Chapter 4

Empirical Results

4.1 Statistical Summary

Figure 4.1 shows the close relationship between the changes in ethanol prices and the changes in crude oil prices from late 2005 through 2009, when rapid expansion of the ethanol industry was taking place. In 2008, international crude oil price registered an incidence of extreme volatility and became a hot issue because the price had risen up to more than 100 dollars per barrel. In the second half of 2008, the crude oil price came tumbling down from the peak to just 33 dollars per barrel due to the severe financial crisis and economic recession that was caused by the American subprime crisis. Since we used the block maxima method, in which the block length is a calendar month (around 22 days), we received 38 maxima. Table 4.1 shows the descriptive statistics of the two energy commodity prices returns maxima.

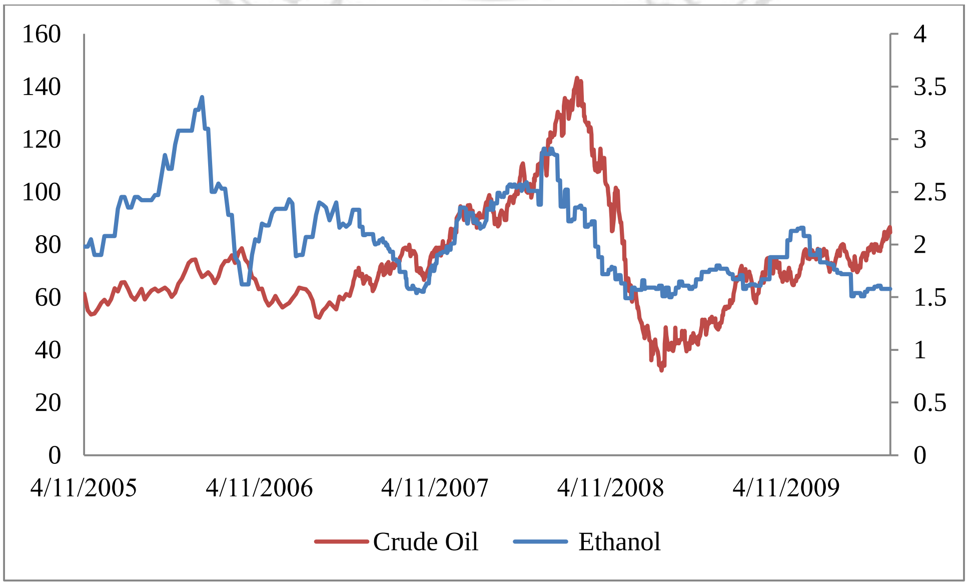

Figure 4.1 The co-movement of crude oil and ethanol price

Note: The primary axis is for the crude oil prices, and the secondary axis is for the ethanol prices.

Table 4.1 Statistical Summary of Ethanol Price and Crude Oil Price Returns

	Ethanol	Crude Oil
Minimum	-0.234	-0.180
Median	0.000	0.001
Mean	0.000	0.000
Maximum	0.159	0.220
Std. Dev.	0.026	0.030
Skewness	-1.751	0.064
Kurtosis	22.638	5.512
Jarque-Bera	18443.560	1070.874
Probability	0.000	0.000
Observation	839	839

The descriptive statistics test (see Table 4.1) showed that the returns of the ethanol prices are skewed to the right tail while the returns of the crude oil prices are almost symmetric, and that the excess Kurtosis is larger than zero. Therefore, the two distributions are in a higher peak when they are compared to the normal distribution. By using the Jarque-Bera test, we rejected the null hypothesis of a normal distribution at the 5% level for both the distributions. Therefore, we concluded that using an extreme value distribution was suitable for our study. The correlation between the two spot price returns is -0.035, which is very weak. But the dependence may be greater when we measure the dependence in the tail.

4.2 Empirical Results

The empirical results can be checked in Table 4.2. In the margin estimation, as we all know, the shape parameter ξ governs the tail behavior of the distribution. The sub-families defined by $\xi = 0$, $\xi > 0$, and $\xi < 0$ correspond, respectively, to the Gumbel, Fréchet, and Weibull families. In our case, the shape parameters are both greater than zero; therefore, the two margins are heavy-tailed: this again justifies the usefulness of the GEV distribution. In the dependence part, we compared the four copulas by using the AIC criterion. The HR copula is the best among them. The dependence parameter is equal to 0.465 and also significant. The dependence structure can be seen in Figure 4.2.

Table 4.2 The Estimation Results of Four Extreme Value Copulas

	Gumbel Copula		Galambos Copula		Tawn Copula		Husler-Reiss Copula	
	Ethanol	Oil	Ethanol	Oil	Ethanol	Oil	Ethanol	Oil
μ	0.034	0.042	0.034	0.041	0.034	0.042	0.034	0.042
	(0.005)***	(0.003)***	(0.005)***	(0.003)***	(0.005)***	(0.003)***	(0.005)***	(0.003)***
σ	0.029	0.0159	0.029	0.0159	0.029	0.016	0.029	0.015
	(0.005)***	(0.003)***	(0.005)***	(0.003)***	(0.005)***	(0.003)***	(0.005)***	(0.003)***
ξ	0.433	0.39	0.432	0.378	0.415	0.409	0.426	0.371
	(0.147)***	(0.194)***	(0.158)***	(0.195)***	(0.139)**	(0.203)**	(0.171)***	(0.193)**
r	1.076(0.157)**		0.239(0.33)		0.246(0.352)		0.465(0.164)***	
AIC	325.978		325.778		325.902		325.738	

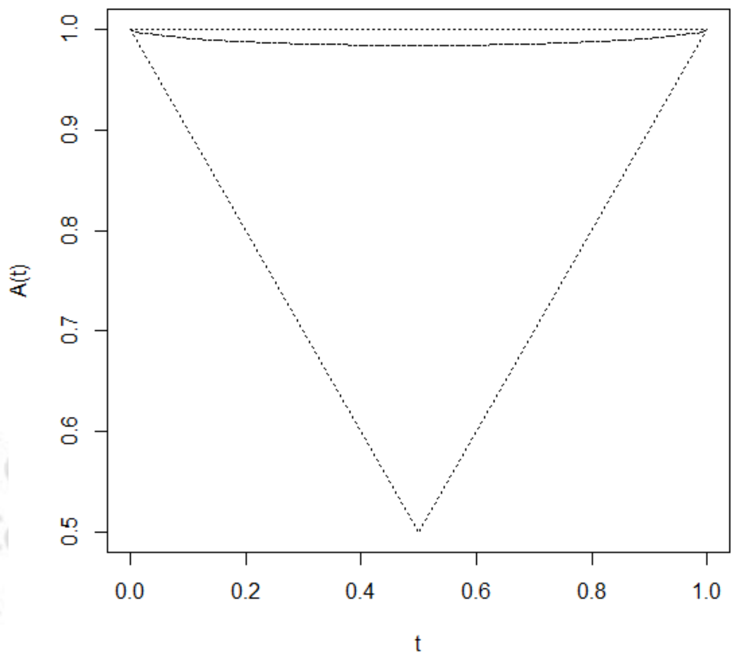

Figure 4.2 The dependence function of the returns between ethanol price return and crude oil price return, using the HR copula.

The dependence function of A(t) of the HR copula is presented in Figure 4.2. Based on the table, we see that the results are consistent with the Kendall tau measure (= 0.02), which we have calculated and presented in Table 4.2. The dependence is close to the upper bound of A(t), and the dependence structure between the oil price and the ethanol price is weak, as we expected.

4.3 Goodness of Fit of Extreme Value Copula

For this part of the study, we used the Cramér–von Mises statistics to test whether or not our data were fit for the selected EV copula: the details of the statistics can be found in the work by Genest, Kojadinovic, G. Nešlehová, and Yan (2010). The statistic is as follows:

$$S_n = \int_0^1 n|A_n(t) - A_{\theta n}(t)|^2 \, dt. \quad (12)$$

The results are demonstrated in Table 4.2. Since the null hypothesis of Cramér–von Mises is the data fit for the specific copulas, all of the copula, except for the Tawn copula, do not reject the null hypothesis.

Table 4.3 Cramér–von Mises Statistics

	Gumbel Copula	Galambos Copula	Tawn Copula	Husler-Reiss Copula
the statistics	0.042	0.029	0.150	0.023
p-value	0.348	0.462	0.016	0.490

Note: The p-value was obtained by using a boots tapping process.