Chapter 5

Modeling Volatility Rubber Price Return with Different Factors

For case study 2, we will model the volatility and interdependencies of Thai rubber spot price return with climatic factors, exchange rate and crude oil markets to compare VARMA-GARCH model and Copula Based GARCH Model.

5.1 Introduction

The rubber industry is one of the most important industries in Thailand. The total area occupied by the industry devoted to rubber is 219,933 hectares; in 2007, the industry also recorded an annual output of 3.056 million tons in 2007 (Office of the Rubber Replanting Aid Fund, 2008). Apart from Thailand, Malaysia and Indonesia are also considered major producers and exporters of rubber. The total rubber output of these three countries reached 8.32 million tons in 2007, accounting for 94% of the total world market (Office of the Rubber Replanting Aid Fund, 2008).

Rubber trees thrive in tropical climates with high temperature (e.g., 26 °C to 32 °C) and rainfall with average precipitation of 2000 mm or more. In the Southeast Asian region, rubber output varies according to the season: (a) output reduction is highest during the high dry period (February to April); (b) highest output is achievable during the monsoon period (May to June), (c) output is reduced to some extent during the mild dry period (August to October), and (d) an increase in output occurs during the high monsoon period (November to January).

Recently, crude rubber output has increased due to the assistance program launched by the Thai government, which aimed to provide better options and varieties to farmers. Heavy monsoon in Thailand normally causes an annual increase in rubber output during the third and the fourth quarters, particularly in the southern regions that comprise the largest area of domestic rubber production. During the same period, rubber prices tend to decline due to the increase in supply.

In December 2008, the domestic price of rubber fell rapidly to only 43 baht per kg in 20 days. Originally, the purchase price of fresh rubber and the production cost were 70 baht and about 27 baht per kg, respectively. Thus, the total production cost of each kilogram of processed rubber should have been almost 97 baht. These figures indicated that farmers suffered a maximum loss of about 54 baht per kg of processed rubber.

Meanwhile, due to the economic recession in the USA, the Cooperative of the Thailand Rubber Farmers urged exporters to focus on China as a potential market for exporting rubber. The Thai Ministry of Agriculture also intervened by extending the repayment duration of rubber loans. When rubber prices fall, most farmers abandon rubber planting and begin planting other crops. Thus, the Rubber Association of Thailand stopped rubber production for six months to allow rubber prices to rise again. The boom in synthetic rubber likewise caused an increasing number of rubber gardens in Thailand to disappear over the past decade.

Given the aforementioned scenario, accurately forecasting the future prices of Thai rubber can safeguard farmers and maintain the competitiveness of Thailand's important export item. Given that rubber is an important industrial product, price fluctuations may be attributable to fluctuations in its production as well as in price fluctuations in this era of globalization. Specifically, industrial commodities traded in the world market are not immune from other important market indices, particularly exchange market and crude oil market returns. Furthermore, climatic conditions in the producing country may play an important role in rubber price fluctuations. Such fluctuations cannot take place in isolation.

With this background, the current study used three robust methods to examine the relationships of Thai rubber price volatility with climatic factors (e.g., precipitation and temperature), the US dollar exchange market, and the crude oil market. The models applied included the copula-Based generalized autoregressive conditional heteroscedasticity (GARCH), vector autoregressive moving average with GARCH (VARMA-GARCH), and VARMA with asymmetric AGARCH (VARMA-AGARCH) models.

5.2 Empirical Results

The results of data analysis in my second part of my study show that all series data are stationary in Table 5.1, as the estimated value of θ of all the returns are significantly less than zero at the 1% level.

Table 5.1 The ADF Test of Unit Roots in Case Study2

Variables	Coefficient	t-statistic
Rubber price	-0.6285	-16.2503
US dollar	-1.0700	-25.7667
Crude Oil	-1.0224	-24.5450
TempD	-1.0109	-24.2884
Rainfall	-0.4068	-8.6020

Table 5.2 shows the descriptive statistics of the variables. The standard deviation of rubber price return is higher than those of the oil index and dollar index returns. The skewness of Price, Dollar, Oil, and TempD are negative, so they are significantly skewed to the left. For the excess kurtosis statistics, all of the variables in this study are positive, indicating that the distribution of returns has larger, thicker tails than the normal distribution. Therefore, the assumption of skewed-t is more appropriate in this study.

Table 5.2 The Summary Statistics of Case Study2

	Rubber price	*US dollar*	*Crude oil*	*TempD*	*Rainfall*
Mean	*0.0006*	*-7.02E-05*	*0.0003*	*-0.0033*	*5.9165*
SD	*0.0133*	*0.0057*	*0.0251*	*0.6099*	*6.1759*
Skewness	*-1.0245*	*-0.0815*	*-0.1803*	*-0.1234*	*2.7080*
Kurtosis	*22.4839*	*5.1712*	*4.8619*	*7.3715*	*21.0084*
Max	*0.1238*	*0.0252*	*0.1153*	*3.3212*	*72.4000*
Min	*-0.1414*	*-0.0306*	*-0.1272*	*-2.7960*	*0.0000*
JB	*25284.2300*	*312.3000*	*236.9238*	*464.0900*	*23310.3400*

Note: For Rubber price, US dollar, and Crude oil, the data type is the volatility data. It measures the differences in the indices between today and yesterday. The values for each observation could be either +ve or –ve. Overall, the mean of these variables are close to 0. The data of TempD is close to 0 because it is the difference between today's average temperature from yesterday.

The analysis of the volatility of rubber price return in relation to the volatility of oil index and dollar index returns, as well as average temperature and average precipitation, was undertaken using the VARMA-GARCH and VARMA-AGARCH models. Time-varying volatility was estimated and the asymmetric effects of positive and negative shocks of equal magnitude and volatility spillovers were tested using these models. The results of the VARMA-GARCH and VARMA-AGARCH are presented in Table 5.3, and the number of volatility spillovers and asymmetric effects are summarized in Table 5.4. Table 5.3 shows that three variables have spillovers to the volatility of rubber price return in the VARMA-GARCH model, including volatility of oil index return and volatility of dollar index return. For the VARMA-AGARCH model, only the volatility of dollar return has spillover effects on the volatility of rubber price. About the relationship between volatility of rubber price and effect factors which are oil and dollar index, the coefficients are positive between volatility of rubber price and volatility of oil return and the coefficients are negative between volatility of rubber price and volatility of dollar index return. Table 5.4 shows that the volatility spillovers are not evident in the VARMA-AGARCH model. From the Table11, the t-value of Γ from VARMA-AGARCH model is only 1.2004 which indicates statistical significance at the 1% level is 1.96. Therefore, the table 5.4 shows that the result of asymmetric effects is “No”. Therefore, we can conclude that VARMA-GARCH is superior to VARMA-AGARCH in examining the volatility of rubber price return.

Table 5.3 Estimates of VARMA-GARCH Model in Case Study 2

Returns of rubber price	ω	α_{price}	α_{oil}	α_{dollar}	α_{tempD}	α_{rain}
VARMA-GARCH	*0.0000******	*0.1076******	*0.0100****	*-0.1699******	*-0.0000******	*0.0000*
	14.1663	*4.3565*	*2.6135*	*-3.0683*	*-96.8093*	*1.1277*
VARMA-AGARCH	*0.0000******	*0.1847******	*0.0099******	*-0.1090****	*-0.0000******	*-0.0000*
	6.0904	*3.2536*	*3.1778*	*-2.3871*	*-16.9753*	*-0.0917*

Table 5.3 (Continued)

Returns of rubber price	Γ	β_{price}	β_{oil}	β_{dollar}	β_{tempD}	β_{rain}
VARMA-GARCH		*0.8570****	*-0.0055*	*0.4064****	*6.88E-07*	*-0.0000*
		39.5998	*-0.7693*	*3.1504*	*0.3306*	*-0.0923*
VARMA-AGARCH	*-0.1031*	*0.8610****	*-0.0122***	*0.2412***	*2.59E-06*	*-0.0000*
	1.2004	*40.2522*	*-2.1605*	*2.3945*	*1.6428*	*-0.1999*

Notes: (1) The two entries for each parameter are their respective estimate and Bollerslev and Woodridge (1992) robust t-ratios.

(2) * indicates statistical significance at the 10% level;

** indicates statistical significance at the 5% level;

*** indicates statistical significance at the 1% level

Table 5.4 Summary of Volatility Spillovers and Asymmetric Effects in Case Study2

Returns	Number of volatility spillovers		Asymmetric effects
	VARMA-GARCH	VARMA-AGARCH	
Rubber price	1	2	NO

Rolling windows are also used to examine time-varying conditional correlations using the VARMA-GARCH and VARMA-AGARCH models. The rolling window size was set at 1,000 for the dollar index and oil index as shown in Figures 5.1 and 5.2, respectively. For the VARMA-GARCH model, the correlations of dollar index and oil index are not constant over time, so the assumption of constant conditional correlations may be too restrictive. However, the changes in the estimated correlations are small. Specifically, the correlation between the volatility of rubber price return and volatility of oil index return is smaller (at around 0.1) than that between volatility of rubber price return and the other variables which are dollar, tempD and rain. The VARMA-AGARCH model shows similar results to VARMA-GARCH in that the correlations vary over time.

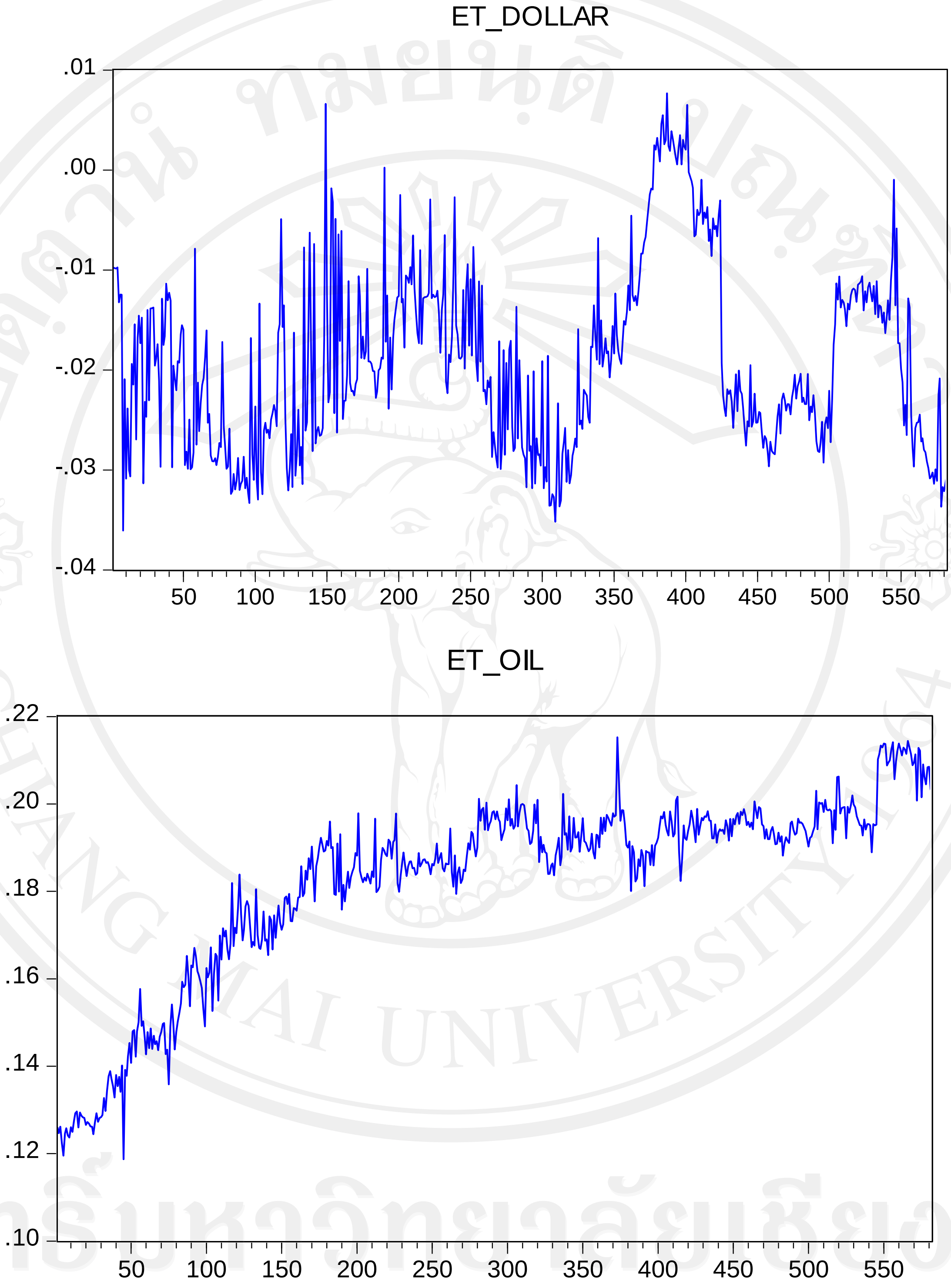
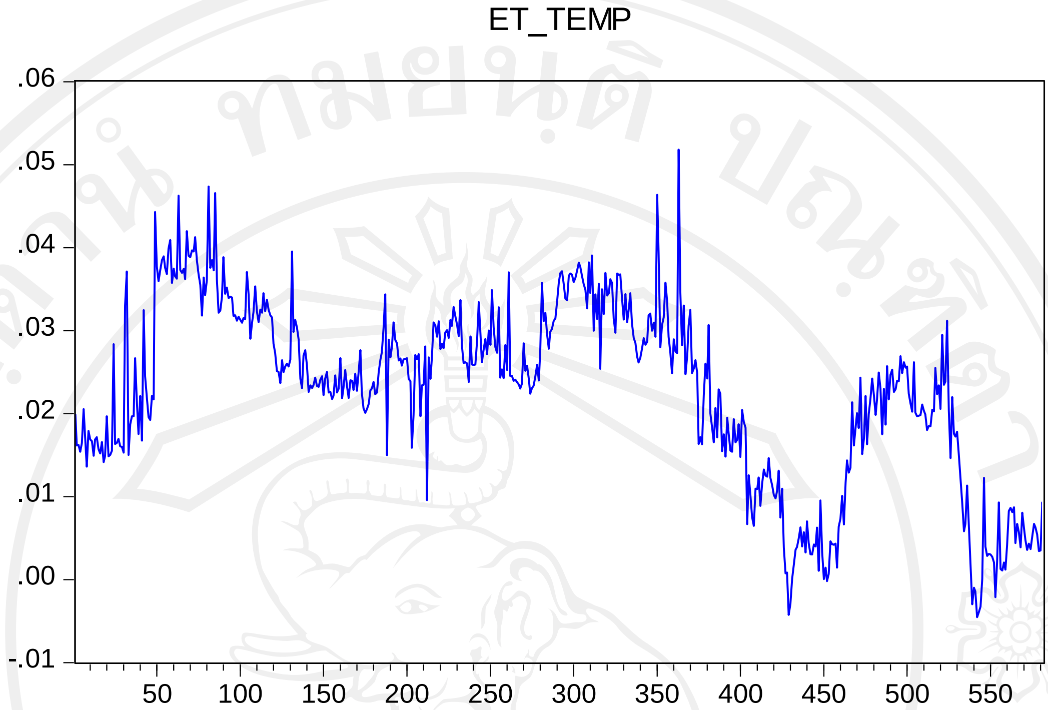


Figure 5.1 Dynamic VARMA-GARCH model in Case Study2



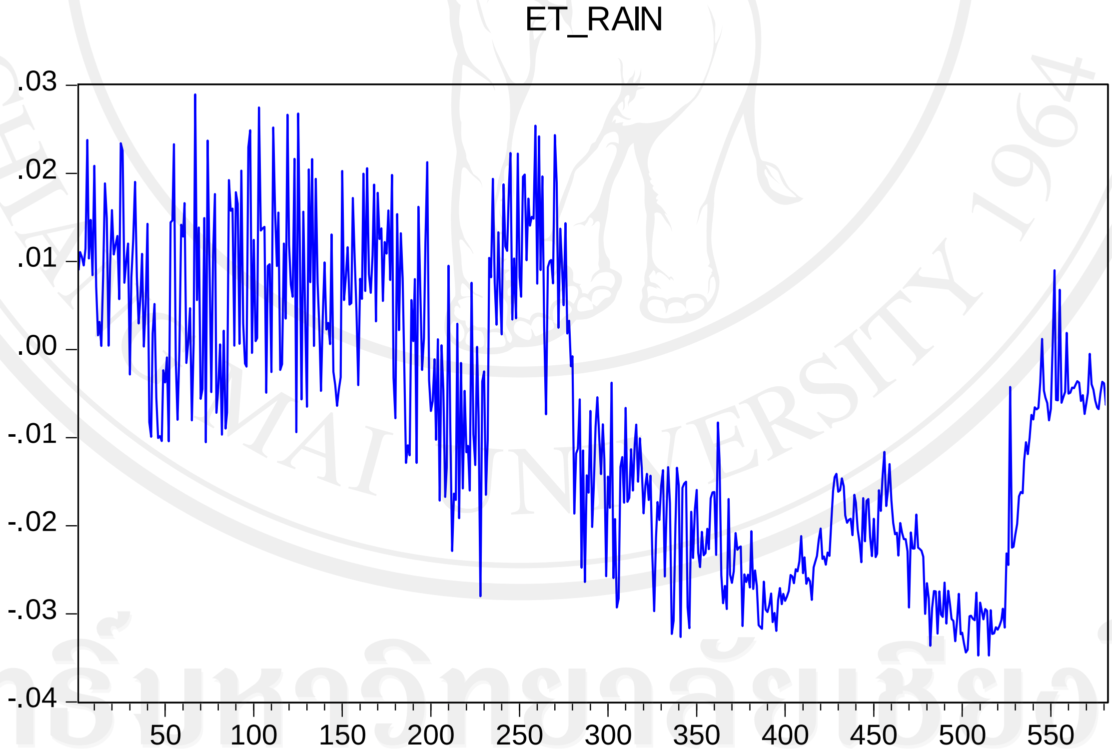


Figure 5.1 (Continue)

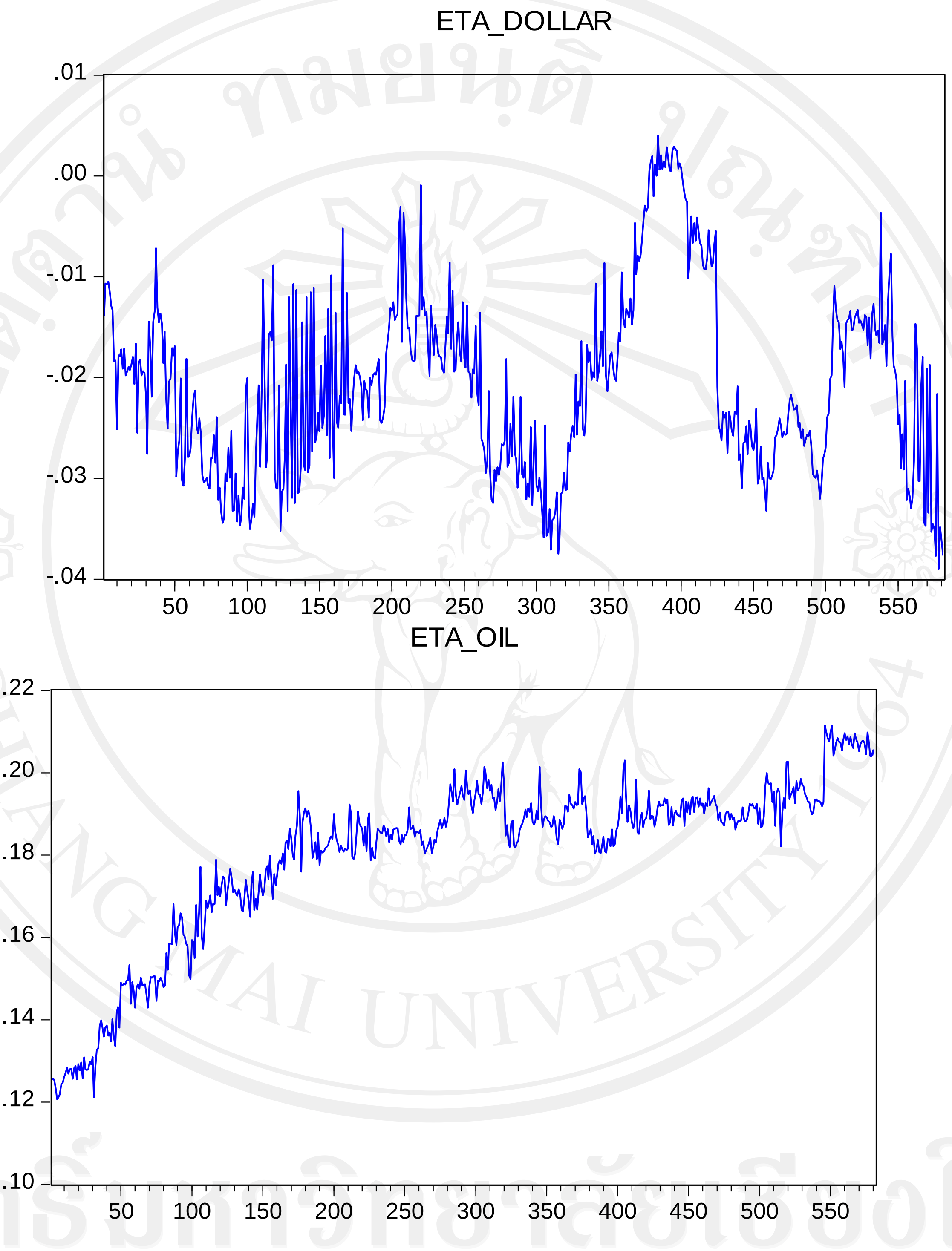
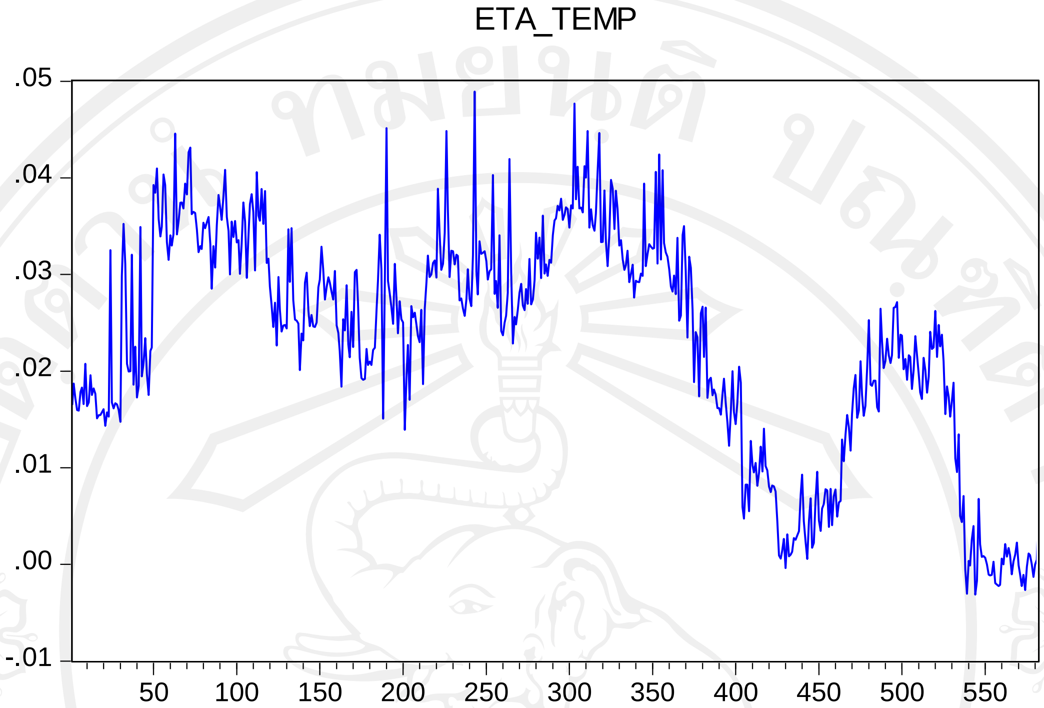


Figure 5.2 Dynamic VARMA-AGARCH model in Case Study2



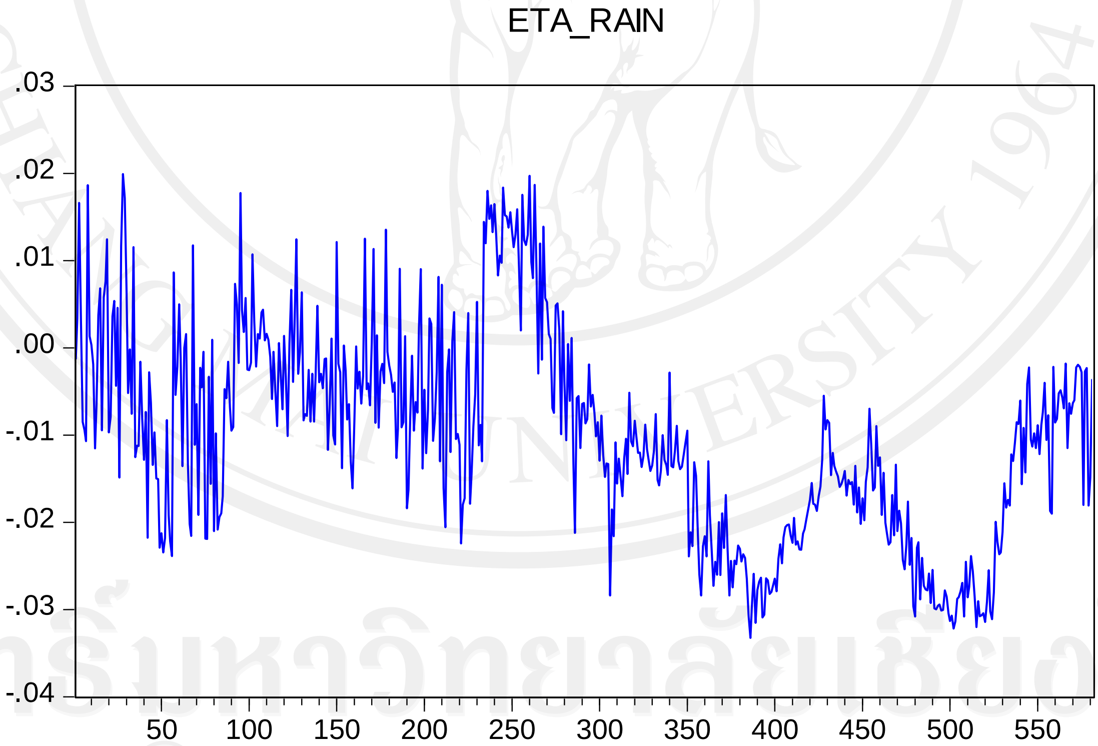


Figure 5.2 (Continue)

Table 5.5 presents the estimated result for copula-based GARCH models with feedback trading activities. Panel A shows the parameter estimates of marginal distributions with the GARCH model. The parameters of greatest interest in the mean equation are the autocorrelation of returns. The constant components of the autocorrelation ω are almost non-significant, except rubber price return. In addition, the parameter β is positive and statistically significant for all of the variables in this study. The asymmetry parameters λ is significant and negative for price, but non-significant for dollar, oil and rain, indicating that the rubber price is skewed to the left. Panels B and C present the parameter estimates for different Gaussian and Student-t copula functions. In terms of the values of AIC and BIC, the Student-t dependence structure only exhibits better explanatory power than that of Gaussian dependence between rubber price and temperature; however, Gaussian dependence shows better relation between rubber price and other variables. Moreover, the autoregressive parameter β is not significant between rubber price and dollar index, but is significant between rubber price and other variables, implying the persistence pertaining to the dependence structure between rubber price return with oil index return, temperature, and precipitation.

Table 5.5 Estimation result of copula based GARCH models in Case Study2

	Price	Dollar	Oil	TempD	Rain
Panel A: Estimation of marginal					
C0	0.0001	-0.0002	0.0006	0.0235**	0.5000**
	(0.5450)	(-1.6246)	(1.0595)	(2.5059)	(2.1817)
C1	0.3932***	-0.0322	-0.0302	0.3348***	0.5000***
	(11.7720)	(-1.3327)	(-1.1429)	(10.7974)	(12.0196)
ω	0.0000***	0.0000	0.0000	0.0000	0.0000
	(3.3659)	(1.3483)	(1.3981)	(0.0095)	(0.0001)
α	0.2225***	0.0336***	0.0557***	0.1659***	0.1807***
	(6.2451)	(4.3679)	(2.9826)	(5.6569)	(3.5839)
β	0.7775***	0.9664***	0.9443***	0.8341***	0.8192***
	(19.4185)	(162.7056)	(63.6227)	(23.6985)	(10.7266)
υ	2.8760***	8.4871***	8.6889***	3.2429***	3.3885***
	(21.0916)	(4.5391)	(4.1105)	(19.8588)	(5.0949)
λ	-0.0580**	-0.0276	-0.0504*	0.0408**	0.1602
	(-2.1364)	(-1.0794)	(-1.7154)	(1.9838)	(0.8989)
Panel B: Estimation of Gaussian dependence structure for Price					
α		0.0203	0.0373*	0.0644***	0.0260**
		(0.8943)	(1.6669)	(6.3721)	(2.2771)
β		0.2107	0.7153***	0.8834***	0.8937***
		(0.4645)	(3.4152)	(42.1275)	(17.8009)
ln(L)		0.705	32.052	3190.197	5.099
AIC		2.5907	-60.1044	-6376.3943	-6.1978
BIC		13.3223	-49.3728	-6365.6627	4.5339
Panel C: Estimation of student-t dependence structure for Price					
ω		35.6467	199.4353***	14.9948***	195.8707*
		(0.6129)	(57.1676)	(3.4301)	(1.6967)
α		0.0187	0.0375*	0.0531***	0.0261**
		(0.8354)	(1.6724)	(5.4367)	(2.2998)
β		0.1351	0.7139***	0.9111***	0.8937***
		(0.2289)	(3.4206)	(44.9850)	(17.8794)
ln(L)		1.517	32.021	3202.538	4.951
AIC		2.9652	-58.0420	-6399.0766	-3.9011
BIC		19.0627	-41.9446	-6382.9791	12.1963

Notes: * indicates statistical significance at the 10% level; ** indicates statistical significance at the 5% level; *** indicates statistical significance at the 1% level.

5.3 Concluding Remarks

Given that Thailand is the world's top rubber producer and exporter, the sources of price changes must be identified to ensure that the country remains competitive in this market. Both changes in climatic factors as well as volatilities in the exchange rate market and crude oil market are assumed to be related to the fluctuation of Thai rubber price returns. The conditional volatility, covariance, and correlation volatility of rubber price return have been estimated using the VARMA-GARCH and copula-based GARCH models. The VARMA-GARCH model showed that volatility spillovers are evident between the volatility of rubber price return and dollar index return, while the VARMA-AGARCH model showed that the volatility spillovers are evident between the volatility of rubber price return with the volatility of dollar index and oil index returns. The coefficients of the volatility of dollar index return in both models are significant, whereas only the coefficient of the volatility of oil index return in the VARMA-AGARCH model is significant. This indicates that the volatility of dollar index return has a stronger effect on Thai rubber price returns. Furthermore, analysis of the rolling windows shows that the correlation between the volatility of rubber price and volatility of oil index return is smaller than the correlation between the volatility of rubber price and other three variables. The copula-based GARCH model shows that the Gaussian dependence has a better explanatory power than the Student-t dependence structure. Dependencies also exist between rubber price return and oil index return, rubber price return and average temperature, and rubber price return and precipitation.

Based on these results, climatic factors and fluctuations in the exchange rate market and crude oil market have significant effects on Thai rubber price returns in the world market. Therefore, the industry should consider the volatilities in these markets as well as climatic conditions when forecasting the future returns from exporting Thai rubber.

With regards the analysis methods, no single method can provide a complete picture of the dependencies and interrelatedness of the various asset markets. Therefore, a set of robust approaches, as applied here, should be used to obtain a complete picture of the complexities associated with analyses of price volatility. We hope that the results of this study can be used by government agencies, the Thai Rubber Association, farmers, as well as other key stakeholders in the rubber industry.