# Chapter 6

# Modeling the Volatility of Futures Return in Rubber and Oil

For this case study, we are forecasting the volatility of Futures return in rubber and oil from different futures market using Bivariate and multivariant Copula-Based GARCH model.

## 6.1 Introduction

Thailand, Malaysia, and Indonesia are the major producers and exporters of rubber in the world. The total rubber output of these three countries was about 8.32 million tons in 2007, representing almost 94% of the total world market. The rubber industry is one of the most important sectors of the Thai economy. The area planted with rubber is 219,933 hectares, with an annual output of 3.056 million tons in 2007 (Office of the Rubber Replanting Aid Fund, 2008). Online information from the United States Department of State shows that the per capita income of Thailand is only about US$ 4,716. As the most important producer and exporter of rubber market in the world, Thailand has some absolute advantages in the industry. However, the income of its citizens does not reflect the benefits gained from rubber production. The key reason is that farmers do not know how to hedge their position in the market.

Rubber has two kinds. The first is natural rubber, which is taken from the rubber tree. Rubber trees grow for about six or seven years and has a life span of around 30 years. The second kind is synthetic rubber, which is produced using oil. Synthetic

rubber is a substitute for natural rubber, and its price is affected by the price of oil. Fluctuations in the prices of natural rubber and gas oil in the Tokyo Commodity Exchange (TOCOM) are shown in Figure 6.1.

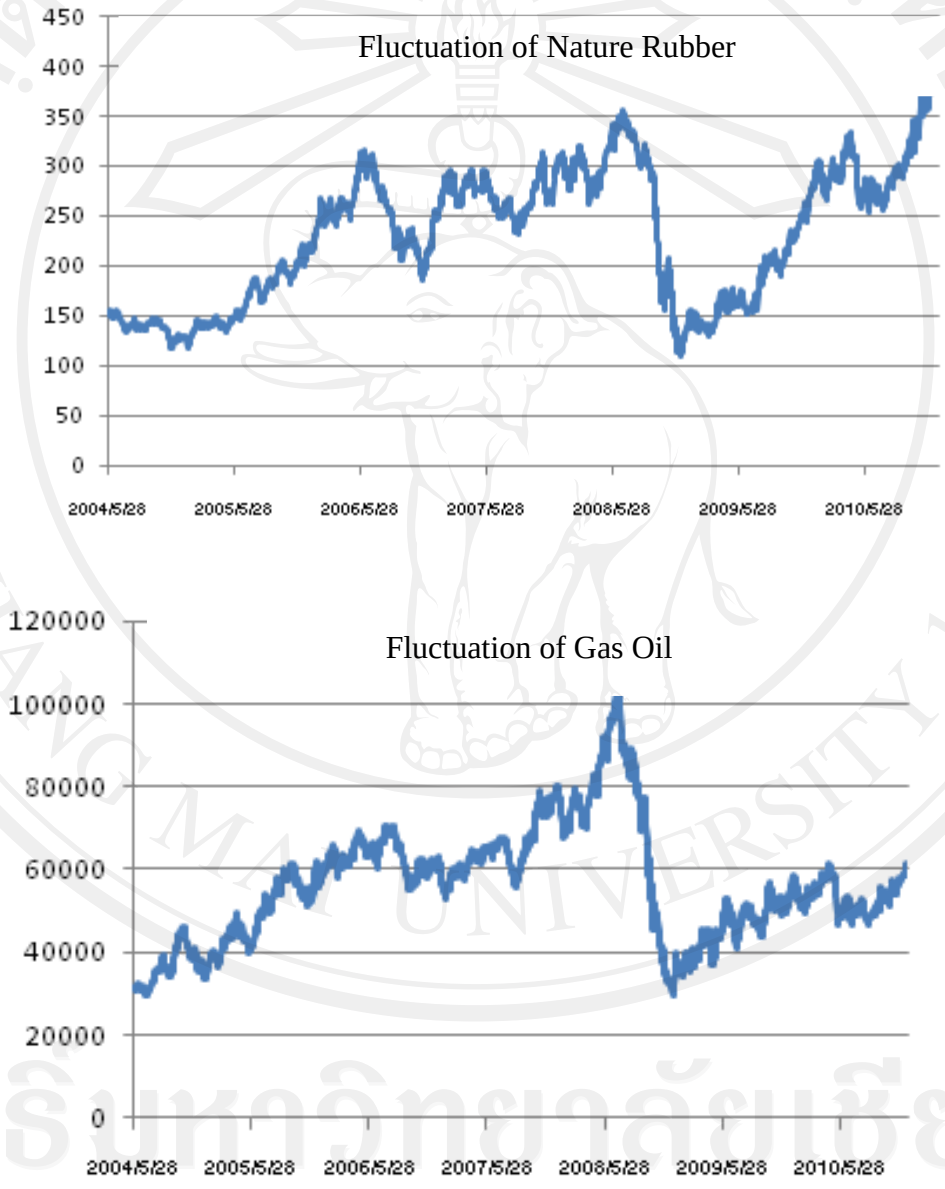


Figure 6.1 The Fluctuation of Nature Rubber and Gas Oil in TOCOM

This case study will use daily data via the Copula model to give a positive analysis on rubber futures and the oil index. A strict basic analysis and model enactment are employed to obtain expected results, which are positive relationships between each variable in those three areas and the price of rubber in Thailand. If the covariance between each series is an unsettled type (i.e., the coefficient of the condition between the error items of two series will change over time), then it will be more rational and can provide another positive analysis to be used as a reference in future research. It can also provide investors and the Thai government some useful information in strategic decision making.

Thailand is the world's number one exporter of rubber, and agriculture is its most important industry. Thus, this paper hopes to determine the relationships between each variable and the futures price of rubber in Thailand. This paper has two objectives. First, it will investigate the relationships between rubber futures and oil futures. Second, it will use historical information to forecast the futures price return in the rubber and oil markets to help farmers hedge their market position and assist investors in their decision making.

For this paper, we try to use bivariate and multivariate Copula model to forecasting the volatility of futures return in rubber. There are just few literature discuss about finance market by using bivariate Copula model, especially in multivariate Copula model. One the other hand, the oil's price is also the important factor for rubber and we choose the optimal one to characterize the dependence structures of the different futures markets. Therefore, this paper focuses on the forecasting the futures price of rubber in Thailand two different rubber futures market and two kinds of oil futures product in TOCOM using Copula-based GARCH models.

**6.2 Empirical Results**

For the ADF test, the results show that all series data are stationary in Table 6.1, which the estimated value of $\theta$ and the t-statistics of all returns are significantly at the 1% level.

Table 6.1 ADF Test of Unit Roots in Returns of Case Study3

| *Returns* | *Coefficient* | *t-statistic* |
|---|---|---|
| *AFET* | *-0.9039* | *-22.3211* |
| *SICOM* | *-0.8337* | *-20.7700* |
| *TOCOM* | *-1.1827* | *-29.5608* |
| *Crude* | *-0.9836* | *-24.1767* |
| *Gas* | *-1.0711* | *-26.4310* |

The Table 6.2 shows the descriptive statistics of variables of this paper. The standard deviation of AFET is higher than SICOOM, TOCOM, CRUDE and GAS. The skewness of SICOM, TOCOM, CRUDE and GAS are negative, so that they significantly skewed to the left. For the excess kurtosis statistics, all of variables in this paper are positive, thereby indicating that the distributions of returns have larger, thicker tails than the normal distribution. Similarly, therefore, the assumption of skewed-t is more appropriate in this paper.

Table 6.2 The Summary Statistics in Case Study3

| | *AFET* | *SICOM* | *TOCOM* | *CRUDE* | *GAS* |
|---|---|---|---|---|---|
| *Mean* | *0.0007* | *0.0008* | *0.0006* | *0.0003* | *0.0004* |
| *SD* | *0.0743* | *0.0163* | *0.0280* | *0.0247* | *0.0236* |
| *Skewness* | *0.2060* | *-0.5837* | *-0.6337* | *-0.1467* | *-0.0645* |
| *Kurtosis* | *679.9909* | *9.2110* | *8.2884* | *4.6793* | *4.8328* |
| *Max* | *2.0265* | *0.0990* | *0.1439* | *0.1153* | *0.1067* |
| *Min* | *-2.0143* | *-0.0163* | *-0.1877* | *-0.1272* | *-0.1211* |
| *JB* | *30707227.0000* | *2675.9610* | *1981.4350* | *194.7152* | *226.1842* |

As mentioned, this paper hopes to analyze the volatility of rubber futures returns in AFET from two different rubber futures market and two kinds of oil futures product in TOCOM using Copula-based GARCH models. Table 6.3 presents the estimated results for Copula-based GARCH models with feedback trading activities. Panel A shows the parameter estimates of marginal distributions with the GARCH model. The parameters in the mean equation are autocorrelations of returns. The constant components of the autocorrelation $\omega$, are significant for AFET and TOCOM, and non-significant for SICOM, CRUDE, and GAS. In addition, the parameter $\beta$ is statistically positive and statistically significant for all variables. The asymmetry parameters $\lambda$ are significant and negative for TOCOM, but non-significant for AFET, SICOM, CRUDE, and GAS, revealing the skew of TOCOM to the left. Panels B and C report the parameter estimates for different Copula functions, namely, Gaussian Copula and Student-t Copula. In terms of the values of AIC and BIC, the Student-t dependence structure has better explanatory ability than the Gaussian dependence structure between AFET and two variables, SICOM and TOCOM, but the Gaussian dependence has better explanatory ability between AFET and the other variables. The result shows that the autoregressive parameter $\beta$ is significantly positive between AFET and all variables in this paper, implying persistence with regard to the dependence structure between rubber futures returns in AFET and four variables in the paper. $\beta$ is positive; thus, if the returns in SICOM, TOCOM, CRUDE, or GAS are positive, then the return of AFET will also be positive. On the other hand, $\beta$ is less than 0.5 between AFET and Gas and higher than 0.9 between AFET and the others.

For the multivariate Copula model, all parameters between AFET and other variables are significant, as presented in Table 6.4.

Table 6.3: Estimation result of Copula based GARCH models in Case Study3

| | *AFET* | *SICOM* | *TOCOM* | *GAS* | *CRUDE* |
|---|---|---|---|---|---|
| *Panel A: Estimation of marginal* | | | | | |
| $C_0$ | *0.0006*$^{*}$ | *0.0010*$^{***}$ | *0.0009* | *0.0008* | *0.0007* |
| | *(1.7012)* | *(3.5563)* | *(1.4709)* | *(1.6193)* | *(1.1665)* |
| $C_1$ | *0.0044* | *0.1218*$^{***}$ | *-0.1814*$^{***}$ | *-0.0441* | *-0.0185* |
| | *(0.2398)* | *(4.7667)* | *(-7.2297)* | *(-1.4796)* | *(-0.6478)* |
| $\omega$ | *0.0000*$^{**}$ | *0.0000*$^{*}$ | *0.0000*$^{**}$ | *0.0000* | *0.0000*$^{*}$ |
| | *(2.1473)* | *(1.8480)* | *(2.3198)* | *(1.5947)* | *(1.7927)* |
| $\alpha$ | *0.3267*$^{***}$ | *0.1161*$^{***}$ | *0.0629*$^{***}$ | *0.0429*$^{***}$ | *0.0497*$^{***}$ |
| | *(8.9666)* | *(7.3630)* | *(4.3210)* | *(3.4918)* | *(4.2073)* |
| $\beta$ | *0.6733*$^{***}$ | *0.8839*$^{***}$ | *0.9137*$^{***}$ | *0.9469*$^{***}$ | *0.9387*$^{***}$ |
| | *(17.5159)* | *(53.8789)* | *(42.7052)* | *(57.8226)* | *(57.1815)* |
| $\upsilon$ | *5.2562*$^{***}$ | *4.8990*$^{***}$ | *6.3875*$^{***}$ | *10.9274*$^{***}$ | *11.9330*$^{***}$ |
| | *(4.2369)* | *(8.1505)* | *(6.5227)* | *(4.0208)* | *(3.6536)* |
| $\lambda$ | *-0.0311* | *-0.0385* | *-0.1193*$^{***}$ | *-0.0097* | *-0.0513*$^{*}$ |
| | *(-1.4901)* | *(-1.6209)* | *(-3.8965)* | *(-0.5336)* | *(-1.7480)* |
| *Panel B: Estimation of Gaussian dependence structure for AFET* | | | | | |
| $\alpha$ | | *0.0517*$^{**}$ | *0.0483* | *0.0451*$^{*}$ | *0.0092*$^{*}$ |
| | | *(2.0182)* | *(1.5480)* | *(1.7362)* | *(1.9521)* |
| $\beta$ | | *0.3773* | *0.9311*$^{***}$ | *0.4495*$^{***}$ | *0.9810*$^{***}$ |
| | | *(0.7122)* | *(17.9143)* | *(2.6075)* | *(93.3557)* |
| *ln(L)* | | *608.566* | *165.645* | *50.038* | *63.530* |
| *AIC* | | *-1213.1327* | *-327.2891* | *-96.0761* | *-123.0607* |
| *BIC* | | *-1202.3672* | *-316.5236* | *-85.3106* | *-112.2953* |

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

Table 6,3 (Continued)

| | *AFET* | *SICOM* | *TOCOM* | *GAS* | *CRUDE* |
|---|---|---|---|---|---|
| *Panel C: Estimation of student-t dependence structure* | | | | | |
| $\upsilon$ | | *15.5083*$^{***}$ | *16.0426*$^{***}$ | *155.4639* | *196.5094*$^{**}$ |
| | | *(5.0382)* | *(3.3401)* | *(1.3597)* | *(2.3069)* |
| $\alpha$ | | *0.0297*$^{***}$ | *0.0510*$^{*}$ | *0.0454*$^{*}$ | *0.0093*$^{*}$ |
| | | *(2.7793)* | *(1.6972)* | *(1.7540)* | *(1.7275)* |
| $\beta$ | | *0.9370*$^{***}$ | *0.9327*$^{***}$ | *0.4505*$^{***}$ | *0.9809*$^{***}$ |
| | | *(45.5626)* | *(20.2403)* | *(2.5750)* | *(87.3008)* |
| *ln(L)* | | *643.316* | *171.078* | *50.108* | *63.329* |
| *AIC* | | *- 1280.6328* | *-336.1566* | *-94.2170* | *-120.6583* |
| *BIC* | | *-1264.4846* | *-320.0083* | *-78.0688* | *-104.5100* |
| *Panel D: Estimation of Clayton dependence structure* | | | | | |
| $\omega$ | | *0.4587*$^{***}$ | *0.2085*$^{**}$ | *-1.3972*$^{**}$ | *-2.1924* |
| | | *(2.8738)* | *(2.4405)* | *(-2.1465)* | *(-0.2894)* |
| $\alpha$ | | *-0.8867* | *-1.6588*$^{**}$ | *-1.0479* | *-1.0299* |
| | | *(-1.5052)* | *(-2.5314)* | *(-1.2427)* | *(-0.3321)* |
| $\beta$ | | *-0.2362* | *0.8483*$^{***}$ | *0.0436* | *-0.4690* |
| | | *(-1.0799)* | *(15.0932)* | *(0.1174)* | *(-0.1190)* |
| *ln(L)* | | *494.402* | *129.631* | *34.481* | *40.300* |
| *AIC* | | *-982.8048* | *-253.2611* | *-62.9620* | *-74.6008* |
| *BIC* | | *-966.6565* | *-237.1128* | *-46.3138* | *-58.4525* |

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

Table 6.4: Estimation result of multivariate Copula based GARCH models

| *Multivariate Copula model(Claton)* | |
|---|---|
| $C_{12}$ | $0.4210^{***}$ |
| | *(22.7427)* |
| $C_{13}$ | $0.1800^{***}$ |
| | *(9.3480)* |
| $C_{14}$ | $0.0644^{***}$ |
| | *(4.0488)* |
| $C_{15}$ | $0.0752^{***}$ |
| | *(4.5182)* |
| $C_{23\|1}$ | $0.0735^{***}$ |
| | *(4.7362)* |
| $C_{24\|1}$ | $0.0285^{***}$ |
| | *(2.6734)* |
| $C_{25\|1}$ | $0.0382^{***}$ |
| | *(3.0658)* |
| $C_{34\|12}$ | $0.0655^{***}$ |
| | *(4.9096)* |
| $C_{35\|12}$ | $0.0401^{***}$ |
| | *(2.9831)* |
| $C_{45\|123}$ | $0.3337^{***}$ |
| | *(19.7358)* |
| *ln(L)* | *1000.582* |
| *AIC* | *-1981.1640* |
| *BIC* | *-1927.3365* |

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

### 6.3 Concluding Remarks

This paper estimated the conditional volatility, covariance, and correlations volatility of rubber futures using the Copula-based GARCH model. Empirical results showed that the Gaussian dependence has better explanatory ability than the Student-t dependence structure and the persistence pertaining to the dependence structure between rubber futures returns in AFET and rubber futures returns in others (i.e., SICOM and TOCOM). The Student-t dependence has better explanatory ability than the Gaussian dependence structure and the persistence pertaining to the dependence structure between rubber futures returns in AFET and oil futures returns in the others (i.e., crude oil futures returns and gas oil futures returns in TOCOM). The results also imply that the rubber futures returns in AFET will follow the rubber futures returns in TOCOM, the rubber futures returns in SICOM, the crude oil futures returns in TOCOM, or the gas oil futures returns in TOCOM in the same manner. Higher relationships are observed between AFET and the two other rubber futures markets because they are trading the same product. The price volatility of synthetic rubber is close to the price of crude oil, indicating higher relationships between AFET and CRUDE. The multivariate Copula model demonstrates that all variables discussed in this paper can affect the rubber futures returns in AFET. For the Coefficients not only in the multivariate Copula, but also in the Gaussian dependence and student-t dependence structure in bivariate Copula are positive. It means that the volatility of futures return in AFET follows those four kinds of futures return in SICOM and TOCOM. Because AFET is a new futures market comparing with SICOM and TOCOM, the volatility of futures price in AFET will follow those two futures market.

Agriculture is Thailand's most important sector. Farmers have an essential role in the Thai economy, and they represent a large sector of the population. Thus, the national government should take care of them. Given their low income, farmers may not have enough money to invest in commodity futures markets. After examining the relationship between rubber futures returns and four variables, this paper proposes that the Thai government should contribute to the hedge mutual funds that are invested in rubber futures in AFET following the volatility of rubber futures of TOCOM, the rubber futures of SICOM, the crude oil futures of TOCOM, and the gas oil futures of TOCOM. By doing so, the government can gather the funds from farmers to invest in each commodities futures market. Sufficient funds will enable Thai farmers to better hedge their bets in the futures market.