conditional correlations between ASEAN and Europe, and ASEAN and the USA, by using the vector autoregressive moving average asymmetric generalize autoregressive conditional heteroskedasticity (VARMA-AGARCH) model of McAleer, M., et al. (2009), which can be used to estimate the covariance matrix. It is used to test for a change in the correlation between ASEAN and Europe and between ASEAN and the USA following the 1997 Asian economic crisis. This paper uses five countries in ASEAN, namely, Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Moreover, we use the rolling windows approach to examine the time-varying nature of the conditional correlation. Finally, we use a Value-at-Risk (VaR) threshold for a portfolio, which include countries in ASEAN, Europe, and the USA to examine effects from the Asian crisis to Value-at-Risk.

The organization of this paper is as follows: section 5.2 presents model and test statistics for testing differences in correlations, and section 5.3 shows the data and estimations. Empirical results, Value-at-Risk, and conclusions are in sections 5.4, 5.5, and 5.6, respectively.

5.2 Model and test statistics for testing differences in correlations

This paper use stock price indices of Indonesia, Malaysia, the Philippines, Singapore, Thailand, Europe and the USA. We compute the returns of each country follows:

$$R_{i,t} = 100 \times \log(P_{i,t} / P_{i,t-1}) \tag{5.1}$$

where $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of country i (i = 1, 2, 3) at days t and t-1, then we use the vector autoregressive moving average asymmetric generalize autoregressive conditional heteroskedasticity (VARMA-AGARCH) model of McAleer, M., et al. (2009) to find out returns and volatility spillover from Europe and the USA to ASEAN countries. Analyses of the samples before and after the Asian crisis are examined. This paper also investigates whether the spillover of volatility was affected by the Asian crisis.

VARMA-AGARCH

The VARMA-AGARCH model of McAleer, M., et al. (2009) assumes asymmetric impacts of positive and negative shocks of equal magnitude. Let the vector of returns on m (≥ 2) financial assets is given by:

$$Y_t = E(Y_t \mid F_{t-1}) + \varepsilon_t \tag{5.2}$$

$$\varepsilon_t = D_t \eta_t \tag{5.3}$$

$$H_t = \omega + \sum_{k=1}^{p} A_k \vec{\varepsilon}_{t-k} + \sum_{k=1}^{p} C_k I_{t-k} \vec{\varepsilon}_{t-k} + \sum_{l=1}^{q} B_l H_{t-l} \tag{5.4}$$

where $H_t = (h_{1t},...,h_{mt})'$, $\omega = (\omega_1,...,\omega_m)'$, $D_t = diag(h_{i,t}^{1/2})$, $\eta_t = (\eta_{1t},...,\eta_{mt})'$, $\vec{\varepsilon}_t = (\varepsilon_{1t}^2,...,\varepsilon_{mt}^2)'$, A_k and B_l are $m \times m$ matrices with typical elements α_{ij} and β_{ij}, respectively, for i,j=1,…,m, I(η_t)=diag(I(η_{it})) is an $m \times m$ matrix, and F_t is the past information available to time t. C_k are $m \times m$ matrices for k = 1,…,p and I_t = diag(I_{1t},…,I_{mt}), so that $I = \begin{cases} 0, \varepsilon_{k,t} > 0 \\ 1, \varepsilon_{k,t} \le 0 \end{cases}$.

Spillover effects are given in the conditional volatility for each asset in the portfolio, specifically where A_k and B_l are not diagonal matrices. Based on equation (5.3), the VARMA-AGARCH model also assumes that the matrix of conditional correlations is given by $E(\eta_t \eta_t') = \Gamma$.

Test statistics for testing differences in correlations

This paper would like to test whether the Asian crisis affected conditional correlation between ASEAN countries and Europe and the USA. Therefore, we estimate the VARMA-AGARCH model for the entire sample, the sub-sample before the Asian crisis (5 January 1988 to 27 December 1996), and the sub-sample after the crisis (5 January 1998 to 13 March 2009) to find out conditional correlation matrices between ASEAN countries, Europe, and the USA. Let ρ_1 and ρ_2 be the correlations from the after and before Asian crisis period, respectively. The test statistic for testing differences in correlations is then given by

$$Z = \frac{\rho_1 - \rho_2}{S.E.} \tag{5.5}$$

$$S.E. = \sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}} \tag{5.6}$$

where n_1 and n_2 are sample sizes used to calculate ρ_1 and ρ_2, respectively.

5.3 Data and Estimation

5.3.1 Data

The data used in the paper is the daily closing stock price indices of Indonesia, Malaysia, the Philippines, Singapore, Thailand, Europe, and the USA. All the data was obtained from the DataStream and the sample ranges from 5/1/1988 up to 13/3/2009 with 4,916 observations. The normality of the variables and the descriptive statistics for the returns of stock indices are given in Table 5.1 because two characteristics of the data, namely normality and stationary, will be investigated before the estimate. Normality is an important issue in estimation since it is typically assumed in the maximum likelihood estimation (MLE) method; otherwise, the quasi-MLE (QMLE) method should be used. All series have similar means and medians, which are close to zero, minima that range between -43.081 and -9.514, and maxima which vary between 10.698 and 44.515. The three standard deviations vary between 1.143 and 2.786. The skewness differs among all series, and the kurtosis that range between 10.660 and 67.539, this is a high degree of kurtosis, so it would seem to indicate the existence of extreme observations. The Jarque-Bera test strongly rejects the null hypothesis of normally distributed returns.

Stationarity is an important characteristic for time series data. If data is nonstationary, it will be necessary to differencing data before estimation because if the data is not differenced, the result is spurious regression. To test stationarity of data, this paper uses the Augmented Dicky Fuller (ADF) test. The test is given as follows:

$$\Delta y_t = \theta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{5.7}$$

$$\Delta y_t = \alpha + \theta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{5.8}$$

$$\Delta y_t = \alpha + \beta t + \theta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{5.9}$$

where equation (5.7) has no intercept and trend, equation (5.8) has intercept but no trend, and equation (5.9) has intercept and trend. The null hypothesis in equation (5.7), (5.8) and (5.9) are $\theta = 0$, which means that y_t is nonstationary (Dickey and Fuller, 1979). However, the ADF test accommodates serial correlation by explicitly modeling the structure of serial correlation, but not heteroscedasticity, while the Phillips-Perron (PP) tests accommodates both serial correlation and heteroscedasticity using non-parametric techniques. The PP test has also been shown to have higher power in finite samples than the ADF test (Phillips and Perron, 1988).

The PP test estimates as follows:

$$\Delta y_t = \theta y_{t-1} + x_t' \delta + \varepsilon_t \tag{5.10}$$

the test is evaluated using a modified t-ratio of the form:

$$\hat{t}_\alpha = t_\alpha \left(\frac{\gamma_0}{f_0} \right)^{1/2} - \frac{T\left(f_0 - \gamma_0\right)\left(se(\hat{\alpha})\right)}{2 f_0^{1/2} s}$$

where $\hat{\alpha}$ is the estimate, t_α is the t-ratio of $\hat{\alpha}$, $se(\hat{\alpha})$ is the standard error of $\hat{\alpha}$, and s is the standard error of the regression. In addition, γ_0 is a consistent estimate of the error variance in (5.10). The remaining f_0 is an estimator of the residual spectrum at frequency zero. The PP test is known as the non-augmented Dickey-Fuller test. The results of test stationary by using ADF test and PP test in Table 5.2 show that all the returns are stationary at the 1% level.

5.3.2 Estimation

The parameters in models (5.4) can be obtained by maximum likelihood estimation (MLE) using a joint normal density, as follows:

$$\hat{\theta} = \arg\min_{\theta} \frac{1}{2}\sum_{t=1}^{n}(\log|Q_t| + \varepsilon_t' Q_t^{-1}\varepsilon_t) \tag{5.11}$$

where θ denotes the vector of parameters to be estimated in the conditional log-likelihood function, and $|Q_t|$ denotes the determinant of Q_t, the conditional covariance matrix. When η_t does not follow a joint normal distribution, equation (5.11) is defined as the Quasi-MLE (QMLE).

5.4 Empirical Results

5.4.1 Returns, volatility spillover, and testing differences in correlations

Tables 5.3 and 5.4 give the estimated parameter of the VARMA-AGARCH model for the entire sample. Evidence of returns spillover is found from EU and USA to IND, PHI, SNG and THA, indicating that past returns of EU and USA affect future returns of IND, PHI, SNG and THA. Returns spillover also exists from USA to MAL, which indicates that past returns of USA affect future returns to MAL. In conditional variance equation, the results show negative volatility spillover from USA to IND. Moreover, evidence of negative volatility spillover is found from EU to SNG and THA. Table 5.4 also shows a positive effect of shock or news from USA to IND, MAL, SNG, and THA. Furthermore, it has positive effect of shock or news from EU to SNG, however, shock or news from EU has a negative effect to MAL. The VARMA-AGARCH model shows PHI and SNG have an asymmetric effect.

The sub-sample before the Asian crisis (5 January 1988 to 27 December 1996) is estimated by using the VARMA-AGARCH model as shown in Tables 5.5 and 5.6. Evidence of returns spillover is found from EU and USA to MAL, PHI, SNG and THA, indicating that past returns of EU and USA affect future returns of MAL, PHI, SNG and THA. For returns spillover from EU to IND, the result indicates that past returns of EU affect future returns to IND. Table 5.6 contains the results for the conditional variance equation. The results show evidence of positive volatility spillover from EU to PHI, and negative effect of shocks or news from EU to IND and PHI. Moreover, positive affect to SNG from shocks or news of USA is also shown. Furthermore, the VARMA-AGARCH model shows MAL and SNG have a significantly asymmetric effect.

The results for the sub-sample after the Asian crisis (5 January 1998 to 13 March 2009) are quite different. The results for the conditional mean equation can be found in Table 5.7. The results suggest that IND, MAL and PHI returns are positively affected by past returns of EU and USA. Moreover, SNG and THA returns are positively affected by past returns of USA. The results of positive effect of shocks or news from USA to PHI and SNG and positive affect to SNG of shocks or news from EU are shown in Table 5.8. The VARMA-AGARCH model shows SNG has a significantly asymmetric effect.

Tables 5.9 – 5.11 give the conditional correlation for the entire sample and sub-sample before and after Asian crisis, respectively. As can be seen, the calculated conditional correlations between ASEAN countries and EU after the Asian crisis are significantly higher than before the crisis, except for MAL, which after the Asian crisis has significantly lower correlations than before the crisis. However, the calculated conditional correlations between ASEAN countries and USA are insignificant. Because trading times of stock market in ASEAN and USA are not overlaps as EU. Moreover, only MAL is less affected by EU and USA after the crisis, which can be attributed to the success of its capital and currency controls. The results same Tan and Tse (2002) in Click, R., et al (2005), which examine the linkages among U.S., Japan, and seven Asian stock markets including Malaysia, the Philippines, Singapore, and Thailand. The test for differences in correlations between samples is shown in Table 5.12.

5.4.2 Correlation dynamics

The VARMA-AGARCH model, as with all the nested variations, imposes the assumption of constant conditional correlations. In the constant conditional correlation framework, Γ is the constant conditional correlation matrix of the standardized shocks, η_t, which are assumed to be either a vector of independently and identically distributed (iid) random variables, or a martingale difference process. However, in the dynamic conditional correlation framework proposed by Engle

(2002), the conditional correlation matrix, Γ, is no longer constant, but follows a restricted multivariate GARCH (1,1) specification.

Using the 'rolling windows' approach, we can examine the time-varying nature of the conditional correlation using the VARMA-AGARCH model. Rolling windows is a recursive estimation procedure whereby the model is estimated for a restricted sample, then re-estimated by adding one observation to the end of the sample and deleting one observation from the beginning of the sample. The process is then repeated until the end of the sample. If the rolling conditional correlations are found to vary substantially over time, the assumption of constant conditional correlations may be too restrictive. In order to strike a balance between efficiency in estimation, and a viable number of rolling regressions, the rolling window size is set at 1,000.

Figure 5.1 - 5.10 plots the dynamic paths of the conditional correlation matrices for the VARMA-AGARCH model using rolling windows. All the conditional correlations display significant variability. These results suggest that the assumption of constant conditional correlations may not be valid.

5.5 Value-at-Risk

Value-at-Risk (VaR) needs to be provided to the appropriate regulatory authority at the beginning of the day, and is then compared with the actual returns at the end of the day. (see McAleer, M. (2008a))

For purposes of the Basel II Accord penalty structure for violations arising from excessive risk taking, a violation is penalized according to its cumulative frequency of occurrence in 250 working days, which is given in Table 5.13.

A violation occurs when VaR_t > negative returns at time *t*. Suppose that interest lies in modeling the random variable Y_t, which can be decomposed as follows: (see McAleer, M. and da Veiga, B. (2008a))

$$Y_t = E(Y_t \mid F_{t-1}) + \varepsilon_t \tag{5.12}$$

This decomposition suggests that Y_t is comprised of a predictable component, $E(Y_t \mid F_{t-1})$, which is the conditional mean, and a random component, ε_t. The variability of Y_t, and hence its distribution, is determined entirely by the variability of ε_t. If it is assumed that ε_t follows a distribution such that:

$$\varepsilon_t \sim D(\mu_t, \sigma_t) \tag{5.13}$$

where μ_t and σ_t are the unconditional mean and standard deviation of ε_t, respectively. The VaR threshold for Y_t can be calculated as:

$$VaR_t = E(Y_t \mid F_{t-1}) - \alpha\sigma_t$$

where α is the critical value from the distribution of ε_t to obtain the appropriate confidence level. Alternatively, σ_t can be replaced by alternative estimates of the conditional variance to obtain an appropriate VaR.

In order to simplify the analysis, we assumed that the portfolio returns are equal weights and constant over time. $E(Y_t \mid F_{t-1})$ is the expected returns for all models and α is the critical value from the distribution of ε_t to obtain the appropriate confidence level of 1%. This paper constructs portfolio returns of each country in ASEAN with Europe and the USA, and in order to eliminate exchange rate risk, all returns are converted to US dollars.

In order to examine the impact of the Asian crisis, the VaR thresholds for the period 3 January 2007 to 13 March 2009 are forecasted using observation from the previous year, 2006, and the number of violations is recorded. The sample is then expanded by adding observations from next previous year, 2005, to the beginning of the sample (1988), and again the VaR threshold for the period 3 January 2007 to 13 March 2009 is forecasted. This process is repeated until the beginning of the sample is reached. The results in Table 5.14 do not appear to show a direct relationship between sample size and the number of violations, which suggests that adjusting for the Asian crisis may not be important.

5.6 Conclusion

Interaction between international stock markets and other stock markets have increased during the past decade. Shocks in one stock market or in one region are very likely to transmit to other market and regions. This paper uses the VARMA-AGARCH model of McAleer, M., et al. (2009) to provide more information about volatility spillover and conditional correlations between ASEAN, Europe, and the USA. We also test the changes from the 1997 Asian crisis the find the affect to the correlation between ASEAN and Europe, and between ASEAN and the USA. This paper used five countries in ASEAN, namely, Indonesia, Malaysia, the Philippines, Singapore, and Thailand.

Evidence of returns spillover is found from EU and USA to IND, PHI, SNG and THA. Returns spillover also exists from USA to MAL. The results show negative volatility spillover from USA to IND. Moreover, evidence of negative volatility spillover is found from EU to SNG and THA. The results also show a positive effect of shock or news from USA to IND, MAL, SNG, and THA. Furthermore, it has a positive effect of shock or news from EU to SNG. However, shock or news from EU has a negative affect to MAL. Furthermore, the calculated conditional correlations between ASEAN countries and EU after the Asian crisis are significantly higher than before Asian crisis, except MAL, which after the Asian crisis has significantly lower correlations than before the crisis because in after the Asian crisis MAL control capital and currency. Finally, the calculated conditional correlations between ASEAN countries and USA are insignificant.

This paper uses the 'rolling windows' approach to examine the time-varying nature of the conditional correlation. We found all the conditional correlations display significant variability. These results suggest that the assumption of constant conditional correlations may not be valid.

Finally, we use a Value-at-Risk (VaR) threshold for a portfolio, which include countries in ASEAN, Europe and the USA to examine effect from Asian crisis to Value-at-Risk. The results do not appear to show a direct relationship between sample size and the number of violations, which suggests that adjusting for the Asian crisis may not be important.

Table 5.1 Descriptive Statistic for Returns

Statistics	IND	MAL	PHI	SNG	THA	EU	USA
Mean	0.017	0.006	0.003	0.011	-0.017	0.002	0.008
Median	0.041	0.029	0.012	0.041	-0.022	0.056	0.047
Maximum	44.515	25.854	21.972	11.846	18.100	10.698	11.043
Minimum	-43.081	-36.967	-10.942	-10.760	-18.084	-10.178	-9.514
Std. Dev.	2.786	1.786	1.759	1.393	2.113	1.146	1.143
Skewness	0.080	-1.192	0.512	-0.147	0.400	-0.269	-0.245
Kurtosis	43.254	67.539	13.502	10.660	12.517	13.726	12.553
Jarque-Bera	331,912.000	854,363.000	22,805.550	12,036.140	18,682.520	23,624.030	18,743.820

Table 5.2 Unit Root Test of Returns

Variables	Trend and intercept	Intercept	None
Augmented Dickey-Fuller test			
IND	**-24.237**	**-24.216**	**-24.215**
MAL	**-64.575**	**-64.569**	**-64.575**
PHI	**-59.312**	**-59.304**	**-59.309**
SNG	**-64.943**	**-64.915**	**-64.918**
THA	**-60.163**	**-60.160**	**-60.163**
EU	**-30.666**	**-30.559**	**-30.562**
USA	**-73.245**	**-73.193**	**-73.197**
Phillips-Perron Test			
IND	**-58.192**	**-58.342**	**-58.346**
MAL	**-64.560**	**-64.556**	**-64.563**
PHI	**-58.979**	**-58.989**	**-58.996**
SNG	**-65.050**	**-65.012**	**-65.017**
THA	**-60.147**	**-60.126**	**-60.129**
EU	**-66.793**	**-66.719**	**-66.726**
USA	**-73.643**	**-73.484**	**-73.485**

Note: Entries in bold are significant at the 99% level.

Table 5.3 Conditional mean equation of VARMA-AGARCH for ASEAN:

5 January 1988 to 13 March 2009

Equation		Constant	ASEANi (-1)	EU (-1)	USA(-1)	MA (1)
IND	ASEANi	0.026	**0.228**	**0.103**	**0.210**	-0.071
		1.372	**2.443**	**2.416**	**6.190**	-0.827
	EU	0.009	-0.007	0.054	**0.299**	**-0.110**
		0.820	-1.486	1.114	**20.375**	**-2.165**
	USA	0.019	-0.002	0.017	0.014	-0.027
		1.585	-0.450	1.115	0.107	-0.200
MAL	ASEANi	**0.108**	**0.400**	0.012	**0.352**	**-0.356**
		7.972	**7.802**	0.368	**16.874**	**-6.113**
	EU	0.008	0.001	0.039	**0.298**	-0.096
		0.746	0.097	0.774	**20.356**	-1.879
	USA	0.019	0.005	0.014	-0.038	0.028
		1.528	0.712	0.876	-0.319	0.230
PHI	ASEANi	0.010	0.027	**0.171**	**0.326**	**0.134**
		0.448	0.442	**5.316**	**13.120**	**2.080**
	EU	-0.009	0.002	0.042	**0.313**	-0.084
		-0.876	0.185	0.901	**21.175**	-1.732
	USA	0.020	-0.007	0.017	-0.006	-0.006
		1.685	-1.015	1.109	-0.049	-0.043
SNG	ASEANi	0.017	**0.138**	**0.043**	**0.332**	-0.081
		1.362	**2.941**	**2.268**	**17.592**	-1.679
	EU	0.008	0.001	0.039	**0.299**	-0.096
		0.738	0.119	0.756	**20.421**	-1.877
	USA	0.019	-0.007	0.019	0.026	-0.038
		1.605	-0.630	1.194	0.195	-0.285
THA	ASEANi	0.004	**0.343**	**0.073**	**0.315**	**-0.217**
		0.216	**6.185**	**2.305**	**10.974**	**-3.954**
	EU	0.009	0.004	0.032	**0.298**	-0.091
		0.832	0.701	0.662	**20.405**	-1.774
	USA	0.019	0.004	0.015	-0.007	-0.005
		1.576	0.529	0.924	-0.056	-0.036

Notes: (1) ASEANi denote country i; i= IND, MAL, PHI, SNG, THA related that equation, ASEANi (-1), IND(-1),EU(-1) and USA(-1) denote the lagged returns for each index.

(2) The 2 entries for each parameter are the parameter estimate and Bollerslev-Wooldridge(1992) robust t-ratios.

(3) Entries in bold are significant at the 95% level.

Table 5.4 Conditional variance equation of VARMA-AGARCH for ASEAN:

5 January 1988 to 13 March 2009

Equation		ω	α_{ASEANi}	β_{ASEANi}	α_{EU}	β_{EU}	α_{USA}	β_{USA}	γ
IND	ASEANi	**0.059**	**0.290**	**0.698**	0.025	0.008	**0.212**	**-0.024**	0.025
		2.261	**4.572**	**27.176**	0.690	0.180	**3.524**	**-5.340**	0.303
	EU	**0.025**	**0.028**	**0.863**	0.000	0.000	**0.020**	-0.001	**0.123**
		4.178	**2.625**	**40.727**	-0.008	0.408	**3.367**	-0.244	**3.803**
	USA	**0.012**	0.008	**0.950**	0.000	0.000	**0.022**	**-0.022**	**0.059**
		5.290	1.041	**109.048**	-1.884	1.953	**2.431**	**-2.009**	**4.151**
MAL	ASEANi	0.720	0.143	**0.775**	**-0.053**	-0.123	**0.128**	0.056	0.018
		1.369	1.339	**4.928**	**-2.378**	-1.516	**2.721**	0.941	0.245
	EU	**0.026**	**0.027**	**0.859**	0.000	0.001	**0.020**	-0.001	**0.128**
		4.172	**2.502**	**39.042**	0.177	0.949	**3.357**	-0.296	**3.845**
	USA	**0.013**	0.007	**0.944**	**-0.001**	**0.001**	**0.022**	**-0.021**	**0.068**
		5.328	0.847	**86.513**	**-3.102**	**2.272**	**2.448**	**-2.009**	**4.448**
PHI	ASEANi	**0.106**	**0.115**	**0.781**	-0.003	0.013	**0.080**	-0.001	**0.075**
		4.970	**5.513**	**37.103**	-0.215	0.484	**2.246**	-0.048	**2.021**
	EU	**0.064**	**0.047**	**0.683**	**-0.002**	**0.007**	0.017	**0.037**	**0.319**
		5.401	**2.919**	**20.345**	**-8.843**	**3.464**	1.627	**2.922**	**6.259**
	USA	**0.011**	0.006	**0.951**	0.004	-0.002	**0.019**	**-0.022**	**0.060**
		2.890	0.954	**113.570**	1.036	-0.527	**2.462**	**-2.395**	**4.339**
SNG	ASEANi	**0.043**	**0.063**	**0.820**	**0.027**	**-0.029**	**0.063**	-0.009	**0.103**
		5.381	**4.527**	**29.245**	**2.257**	**-2.263**	**3.479**	-0.747	**4.039**
	EU	**0.026**	**0.027**	**0.858**	0.002	0.000	**0.020**	-0.001	**0.126**
		4.059	**2.508**	**39.395**	0.643	0.096	**3.110**	-0.179	**3.912**
	USA	**0.012**	0.009	**0.949**	0.001	-0.001	**0.022**	**-0.021**	**0.059**
		5.392	1.086	**99.035**	0.358	-0.184	**2.352**	**-2.001**	**3.889**
THA	ASEANi	**0.117**	**0.094**	**0.827**	0.039	**-0.069**	**0.060**	0.009	0.093
		3.379	**5.063**	**22.487**	1.348	**-2.725**	**2.305**	0.385	1.422
	EU	**0.022**	**0.026**	**0.868**	**0.000**	**0.001**	**0.020**	-0.002	**0.120**
		3.935	**2.517**	**43.438**	**-2.192**	**2.851**	**3.386**	-0.689	**3.821**
	USA	**0.010**	0.007	**0.951**	0.000	0.001	**0.021**	**-0.021**	**0.058**
		4.687	0.967	**113.492**	-1.677	1.427	**2.299**	**-1.974**	**3.850**

Notes: (1) ASEANi denote country i; i= IND, MAL, PHI, SNG, THA related that equation, ASEANi (-1), IND(-1),EU(-1) and USA(-1) denote the lagged returns for each index.

(2) The 2 entries for each parameter are the parameter estimate and Bollerslev-Wooldridge(1992) robust t-ratios.

(3) Entries in bold are significant at the 95% level.

Table 5.5 Conditional mean equation of VARMA-AGARCH for ASEAN:

5 January 1988 to 27 December 1996

Equation		Constant	ASEANi (-1)	EU (-1)	USA(-1)	MA (1)
IND	ASEANi	0.045	**0.411**	**0.175**	0.138	-0.144
		1.201	**4.040**	**2.291**	0.845	-1.412
	EU	0.014	**-0.008**	-0.059	**0.273**	0.100
		0.773	**-5.948**	-0.768	**11.517**	1.224
	USA	0.022	**-0.011**	0.007	**0.086**	-0.044
		1.460	**-8.837**	0.299	**2.079**	-0.887
MAL	ASEANi	0.032	**0.370**	**0.098**	**0.350**	**-0.219**
		1.709	**3.452**	**2.184**	**9.873**	**-1.988**
	EU	0.012	0.017	-0.069	**0.274**	0.104
		0.659	0.791	-0.840	**11.384**	1.313
	USA	0.026	0.009	0.025	-0.139	0.181
		1.369	0.441	1.184	-1.044	1.355
PHI	ASEANi	0.029	**0.225**	**0.095**	**0.237**	-0.047
		1.161	**2.615**	**6.149**	**5.537**	-0.517
	EU	0.012	-0.004	-0.073	**0.270**	0.115
		0.674	-0.380	-0.961	**11.372**	1.418
	USA	**0.035**	-0.016	0.016	0.052	-0.015
		2.270	-1.499	0.742	0.375	-0.107
SNG	ASEANi	0.029	0.121	**0.086**	**0.288**	-0.020
		1.648	1.603	**3.315**	**10.289**	-0.267
	EU	0.013	0.016	-0.083	**0.272**	0.118
		0.738	0.752	-1.027	**11.193**	1.479
	USA	-0.018	0.020	0.020	0.018	0.069
		-1.022	0.852	0.745	0.165	0.592
THA	ASEANi	0.012	**0.375**	**0.161**	**0.290**	**-0.236**
		0.561	**4.989**	**3.697**	**7.410**	**-3.001**
	EU	0.012	0.013	-0.067	**0.268**	0.105
		0.638	1.228	-0.841	**11.255**	1.248
	USA	**0.031**	-0.010	0.019	**0.128**	-0.093
		2.171	-0.992	0.855	**2.114**	-1.419

Notes: (1) ASEANi denote country i; i= IND, MAL, PHI, SNG, THA related that equation, ASEANi (-1), IND(-1),EU(-1) and USA(-1) denote the lagged returns for each index.

(2) The 2 entries for each parameter are the parameter estimate and Bollerslev-Wooldridge(1992) robust t-ratios.

(3) Entries in bold are significant at the 95% level.

Table 5.6 Conditional variance equation of VARMA-AGARCH for ASEAN:

5 January 1988 to 27 December 1996

Equation		ω	α_{ASEANi}	β_{ASEANi}	α_{EU}	β_{EU}	α_{USA}	β_{USA}	γ
IND	ASEANi	**2.827**	0.159	**0.535**	**-0.070**	-0.170	-0.055	-0.054	-0.192
		2.214	0.765	**2.556**	**-5.156**	-0.629	-0.625	-0.849	-0.811
	EU	**0.062**	0.020	**0.756**	**0.000**	0.000	**0.030**	-0.001	**0.195**
		2.906	0.956	**10.546**	**-14.177**	-0.079	**2.012**	-0.110	**2.020**
	USA	**0.404**	0.008	0.321	**0.000**	**0.000**	-0.003	0.002	**0.107**
		2.615	0.236	1.382	**-4,220.139**	**-2.546**	-0.098	0.053	**2.253**
MAL	ASEANi	**0.107**	**0.070**	**0.729**	0.065	-0.047	0.081	-0.017	**0.194**
		4.574	**2.165**	**9.155**	1.898	-0.715	0.993	-0.733	**2.593**
	EU	**0.060**	0.020	**0.788**	0.009	-0.015	**0.032**	-0.002	**0.162**
		3.146	1.129	**13.083**	1.524	-1.707	**2.035**	-0.349	**2.053**
	USA	**0.031**	-0.012	**0.906**	-0.002	0.002	0.013	0.016	**0.052**
		2.451	-1.002	**23.876**	-1.602	0.417	1.129	0.650	**2.579**
PHI	ASEANi	0.014	**0.108**	**0.794**	**-0.023**	**0.202**	0.067	0.004	0.038
		0.298	**3.900**	**22.770**	**-5.925**	**2.716**	1.239	0.126	0.847
	EU	**0.041**	0.001	**0.779**	0.003	0.008	0.024	-0.004	0.191
		2.274	0.035	**10.283**	0.935	1.200	1.748	-0.728	1.915
	USA	0.007	0.008	**0.982**	0.004	-0.003	0.007	-0.015	0.007
		1.433	0.800	**154.924**	1.126	-0.703	0.783	-0.978	0.513
SNG	ASEANi	**0.133**	**0.069**	**0.574**	0.001	0.003	**0.098**	0.015	**0.200**
		4.469	**2.431**	**8.453**	0.030	0.065	**2.141**	0.477	**2.517**
	EU	**0.060**	0.018	**0.815**	0.025	-0.042	**0.028**	-0.002	**0.140**
		3.078	1.130	**15.166**	1.559	-1.672	**1.987**	-0.312	**2.068**
	USA	**0.209**	**-0.062**	**0.653**	**-0.024**	**0.064**	**0.031**	0.067	**0.113**
		2.298	**-3.316**	**5.114**	**-4.887**	**2.897**	**2.228**	1.297	**3.872**
THA	ASEANi	**0.178**	**0.140**	**0.727**	0.087	-0.084	0.060	-0.011	0.104
		4.327	**3.490**	**18.493**	1.529	-1.726	1.261	-0.585	1.917
	EU	**0.047**	0.011	**0.787**	0.000	0.004	**0.027**	-0.002	0.175
		2.450	0.657	**11.347**	-0.160	0.926	**1.973**	-0.337	1.889
	USA	0.006	0.009	**0.981**	-0.001	0.001	0.010	-0.016	0.008
		1.130	0.813	**167.899**	-0.781	0.601	1.002	-0.991	0.502

Notes: (1) ASEANi denote country i; i= IND, MAL, PHI, SNG, THA related that equation, ASEANi (-1), IND(-1),EU(-1) and USA(-1) denote the lagged returns for each index.

(2) The 2 entries for each parameter are the parameter estimate and Bollerslev-Wooldridge(1992) robust t-ratios.

(3) Entries in bold are significant at the 95% level.

Table 5.7 Conditional mean equation of VARMA-AGARCH for ASEAN:

5 January 1998 to 13 March 2009

Equation		Constant	ASEANi (-1)	EU (-1)	USA(-1)	MA (1)
IND	ASEANi	0.076	0.107	**0.117**	**0.400**	0.013
		1.901	1.270	**2.413**	**9.167**	0.153
	EU	0.005	0.002	**0.143**	**0.340**	**-0.292**
		0.418	0.325	**2.335**	**16.812**	**-4.645**
	USA	-0.004	0.002	**0.048**	**0.550**	**-0.607**
		-0.471	0.465	**2.319**	**2.465**	**-2.790**
MAL	ASEANi	0.026	0.098	**0.045**	**0.228**	0.039
		1.473	1.507	**2.235**	**11.664**	0.574
	EU	0.006	-0.003	**0.145**	**0.340**	**-0.292**
		0.490	-0.280	**2.388**	**16.803**	**-4.657**
	USA	-0.022	0.014	0.008	**-0.792**	**0.773**
		-0.673	1.937	0.627	**-6.082**	**5.706**
PHI	ASEANi	0.008	-0.036	**0.211**	**0.352**	**0.186**
		0.241	-0.490	**4.548**	**12.641**	**2.196**
	EU	-0.002	0.014	0.085	**0.353**	**-0.231**
		-0.113	0.667	1.379	**17.444**	**-3.706**
	USA	-0.005	**0.007**	**0.045**	**0.545**	**-0.605**
		-0.649	**3.923**	**2.291**	**2.777**	**-3.185**
SNG	ASEANi	0.022	**0.237**	0.008	**0.378**	**-0.245**
		1.356	**3.957**	0.277	**14.463**	**-4.009**
	EU	0.006	-0.005	**0.148**	**0.339**	**-0.293**
		0.432	-0.349	**2.360**	**16.795**	**-4.611**
	USA	-0.004	-0.002	**0.050**	**0.582**	**-0.638**
		-0.501	-0.137	**2.386**	**2.889**	**-3.273**
THA	ASEANi	0.011	**0.315**	0.026	**0.334**	**-0.201**
		0.427	**4.332**	0.647	**9.102**	**-2.751**
	EU	0.007	-0.004	**0.143**	**0.341**	**-0.291**
		0.527	-0.510	**2.368**	**16.861**	**-4.663**
	USA	-0.004	0.009	**0.042**	**0.568**	**-0.624**
		-0.547	1.433	**2.084**	**3.035**	**-3.431**

Notes: (1) ASEANi denote country i; i= IND, MAL, PHI, SNG, THA related that equation, ASEANi (-1), IND(-1),EU(-1) and USA(-1) denote the lagged returns for each index.

(2) The 2 entries for each parameter are the parameter estimate and Bollerslev-Wooldridge(1992) robust t-ratios.

(3) Entries in bold are significant at the 95% level.

Table 5.8 Conditional variance equation of VARMA-AGARCH for ASEAN:

5 January 1998 to 13 March 2009

Equation		ω	α_{ASEANi}	β_{ASEANi}	α_{EU}	β_{EU}	α_{USA}	β_{USA}	γ
IND	ASEANi	**0.161**	**0.082**	**0.852**	0.111	-0.195	0.107	0.058	0.051
		4.235	**3.831**	**42.417**	1.597	-1.853	1.439	0.583	1.239
	EU	**0.032**	0.027	**0.837**	0.000	0.000	0.020	0.019	**0.130**
		3.948	1.615	**29.670**	0.833	-0.444	1.895	1.185	**4.705**
	USA	**0.014**	**-0.025**	**0.919**	0.000	0.000	**0.029**	-0.006	**0.147**
		2.967	**-2.010**	**65.236**	-0.065	0.013	**2.202**	-0.453	**5.818**
MAL	ASEANi	**0.010**	**0.075**	**0.904**	0.008	-0.017	0.016	-0.004	0.053
		2.377	**4.557**	**72.465**	0.694	-1.208	1.616	-0.316	1.879
	EU	**0.033**	0.027	**0.833**	0.001	0.000	0.019	0.022	**0.133**
		3.936	1.632	**28.972**	0.982	-0.296	1.745	1.308	**4.705**
	USA	**0.015**	**-0.029**	**0.921**	**-0.001**	**0.001**	**0.030**	-0.009	**0.155**
		3.292	**-2.354**	**68.815**	**-6.781**	**3.941**	**2.277**	-0.675	**6.031**
PHI	ASEANi	**0.170**	**0.132**	**0.723**	0.033	-0.086	**0.091**	0.056	0.096
		4.744	**3.705**	**21.054**	1.288	-1.421	**2.516**	0.930	1.414
	EU	**0.025**	0.030	**0.827**	**-0.003**	**0.006**	**0.025**	0.016	**0.138**
		2.981	1.810	**29.935**	**-2.735**	**2.813**	**2.334**	1.024	**4.867**
	USA	0.008	**-0.025**	**0.912**	**-0.003**	**0.005**	**0.027**	-0.004	**0.158**
		1.576	**-1.960**	**54.408**	**-12.356**	**4.246**	**2.089**	-0.278	**6.436**
SNG	ASEANi	**0.031**	**0.051**	**0.891**	**0.034**	-0.035	**0.052**	-0.025	**0.051**
		4.915	**3.448**	**55.224**	**2.098**	-1.780	**3.334**	-1.661	**2.505**
	EU	**0.032**	0.026	**0.839**	-0.002	0.002	**0.021**	0.016	**0.133**
		3.940	1.566	**30.512**	-0.508	0.757	**1.959**	1.028	**4.859**
	USA	**0.014**	-0.023	**0.927**	0.002	0.000	**0.028**	-0.012	**0.138**
		3.060	-1.799	**74.430**	0.554	-0.212	**2.130**	-0.896	**5.316**
THA	ASEANi	0.153	0.065	**0.874**	0.030	-0.102	0.042	0.037	0.048
		1.922	3.187	**19.274**	0.971	-2.364	1.208	0.781	0.678
	EU	**0.029**	0.026	**0.836**	**-0.001**	**0.002**	0.021	0.019	**0.131**
		3.488	1.556	**29.732**	**-8.254**	**2.475**	1.941	1.201	**4.731**
	USA	**0.013**	**-0.025**	**0.919**	**0.000**	0.001	**0.027**	-0.006	**0.148**
		2.940	**-1.973**	**65.044**	**-2.131**	1.321	**2.088**	-0.398	**5.774**

Notes: (1) ASEANi denote country i; i= IND, MAL, PHI, SNG, THA related that equation, ASEANi (-1), IND(-1),EU(-1) and USA(-1) denote the lagged returns for each index.

(2) The 2 entries for each parameter are the parameter estimate and Bollerslev-Wooldridge(1992) robust t-ratios.

(3) Entries in bold are significant at the 95% level.

Table 5.9 Conditional correlation between ASEAN and EU,USA:

5 January 1988 to 13 March 2009

Countries	EU	USA
IND	0.112	0.045
MAL	0.138	0.060
PHI	0.065	0.049
SNG	0.286	0.135
THA	0.155	0.073

Table 5.10 Conditional correlation between ASEAN and EU,USA:

5 January 1988 to 27 December 1996

Countries	EU	USA
IND	0.063	0.037
MAL	0.192	0.086
PHI	0.019	0.031
SNG	0.252	0.116
THA	0.102	0.069

Table 5.11 Conditional correlation between ASEAN and EU,USA:

5 January 1998 to 13 March 2009

Countries	EU	USA
IND	0.166	0.063
MAL	0.116	0.044
PHI	0.111	0.066
SNG	0.328	0.172
THA	0.212	0.094

Table 5.12 Test for differences in correlation between samples

Countries	EU	USA
IND	**3.465**	0.871
MAL	**-2.559**	-1.419
PHI	**3.133**	1.202
SNG	**2.597**	1.907
THA	**3.713**	0.859

Notes: (1)The values given are the z scores given by Eq. (5).

(2)Values in bold are significant at the 99% level.

Table 5.13 Number of violations IND, MAL, PHI, SNG, and THA portfolio for the period 3 January 2007 to 13 March 2009

Sample size	IND	MAL	PHI	SNG	THA
2006	5	4	5	5	5
2005	5	4	5	5	5
2004	5	4	5	5	5
2003	5	4	5	5	5
2002	5	4	5	5	5
2001	5	4	5	5	5
2000	5	4	5	5	5
1999	5	4	5	5	5
1998	5	4	5	5	5
1997	5	5	5	5	5
1996	5	5	5	5	5
1995	5	5	5	5	5
1994	5	5	5	5	5
1993	5	5	5	5	5
1992	5	5	5	5	5
1991	5	3	5	5	5
1990	5	3	5	5	5
1989	5	5	5	5	5
1988	5	5	5	5	5

Notes: (1)The expected number of violations is 5 at 1% level of significance.

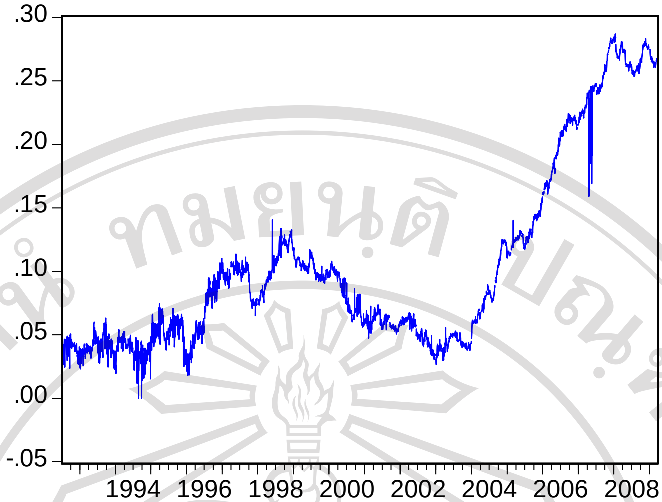

Figure 5.1 Rolling conditional correlation between IND and EU

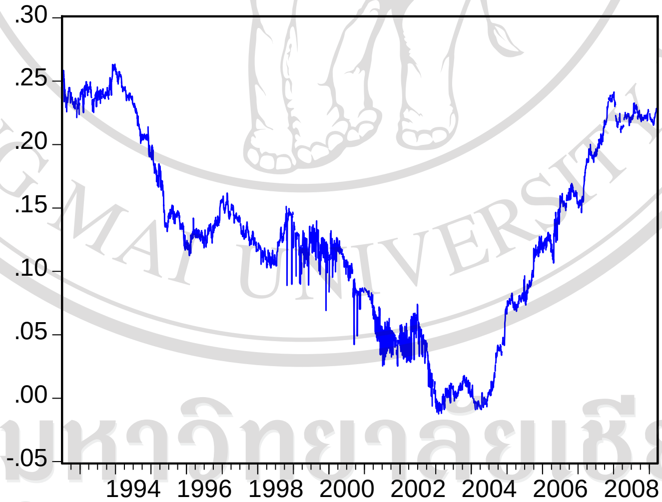

Figure 5.2 Rolling conditional correlation between MAL and EU

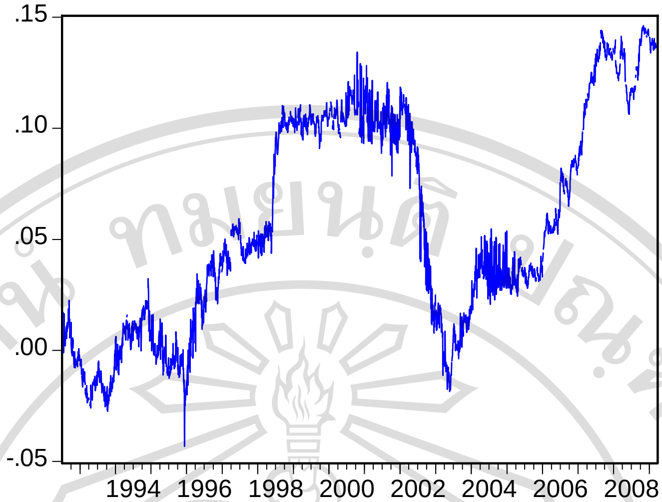

Figure 5.3 Rolling conditional correlation between PHI and EU

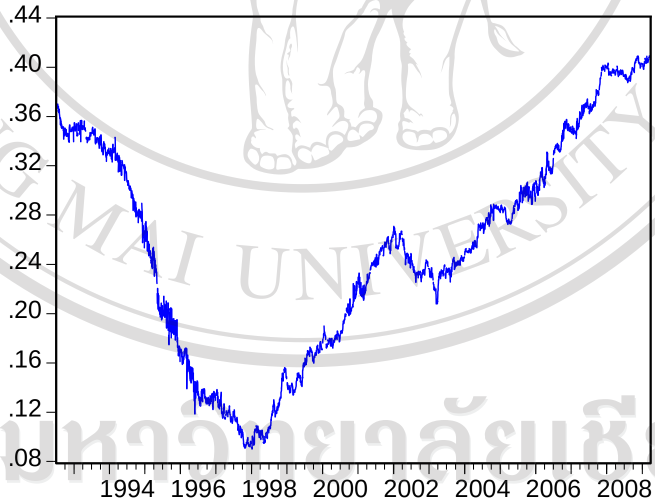

Figure 5.4 Rolling conditional correlation between SNG and EU

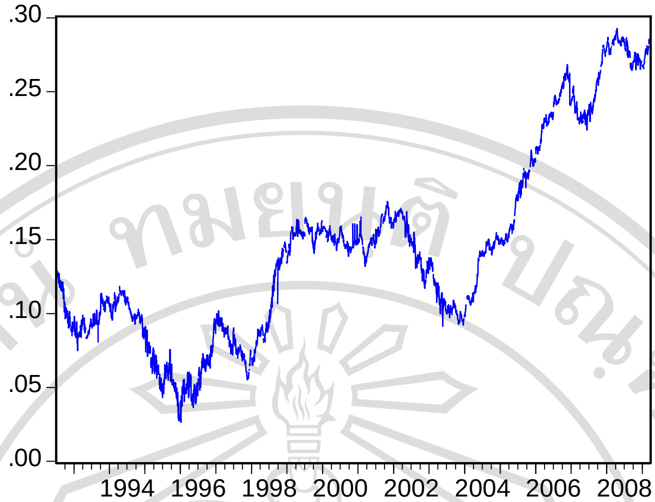

Figure 5.5 Rolling conditional correlation between THA and EU

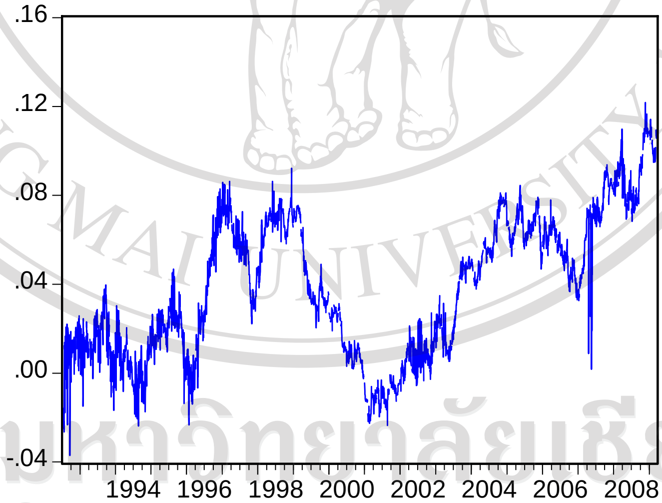

Figure 5.6 Rolling conditional correlation between IND and USA

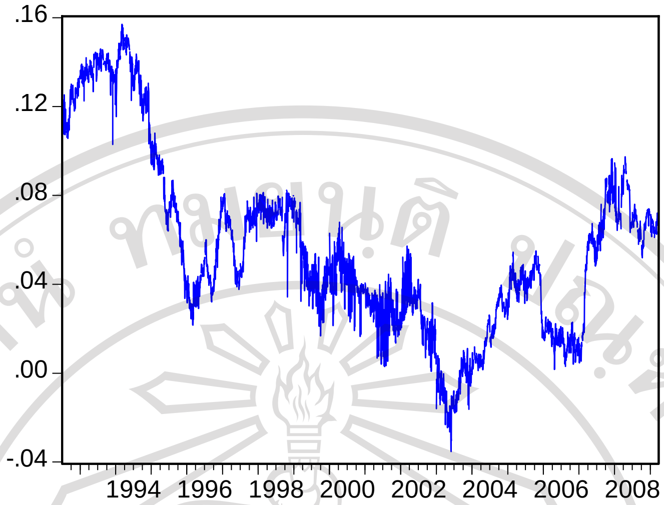

Figure 5.7 Rolling conditional correlation between MAL and USA

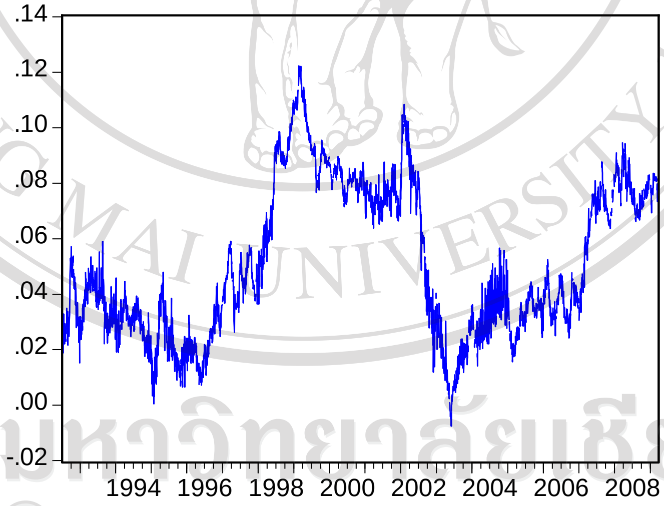

Figure 5.8 Rolling conditional correlation between PHI and USA

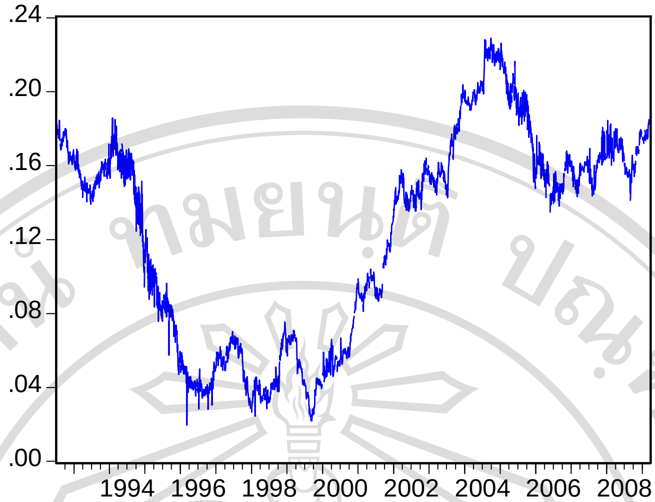

Figure 5.9 Rolling conditional correlation between SNG and USA

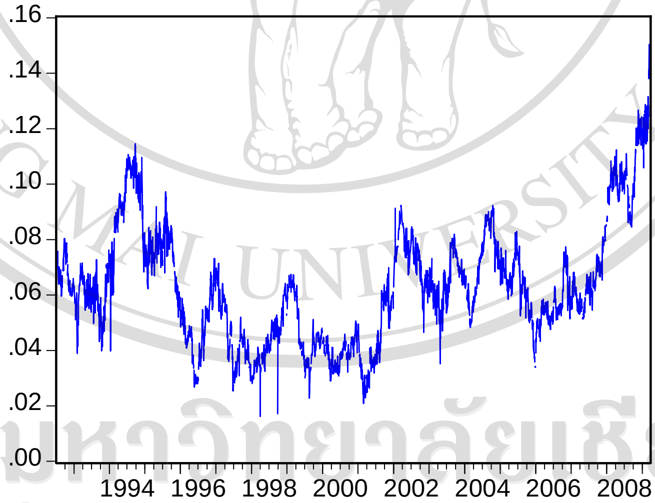

Figure 5.10 Rolling conditional correlation between THA and USA