Chapter 8

Co-movement of tourist arrival to three ASEAN countries: A trivariate Vine Copula GARCH Application

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ASEAN countries namely Malaysia, Singapore and Thailand are considered as the tourism destinations that posses the similar tourism endowment. This paper aims to examine the co-movement of growth rate of international tourism arrival. The AR (4), AR (6) and AR (6) are appropriate autoregressive model for data of Malaysia, Singapore and Thailand respectively. The marginal distribution of Malaysia is Gaussian distribution and student-t distribution for Thailand and Singapore. Dependence structure is verified by using trivariate vine copula GARCH model. The results confirm the tail dependence and positive correlation among countries. However Thailand is considered as the most influent to tourist who decided to travel in Malaysia and Singapore.

1. Introduction

Three ASEAN countries namely Malaysia, Singapore Thailand are considered as the high performance in term of their economic development. Factors affecting the magnificent growth were proved in the study of Wang and Chien (2007) that efficiency of government and technology development are the main factor that lead Malaysia and Singapore dominate the rest of ASEAN countries including Thailand. Additional, Rammal and Zurbruegg (2006) and Ariyasajjakorn, et al. (2009) emphasized the role of international factors of trade and investments are the advantages of Malaysia, Singapore as well as Thailand to be the economic leader in the region. Besides the government and foreign sectors which empirically studied, the monetary sector and capital market also believed to be the crucial means of development of these three countries. One may future explore in the study of Lim (2009) and Ziaei (2012). Another factor that was given the importance role to ASEAN development is tourism. Var, et al. (1999) is the prominent example that refers the empiric evidence of ASEAN tourism study.

Providing the wider choices for tourism demand, three main destinations of ASEAN have drawn back the attraction to visitors around the world. Malaysia, an ASEAN country which is one of the major destinations in tourism following the well-known, “Malaysia - Truly Asia” campaign, Singapore, the smallest country in term of area in ASEAN but contributes the great GDP per capita of all its neighbors within the region. Finally, Thailand which considered as the leader of tourism destination for all visitors around the world will be associated with trivariate copula GARCH model, or vine copula, will be adopted to analyze the conditional relationship among three attractive destinations. The results will provide the nature of favorite choices of tourists that implies the competitiveness of ASEAN tourism destinations and leads to the launching of appropriate cooperative tourism policy among the authorities of ASEAN countries.

2. Literature review

Beyond the estimation bivariate models, some scholars have looked forward to verify the model of copula by giving the conditional of probability distribution, so-called multivariate copula or vine copula. Precisely, the review of literature will focus on the related methodology of trivariate copula GARCH model. The majority of the studies have been devoted to analysis of financial data. For the details of studies, one may explore the papers of Fischer, et al. (2009), Fantazzini (2008) and Chollete, et al. (2009). With the latest of Li and Wu (2012), Acar, et al. (2012) and Gräler and Pebesma (2011) offer the various benefits of pair copula structure. For the exceptional papers that deviated from financial data analysis, including Zimmer and Trivedi (2006) who adopted trivariate copula to health care demand, Balistrocchi and Bacchi (2011) applied a trivariate copula function to model the statistical dependence of rain forest. Kim, et al (2011) adopted pair correlation of vine copula to study the relationship of gene analysis.

However, up to the best knowledge, lacks of studies have combined the use of conditional variance prediction form GARCH model with the dealing with the dependency of variables in tourism study. This study will be the pioneer that explores the cooperation of the double benefits to the tourism field of research.

3. Methodology

Differing from bivariate copula, in trivariate case, we may extend the estimation of bivariate copula estimation under the same conceptual methodology. The previous studies of Bedford and Cooke (2002) and Kurowicka and Cooke (2006) have used the modeling that simply constructs the pair-copula. Bedford and Cooke (2002) offered the pairwise composition that does not require the conditional indigence assumption. On the other hand, Kurowicka and Cooke (2006) presented the modeling approach that uses partial correlation and the determinant of correlation matrix as a measurement of linear dependence. Following Bedford and Cooke (2001), who offered the density of multi dimensions of vine copula by giving the regular vine, the distinction of vine copula based on the pairwise construction is categorized in to two types, canonical vine or C-vine and D-vine.

3.1 Procedure of conditioned pair of C-Vine and D-Vine copula

Canonical Vine, C-Vine

Let x_1, x_2 and x_3 be number of tourists entering to Malaysia, Singapore and Thailand respectively. For the density function $f(x_1, \dots, x_n)$ of *n* dimensions, the identification of C-vine can be written as:

$$\prod_{k=1}^{n} f(x_k) \prod_{j=1}^{n-1} \prod_{i=1}^{n-j} c_{i,i+j|i+1,\dots,i+j-1} \{F(x_i|x_{i+1}, \dots, x_i|x_{i+j-1}), F(x_{i+j}|x_{i+1}, \dots, x_{i+j-1})\}$$

(1)

For this study, there exist three dimensions; each tree has a unique node that is connected to the rest of other nodes.

$$f(x_1, x_2, x_3) = f_1(x_1).f_2(x_2).f_3(x_3).c_{12}\{F_1(x_1),(x_2)\}.c_{13}\{F_1(x_1),F_3(x_3)\}.c_{23|1}\{F(x_2|x_1),F(x_1|x_3)\}$$

(2)

The structure of tree for the case of three variables of c-vine can be illustrated as Figure 1:

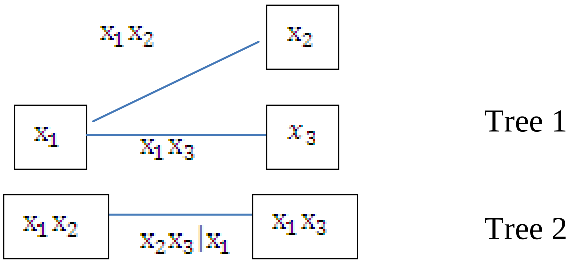


Figure 1: 3 dimensions of C-vine with 3 levels $(j = 1,2,3)$

D-vine copula

We can present the conditional relation as follows:

$$\prod_{k=1}^{n} f(x_k) \prod_{j=1}^{n-1} \prod_{i=1}^{n-j} c_{j,j+i|1,\dots,j-1} \{F(x_j|x_1, \dots, x_{j-1}), F(x_{j+1}|x_1, \dots, x_{j-1})\} \quad (3)$$

Therefore, the structure of tree for the case of three variables as this study can be illustrated as:

$$f(x_1,x_2,x_3) = f_1(x_1).f_2(x_2).f_3(x_3).c_{12}\{F_1(x_1),(x_2)\}.$$

$$c_{23}\{F_2(x_2),F_3(x_3)\}.c_{13|2}\{F(x_1|x_2),F(x_2|x_3)\} \quad (4)$$

Thus, the structure of tree for the case of three variables of d-vine follows Figure 3.

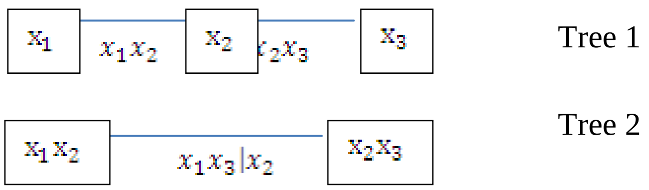


Figure2: 3 dimensions of D-vine with 3 levels $(j = 1,2,3)$

3.2 The construction and estimation procedure of vine copula

After estimating the appropriate GARCH model and obtaining the margin for each time series of tourism demand for Malaysia, Singapore and Thailand, the inference for a specified pair-copula and the model selection or the goodness of fit of the model have to be made. For the three variables (tourist arrivals to Malaysia, Singapore and Thailand) and T observations (144 monthly sets of data for this study), the data set denoted by $x_i = (x_{i,1}, \dots, x_{i,T})$, $i = 1,2,3$ and $T = 1, \dots, 144$, and , the observations are assumed to be independence overtime and the uniform within$[0,1]$. Following the

original study of Oakes (1994) and later widely used in the studies of copula estimation of Genest, et al. (1995), Shih and Louis (1995) and Kim (2007), and the recent study of Aas, et al (2009), the log likelihood estimation will be conducted.
The log likelihood for the c-vine will be computed by:

$$L_{CV} = \sum_{j=1}^{n-1}\sum_{i=1}^{n-j}\sum_{t=1}^{T}\log[c_{j,j+i|1,\dots,j-1}\{F(x_{j,t}|x_{1,t},\dots,x_{j-1,t}),F(x_{j+1,t}|x_{1,t},\dots,x_{j-1,t})\}] \quad (5)$$

And for D-vine parameter estimation, value of log likelihood is determined by:

$$L_{DV} = \sum_{j=1}^{n-1}\sum_{i=1}^{n-j}\sum_{t=1}^{T}\log[c_{i,i+j|i+1,\dots,i+j-1}\{F(x_{i,t}|x_{i+1,t},\dots,x_{i+j-1,t}),F(x_{i+j,t}|x_{i+1,t},\dots,x_{i+j-1,t})\}] \quad (6)$$

For the trivariate estimation of tourism demand into three ASEAN countries, Malaysia (1), Singapore (2) and Thailand (3) with the uniform distribution $U(0,1)$, the application of vine copula can be reduced to the following equation:

$$LL = \sum_{t=1}^{T}\{\log c_{12}(x_{1,t},x_{2,t},\Theta_{11}) + \log c_{23}(x_{2,t},x_{3,t},\Theta_{12}) + \log c_{13|2}(\upsilon_{1,t},\upsilon_{2,t},\Theta_{21})\} \quad (7)$$

Where

$\upsilon_{1,t} = F(x_{1,t}|x_{2,t}) = h(x_{1,t},x_{2,t},\Theta_{11})$ and $\upsilon_{2,t} = F(x_{3,t}|x_{2,t}) = h(x_{3,t},x_{2,t},\Theta_{12})$

The set of parameters that has to be estimated is *and is* $\Theta = (\Theta_{11},\Theta_{12},\Theta_{21})$and Θ_{ij} *is* set of parameter that corresponding to the copula density, $c_{i,i+j|i+1,\dots,i+j-1(\dots)}$. The parameter of copula will be firstly estimated by sequential procedure according to each country's tourism demand followed by maximizing the log-likelihood value by adopting the parameters that are received from the stepwise steps as the starting included value.

3.3 Model selection of vine copula

Since in this study, the dimension of variables says three variables is quite small enough to estimate all parameters of feasible decompositions and consider the appropriate models by looking at the interested components, the selection from the indicators of AIC, SBIC and LL as the study in bivariate copula GARCH model, the significance of estimated parameters as well as the family classes of copula which does not necessary to be the same type for every pair are the criteria of model selection. Additionally, the goodness of fit test (GOF) based on the probability integral transform (PIT), which was proposed by Rosenblatt (1952) and extended to the empirical study by Breymann, et al. (2003), will be followed. PIT test will transform dependence variable to be independence and uniform under the null hypothesis that the included data are derived from the multivariate distribution. Let $X = (x_1,\dots,x_n)$be the random variable vector, in this study, the number of tourist arrival to Malaysia, Singapore and Thailand with marginal distribution $F(x_i)$ and conditional distribution $F(x_i|x_1,\dots,x_{i-1})$ for $i = 1,\dots,n$. The PIT of X defined by:

$$T(X) = \{T(X_1),\dots,T(X_n)\} \quad (8)$$

Where

$$T(X_1) = F(x),\ T(X_2) = F(x_1|x_2),\dots,T(X_n) = F(x_n|x_1,\dots,x_{n-1}) \quad (9)$$

For the random variable $Z_i = T(X_i)$which independence and behave uniformly distribution on $[0,1]^n$. The normal test that is also used in Aas, et al. (2009) is to check whether or not the variables do independence with uniform distribution on $[0,1]$ by computing the statistic S:

$$S = \sum_{i=1}^{n}\{\Phi^{-1}(Z_i)\}^2 \quad (10)$$

And to test the uniformity of variable Z_i, the statistic S will be proved to come from the Chi-square distribution with degree of freedom .

4. Data

In this study, we adopt monthly data of number of international tourist arrival enter to Malaysia, Singapore and Thailand during January 1997 to December 2010. Data are obtained from Ecowin database.

TABLE1. Statistic of studied raw data variables

Statistic	RMALAYSIA	RSINGAPORE	RTHAILAND
Mean	1361384	728738.2	1007145
Median	1351141	709778	967194
Maximum	2246084	1127020	1819751
Minimum	459374	177808	404563
Std. Dev.	464770.2	150834.7	248727.4
Skewness	-0.004583	-0.280163	0.719218
Kurtosis	1.997226	4.27158	3.864346
Jarque-Bera	6.075738	11.66574	17.01451
Probability	0.047937	0.00293	0.000202
Sum	1.97E+08	1.06E+08	1.46E+08
Sum Sq. Dev.	3.11E+13	3.28E+12	8.91E+12
Observations	145	145	145

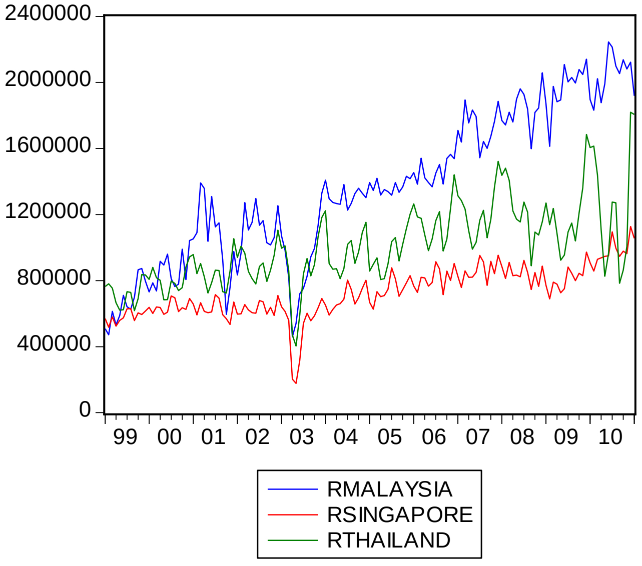
Data are transformed to growth basis by the following equation:

$$\text{Arrival}_{\text{Growth}} = \log \frac{\text{Arrival}_t}{\text{Arrival}_{t-1}} \tag{11}$$

TABLE2. Descriptive statistic of growth of tourist arrival data

Statistic	GMALAYSIA	GSINGAPORE	GTHAILAND
Mean	0.009	0.004	0.006
Median	0.012	-0.005	0.015
Maximum	0.284	0.577	0.591
Minimum	-0.579	-1.012	-0.604
Std. Dev.	0.126	0.142	0.148
Skewness	-0.733	-1.693	-0.324
Kurtosis	6.375	22.171	6.201
Jarque-Bera	81.242	2273.829	64.023
Probability	0.000	0.000	0.000
Sum	1.328	0.616	0.860
Sum Sq. Dev.	2.253	2.880	3.132
Observations	144	144	144

According to table 2, the Kurtosis of each growth data is greater than 3. Additional skewness is less than 0. All series data have fat and leptokurtosis. Considering Jarque-Bera staistics with the null hypothesis of normality, the rejection of the null inform us that they do not follow the normal distribution. The nature of data in term of level and growth data are depicted in figure 1.



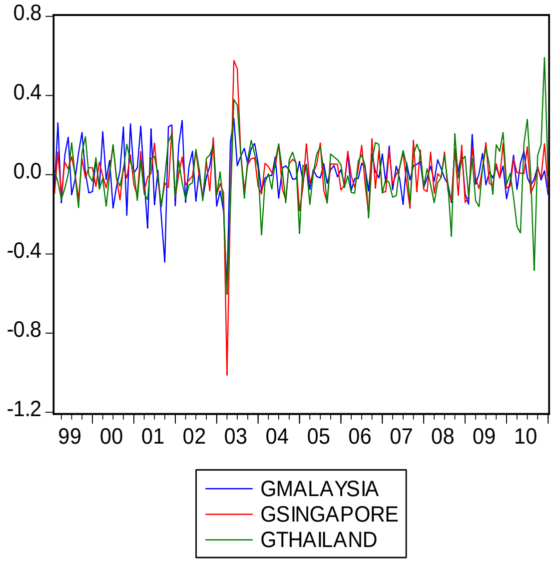


Figure 1. Data employed in the study with raw data and growth data

5. Results

First steps, the appropriate order of AR model are selected for three countries. The results is presented in table 3. According to the p-value and statistics for autocorrelation, the winners for each country is AR(4), AR(6) and AR(6) for Malaysia, Singapore and Thailand respectively.

TABLE3. The selection of AR(p) GARCH(1,1) model

Para meter	Malaysia AR(4)				Singapore AR(6)				Thailand AR(6)			
	Coef.	**std er**	**t-stat**	**p-value**	**Coef.**	**std err**	**t-stat**	**p-value**	**Coef.**	**std er**	**t-stat**	**p-value**
ar(1)	-0.10	0.0069	-13.764	0.000	0.01	0.0066	0.865	0.100	0.127	0.007	18.514	0.000
ar(2)	-0.16	0.0069	-23.598	0.000	-0.38	0.0065	-58.942	0.000	-0.350	0.008	-45.140	0.000
ar(3)	0.08	0.0067	12.442	0.000	-0.20	0.0071	-27.694	0.000	-0.276	0.009	-31.882	0.000
ar(4)	-0.16	0.0067	-24.414	0.000	-0.26	0.0070	-37.416	0.000	-0.063	0.009	-6.671	0.000
ar(5)					0.04	0.0066	6.212	0.000	-0.037	0.009	-4.178	0.000
ar(6)					-0.32	0.0064	-50.099	0.000	-0.258	0.009	-30.340	0.000

To estimate the marginal distribution, the three series exhibit different type of marginal distribution. The GARCH (1,1) is applied for individual time series. GARCH (1,1) is considered as The result for Malaysia is Gaussian and student-t for the rest of two countries.

TABLE4. Marginal distribution for three ASEAN countries

Malaysia				Singapore				Thailand			
AR(4) Gaussian GARCH (1,1)				AR(6) Student t GARCH(1,1)				AR(6) Student t GARCH(1,1)			
Coef.	std er	t-stat	Prob.	Coef.	std er	t-stat	Prob.	Coef.	std er	t-stat	Prob.
-0.014	0.006	-2.358	0.003	0.005	4.226	1156.000	0.000	0.003	1.077	319.2	0.000
-0.299	0.097	-3.091	0.031	0.486	0.077	6.277	0.000	0.158	0.017	9.168	0.000
-0.164	0.092	-1.786	0.052	0.168	0.050	3.319	0.001	0.654	0.064	10.12	0.000
-0.020	0.092	-0.214	0.430	5.564	4.163	1.337	0.092	8.179	18.224	0.449	0.327
-0.168	0.076	-2.208	0.034								
0.001	0.000	1.561	0.000								
0.353	0.176	2.004	0.088								
0.646	0.111	5.806	0.019								
AIC	-235.550			AIC	-274.145			AIC	-180.698		
BIC	-211.791			BIC	-241.477			BIC	-148.030		
LL	125.775			LL	148.073			LL	101.349		

After obtain marginal distribution, the next step is to verify the dependence structure among data series. According to C-vine and d-vine, there are possible 3 alternative relationships among series for particular type of vine. The parameters estimated for C-vine are x_1x_2 , x_1x_3 and the conditional correlation of $x_2x_3|x_1$. Whilst the parameters estimated for D-vine are x_1x_2, x_2x_3 and $x_1x_3|x_2$. The estimated results are presented in table 5 to 7.

TABLE 5. Vine copula estimation of Thailand as conditional country (sequence; MST)

C-vine						D-Vine					
t-copula			Clayton-copula			t-copula			Clayton-copula		
Parameter	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**
6.698	6.491	0.032	0.091	0.074	1.219	5.422	3.321	1.633	0.141	0.060	2.338
17.843	3.856	2.527	0.130	0.077	1.678	3.910	2.269	1.723	0.366	0.037	10.023
3.980	1.601	1.530	0.332	0.048	6.874	199.348	0.658	302.957	0.682	0.053	1.293
AIC	-70.480		AIC	-36.477		AIC	-73.543		AIC	-39.675	
BIC	-61.570		BIC	-27.568		BIC	-64.634		BIC	-30.766	
LL	38.240		LL	21.239		LL	39.772		LL	22.838	

TABLE 6. Vine copula estimation of Singapore as conditional country (Sequence; TMS)

C-vine						D-Vine					
t-copula			Clayton-copula			t-copula			Clayton-copula		
Parameter	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**
10.847	10.916	0.994	0.167	0.059	2.830	17.843	33.859	0.527	1.300	0.078	1.678
3.824	2.229	1.715	0.369	0.036	10.246	6.698	6.491	1.032	0.091	0.074	1.218
11.674	13.025	0.896	0.039	0.044	1.882	3.980	2.601	1.530	0.332	0.048	6.873
AIC	-70.756		AIC	-40.567		AIC	-70.480		AIC	-36.477	
BIC	-61.846		BIC	-31.658		BIC	-61.570		BIC	-27.568	
LL	38.378		LL	23.284		LL	38.240		LL	21.239	

TABLE 7. Vine copula estimation of Malaysia as conditional country (Sequence; STM)

C-vine						**D-Vine**					
t-copula			**Clayton-copula**			**t-copula**			**Clayton-copula**		
Parameter	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**	**parameter**	**std err**	**t-stat**
3.910	2.269	1.723	0.366	0.037	10.023	3.824	2.229	1.716	0.369	0.036	10.254
5.422	3.321	1.633	0.141	0.060	2.238	10.847	10.916	0.994	0.167	0.059	2.830
199.351	0.664	300.352	0.068	0.053	1.296	11.674	13.017	0.897	0.039	0.044	1.884
AIC	-73.543		AIC	-39.675		AIC	-70.756		AIC	-40.567	
BIC	-64.634		BIC	-30.766		BIC	-61.846		BIC	-31.658	
LL	39.772		LL	-22.838		LL	38.378		LL	23.284	

TABLE8. Summary of dependence parameters among three ASEAN countries

Pair copula	r_{MS}	r_{ST}	r_{MT}	$r_{MS\|T}$	$r_{MT\|S}$	$r_{ST\|M}$
C-vine	0.091 (0.074)	0.366 (0.037)	0.130 (0.077)	0.039 (0.044)	0.068 (0.053)	0.332 (0.048)
D-vine	0.141 (0.060)	0.366 (0.037)	0.167 (0.059)	0.039 (0.044)	0.682 (0.053)	0.332 (0.048)

Where: M S and T refer to Malaysia Singapore and Thailand respectively and number in parentheses indicates standard error value.

Table 8 is the estimation of parameters from the two canonical vine or c-vine and d-vine. The selections are made from the criteria of Log Likelihood, AIC and BIC. However, for the t-copula, those indicators do dominate the Clayton copula. The standard error and t-statistics in the other hand, Clayton copula is more beneficial to interpret the parameter attitude as well as the size of standard error. This conclusion also suggested in the study of Kim et al. (2011) The results therefore are summarized as table 8.

From the results, correlation between growth rates of tourist arrival is highest for series of Singapore and Thailand which is 0.366 and 0.332 in the given condition of Malaysia for both c-vine and d-vine. The other interesting results are the coefficients with the given third country as a condition, Thailand deviate the number of tourist arrival from Malaysia and Singapore greater than giving Singapore and Malaysia as the conditional country. This evidence does appear from the size of parameter which are 0.039, 0.068 and 0.332 respectively for c-vine and 0.039, 0.332 and 0.682 for d-vine. The fit copula class is Clayton copula, the lower tail dependence. This implies the positive directive among time series variables (Breymann et al., 2003)**.**

6. Concluding remarks

This paper examines the co-movement of growth rate of international tourism arrival. The AR(4), AR(6) and AR(6) are appropriate autoregressive model for data of Malaysia, Singapore and Thailand respectively. The marginal distribution of Malaysia is Gaussian distribution and student-t distribution for Thailand and Singapore. Dependence structure is verified by using trivariate vine copula GARCH model. The results confirm the tail dependence and positive correlation among countries. However Thailand is considered as the most influential country to determine number of tourist who decided to travel in Malaysia and Singapore. From the study, the cooperative policy between Malaysia and Singapore should be issued. In the other hand, competitive tourism policy between Malaysia and Thailand as well as between Singapore and Thailand should be conducted.

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