Thai Journal of Mathematics (2014) 199–210
Special Issue on : Copula Mathematics and Econometrics

http://thaijmath.in.cmu.ac.th
Online ISSN 1686-0209

Dependence Structure between TOURISM and TRANS Sector Indices of the Stock Exchange of Thailand

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Abstract : Sriboonchitta et al. [1] argued that the traditional multivariate analysis imposed some strong assumptions and suggested to use the copula approach that provided better flexibility for the analysis. Thus, this study used the copula based ARMA-GARCH to examine the dependence structure between the price of two sectors, the Tourism & Leisure Index (TOURISM) and the Transportation & Logistics Index (TRANS), of the stock exchange of Thailand (SET). Our results provide evidence of a relatively small positive dependence between two sector indices. The BB1 copula that can capture both the lower tail and upper tail dependences is chosen to describe the dependence structure. The result shows that the lower tail dependence is stronger than the upper tail dependence. This information is useful for investors in recognizing that the chances for two indices will have to face the probability of joint occurrences of crashing all together.

Keywords : ARMA-GARCH; copula; dependence structure; TOURISM Index; TRANS Index
2010 Mathematics Subject Classification : 91G70; 62P20 (2010 MSC)

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1 Introduction

Over the past decade the travel and tourism sector have played an important role in Thailand's economy. The total contribution of travel and tourism sector to the gross domestic product (GDP) in 2012 was 1,896.7 billion baht (16.7% of GDP). The direct contribution of Travel & Tourism to GDP in 2012 was 825.6 billion baht (7.3% of GDP) [2]. This primarily reflects the economic activity generated by industries such as hotels, travel agents, airlines and other passenger transportation services. The Department of Tourism of Thailand [3] reported that the number of international tourist arrivals to Thailand in 2013 was 26.7 million (19.6% growth from 2012) and the tourism receipts was 1.1 trillion Baht (19.08% growth from 2012).

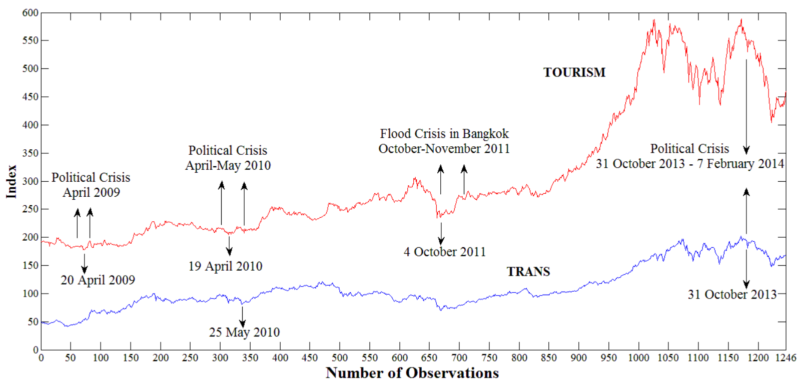
However, Thailand continues to face challenges due to some uncertainty events such as global economic recession, terrorism, outbreak of disease, natural disasters, and political unrest. The negative shocks will have an impact to the growth of tourist arrivals, as it starts slowing down. Moreover, the negative shocks can have an adverse effect on the travel and tourism industry and related businesses such as hotels, airlines, transportation services, and restaurants. Consequently, the shocks can have an influence on investment in the stock market, particularly with stocks that are related to these industries. Figure 1 displays the indices of two sectors in a service industry group of the stock exchange of Thailand (SET), the Tourism & Leisure Index (TOURISM) and the Transportation & Logistics Index (TRANS), and also presents the major events which had affected the sector indices during the period from 5 January 2009 to 7 February 2014. This graph shows that the negative shocks affected volatility on both indices.

The purpose of this study is to analyze the dependence between the Tourism & Leisure Index and the Transportation & Logistics Index by using the copula based ARMA-GARCH model.

Since financial data usually show the evidence of autoregression and volatility clustering, and the ARMA-GARCH model can effectively capture autoregression in mean and volatility clustering in variances, the ARMA-GARCH model is used for this study. The reason of using copula for measuring the dependence is that the data of financial assets' return exhibit evidence of non-normal distribution with skewness and excess kurtosis that might not be the same margins for each random variable, therefore measuring the dependence by using the conventional approach is not appropriate. The copula model can cross over this restriction as copula can measure the dependence between two random variables without making the assumptions of normal distribution and linear correlation.

The copula model is widely used in the financial field. For example, Jondeau and Rockinger [4] used the copula based GARCH to model the dependence structure between stock markets. Patton [5] used the copula based the ARMA (p,q)-GARCH(1,1) model to find the dependence structure between the Deutsche mark–US dollar and Japanese yen–US dollar exchange rates. Similarly, Dias and Embrechts [6] adopted the dynamic copula to model the dependence of exchange rates: Euro–US dollar and Japanese Yen–US dollar. Reboredo [7] extended the

Figure 1: The TOURISM and the TRANS indices during 5 January 2009 to 7 February 2014



copula based ARMA (p,q)-TGARCH(1,1) to find the co-movements between the world oil prices and the global prices for corn, soybean, and wheat. Chollete et al. [8] used a copula to measure the dependence between international stock markets.

2 Methodology

The copula based ARMA-GARCH is used to find the dependence between the Tourism & Leisure Index (TOURISM) and the Transportation & Logistics Index (TRANS). First, the ARMA-GARCH model is used to filter the marginal distributions for the copula model. Then, the standardized residuals (z_t) from the appropriate ARMA-GARCH models will be transformed using the empirical distribution function and, thereafter, we get the marginals, $(F(x), G(y))$. These marginals are then used to estimate copulas. Since there are two random variables in this study, the bivariate copula model is used to find the dependence structure.

2.1 ARMA-GARCH model

This study adopts the ARMA (p,q)-GARCH(1,1) model with skewed student-T distribution residual (SkT) for the marginal distribution of the log-difference $\ln \dfrac{P_t}{P_{t-1}}$, y_t, of the TOURISM and the TRANS.

$$y_t = a_0 + \sum_{i=1}^{p} a_i y_{t-i} + \sum_{i=1}^{q} b_i \varepsilon_{t-i} + \varepsilon_t \tag{2.1}$$

$$\varepsilon_t = z_t\sqrt{h_t}, z_t \sim SkT(\nu, \gamma) \tag{2.2}$$

$$h_t = \omega_t + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1} \tag{2.3}$$

The general form of ARMA (p,q) process is presented in (2.1) where y_{t-i} is an autoregressive term of y_t and ε_t is an error term. Equation (2.2) this error term is defined as the product between conditional variance h_t and a residual z_t. A residual z_t is assumed to follows the skewed student T (SkT) distribution with the shape parameter ν and the skewness parameter γ. The GARCH(1,1) process is displayed in (2.3) where $\omega_t > 0$, $\alpha \geq 0$, $\beta \geq 0$ are sufficient to ensure that the conditional variance $h_t > 0$. The $\alpha\varepsilon_{t-1}^2$ is the ARCH term and α indicates to the short run persistence of shocks, while βh_{t-1} is the GARCH term and β indicates to the contribution of shocks to long run persistence $(\alpha + \beta)$.

2.2 Copula Model

The copula is widely used to model the multivariate dependence. It offers us the flexibility of merging marginal distribution to get a joint distribution with an appropriate dependence structure. The fundamental theorem of copula is Sklar's theorem by Sklar [9].

2.2.1 Definition of copula

A function $C : [0,1]^2 \to [0,1]$ is a copula if it satisfies the following properties [10]:

For every u, v in $[0,1]$.

$C(u,0) = 0 = C(0,v)$ and

$C(u,1) = u$ and $C(1,v) = v$

For every u_1, u_2, v_1, v_2 in $[0,1]$ such that $u_1 \leq u_2$ and $v_1 \leq v_2$.

$C(u_2,v_2) - C(u_2,v_1) - C(u_1,v_2) + C(u_1,v_1) \geq 0$

2.2.2 Sklar's Theorem

Let H be a joint distribution function with marginal distributions F, G. Then there exists a copula C such that for all x, y in real line,

$$H(x,y) = C(F(x), G(y)) \tag{2.4}$$

If F and G are continuous, then C is unique. Conversely, if C is a copula and F and G are distribution functions, then the above function $H(x,y)$ in (2.4) is a joint distribution function with marginal distributions F, G.

If H is known, then the copula C is obtained as

$$C(u,v) = H(F^{-1}(u), G^{-1}(v)), \tag{2.5}$$

where F^{-1} and G^{-1} are inverse distribution functions of the marginals.

2.2.3 Copula Families

The five copula families are chosen to measure the dependence in this study, as shown in Table 1. Each copula family has its own different characteristics. For example, the dependence structure of the Gaussian copula is tail independent while the Student's T copula is symmetric tail dependence. The Clayton copula shows strong lower tail dependence that can be used to analyze the lower tail risk while the Gumbel copula shows strong upper tail dependence that is an extreme value copula. The BB1 (Clayton-Gumbel) copula can capture both lower tail dependence and upper tail dependence. These are the justifications of using these five copula functions.

Table 1: Characteristics of Copula Families

Name	Pair-copula function	Parameter range
Gaussian	$C\,(u,v;\rho)=\Phi_G(\Phi^{-1}(u),\Phi^{-1}(v);\rho)$ $=\int_{-\infty}^{\phi^{-1}(u)}\int_{-\infty}^{\phi^{-1}(v)}\frac{1}{2\Pi\sqrt{(1-\rho^2)}}\times[\frac{-(s^2-2\rho st+t^2)}{2(1-\rho^2)}]dsdt$	$\rho\in(-1,1)$
Student's T	$C^T\,(u,v;\rho,\nu)=\int_{-\infty}^{T_\nu^{-1}(u)}\int_{-\infty}^{T_\nu^{-1}(v)}\frac{1}{2\Pi\sqrt{(1-\rho^2)}}\times$ $[1+\frac{(s^2-2\rho sT+T^2)}{\nu(1-\rho^2)}]^{-(\frac{\nu+2}{2})}dsdT$	$\rho\in(-1,1)$, $\nu>2$
Clayton	$C(u,v;\theta)=(u^{-\theta}+v^{-\theta}-1)^{-1/\theta}$	$\theta\in(0,\infty)$
Gumbel	$C(u,v;\theta)=exp(-[(-\ln(u))^\theta+(-\ln(v))^\theta]^{\frac{1}{\theta}})$	$\theta\in[1,\infty)$
BB1	$C(u,v;\theta,\delta)=\{1+[(u^{-\theta}-1)^\delta+(v^{-\theta}-1)^\delta]^{1/\delta}\}^{-1/\theta}$	$\theta\in(0,\infty)$, $\delta\in[1,\infty)$

Source: Copula functions were presented in Trivedi and Zimmer [11], and Manner [12].

2.2.4 Maximum Likelihood Estimation

This study used the method of maximum pseudo-log likelihood, as in Genest et al. [13], for estimation since the marginal distribution functions F_X and G_Y are transformed into uniform [0,1] by using the empirical distribution functions.

Under the assumption that the marginal distributions F and G are continuous, the copula C_θ is a bivariate distribution with density c_θ and pseudo-observations, $F_n(X_i)=\dfrac{1}{n+1}\sum_{i=1}^n 1(X_i\le x)$, $G_n(Y_i)=\dfrac{1}{n+1}\sum_{i=1}^n 1(Y_i\le y)$, $i=1,2,...,n$.

The pseudo-log likelihood function of θ can be written as

$$L(\theta)=\sum_{i=1}^{n}\log[c_\theta(F_n(X_i),(G_n(Y_i))] \tag{2.6}$$

2.2.5 Copulas Selection

The Akaike Information Criterion (AIC) (see Akaike [14]) was used to select a copula family. Moreover, a goodness-of-fit test based on Kendall's tau process was used to ensure that the dependence structure of the data series is appropriate for a chosen family of copulas.

3 Data

This study used two sector indices from two sectors in a service industry group of the stock exchange of Thailand (SET), the Tourism & Leisure Index (TOURISM) and the Transportation & Logistics Index (TRANS), to analyze the dependence structure. The daily sector indices were obtained from the EcoWin database during the period from 5 January 2009 to 7 February 2014.

Each data series was transformed into log-difference ($\ln P_t - \ln P_{t-1}$), before it was used for analysis using the ARMA-GARCH model and the copula model.

Table 2 presents the descriptive statistics of the log-difference of two data series, the TOURISM and the TRANS. The two data series have a positive average growth rate and exhibit negative skewness and the excess kurtosis. This means that the two data series have asymmetric distributions and heavy tail. The null hypotheses of normality of the Jarque-Bera tests are rejected in all the data series. The Augmented Dickey-Fuller (ADF) test shows that these data series are stationary at p-value less than 0.01.

Table 2: Data Descriptive Statistics

	TOURISM	TRANS
Mean	0.0007	0.0010
Median	0.0007	0.0011
Maximum	0.0591	0.0794
Minimum	-0.0882	-0.0978
Skewness	-0.3802	-0.3151
Kurtosis	8.0298	5.9783
p-value of Jarque-Bera	0.01	0.01
p-value of ADF test	(< 2.2e-16)	(< 2.2e-16)
No. of Observations	1245	1245

Table 3: Results of GARCH(1,1) for TOURISM and ARMA(3,3)-GARCH(1,1) for TRANS

	TOURISM	SE	p-value	TRANS	SE	p-value
mu	6.60e-04	3.15e-04	0.0361	0.0023	8.64e-04	0.0078
ar1	-	-	-	-0.2840	0.1549	0.0667
ar2	-	-	-	-0.6416	0.1094	4.56e-09
ar3	-	-	-	0.4301	0.1463	0.0033
ma1	-	-	-	0.3298	0.1584	0.0373
ma2	-	-	-	0.6540	0.1156	1.52e-08
ma3	-	-	-	-0.4050	0.1494	0.0067
ω	5.58e-06	3.03e-06	0.0658	1.05e-05	4.19e-06	0.0120
α	0.1199	0.0437	0.0060	0.1312	0.0294	8.24e-06
β	0.8645	0.0481	<2e-16	0.8409	0.0343	<2e-16
ν (shape)	3.989	0.5067	3.55e-15	5.909	1.012	5.33e-09
λ (skewness)	0.9916	0.0381	<2e-16	0.9595	0.0374	<2e-16
LL	3,795.81	-	-	3,424.96	-	-
AIC	-7,579.63	-	-	-6,825.91	-	-

4 Empirical Results

4.1 Results of ARMA-GARCH model

Table 3 presents the appropriate marginal models for the log-difference of two data series: The GARCH(1,1) with skewed student-T residual for the TOURISM data and the ARMA(3,3)-GARCH(1,1) with skewed student-T residual for the TRANS data. The models are selected by using the AIC criterion. The choice of skewed student-T distribution is because of the reason that the two data series exhibit negative skewness and excess kurtosis.

For the TOURISM and the TRANS, the values of parameters $\alpha + \beta$ are 0.98 and 0.97, respectively; this means that their volatilities have a long-run persistence.

Next, the standardized residuals from each ARMA-GARCH model was transformed into the uniform [0,1] by using the empirical distribution function $F_n(x) = \frac{1}{n+1}\sum_{i=1}^{n} 1(X_i \leq x)$, where $X_i \leq x$ is the order statistics and 1 is the indicator function. Then the transformed data were checked for uniformity [0,1] by using the Kolmogorov-Smirnov (K-S) test, and for serial correlation by using the Box-Ljung test. These tests are necessary to check for the marginal distribution models' misspecification before using the copula model.

The p-values K-S test and Box-Ljung test in Table 4, show that two marginal distributions are uniform and i.i.d., by not rejecting the null hypothesis. Therefore, our marginal distributions are not misspecified and can be used for the copula model.

Table 4: P-values of K-S Test and Box-Ljung Test

	TOURISM	TRANS
K-S test	1	1
Box-Ljung test		
1^{st} moment	0.1792	0.5055
2^{nd} moment	0.4222	0.6289
3^{rd} moment	0.4313	0.5845
4^{th} moment	0.6587	0.4083

Note: The null hypothesis of the K-S test = data is uniform; the null hypothesis of the Box-Ljung test = no serial correlation.

4.2 Results of Copula model

Figure 2 shows the pairs plot of the uniform data set of the TOURISM and the TRANS, with scatter plot above and the contour plot with standard normal margins below the diagonal. This figure shows that the lower tail dependence is stronger than the upper tail dependence. Therefore, to examine the true dependence structure between the two marginals, we used various families of the copulas.

Table 5 shows the results of each family of copula, including the copula parameters, the Kendall's tau correlations (τ), the lower tail (T^L) and upper tail (T^U) dependences, the AIC values. Table 6 shows the p-values of the Cramér-von Mises test (CvM) and the Kolmogorov-Smirnov test (KS) for a goodness-of-fit test based on Kendall's tau process.

The Kendall's tau correlations that were bounded on the interval $[-1, 1]$ were transformed from the copula parameters. With each copula family having a different range of copula parameters, if we inverse a copula parameter into a same range of Kendall's tau correlation then we can compare them.

The lower tail and upper tail dependences can model the dependence of extreme events. This is important in the financial field so that we can be aware of possible concurrent loss events in the tails. If there exists a lower tail dependence, then it indicates that the joint occurrence of extreme values of the two indices crashes together. Conversely, if there exists upper tail dependence, then it indicates that the joint occurrence of extreme values of the two indices rises together.

The results show that the BB1 copula is better fit than the other four copulas by taking into consideration of the values of the AIC, and the p-values of two statistical analyses, the CvM test and the KS test, of a goodness-of-fit test based

Figure 2: Pairs plot of the uniform data set of the TOURISM and the TRANS

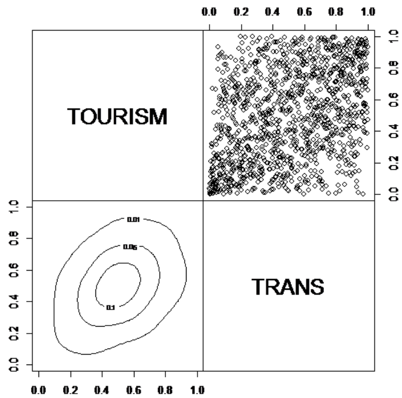


Table 5: Results of Copula Models

Copula	Parameter	SE (p-value)	τ	T^L	T^U	AIC
Gaussian	$\theta = 0.3892$	0.0224 (0.0000)	0.26	0	0	-202.15
Student's T	$\theta = 0.3911$ $\nu = 17.7694$	0.0237 (0.0000) 9.2997 (0.0281)	0.26	0.001	0.001	-204.52
Clayton	$\theta = 0.5774$	0.0462 (0.0000)	0.22	0.3011	0	-214.16
Gumbel	$\theta = 1.2766$	0.0273 (0.0000)	0.22	0	0.2789	-145.24
BB1	$\theta = 0.4607$ $\delta = 1.0751$	0.0608 (0.0000) 0.0301 (0.0000)	0.24	0.2467	0.0946	-219.72

Table 6: Goodness-of-Fit Test Based on Kendall's tau Process

	Gaussian	Student's T	Clayton	Gumbel	BB1
P-value of CvM	0.02	NA	0.1	0	0.65
P-value of KS	0.03	NA	0.2	0	0.9

on Kendall's tau process. Therefore, the BB1 copula is chosen to describe the dependence structure of the TOURISM and the TRANS.

The BB1 copula can capture both the lower tail and upper tail dependences. The estimated parameters are, $\theta = 0.4607$ and $\delta = 1.0751$, the Kendall's tau correlation is 0.24, the lower tail dependence (T^L) is 0.2467, and the upper tail dependence (T^U) is 0.0946.

The results of tail dependence are consistent with the pairs plots in Figure 2; this demonstrates that the lower tail dependence is stronger than the upper tail dependence.

These results imply that there exists a relatively small positive dependence between the Tourism & Leisure Index and the Transportation & Logistics Index. The rise or crash of the Tourism & Leisure Index is slightly correlated by the rise or crash of the Transportation & Logistics Index. Moreover, it appears that there is an evidence of the lower tail dependence. Therefore, this indicates that there are chances that the two indices will have to face the probability of joint occurrences crashing all together.

5 Conclusion

This study used the copula based ARMA-GARCH model to examine the dependence between two sector indices of the stock exchange of Thailand (SET), the Tourism & Leisure Index (TOURISM) and the Transportation & Logistics Index (TRANS).

With the results discovered, it can be concluded that the TOURISM, and the TRANS have a relatively small positive dependence, regardless of whether it is an upward or a downward trend. The BB1 copula that can capture both the lower tail and the upper tail dependences is chosen to describe the dependence structure. Moreover, the results show that the lower tail dependence was greater than the upper tail dependence. This finding is useful for investors to implement a strategic decision for attaining greater desired results. The evidence of the lower tail dependences between two sector indices can be useful in risk management for investment in the stock market. This information can tell us about the probability of joint occurrence of crashing together in two indices.

For further study, we will study in details about the dependence between the securities prices in each sector. There are various companies or many securities in each sector. The Stock Exchange of Thailand [15] has classified listed companies into each sector. For the Tourism & Leisure (TOURISM) sector they are the companies involved in operating hotels or temporary accommodation; this includes those providing travel or tourism services, such as travel agencies, the operating leisure facilities, such as zoos, entertainment venues, fitness centers, or stadiums. For the Transportation & Logistic (TRANS) sector they are the companies involved in providing transportation-related services, such as air freight (e.g. airports or airlines), marine transportation (e.g. ports or shipping), railway transportation, land transportation, or logistics. By understanding the dependence between the securities prices in each sector this allows investors to have a better guide in decision making on risk management.

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(Received 30 March 2014)
(Accepted 10 September 2014)