A COMPARATIVE ANALYSIS OF ASEAN CURRENCIES USING A COPULA APPROACH AND A DYNAMIC COPULA APPROACH

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ABSTRACT: *The ASEAN Economic Community (AEC) will be shaped developing to be a single market and production base in 2015, moving towards regional Economic Integration, 2009. These developments in international financial markets do lead to some adverse cost for AEC country borrowers. The specific objective aims to investigate the dependent measures and the co-movement among selected ASEAN currencies. A Copula Approach was used to examine dependent measures of Thai Baht exchange rate among selected ASEAN currencies during the period of 2008-2011. Also, a Dynamic Copula Approach was tested to investigate the co-movement of Thai Baht exchange rate among selected ASEAN currencies during the period of 2008-2011.*

The results of the study based on a Pearson linear correlation coefficient confirmed that Thai Baht exchange rate and each of selected ASEAN currencies have a linear correlation during the specific period excluding Vietnam exchange rate. Furthermore, based on empirical Copula Approach, Thai Baht exchange rate had a dependent structure with each of the selected in ASEAN currencies including Brunei exchange rate, Singapore exchange rate, Malaysia exchange rate, Indonesia exchange rate, Philippine exchange rate, and Vietnam exchange rate respectively. The results of Dynamic Copula estimation indicated that Thai Baht exchange rate had a co-movement with selected ASEAN currencies. The research results provide an informative and interactive ASEAN financial market to all users, including Global financial market.

KEY WORDS: *Empirical Copula; Dynamic Copula; Exchange Rate; Thailand; AEC*

JEL CLASSIFICATION: *C5, F3, F4*

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1. INTRODUCTION

ASEAN had target to be a single market and production base in 2015, (Charting Progress towards regional Economic Integration, 2009). The importance thing should to concern is the international financial linkage among of ASEAN countries. Mohd and Zaidi (2006) found that currency movement among of three ASEAN countries (Malaysia, Singapore and Thailand) showed the possibilities of nonlinearity. The empirical copulas approach was employed to calculate the dependent measurement between Thai Baht exchange rate and the selected ASEAN currencies consisting of Brunei exchange rate, Singapore exchange rate, Malaysia exchange rate, Indonesia exchange rate, Philippine exchange rate, and Vietnam exchange rate during period of 2008-2011. Based on a few financial literatures the copula functions are the standard tool in financial modeling (Vogiatzoglou, 2010). Patton (2006) tried to estimate the asymmetry in the constant and dynamics dependence between the Deustche mark and the Yen based on copula approach. Benediktsdóttir and Scotti (2009) tested for all the possible joining of the following six bivariate exchange rates against the U.S. dollar such as Australian dollar, Canadian dollar, Swiss franc, Euro, British pound, Japanese yen based on dynamics copula and co-movement approach for during period of 1990-2007.

2. RESEARCH OBJECTIVE

The specific objective is to find the dependence measures and to find the co-movement between Thai exchange rates and selected ASEAN currencies during the period of 2008-2011.

3. SCOPE OF THIS RESEARCH

The daily data of Thai Baht exchange rate and each of selected ASEAN currencies shown as the exchange returns in percentage were collected during period of 2008-2011 shown in small percents.

4. THE RESEARCH FRAMEWORK AND METHODOLOGY

4.1. The copula concept

The copula concept was first proposed by Sklar's theorem (Sklar, 1959) and this concept can be explained by equations (1A).

$$H(x_1,x_2, \ldots,x_n) = C(F_1(x_1), F_2(x_2),\ldots, F_n(x_n)) \tag{1A}$$

H : n-dimensional distribution with marginal F_i , i=1,2,..,n.
C : n-copula for all $x_1,x_2,\ldots, x_n$

Sklar's Theorem with two dimensions can be explained by equation (2A) and this equation has already shown below that:

$$H(x,y) = C(F(x), F(y)) \tag{2A}$$

H(.,.) : 2-dimensional or bivariate distribution with marginal distributions F and G
C(.,.) : copula for all x, y in R

4.2. Spearman's rho and Kendal's tau with empirical copula approach

Nelson (1999) proposed the estimation of both Spearman's rho and Kendal's tau for a sample size n calculated from the empirical copula approach. Therefore, the Kendal's tau and Spearman's rho based on empirical copula calculation was able to show the formula of them from both equation (3A) and equation (4A).

$$\hat{\tau} = \frac{2n}{n-1}\sum_{j=2}^{n}\sum_{i=2}^{n}\left[\hat{C}\left(\frac{i}{n},\frac{j}{n}\right)\hat{C}\left(\frac{i-1}{n},\frac{j-1}{n}\right)-\hat{C}\left(\frac{i}{n},\frac{j-1}{n}\right)\hat{C}\left(\frac{i-1}{n},\frac{j}{n}\right)\right] \tag{3A}$$

$$\hat{\rho}_s = \frac{12}{n^2-1}\sum_{j=1}^{n}\sum_{i=1}^{n}\left[\hat{C}\left(\frac{i}{n},\frac{j}{n}\right)-\frac{i}{n}*\frac{j}{n}\right] \tag{4A}$$

- The equation (3A): Kendal's tau empirical copula based.
- The equation (4A): Spearman's rho empirical copula based.
- $\hat{C}$ is empirical copula (see more detail Deheuvels, 1978)

4.3. Dependence Measures and Copulas

The general properties of dependence measures can be explained by the 4 items properties shown below (Embrechts, Lindskog, and McNeil (2003)):

1. δ (X,Y) = δ (Y,X).
2. -1≤ δ (X,Y) ≤ 1.
3. δ (X,Y) = 1 if X and Y are comonotonic; as well as δ (X,Y) = -1 if X and Y are comonotonic.
4. If *T* is exactly monotonic, then δ (*T*(X),Y) = { δ (X,Y), *T* = increasing or - δ (X,Y), *T* = decreasing

Normally, the Pearson linear correlation fits only the first two properties but the rank correlation measures Spearman's rho and Kendall's tau fits all of the 4 properties. Therefore, the Copulas calculates the Spearman's rho and Kendall's tau as the dependence measures between X and Y which are random variables.

4.4. Dynamic copula and Co-movement

The dynamic copula and co-movement in international finance became more interesting. A few literatures discussed about these topics. For example, Patton(2006) estimated the asymmetry in the constant and dynamics dependence between Japanese yen and US dollar, Euro and US dollar exchange rates based on copula approach. Benediktsdóttir and Scotti(2009) investigated for all the possible joining of the following six bivariate exchange rates such as Australian dollar, Canadian dollar, Swiss franc, euro, British pound, Japanese yen against the U.S. dollar based on dynamics copula and co-movement approach for during period of 1990-2007. Literatures were conducted to produce this study of the dependence measurement and co-movement toward between Thai Baht exchange rate and the exchange returns of selected ASEAN currencies.

Moreover, this study introduced criteria for selecting the pair of currency between Thai exchange rate and ASEAN currencies by utilizing empirical copula approach. The first currency in the pair is called the base currency and the second is called the quote currency An AR (1)-GJR (1, 1) marginal model with either Skew-T or T residuals was fitted to each of ASEAN currencies. And this model can be written in equation (5A) - (7A).

$$r_{i,t} = c_0 + c_1 r_{i,t-1} + e_{i,t} \qquad (5A)$$

$$e_{i,t} = h_{i,t}\varepsilon_{i,t,} \quad \varepsilon_{i,t} \approx SkT(\upsilon, \lambda) \qquad (6A)$$

$$h_{i,t} = \omega_{i,t} + \alpha e_{i,t-1}^2 + \beta h_{i,t-1} + \gamma e_{i,t-1}^2 1(e_{i,t-1} < 0) \qquad (7A)$$

The copula family was employed to estimate the pair of currency between Thai exchange rate and each of ASEAN exchange rate such as static t copula (t), the time varying t copula (tDCC), the Clayton copula (tvC), the static SJC copula, and the time varying SJC copula (tvSJC). Both static t copula (tDCC) and the time varying t copula (tDCC) were called Elliptical copulas family. Furthermore, the Clayton copula (tvC), the static SJC copula, and the time varying SJC copula (tvSJC) were called Archimedean copulas family. The model of static t copula (t) and the time varying t copula (tDCC) were explained by equation (8A) and (9A).

$$Q_t = (1-\alpha-\beta).\bar{Q} + \alpha\varepsilon_{t-1}.\varepsilon'_{t-1} + \beta.Q_{t-1} \qquad (8A)$$

$$R_t = \widetilde{Q}_t^{-1} Q_t \widetilde{Q}_t^{-1}, \qquad (9A)$$

Define:

- R_t : the value of correlation evolves through time as in the DCC(1,1) model was proposed by Engle(2002);
- □$_t$: the sample covariance of □$_t$;
- α , β : the parameters were estimated from equation (8A);
- v : the degree of freedom parameter of the t copula;

The Archimedean copulas such as the Clayton copula (tvC), the static SJC copula, and the time varying SJC copula (tvSJC) explained by equation (10A), (11A), (12A), and (13A) respectively.

$$\Lambda(\omega+\beta\tau_{t-1}+\alpha.\left|\mu_{1,t-i}-\mu_{2,t-i}\right|), \tag{10A}$$

Define:

- □ : the logistic transformation to keep the parameters of both Clayton and SJC (Symmetrized Joe-Clayton copula). (see more detail in Vogiatzoglou,2010).
- ω,β,α : the parameters were estimated for Clayton copula model.
- μ_1, μ_2 : the error terms of bivariate exchange rate.

$$\tau_t=\Lambda(\omega+\beta\tau_{t-1}+\alpha.\frac{1}{10}\sum_{i=1}^{10}\left|\mu_{1,t-i}-\mu_{2,t-i}\right|), \tag{11A}$$

And define that:

- □ : the logistic transformation to keep the parameters of SJC(Symmetrized Joe-Clayton copula).
- ω,β,α : the parameters were estimated for SJC copula model.
- μ_1, μ_2 : the error terms of bivariate exchange rate.
- τ_t : the Kendall's tau for the SJC copula in upper tail and lower tail (see more detail in Patton,(2006), and Vogiatzoglou,2010).

Moreover, the time varying SJC copula (tvSJC) can be explained by equation (12A) for upper tail and (13A) for lower tail.

$$\Lambda(\omega+\beta\tau_{t-1}+\alpha.\frac{1}{10}\sum_{i=1}^{10}\left|\mu_{1,t-i}-\mu_{2,t-i}\right|), \tag{12A}$$

$$\Lambda^{*}(\omega+\beta\tau_{t-1}+\alpha.\frac{1}{10}\sum_{i=1}^{10}\left|\mu_{1,t-i}-\mu_{2,t-i}\right|), \tag{13A}$$

And also define that:

- □ : the logistic transformation to keep the parameters of SJC(Symmetrized Joe-Clayton copula) for upper tail.
- □* : the logistic transformation to keep the parameters of SJC(Symmetrized Joe-Clayton copula) for lower tail.
- ω,β,α : the parameters were estimated for SJC copula model.
- μ_1, μ_2 : the error terms of bivariate exchange rate.
- τ_t : the Kendall's tau for the SJC copula in upper and lower tail (see more detail in Patton, 2006; Vogiatzoglou, 2010).

5. DATA DESCRIPTION

Figure (1a) shows daily data of ASEAN exchange rates in percentage returns during the period of 2008 to 2011. Moreover, Table (1a) shows descriptive statistics of ASEAN exchange rates in percentage returns during the period of 2008 to 2011.

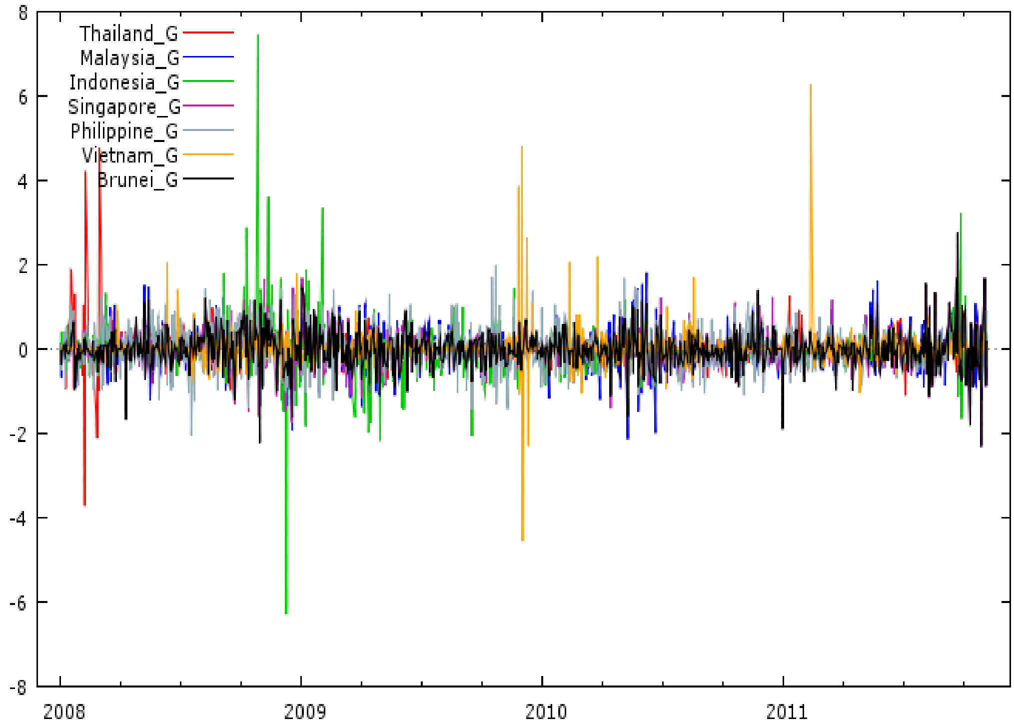

Figure (1a). The ASEAN exchange rates in percentage returns during period of 2008-2011 (daily data)

Table (1a). The statistics of ASEAN exchange rates in percentage returns during the period of 2008 to 2011(daily data)

Items	Thailand	Malaysia	Indonesia	Singapore	Philippine	Vietnam	Brunei
Mean	0.003090	-0.004775	-0.003230	-0.011818	0.005344	0.027920	-0.011930
Median	0.000000	0.000000	0.000000	-0.027175	0.000000	0.000000	-0.022006
Maximum	4.745763	1.802077	7.436282	2.700345	1.978491	6.262834	2.753971
Minimum	-3.721683	-2.141981	-6.293103	-2.306903	-2.061628	-4.563969	-2.314413
Std. Dev.	0.396876	0.454471	0.555336	0.440743	0.487157	0.420956	0.436556
Skewness	2.227425	-0.068831	1.630686	0.219288	0.082685	4.701804	0.059016
Kurtosis	45.20574	4.978748	56.28973	6.822453	4.056245	90.79956	7.417489
Jarque-Bera	75273.90	164.4248	119124.3	618.6629	47.76793	325857.6	816.1136
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1003	1003	1003	1003	1003	1003	1003

From: computed

6. EMPIRICAL RESULTS OF RESEARCH

6.1. The dependence measure of Thai Baht exchange rate and selected ASEAN exchange rates

In this research pointed out that the general properties of dependence measures can be explained by four important potential properties of statistics as shown on table(1g) below (Embrechts, Lindskog, and McNeil (2003)). From computed there is a perfect harmony between the two sets of ranks of dependent measurement based on Kendall's tau statistics and Spearman's rho statistics (a non-parametric measure of statistical dependence between two variables). Ranking of dependent measurement based on the Pearson linear correlation coefficient is a settle on of the strong point of a linear determined a linear mixture of the dependent variables (see table (1b)).

Table (1b). The dependence measure of Thai Baht exchange rate and each selected ASEAN exchange rates during period of 2008-2011

Properties of statistics	Malaysia	Indonesia	Singapore	Philippine	Vietnam	Brunei
Pearson linear correlation coefficient	0.340**	0.181**	0.326**	0.218**	0.008	0.335**
Kendall's tau statistics	0.312976	0.208214	0.3171003	0.2064734	0.01975112	0.3411878
Spearman's rho statistics	0.452674	0.3059663	0.4533679	0.3015882	0.02844642	0.4865837
Ranking of dependent measurement based on Kendall's tau statistics and Spearman's rho statistics	3	4	2	5	6	1
Ranking of dependent measurement based on the Pearson linear correlation coefficient	1	5	3	4	6	2

***: Correlation is significant at the 0.01 level (2-tailed)*
Source: From computed.

6.2. The dynamic copula and co-movement between Thai Baht exchange rate and each of selected ASEAN exchange rates

The LM test and the Kolmogorov-Smirnov test were employed to test the marginal distributions of AR (1)-GJR (1, 1) marginal model for each selected ASEAN's exchange rate (see the result of testing in appendix A, (Sigríður Benediktsdóttir And Chiara Scotti, 2009)). The results of estimation based on dynamic copula and co-movement between Thai Baht exchange rate and each of selected ASEAN exchange rate presented in table (1c). Estimation of the static t-copula found that the exchange rate of Thailand had a co-movement with each of ASEAN exchange rates such as Brunei exchange rate, Singapore exchange rate, Malaysia exchange rate and Indonesia exchange rate. But Philippine exchange rate had no co-movement with Thai exchange rate. Estimation of the time varying t copula (tDCC) found that the exchange rate of Thailand had a co-movement with both Brunei exchange rate and Malaysia exchange rate. However, Thai's exchange had no co-movement with Singapore exchange rate, Indonesia exchange rate and Philippine exchange rate.

Based on estimation of the Clayton copulas (tVC) the exchange rate of Thailand had a co-movement with only one currency in ASEAN is Malaysiaexchange rate. In addition, based on estimation of the static SJC copula (Symmetrized Joe-Clayton copula) was found that both upper tail and lower tail have a statistics significantly. It is meaning that Thai exchange rate had a co-moment with all of ASEAN exchange rates in upper tail regime and lower tail regime (during period of world's financial crisis 2008-2010). Finally, estimation of the time varying SJC copula (Symmetrized Joe-Clayton copula) found that the exchange rate of Thailand had a co-movement with Brunei exchange rate in upper tail regime. During period of world's financial crisis, Thai exchange rate and Brunei exchange rate had a co-movement shown depreciation against US dollar.

Table (1c). The estimated marginal parameters correspond to AR(1)-GJR(1,1) toward the copula-family

AR(1)-GJR(1,1)	**Thailand (marginal parameters)**	**SE.**	**Brunei (marginal parameters)**	**SE**	**Thailand (marginal parameters)**	**SE.**	**Singapore (marginal parameters)**	**SE**
C_0	-0.0051	0.006	-0.0254**	0.01	-0.0051	0.006	-0.0296**	0.011
C_1	0.0466*	0.034	-0.0315	0.031	0.0466*	0.034	-0.0424*	0.029
ω	0.0023*	0.001	0.0051*	0.003	0.0023**	0.001	0.0017*	0.001
α	0.2535***	0.061	0.1490***	0.068	0.2535***	0.061	0.0777***	0.019
β	0.8006***	0.036	0.8965***	0.048	0.8006***	0.036	0.9421***	0.016
γ	-0.0664*	0.058	-0.1253*	0.064	-0.0664*	0.058	-0.0511**	0.025
v	3.9853***	0.5	4.2724***	0.612	3.9853***	0.5	4.9077***	0.776
λ	-	-	-		-	-	-	-
Log-likelihood	-75.733		-455.324		-75.733		-474.3	
AIC	165.4664		924.6471		165.4664		962.6005	
BIC	199.8417		959.0223		199.8417		996.9757	
Static t-copula (t)			**parameters**	**SE.**			**parameters**	**SE.**

v			11.3419***	4.545			9.5014***	3.001
AIC			-278.5438				-260.5068	
BIC			-273.6331				-255.596	
Log-likelihood			140.272				131.253	
Time varying t(tDCC)			**parameters**	**SE.**			**parameters**	**SE.**
v			14.0819*	7.4			9.0609***	2.832
α			0.0317*	0.018			0.0218	0.026
β			0.8984***	0.076			0.8803***	0.278
AIC			-282.5605				-258.8045	
BIC			-267.8282				-244.0722	
Log-likelihood			144.28				132.402	
Clayton Copulas (tVC)			**parameters**	**SE.**			**parameters**	**SE.**
ω			-0.0283	0.138			-1.4084***	0.216
α			-0.7831*	0.417			0.6571*	0.381
β			0.7007**	0.256			-0.7331***	0.131
AIC			-203.8507				-188.3311	
BIC			-189.1184				-173.5989	
Log-likelihood			104.925				97.166	
Static SJC copula			**parameters**	**SE.**			**parameters**	**SE.**
τ^U			0.3102***	0.044			0.2885***	0.042
τ^L			0.2696***	0.048			0.2651***	0.046
AIC			-261.2982				-243.8058	
BIC			-251.4767				-233.9843	
Log-likelihood			132.649				123.903	
Time varying SJC copula	**Upper Tail**	**SE.**	**Lower Tail**	**SE.**	**Upper Tail**	**SE.**	**Lower Tail**	**SE.**
ω	1.7852***	0.417	0.0954	0.756	0.0723	1.124	-0.0704	0.554
α	-9.9999***	0.002	-3.1715	4.981	-3.9123	5.161	-1.3339	2.839
β	-0.9838***	0.007	0.0604	0.83	-0.7521***	0.155	0.3951*	0.266
AIC			-269.8925				-237.1479	
BIC			-240.428				-207.6834	
Log-likelihood			140.946				124.574	

From: computed, **SE:** Standard errors are in parenthesis and *, **, ***: Significance at 1%,5%,10%

Table (1c): Present the estimated marginal parameters correspond to AR(1)-GJR(1,1) toward the copula-family (continue with Table(1c))

AR(1)-GJR(1,1)	**Thailand (marginal parameters)**	**SE.**	**Malaysia (marginal parameters)**	**SE**	**Thailand (marginal parameters)**	**SE.**	**Indonesia (marginal parameters)**	**SE**
C_0	-0.0073*	0.007	-0.0146*	0.013	-0.0051	0.006	-0.0150**	0.007
C_1	0.0493*	0.035	-0.0189	0.028	0.0466*	0.034	-0.0514*	0.032
ω	0.0023**	0.001	0.0078**	0.004	0.0023*	0.001	0.0070*	0.005
α	0.2528***	0.061	0.1677***	0.049	0.2535***	0.061	0.2362*	0.18
β	0.8018***	0.036	0.8508***	0.035	0.8006***	0.036	0.8536***	0.071
γ	-0.0666*	0.058	-0.0867*	0.055	-0.0664*	0.058	0.0565	0.104
v	3.9798***	0.501	5.6849***	1.038	3.9853***	0.5	2.3742***	0.151
λ	-0.0267	0.041	-0.0281	0.04	-	-	-	-
Log-likelihood	-75.528		-551.095		-75.733		-295.23	
AIC	167.0559		1118.1899		165.4664		604.4597	
BIC	206.3419		1157.4759		199.8417		638.835	
Static t-copula (t)			**parameters**	**SE.**			**parameters**	**SE.**
v			15.9104**	7.933			16.3510*	10.907
AIC			-223.4681				-115.5455	
BIC			-218.5574				-110.6348	
Log-likelihood			112.734				58.773	
Time varying t(tDCC)			**parameters**	**SE.**			**parameters**	**SE.**
v			15.2286**	7.461			16.3281*	10.189
α			0.0399**	0.018			0.002	0.015
β			0.8743***	0.066			0.8604***	0.052
AIC			-229.0344				-111.5174	
BIC			-214.3021				-96.7851	
Log-likelihood			117.517				58.759	
Clayton Copulas (tVC)			**parameters**	**SE.**			**parameters**	**SE.**
ω			-0.4380*	0.336			-1.0959**	0.448
α			-0.1778	0.515			-1.4727*	0.979
β			0.4513*	0.298			-0.1689	0.319
AIC			-152.9157				-86.6304	
BIC			-138.1834				-71.8981	
Log-likelihood			79.458				46.315	
Static SJC copula			**parameters**	**SE.**			**parameters**	**SE.**
τ^U			0.2797***	0.042			0.1396***	0.043
τ^L			0.2131***	0.046			0.1515***	0.045
AIC			-210.21				-108.4114	
BIC			-200.3885				-98.5899	
Log-likelihood			107.105				56.206	

Time varying SJC copula	Upper Tail	SE.	Lower Tail	SE.	Upper Tail	SE.	Lower Tail	SE.
ω	1.5064	2.985	-1.4923	1.96	-0.4504	1.619	0.2004	1.428
α	-9.4706	18.461	-1.0989	7.918	-9.9975*	6.444	-9.9997**	4.838
β	-0.2787	2.677	-0.8470***	0.08	-0.9255***	0.048	-0.9127***	0.101
AIC			-208.8808				-109.2253	
BIC			-179.4163				-79.7608	
Log-likelihood			110.44				60.613	

From: computed, SE: Standard errors are in parenthesis and,, **, ***: Significance t 1%,5%,10%*

Table (1c): Present the estimated marginal parameters correspond to AR(1)-GJR(1,1) toward the copula-family(continue with Table(1c)).

AR(1)-GJR(1,1)	Thailand (marginal parameters)	SE.	Philippine (marginal parameters)	SE
C_0	-0.0051	0.006	-0.0104	0.028
C_1	0.0466*	0.034	-0.0773**	0.033
ω	0.0023*	0.001	0.00001	0.01
α	0.2535**	0.061	0.0068	0.008
β	0.8006***	0.036	0.9769***	0.037
γ	-0.0664*	0.058	0.0393	0.112
v	3.9853***	0.5	7.7887*	5.157
λ	-	-	-	-
Log-likelihood	-75.733		-671.449	
AIC	165.4664		1356.8986	
BIC	199.8417		1391.2739	
Static t-copula (t)			**parameters**	**SE.**
v			46.1557	76.026
AIC			-94.1893	
BIC			-89.2785	
Log-likelihood			48.095	
Time varying t(tDCC)			**parameters**	**SE.**
v			62.7767*	44.064
α			0.0268	0.023
β			0.8463***	0.156
AIC			-93.1355	
BIC			-78.4032	
Log-likelihood			49.568	
Clayton Copulas (tVC)			**parameters**	**SE.**
ω			-0.6579	2.23
α			0.0929	1.747
β			0.5568	1.229
AIC			-60.6954	
BIC			-45.9631	

Log-likelihood			33.348	
Static SJC copula			**parameters**	**SE.**
ω				
τ^U			0.1401***	0.047
τ^L			0.1038**	0.046
AIC			-85.1033	
BIC			-75.2818	
Log-likelihood			44.552	
Time varying SJC copula	**Upper Tail**	**SE.**	**Lower Tail**	**SE.**
ω	0.945	1.291	-0.1789	0.776
α	-10.0000*	7.295	-0.8908	1.87
β	-0.1541	0.772	0.7791***	0.176
AIC			-84.046	
BIC			-54.5815	
Log-likelihood			48.023	

*From: computed, SE: Standard errors are in parenthesis and *, **, ***: Significance at 1%,5%,10%*

7. CONCLUSIONS

In conclusion, the study found a dependent structure as an appropriate solution for Thai Baht exchange rate in percentage returns and each of selected ASEAN currencies excluding Vietnam exchange rate return during period of 2008-2011. The copula approach to construct statistical models provided strong evidence showing a relationship between Thai Baht exchange rate against each of selected ASEAN currencies.

Pearson linear correlation coefficient suggested that Thai Baht exchange rate returns had a moderate correlation with each of selected ASEAN currencies, except Vietnam. Kendall's tau statistics and Spearman's tau statistics confirmed a dependent structure as an appropriate solution for Thai Baht exchange rate and each of selected ASEAN currencies.

Moreover, the Dynamic Copula estimation indicated that Thai Baht exchange rate had a co-movement with some selected in ASEAN's currencies. Based on Elliptical copulas family estimation, Thai Baht exchange rate had a co-movement with each of selected ASEAN exchange rates including Brunei exchange rate, Singapore exchange rate, Malaysia exchange rate and Indonesia exchange rate.

But Philippine exchange rate had no co-movement with Thai Baht exchange rate. And based on Archimedean copulas family estimation, the exchange rate of Thailand had a co-movement with each of selected ASEAN exchange rates such as Brunei exchange rate, Singapore exchange rate, Malaysia exchange rate, Indonesia exchange rate and Philippine exchange rate. But based on estimation of the time varying SJC copula (Symmetrized Joe-Clayton copula) Thai Baht exchange rate had a co-movement with only Brunei exchange rate in upper tail regime. During period of world's financial crisis Thai exchange rate and Bruneiex change rate had a co-movement shown depreciation against US dollar.

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Appendix A

Table (1d). Testing of the Marginal Distribution Models based on LM-test and K-S test

	Thailand	Brunei	Singapore	Malaysia	Indonesia	Philippine
First moment LM test	0.302	0.225	0.363	0.115	0.128	0.363
Second moment LM test	0.312	0.138	0.211	0.131	0.071	0.211
Third moment LM test	0.339	0.358	0.272	0.475	0.649	0.272
Forth moment LM test	0.594	0.060	0.531	0.871	0.105	0.531
K-S test	0.125	0.076	0.063	0.057	0.166	0.045

LM-test: test for serial independence of the residual terms of marginal model (all of residual terms are satisfied for all of marginal models were employed to estimate the copula model).

K-S test: test for the uniform distribution of marginal models (If a p value more than 0.05 then the marginal model is well-specified (except, Philippine)).