Chapter 4

Empirical results

4.1 Data

This study is mainly based on international settlement tool—foreign exchange rate. This study collects 7 years' daily data as our study sample, from 2006 to 2012. The data are secondary data, which are derived from the official website, namely the sample of People's Republic of China's Exchange Rate (Cex), Thailand's Exchange Rate (Tex). All variables are in natural logarithms term. The logarithm form of data will provide more accurate information. It shows when a variable change, how does the others influenced. Exchange rate of USD per CNY: the data from 13th June, 2006 to 13th June, 2012. Exchange rate of USD per THB: the data from 13th June, 2006 to 13th June, 2012. The data have been collected from People's Republic of China Statistics Bureau website, Federal Reserve Bank website and Quantity Analysis Room (QA) at Chiang Mai University.

All the results calculate by software R, MATLAB, S-PLUS, E-Views and Excel.

The statistic of Cex and Tex from 13th June 2006 to 13th June 2012 showed as below. In table 4.1, this study can be seen that, there are 1402 observations of People's Republic of China's exchange rates return in percentage and Thailand's exchange rates return in percentage respectively. The mean value of Cex is -0.000168. The median value of Cex is -2.93e-0.5. The maximum value and minimum value are 0.003638 and -0.004330 respectively. The standard deviation is 0.000902. From Skewness value and Kurtosis value this study gets the normal distribution that is not suiting for Cex, it shows the heavy-tailed characteristic.

On the other hand, the mean value of Tex is -0.000135. The median value of Tex is 0.000000. The maximum value and minimum value of Tex are 0.044702 and -0.032345 respectively. The standard deviation is 0.004895. This study also gets the characteristic of Tex that shows the heavy-tailed distribution.

Table 4.1 The descriptive statistics of People's Republic of China's exchange return in percentage and that of Thailand from 2006 to 2012

	People's Republic of China exchange return in percentage (Cex)	Thailand's exchange return in percentage (Tex)
Mean	-0.000168	-0.000135
Median	-2.93e-05	0.000000
Maximum	0.0036380	0.044702
Minimum	-0.004330	-0.032345
Std.Dev	0.000902	0.004895
Skewness	-0.469677	0.448775
Kurtosis	5.306592	14.00870
Jarque-Bera Statistic	362.0875	7121.581
Number of obs.	1402	

Source: From computed

Figure 4.1, 4.2 and 4.3 show the data information of each country's exchange rates and the overview of the data return in percentage. The fluctuation of Thailand's exchange return is serious than China's. Figure 4.3 and Figure 4.4 are the nominal exchange rates of these two countries. Combine with the monetary policies this study mentioned in Chapter 2, this study will get that after 1997 Thailand adopted the managed-floated monetary policy and after 2000 Thailand adopted inflation targeting regime. From 2006 to 2012 the value of Thailand's currency has kept in the area between 30B per USD and 36B per USD and the main trend of it increase year on year. For People's Republic of China's currency value this study found that after 2005 when China use managed-floated regime and with the IMF urge, the exchange rates of

CNY increased rapidly and the value increase trend was very significant in this special period from 2006 to 2012. Figure 4.3 and Figure 4.4 show that the increase trend of People's Republic of China's currency value is smooth than the increase trend of Thailand's currency value.

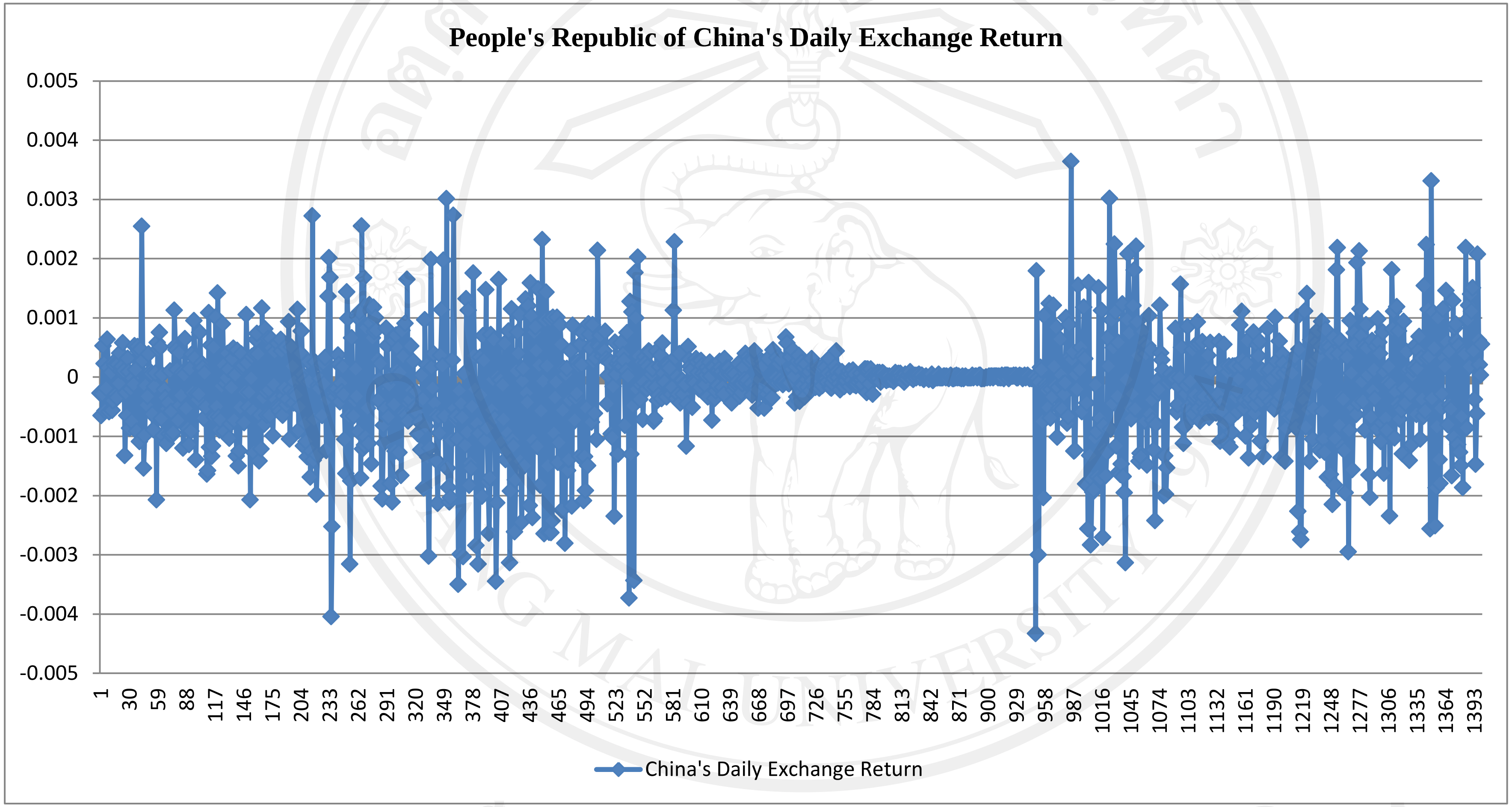

Figure 4.1: The historical daily data of People’s Republic of China’s exchange return in percentage during the periods of 2006 to 2012

Source: People’s Republic of China Statistics Bureau

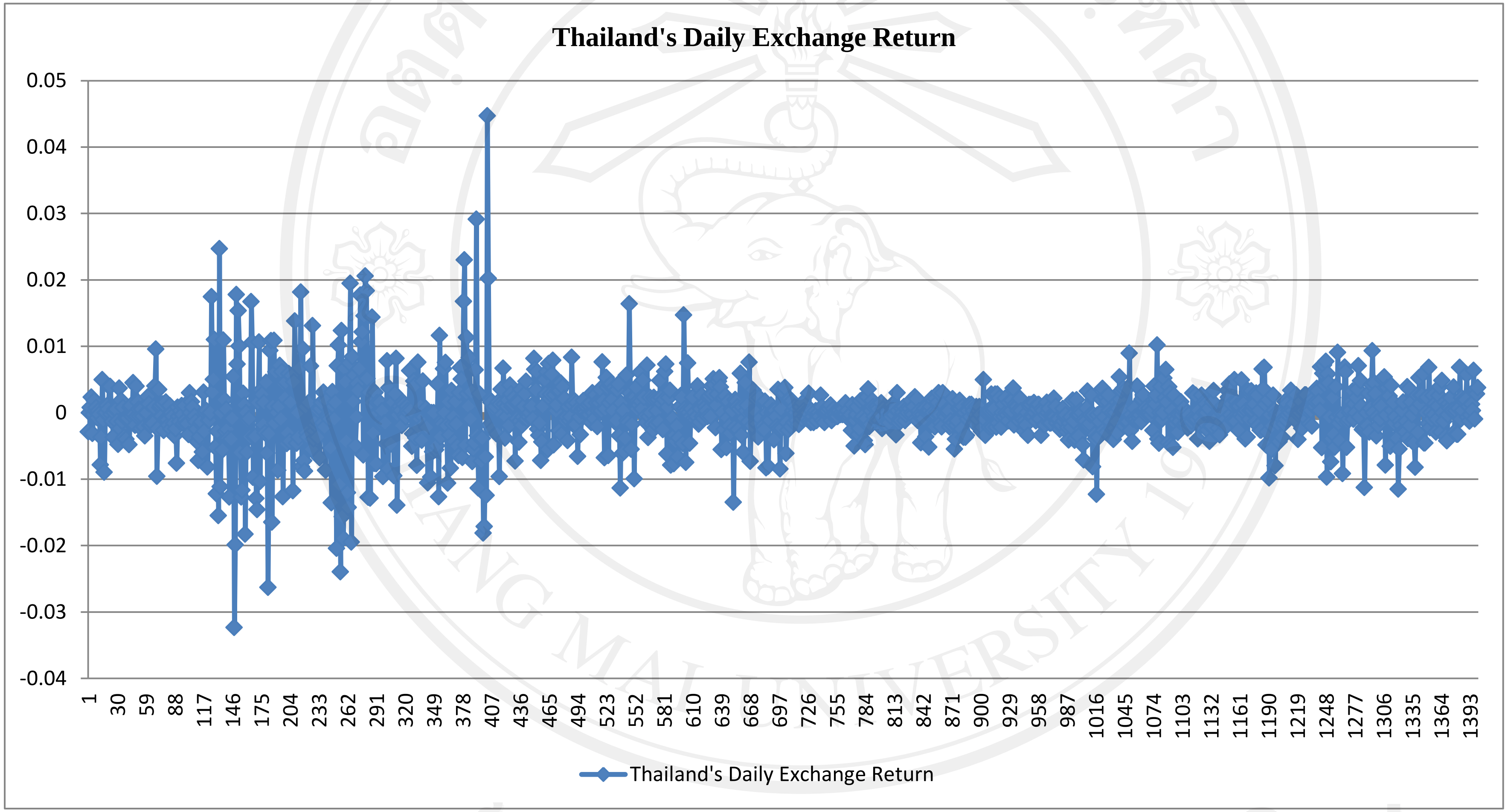

Figure 4.2: The historical daily data of Thailand's exchange return in percentage during the periods of 2006 to 2012

Source: Federal Reserve Bank

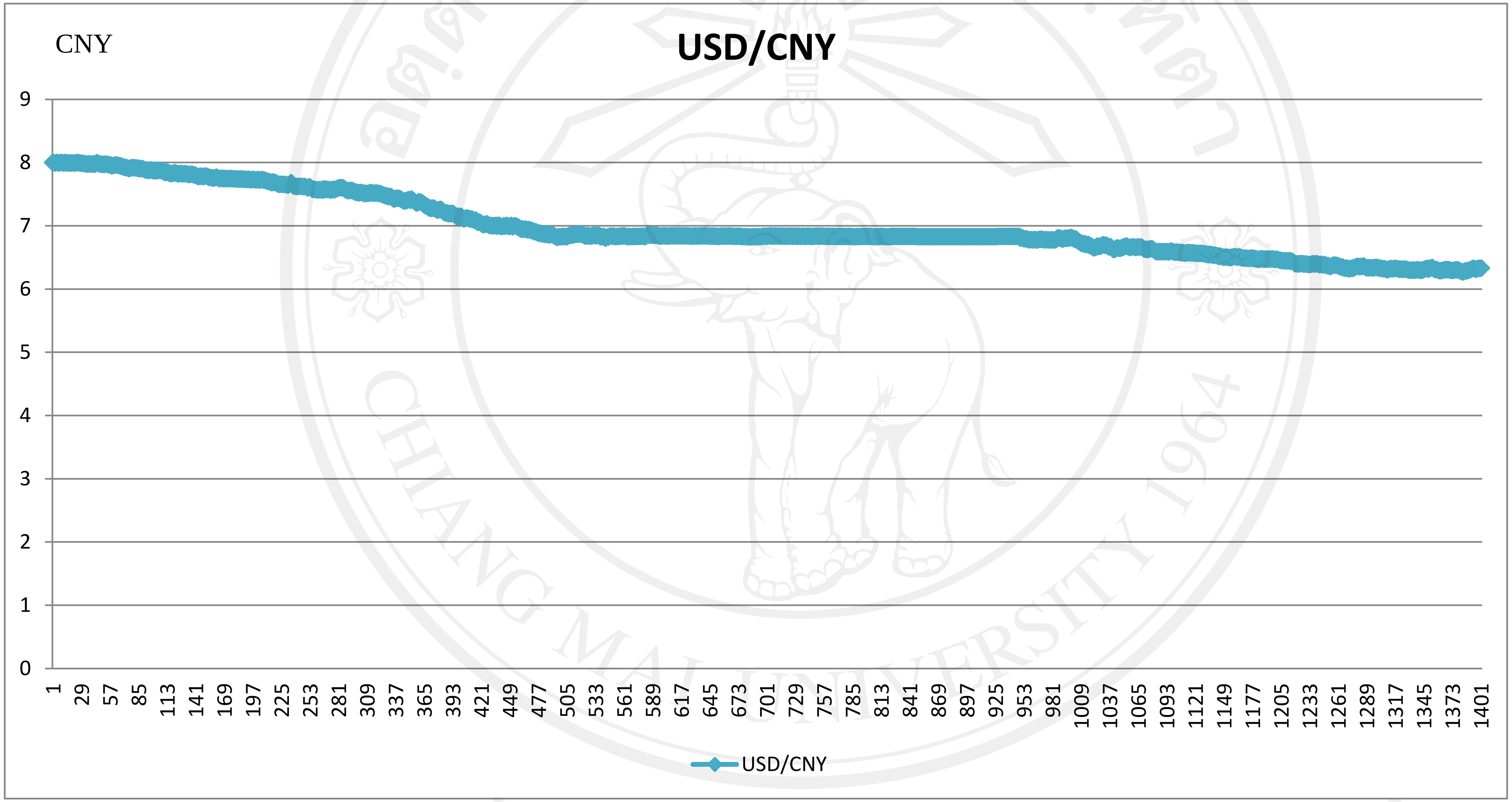

Figure 4.3 People's Republic of China's nominal exchange rates from 2006 to 2012

Source: People's Republic of China Statistics Bureau

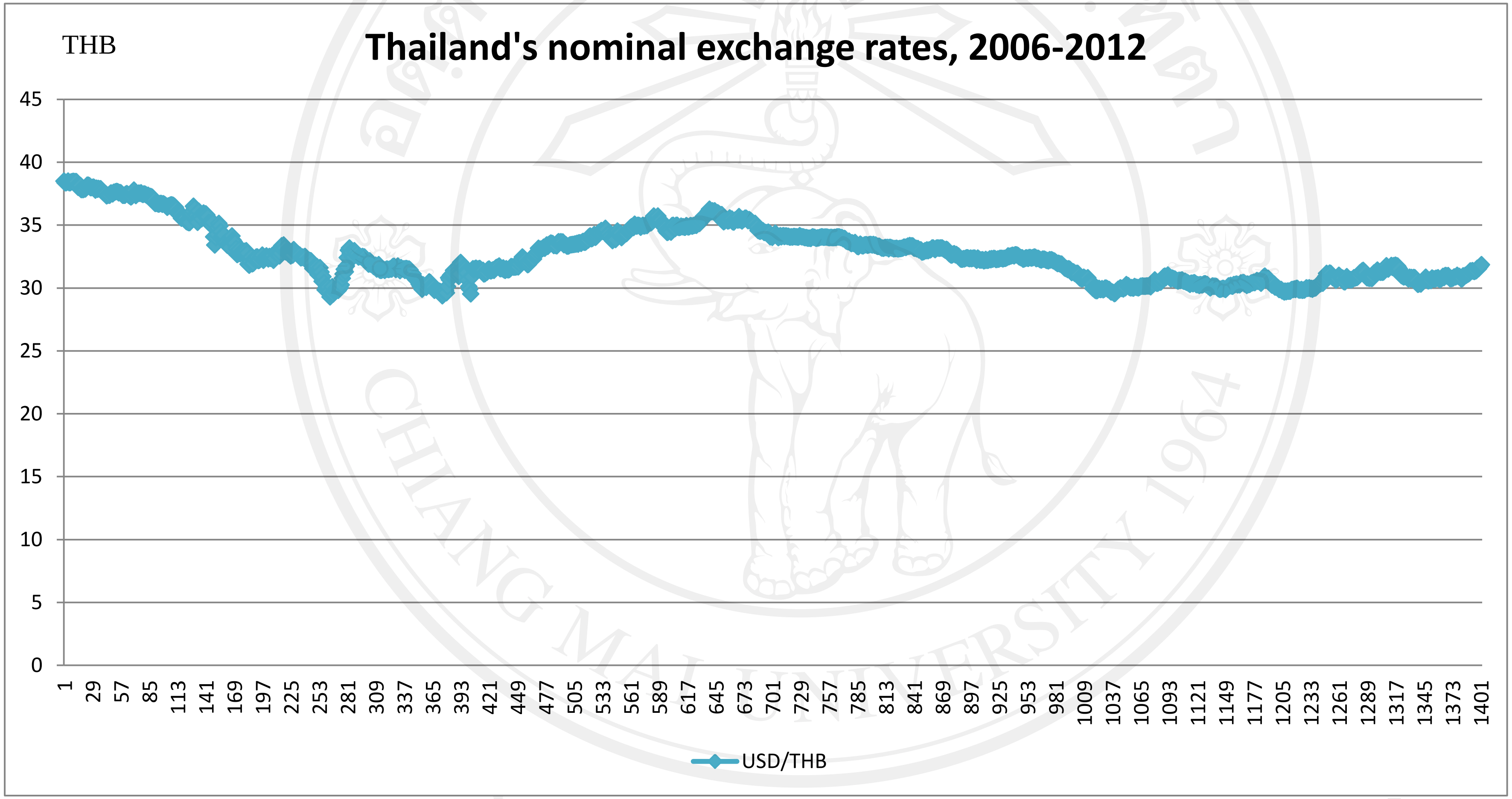

Figure 4.4 Thailand's nominal exchange rates from 2006 to 2012

Source: Federal Reserve Bank

4.1.1 Unit root test results

The econometric statistical software R is used to conduct a unit root test of both observations. Table 4.2 and Table 4.3 summarize People's Republic of China's exchange rates observation and Thailand's exchange rates observation results respectively. The results strongly support that both series are no unit root and stationary at 1% significant level.

Table 4.2: Results of People's Republic of China's exchange return in percentage Unit Root test

Name of Observation: Cex		
Null Hypothesis: Cex has a unit root		
Augmented Dickey-Fuller test statistic		
Intercept	Trend and Intercept	None
-35.49690***	-35.61474***	-34.39595***
(0.0000)	(0.0000)	(0.0000)
Phillips-Perron test statistic		
Intercept	Trend and Intercept	None
-35.49690***	-35.61474***	-34.39595***
(0.0000)	(0.0000)	(0.0000)

Note: *** means rejection of null hypothesis of non-stationarity at 1% significant level.

Source: From computed

Table 4.3: Results of Thailand's exchange return in percentage Unit Root test

Name of Observation: Tex		
Null Hypothesis: Tex has a unit root		
	Augmented Dickey-Fuller test statistic	
Intercept	Trend and Intercept	None
-35.90944***	-35.93883***	-35.89689***
(0.0000)	(0.0000)	(0.0000)
	Phillips-Perron test statistic	
Intercept	Trend and Intercept	None
-35.90944***	-35.93883***	-35.89689***
(0.0000)	(0.0000)	(0.0000)

Note: *** means rejection of null hypothesis of non-stationarity at 1% significant level.

Source: From computed

4.1.2 Two-Sample Kolmogorov-Smirnov test

Statistical software MATLAB is used to do Two-Sample Kolmogorov-Smirnov test of both observations. Table 4.4 and Table 4.5 summarize the results respectively.

Table 4.4: Two sample Kolmogorov-Smirnov test for People’s Republic of China’s exchange return in percentage

Name of observation: Cex	
Null hypothesis: Cex observation distribution obey continuous uniform distribution	
	Cex
K-S Two-Sample Statistic	0.0180
P-Value	0.9765
h	0

Note: h=0 means accept the null hypothesis at 5% Significant level.

Source: From computed

Table 4.5: Two sample Kolmogorov-Smirnov test for Thailand’s exchange return in percentage

Name of observation: Tex	
Null hypothesis: Tex observation distribution obey continuous uniform distribution	
	Tex
K-S Two-Sample Statistic	0.0217
P-Value	0.8937
h	0

Note: h=0 means accept the null hypothesis at 5% Significant level.

Source: From computed

Table 4.4 and Table 4.5 show the two-sample K-S test results, the null hypothesis is that People's Republic of China's exchange return in percentage distribution and a random uniform distribution which based on People’s Republic of China’s real exchange rates return in percentage are from the same continuous uniform distribution. And Thailand's exchange return in percentage distribution and a random uniform distribution which based on Thailand's real exchange rates return in percentage are from the same continuous uniform distribution. The alternative hypothesis is that they are not from the same continuous uniform distributions. The result h is 0 means the test accepts the null hypothesis at the 5% significance level. These results indicate that this study can use parametric copulas to describe the dependence measures between these two sample data.

4.2 The appropriate forecasting models selection of People's Republic of China's exchange return in percentage and that of Thailand

4.2.1 The appropriate forecasting model of People's Republic of China's exchange return in percentage

This study use AIC, BIC and MAPE (%) (Mean Absolute Percent Error) help us to select the appropriate model for People's Republic of China's exchange rates return in percentage.

Table 4.6: The model selection of People's Republic of China's exchange return in percentage based on AIC, BIC and MAPE (%)

	AIC	BIC	MAPE (%)
Autoregressive Linear Model	-19659.59	-19643.85	2.073917
Self-Exciting Threshold Autoregressive Model	-19674.13	-19637.42	1.613032
Logistic Smooth Transition Autoregressive Model	-19656.06	-19614.10	1.932661
Neural Network Model	-19639.53	-19571.33	2.065262
Additive Autoregressive Model	-19643.96	-19544.29	1.673697

Source: From computed

From Table 4.6, the forecasting evaluation statistics indicated that Self-Exciting Threshold Autoregressive Model (SETAR Model) is the best model to forecast the People's Republic of China's exchange rates return in percentage of exploration period, which minimizes AIC and MAPE (%) among all candidate models.

For People's Republic of China's exchange rates return in percentage the appropriate forecasting model's function shows below:

$$Y_{ct+1} = \begin{cases} -9.286e-05 + 8.169e-02 Y_{ct-1} + \varepsilon_{ct+1} & Z_{ct} \leq 0.0004431 \\ -0.00034 + 0.17538 Y_{ct} + \varepsilon_{ct+1} & Z_{ct} > 0.0004431 \end{cases} \quad (4.1)$$

Table 4.7: Appropriate forecasting model summary for People's Republic of China

For the lower regime (Z_{ct} less than threshold value)		
const L	PhiL.1	PhiL.2
-9.285588e-05**	1.123082e-02	8.169066e-02**
(0.002630)	(0.707899)	(0.023378)
For the lower regime (Zct greater than threshold value)		
const H	PhiH.1	PhiH.2
-0.0003446259**	0.1753768440**	0.0368176554
(0.002952)	(0.002393)	(0.708853)

where '**' indicate the value significant at level 0.001.

Source: From computed

This study will put the appropriate forecasting model's function into generated map:

$$\hat{Y}_{ct+1} = \begin{cases} \hat{f}\,(Y_{ct-1}) \\ \hat{f}\,(Y_{ct}) \end{cases} \tag{4.2}$$

where $\hat{f} = f(\cdot,\hat{\theta})$, f is generic function. (More detail mentioned in Chapter 2)

This function indicates that, in the low regime, People's Republic of China's exchange rate of return tomorrow's exchange rate of return based on the yesterday's exchange rate of return. And in the high regime, People's Republic of China's exchange rate of return tomorrow's exchange rate of return based on today's exchange rate of return.

4.2.2 The appropriate forecasting model of Thailand's exchange return in percentage

The function AIC, BIC and MAPE (%) can be used to compare all models fitted to the same data. Therefore AIC, BIC and MAPE (%) will help us find the appropriate model for Thailand's exchange rates return in percentage.

Table 4.8: The model selection of Thailand's exchange return in percentage based on AIC, BIC and MAPE (%)

	AIC	BIC	MAPE (%)
Autoregressive Linear Model	-14921.36	-14905.62	1.016519
Self-Exciting Threshold Autoregressive Model	-14926.78	-14890.06	1.016747
Logistic Smooth Transition Autoregressive Model	-14918.4	-14876.44	1.016734
Neural Network Model	-14901.47	-14833.28	1.016385
Additive Autoregressive Model	-14911.08	-14811.41	1.036549

Source: From computed

From Table 4.8, the forecast evaluation statistics found that Autoregressive Linear Model (AR-linear model) is the best model to forecast the Thailand's exchange rates return in percentage during exploration period because this model has minimize value of BIC and MAPE (%).

For Thailand's exchange rates return in percentage the appropriate forecasting model's function shows below:

$$Y_{bt+1} = -0.00014 + 0.06864 Y_{bt-1} + \varepsilon_{bt+1} \quad (4.3)$$

Table 4.9: Appropriate forecasting model summary for Thailand

const	Phi.1	Phi.2
-0.0001364323*	-0.0430408808	0.0686352982*
(0.029609)	(0.002393)	(0.01018)

where '*' indicate significant at level 0.01.

Source: From computed

This study will put the appropriate forecasting model's function into generated map:

$$\hat{Y}_{bt+1} = \hat{f}(Y_{bt-1}) \quad (4.4)$$

where $\hat{f} = f(\cdot, \hat{\theta})$, f is generic function. (More detail mentioned in Chapter 2)

This function indicates that, Thailand's tomorrow's exchange rate of return based on yesterday's exchange rate of return.

Notice that the appropriate forecasting model's functions are based on the sample this study collect and they are workable in the special period from 2006 to 2012. These results all indicate that the exchange rates data's characteristic of People's Republic of China is different with that of Thailand's. Because different forecasting model fit different exchange rates return in percentage. These two countries took the different monetary policies are the main reason of these results. From Bank of Thailand, this study found that Thailand has adopted the managed-float exchange rates policy in 1997, which is also compliance with the inflation targeting policy that has adopted in 2000. Since 2005, Chinese government took the similar monetary policies, and switch to more flexibility exchange rates regime near 2010. Therefore there is a time gap between this two countries' exchange rate policy and the point of these two countries' exchange rate policy are different. In a word, People's Republic of China's exchange rate policy focus on the currency flexibility, but Thailand see stable purchasing power or price level as the main point. Notice that, for Thailand's exchange rates the linear model was used perhaps due to the world's financial crisis which affect Thailand's economy seriously. The foreign exchange investors' expectations are different will be another reason. With the People's Republic of China's economic status growth and IMF urge in recently years, more and more countries and investors reserve and arbitrage China's currency. Therefore, China's exchange rates return in percentage shows the nonlinear characteristic. Figure

4.5 and Figure 4.6 are the exchange policy review of People's Republic of China and Thailand. These two figures will help us understand the history of each country's exchange policy and the policy differences between these two countries.

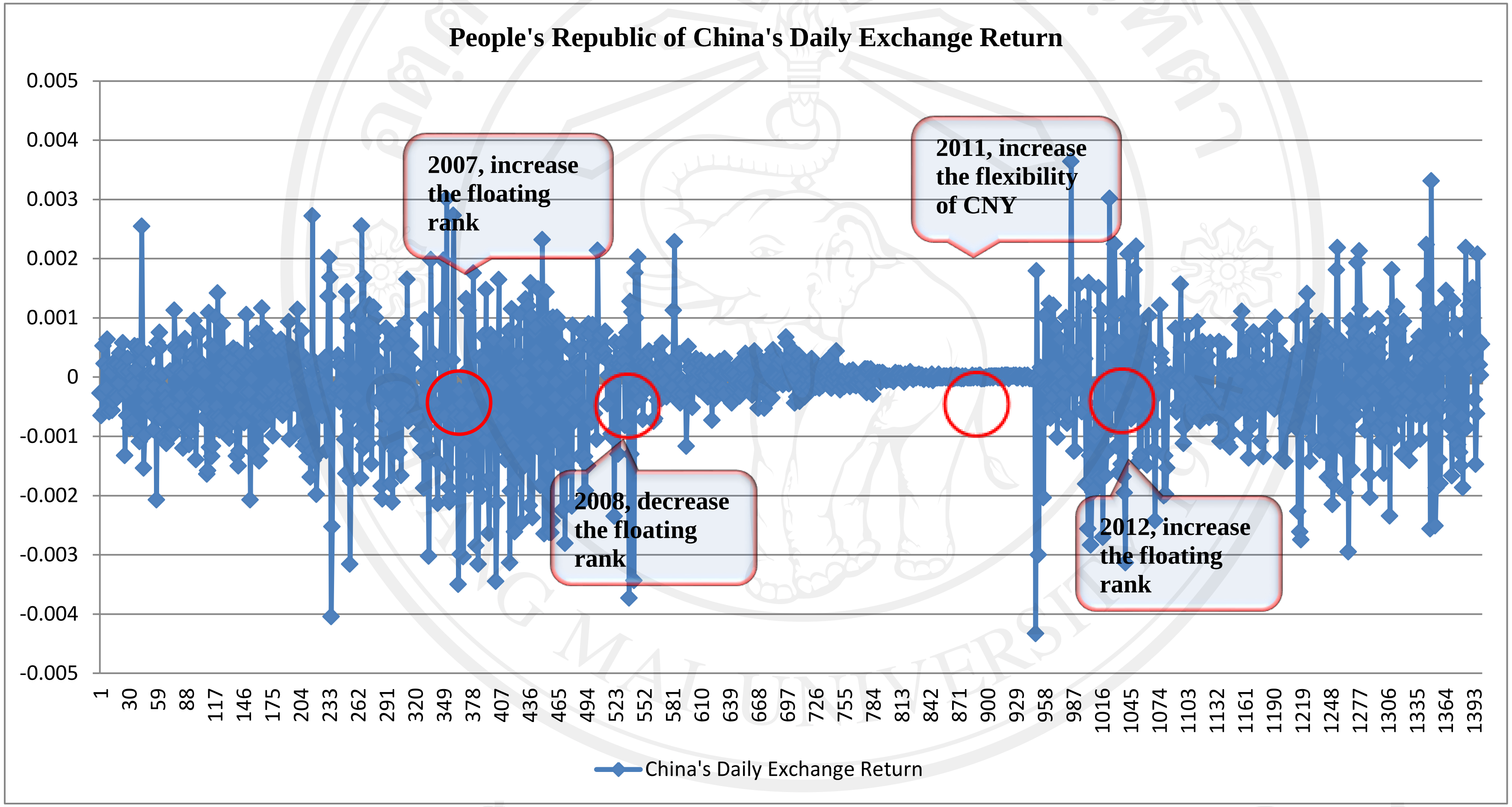

Figure 4.5 Exchange policy review of People's Republic of China, 2006-2012

Source: People's Republic of China Statistics Bureau

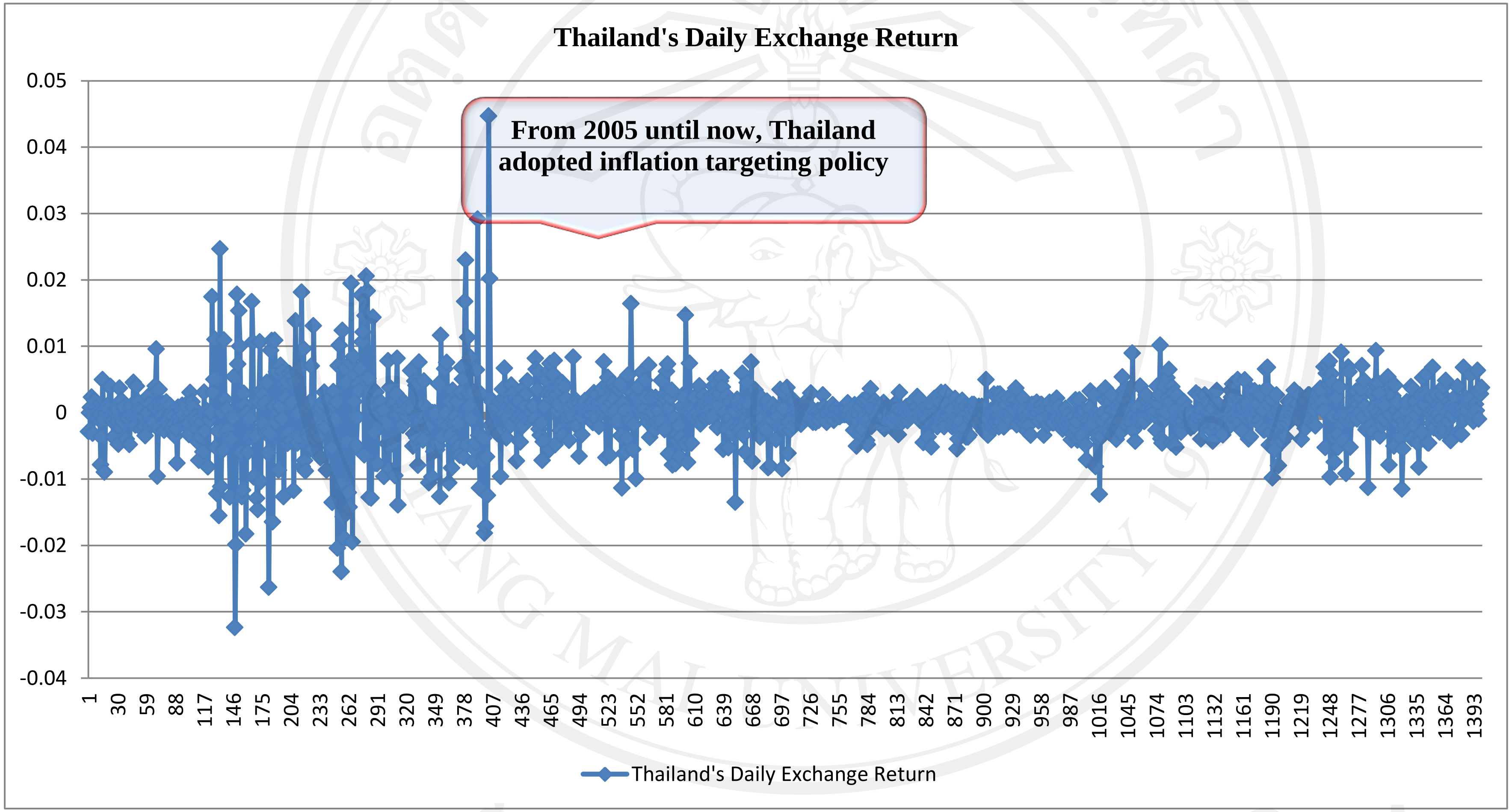

Figure 4.6 Exchange policy review of Thailand, 2006-2012

Source: Federal Reserve Bank

From micro aspect, these appropriate models will as a tool to capture the data behaviors and operation rules which will help us to forecast each country's exchange rates in the future. From macro aspect, it provides some suggestions for government monetary policies. If the exchange rates expected decrease or increase rapidly, the government should use an appropriate economic leverage to modify the foreign exchange market and let their own currency value keep a healthy development.

4.3 Copula modeling

The function AIC, BIC can be used to compare all copulas fitted to the same data sample. Therefore AIC, BIC will help us to find the appropriate parametric copula. This study should notice that different copulas measure the different dependence structures. The Normal copula has zero tail dependence, Clayton copula has zero upper tail dependence, Rotated Clayton copula has zero lower tail dependence, Plackett copula has zero tail dependence, Frank copula has zero tail dependence, Gumbel copula has zero lower tail dependence, Rotated Gumbel copula has zero upper tail dependence, Student's t copula has symmetric tail dependence and SJC copula parameters are the tail dependence coefficients, but in reverse order. Zhou Haowen and Yan Fugui (2010) and Liu Qiongfang and Zhang Zongyi (2011) in their researches provide that based on AIC and BIC can select the appropriate parametric copula to analysis the dependence structure between financial observations. And they also explained the meaning of parameters' value. This study will use the similar method to select the appropriate parametric copula. And through the appropriate parametric copula, this study will understand the tail dependence structure form clearly. Table 4.10 will shows the selection result based on AIC and BIC.

Table 4.10: Copula selection based on AIC and BIC

Copula Classes		Log Likelihood	AIC	BIC	θ	ρ	DOF	τ^U	τ^L
EV Copulas	Normal copula	-6.29	-12.59	-12.58		0.0949 (8.9e-04)			
	Plackett copula	-10.82	-21.64	-21.63	1.5161 (0.0036)				
	Gumbel copula	-15.26	-30.52	-30.52	1.1 (8.74e-04)				
	Rotated Gumber	-7.28	-14.55	-14.54	1.1 (8.86e-04)				
Archimedean Copulas	Frank Copula	-9.44	-18.89	-18.88	0.7299 (0.0045)				
	Clayton copula	4.52	-9.05	-9.05	0.0918 (8.81e-04)				
	Rotated Clayton	-11.2	-22.47	-22.46	0.1449 (9.24e-04)				
	Student's t copula	-30.3	-60.71	-60.70		0.1198 (0.71)	4.5335 (0.71)		
	Symmetrised Joe-Clayton copula	-13.56	-27.13	-27.12				0.061 (2.02e-12)	6.98e-10 (0)

Source: From computed

Different parametric copula has different parameter's value interval. The parameter's value interval of Normal copula is [-1, 1]. The parameter's value interval of Plackett copula is $[1,+\infty]$. The parameter's value interval of Gumbel Copula and rotated Gumbel Copula is $[1,+\infty]$. The parameter's value interval of Frank copula is $[0,+\infty]$. The parameter's value interval of Clayton copula and rotated Clayton Copula is $[1,+\infty]$. The parameter's value interval of Student's t Copula is [-1, 1]. And the parameter's value interval of Symmetrised Joe-Clayton Copula is [0, 1]. The parameter's value will indicate the tail dependence measures only. With the value of parameter increase the dependence structure will become stronger. Notice that in Student's t copula the Degree of Freedom (DOF) as a parameter, and this value will indicate that our sample's distributions is not the normal one but show the heavy-tailed characteristic.

This study still uses the AIC and BIC find the appropriate parametric copula list in Table 4.10. And for copula, the AIC and BIC function as below:

$$AIC = 2 * LL + 2 / T * params \tag{4.3}$$

$$BIC = 2 * LL + \log(T) / T * params \tag{4.4}$$

where LL is Log likelihood, T is the total number of the samples and params is the total number of parameters in the copula, respectively.

Therefore this study will use the parametric copula to confirm our tail dependence characteristic.

Table 4.10 presents the Student's t copula is the best copula to measure the dependence coefficient, which minimizes AIC and BIC among all candidate copulas. Based on minimum AIC and BIC theory, this study only accept Student's t copula as the appropriate parametric copula and reject all other copulas in Table 4.10. This result indicates that the relationship between these two countries' exchange return in percentage shows the symmetric tail dependence characteristics.

Therefore this study combine Empirical Copula which is non-parametric copula with Student's t Copula which this study selected from all candidate parametric copulas together to measure dependence relationship between People's Republic of China's exchange rates return in percentage and that of Thailand's exchange rates. This combination will help us solve the problem this study mentioned in Chapter 3.

4.3.1 The dependence measures of People's Republic of China's exchange return and Thailand's exchange return based on Empirical copulas approach

Table 4.11: The dependence measure of People's Republic of China's exchange return and Thailand's exchange return based on Empirical Copula, 2006-2012

Correlation items based on Empirical Copula	People's Republic of China's exchange rate and Thailand's exchange rate Dependence Coefficients
Kendall's tau statistics	0.07931982
Spearman's rho statistics	0.1102664

Source: From computed

From Table 4.11 this study will get that based on Empirical Copula the Kendall's tau statistics of dependence measure between exchange rates return in percentage of People's Republic of China and Thailand is 0.07931982. In addition, the Spearman's rho statistics of dependence measure between People's Republic of China's currency and Thailand's currency is 0.1102664. It means when this study use GPD model select each country's exchange rates return in percentage tail distributions and this study found the dependence measure is not strong. From the Empirical copula results this study cannot capture the tail dependence structure characteristic. Based on the appropriate parametric copula--Student’s t copula which will help us capture the characteristic of tail dependence structure and measure it.

4.3.2 The dependence measure of People’s Republic of China’s exchange return and Thailand’s exchange return based on Student’s t copula approach

Table 4.12: The dependence measure of People’s Republic of China’s exchange return and Thailand’s exchange return based on Student’s t Copula, 2006-2012

Correlation items based on Student's t copula	People's Republic of China's exchange rate and Thailand's exchange rate Dependence Coefficients
Kendall's tau statistics	0.0573

Source: From computed

The function of Kendall’s tau shows as below:

$$Kendall.tau = 2t_{v+1}(-\sqrt{v+1}\sqrt{1-\rho} / \sqrt{1+\rho} \quad (4.5)$$

where v is the degree of freedom ρ is the value of parameter.

Table 4.12 shows that based on Student’s t Copula the Kendall’s tau statistics of dependence measure between People’s Republic of China’s currency and

Thailand's currency is 0.0573. From this result, first this study will get that, our tail dependence of each country's exchange rates return in percentage shows the symmetric characteristic. And based on this tail dependence structure, the dependence measure is small.

All the copulas approaches dependence coefficients results indicate that the dependence measure between these two countries' exchange rates return in percentage is not strong.

These results show that, on the one hand the interaction between these two countries' exchange rates is small, if one of them breaks up the financial crisis, another one will not affected by the crisis seriously, if only based on the foreign exchange markets analysis. On the other hand, the static copula results mirror that the value of each country's currency increase or decrease on their own track and will not affected by another one. As international settlement tool, each country's currency will not easy to challenge. The classical linear approach should be used when financial crisis break up, because economic conditions will be inertia changed by external impact. And linear approach hard to capture the heavy-tailed observation's characteristic, it fit normal distribution. In the future, when 2015 ASEAN become a single market, the financial cooperation between China and Thailand will more and more closer. The conclusion and the policy recommendations based on these results will present in Chapter 5.