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MODELING DEPENDENCY AND CONDITIONAL VOLATILITY BETWEEN ASIAN ECONOMIC COMMUNITY (AEC) COUNTRY EXCHANGE RATE AND INFLATION USING THE COPULA-GARCH MODEL.

Abstract:

Structural dependence and conditional volatility are solutions to comprehend financial crisis behavior. Investigation has been widely analyzed especially to what circumstances occurred in EURO zone countries. This leads many economic researchers attention to prepare uncertainty beyond relationship and variation. This paper aims at estimating the dependency and conditional volatilities the growth rate of AEC exchange rate and inflation of Thailand using COPULA-GARCH models. The motivation of this journal is to reach the most rational policy for BANK of Thailand, since exchange rate is one among tangible strategies. Both margins are distributed by skewed-t, and ARMA-GARCH is fitted to monthly data. Growth rate of those variables residual independence are checked by bivariate random dependence which is represented by P-Value and for Marginal Persistence Volatilities will be tested by using Dynamic Conditional Correlation Method, Fifteen static copulas are applied to those dependencies. AIC, SIC and Kendall’s tau will be an appropriate approach to assess results. Empirical results show huge coefficients of correlations between AEC exchange rates and Thailand inflation in the short-term period and slightly correlated in the long-term period of conditional volatility and dependency. In addition, there is evidence to convince that it was a positive relationship.

Keywords:

Copula; Conditional Valatility; ARMA-GARCH; Exchange Rate; Dynamic Conditional Correlation; Bivariate Independent Test

JEL Classification: C01, C50, C58

1. Introduction

The inflation problem reflects the effects on two sides. On the one hand, when inflation is in a mild state it could lead to an expansionary economy because the entrepreneur have intensives to increase private investment due to the higher forecasted revenue. On the other hand, if the inflation is in a hyper state which could affect many economic indicators, would make a decrease in purchasing power. We also call those correlations as “Conditional Volatilities”. One of among effected indicators is export and import both in quantitative (volumn) and qualitative (price).

Volatility from exchange rate can undeniably lead to an unobservable fluctuation on economic indicators. Consider Thailand financial crisis in 1997, when it was fixed with no condition, Bank of Thailand had no exchange rate instrument to control quantitative and qualitative of export and import. These led to unexpected debt and other massive indicators especially inflations. Euro zone crisis also demonstrate the example to all countries around the world of national bank when the trade-open countries have no independence on monetary policy to operate the stability of equilibrium on money market.

In the past decade, Thailand usually aims at prevailing profit from exporting to Europe countries. But since Euro zone crisis has occurred, Export market shares from Europe have dropped dramatically. This has led to an increase in international trade between Asian countries as previewed in table 1#. In addition, Thailand is participating in the Asian Economic Community which consist ten Asian countries. Therefore, understanding conditional volatilities from AEC countries exchange rate and Thailand inflation and preparing for the policy is really essential to gain benefit from AEC emerging based on tangible monetary instrument for Bank of Thailand.

Table 1. Marginal Value Exports of Thailand

Value: Million dollar

Country		Q1/2015	% Share
Total export		56,559,672.53	100.0
1	US	6,199,975.76	11.0
2	China	5,917,316.70	10.5
3	Japan	5,435,090.20	9.6
4	Hongkong	3,107,849.13	5.5
5	Malaysia	2,783,298.21	4.9
6	Australia	2,512,189.45	4.4
7	Indonesia	2,159,683.42	3.8
8	Singapore	2,150,761.16	3.8

9	Vietnam	2,053,843.79	3.6
10	Philippines	1,512,380.39	2.7
11	Other	22,727,284.32	40.2

2. Literature Review

Exchange rate is one among many influencing factors that can be a huge effect to macroeconomic variables. For most recent example is from Ramasamy and Karimi Abar, (2015), studied about influence of macroeconomic variables (International-Trade) on exchange rate. When results proved that inter-trade has a negative relationship with exchange rate, not only in fixing the prices but also in determining the nature of hedging to be arranged to avoid exchange rate risks which was modeled and computed by bootstrapping linking complementary technique. Second is the correlation of volatilities from Singapore nominal exchange rate and volatilities real macroeconomic variables. Supaat, Phang Seow Jiun, Tiong and Robinson, (2013) which argue the past evidence that there is no correlation between them but in the very short-term and small relationship. Also from G. Stotsky, Ghazanchyan, Adedeji and Maehle, (2012) with publication by International Monetary Fund (IMF) in 2012, researched about dependency of foreign exchange regime (real and nominal exchange rate) and macro-performance (such as lagged inflation and liberalization) in Eastern Africa. The consequences presented theoretically as all determinants mentioned above are slightly significant except between exchange regime and liberalization. Xiougtoua and Sriboonchitta, (2014) proved the dependency of volatility in Lao exchange rate and inflation by using Copula-GARCH model. The results evinced that there is a long-term positive relation between those variables and could be used to design policy for policy maker and launcher to understand and forecast about what changes will approximately be happened. Stephen Morris, (1995) tested the dynamics of inflation and the foreign exchange parallel market. Chih-Chiang Wu, (2012) studied the value of economic of parallel movement on oil prices exchange rate using Copula GARCH models.

3. Econometric Methods

3.1 Marginal Distribution of residual conditional volatilities

Data used in this article are the growth rate of exchange rate and Thailand inflation where exchange rates are Asian Economic Community countries (Thailand, Cambodian, Myanmar, Malaysia, Singapore, Indonesia, Brunei, Laos and Philippine, Vietnam is excluded due to the unobservable growth rate of conditional volatilities.) Both data is showing obviously that there is heteroscedasticity volatility. Also skewness student t distribution and ARMA-GARCH model is assumed to be fitted in this historic information. Based on the propose of Bollerslev (1986) ARMA-GARCH (Auto Recursive Moving Average Generalized Autoregressive Conditional Heteroskedasticity) will be modeled which ARMA (p,q)-GARCH (k,1) Songsak (2013) is being generated as follow:

$$r_t = c + \sum_{i=1}^{p} \varphi_i r_{t-i} + \sum_{i=1}^{q} \psi_i \varepsilon_{t-i} + \varepsilon_t \quad (1)$$

$$\varepsilon_t = h_t \bullet \eta_t \quad (2)$$

$$h_t = \varpi + \sum_{i=1}^{k} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{l} \beta_i h_{t-i} \qquad (3)$$

Where $\sum_{i=1}^{k} \alpha_i + \sum_{i=1}^{l} \beta_i < 1$, $\sum_{i=1}^{p} \phi_i < 1$, $\omega > 0, (\alpha_i, \beta_i \geq 0)$

The coefficient correlation of short-run effects can be simulated by the value of α_i and β_i. The unexpected error has the positive relationship to the value of them which means the higher both parameters, the longer period effect will affect to volatility.

3.2 Univariated Skewed Student-T Distribution (Ferreira and Mark F. J. Steel, 2007)

$$p(\ni | \gamma, e) = \frac{2}{\gamma + \frac{1}{\gamma}} \left\{ f(\frac{\ni}{\gamma}) I_{[0,\infty)}(\ni) + f(\gamma \ni) I_{(-\infty,0)}(\ni) \right\} = \frac{2}{\gamma + \frac{1}{\gamma}} f(\ni \gamma^{-sign(\ni)}) \qquad (4)$$

Where $I_s(\bullet)$ is the indicator function on S , and $sign(\bullet)$ is the usual sign function. Which are formulated from 0 to ∞ . γ, e represent a degree of freedom and the skewed student-t distributional parameter respectively.

3.3 Copula Framework

The copula formation can be generalized for any collection of marginal distributions and joint distributions. (Donald J, Sinko, SAS Institute Inc, 2008) Based on Sklar's theorem: if is a join distribution with marginal distribution functions, the C copula function can be illustrated such that:

$$H(x_1, x_2, x_3, ..., x_d) = C(F_1(x_1), ..., F_d(x_d)) \qquad (5)$$

Assume that $F_1, F_2, F_3, ..., F_d$ are continuous terms. Conventional formula has the assumption that the inputs which are linked to the copula function are random variables with a unique uniform distribution but not a exact requirement for the theory to hold. Sklar stated that any C-Copula can be generated when you have determined the marginal distributions which finally lead to the two dimensional distribution formula as:

$$H(e,v) = C(F_e(E), F_v(V)) \qquad (6)$$

3.3.1 Static Copulas

1) Gaussian copula

$$C_{Ga}(u,v \mid \rho) = \int_{-\infty}^{\varphi^{-1}(u)} \int_{-\infty}^{\varphi^{-1}(v)} \frac{1}{2\pi\sqrt{1-\rho^2}} \exp\left\{ -\frac{X^2 - 2\rho XY + Y^2}{2(1-\rho^2)} \right\} dXdY \qquad (7)$$

Since this is the bivariate analysis, e, v which was standardized by residuals subjected to a unique uniform distribution from 0 to 1 are empirical cumulative distribution functions.

2) T-Copula

$$C_T(u,v|) = \int_{-\infty}^{T^{-1}(u)} dX \int_{-\infty}^{T^{-1}(v)} dY \frac{1}{2\pi\sqrt{1-\rho^2}} \left\{1 + \frac{X^2 - 2\rho XY + Y^2}{v(1-\rho^2)}\right\}^{\frac{-(v+2)}{2}} \tag{8}$$

Which $T_v(e) = \int_{-\infty}^{x} \frac{\Gamma((v+1)/2)}{\sqrt{\pi v}\Gamma(v/2)}(1+\frac{Z^2}{v})^{\frac{-(v+2)}{2}}$

Where v is the number of degrees of freedom and ρ is linear correlation coefficient, both are the purpose of copula method which are parameters of the copulas.

3) Archimedean Copulas

- Clayton

Clayton copula is an asymmetric Archimedean copula, demonstrating better dependence in negative tails than in positives which can be formulated as follow:

$$C_\alpha(e,v) = \max([u^{-\alpha} + v^{-\alpha} - 1]^{\frac{-1}{\alpha}}, 0) \tag{9}$$

Generated as: $\varphi_\alpha(t) = \frac{1}{\alpha}(t^{-\varepsilon} - 1)$ where $\alpha \in [-1,\infty) \setminus \{0\}$

- Frank

$$C_\alpha(e,v) = -\frac{1}{\alpha}\ln(1 + \frac{(l^{-\alpha e} - 1)(l^{-\alpha v} - 1)}{l^{-\alpha} - 1}) \tag{10}$$

Generated as: $\varphi_\alpha(t) = -\ln(\frac{\exp(-\alpha t) - 1}{\exp(-\alpha) - 1})$ where $\alpha \in (-\infty,\infty) \setminus \{0\}$

- Gumbel

Gumbel is exhibiting greater dependence in positive tails than in negative tails.

$$C_\alpha(e,v) = \exp\{-[-(\ln e)^\alpha + (-\ln v)^\alpha]^{\frac{1}{\alpha}}\} \tag{11}$$

Its generator is $\varphi_\alpha(t) = (-\ln t)^\alpha$ where $\alpha \in [1,\infty)$

4) BBX Copulas

BBX copulas include two-parameter estimator with greater dependence in upper tail and both lower and upper tail dependence which are BB6, BB8 and BB1, BB7 respectively.

5) Rotated Copulas

Modeling risk can be conditioned if copulas cannot simulate the negative tail dependence such as Gumbel, Clayton, Joe and BBX copulas. By the way, those copulas can be fitted with negative value by rotation technic as 90, 180 and 270 degree as so-called “Rotated Copulas”.

3.4 Goodness of fit Tests

Generating the best copulas can be finished by selecting the lowest Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC)

$$AIC = (\frac{2n}{n-k-1})k - 2\ln[L_{\max}] \tag{12}$$

$$SIC = \ln[n]k - 2\ln[L_{\max}] \tag{13}$$

Where n = number of observations (e.g. data values, frequencies)

k = number of parameters to be estimated (e.g. the Normal Distribution has 2: mu and sigma)

$L_{\max}$ = the maximized value of the log-Likelihood for the estimated model (i.e. fit the parameters by MLE and record the natural log of the Likelihood)

3.5 Dynamic Conditional Correlation

CCC GARCH was developed by simply introducing scalar BEKK-like dynamics to the conditional correlations to become the Dynamic Conditional Correlation (DCC) which can be formulated as:

1) Tse and Tsui Dynamic Conditional Correlation (Tse and Tsui, 2002)

$$R_t = \overline{R}(1-\theta_1-\theta_2) + \theta_1 r_{t-1}^{\ k} + \theta_2 R_{t-1} \tag{14}$$

Where $r_t^k = diag[\frac{1}{k}\sum_{s=t-k}^{t}\varepsilon_s\varepsilon_s']^{-\frac{1}{2}}[\frac{1}{k}\sum_{s=t-k}^{t}\varepsilon_s\varepsilon_s'][\frac{1}{k}\sum_{s=t-k}^{t}\varepsilon_s\varepsilon_s']^{-\frac{1}{2}}$

2) Engle DCC **(**Engle, R.F., 1982)

$$Q_t = \overline{R} + \sum_{i=1}^{p}\alpha_i(\varepsilon_{t-1}\varepsilon'_{t-1} - \overline{R}) + \sum_{i=1}^{q}\beta_i(Q_{t-i} - \overline{R}) \tag{15}$$

θ_1 and θ_2 are non-negative parameters and subjected to $0 \le \theta_1 + \theta_2 \le 1$, R is positive definite parameter matrix with the dimension equal to $k \times k$.

4. Empirical Result

The investigation intercepts interactions between nine AEC country exchange rates and Thailand inflation started from January 1996 to December 2014. All data is sampled at a monthly frequency. AEC country exchange rates consisted Cambodian (THCAM), Brunei (THBRU), Indonesia (THIND), Singapore (THSIN), Malaysia (THMAY), Myanmar (THMYA), Laos (THLAO) and Philippines (THPHI). Vietnam (THVIE) is undeniably excluded due to the lack of information and unchanged lagged correlation terms.

4.1 Descriptive Result

Table 2. Descriptive Statistics of All Variables Used.

	Mean	Median	Maximum	Minimum	Observation
INF	0.00232980	0.002178200	0.017131	-0.012876	
THVIE	-0.00187480	0.000000000	0.145180	-0.071459	
THSIN	0.00149660	-0.000093041	0.097698	-0.043981	
THPHI	-0.00126130	-0.000885050	0.052300	-0.059478	228
THMYA	-0.02160500	-0.002321100	0.141990	-0.150880	
THMAL	-0.00018788	-0.000133020	0.039062	-0.054514	
THLAO	-0.00834740	0.000000000	0.140390	-0.378800	
THIND	-0.00625180	-0.003408000	0.162380	-0.204010	
THCAM	-0.00134220	5.000000000	0.103680	-0.107100	
THBRU	0.00149370	0.001238600	0.097815	-0.042273	

Source: computed

4.2 Marginal Distribution

Marginal Distribution functions for all AEC growth rate of exchange rate and Thailand inflation are distributed by ARMA(1,1)-GARCH(1,1) with skewed-t distributions. The logic behind this distribution is we notice that with the data given above are significant for all growth rate series at 99 percent of confident level. These alpha1 and omega marginal functions represent that there is some AEC country exchange rates in which still being correlated with constant such as THCAM, THBRU, THSIN, THPHI and THLAO, however, THMYA, THIND, THMAL and INF are uncorrelated. The long-term persistence of volatilities of those variables existed proved by beta1 in each Error Analysis Result. (For deep detail can be seen in Table 3.)

Table3. Computed Growth Rate of All Variables with ARMA(1,1)-GARCH(1,1) Model.

Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
INF-EST	0.6670	-0.3390	0.0000	1.0000	0.7710	0.8240	2.1100
Std.Error	0.1710	0.2180	0.0000	2.5400	0.0742	0.0669	0.3040
t value	3.8940	1.5520	0.3750	0.3930	10.3910	12.3130	6.9470
Pr(>|t|)	0.987E-4***	0.1210	0.7070	0.6940	<2E-16***	<2E-16***	<2E-16***

Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
THCAM-EST	-0.0469	0.3275	0.0001	0.3540	0.5338	1.1141	3.2597
Std.Error	0.1832	0.1625	0.0001	0.2010	0.2116	0.0927	0.9072
t value	0.2560	2.0160	1.7110	1.7610	2.5220	12.0200	3.5930
Pr(>|t|)	0.7977	0.0438*	0.087031(.)	0.078183(.)	0.011658*	<2E-16***	0.327E-3***
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
TH-BRU-EST	0.1080	0.3000	0.0000	0.2090	0.6900	1.1300	3.5000
Std.Error	0.1980	0.1970	0.0000	0.1080	0.1080	0.0875	0.9090
t value	0.6000	1.5220	1.9120	1.9440	6.4070	12.9150	3.6860
Pr(>|t|)	0.584226*	0.127911***	0.055936*	0.051845*	0.148***	<2E-16***	0.228E-3***
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
TH-SIN-EST	0.0795	0.3340	0.0000	0.2070	0.6990	1.1100	3.3400
Std.Error	0.2000	0.1970	0.0000	0.1060	0.1050	0.0899	0.9170
t value	0.7970	1.6900	1.9050	1.9500	6.6370	12.3050	3.6470
Pr(>|t|)	0.6915**	0.090933(.)	0.056822(.)	0.051162(.)	0.32E-10***	<2e-16***	0.265E-3***
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
THMAL-EST	0.0023	0.2440	0.0000	0.0945	0.8850	1.1200	3.1400
Std.Error	0.1890	0.1800	0.0000	0.0628	0.0691	0.0943	0.9590

Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
t value	0.0120	1.3570	1.1340	1.5060	12.8070	11.9130	3.2680
Pr(>|t|)	0.9905	0.1750	0.2568	0.1322	<2e-16***	<2e-16***	0.108E-2**
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
THPHI-EST	0.0324	0.2610	0.0000	0.2630	0.7100	1.0700	3.2300
Std.Error	0.1950	0.1780	0.0000	0.1410	0.1040	0.0792	0.9220
t value	0.1660	1.4630	1.6560	1.8690	6.8030	13.5060	3.5080
Pr(>|t|)	0.8684	0.1430	0.097681(.)	0.061627(.)	0.102E-10***	<2e-16***	0.452E-3***
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
THLAO-EST	0.7790	-0.7310	0.0005	1.0000	0.6170	0.9800	2.1200
Std.Error	0.1300	0.1460	0.0003	0.5520	0.1840	0.0336	0.1010
t value	5.9880	4.9950	1.4890	1.8110	3.3560	29.1810	21.0220
Pr(>|t|)	0.213E-8***	0.589E-6***	0.1366	0.070076(.)	0.789E-3***	<2e-16***	<2e-16***
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
THIND-EST	0.1290	0.1750	0.0002	1.0000	0.6290	1.0800	2.3200
Std.Error	0.1730	0.1680	0.0003	1.6900	0.1640	0.0656	0.8540
t value	7.4300	10.3700	0.5580	0.5900	3.8360	16.4040	2.7170
Pr(>|t|)	0.457205**	0.299928**	0.5765	0.5549	0.000125***	<2e-16***	0.6593E-2**
Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape

Error Analysis:	ar1	ma1	omega	alpha1	betal	skewed	shape
THMYA-EST	0.2770	0.0314	0.0010	1.0000	0.0000	1.0600	2.2200
Std.Error	0.0763	0.0664	0.0008	0.8800	0.5432	0.0585	0.2050
t value	3.6310	0.4720	1.2130	1.1360	0.1521	18.0550	10.7940
Pr(>|t|)	0.282E-3***	0.6370	0.2253	0.2560	5.5561	<2e-16***	<2e-16***

Source: computed

4.3 KS and Box_LJung

As the objective of this article is "Modeling conditional volatilities of variables between AEC exchange rate and Thailand inflation" Therefore, marginal value of $\hat{e}$ and $\hat{v}$ must be obtained. The consequence formulated as accept the null hypothesis meaning that there is no autocorrelation with the four period tested below.

Table 4. KS and Box-LJung Uniform Distribution and Autocorrelation.

		X-Squared	P-Value			X-Squared	P-Value
Marginal Value	1st Period	1.6579	0.8942	Marginal Value	1st Period	5.6067	0.3464
of THCAM X-rate	2nd Period	4.7149	0.4517	of THBRU X-rate	2nd Period	3.192	0.6704
	3rd Period	1.5898	0.9025		3rd Period	8.6702	0.123
	4th Period	8.8128	0.1168		4th Period	4.6443	0.4608
		X-Squared	P-Value			X-Squared	P-Value
Marginal Value	1st Period	5.9928	0.3069	Marginal Value	1st Period	4.5749	0.4699
of THSIN X-rate	2nd Period	4.3666	0.4979	of THMAL X-rate	2nd Period	7.1825	0.2074
	3rd Period	9.27	0.09877		3rd Period	6.7162	0.2426
	4th Period	5.3391	0.3759		4th Period	8.8467	0.1153
		X-Squared	P-Value			X-Squared	P-Value
Marginal Value	1st Period	2.8277	0.7265	Marginal Value	1st Period	7.0349	0.2181
of THPHI X-	2nd	4.339	0.5017	of THLAO X-	2nd	13.241	0.02122

rate	Period			rate	Period		
	3rd Period	4.33	0.5029		3rd Period	4.3214	0.5041
	4th Period	4.4421	0.4877		4th Period	13.219	0.02141
		X-Squared	P-Value			X-Squared	P-Value
Marginal Value	1st Period	1.7005	0.8888	Marginal Value	1st Period	1.7396	0.8839
of THIND X-rate	2nd Period	7.3129	0.1984	of THMYA X-rate	2nd Period	1.9634	0.8542
	3rd Period	5.0102	0.4146		3rd Period	3.531	0.6187
	4th Period	5.1155	0.4019		4th Period	3.4939	0.6243

Source: computed

4.4 Copula

One parameter and two parameters copulas are being illustrated in Table 5 for modeling those volatilities. In addition, Dynamic Conditional Correlation will be applied to calculate the correlation of residual between AEC exchange rates and Thailand inflation. Parameters in each type of copulas will be displayed in Table 5 and 6. For one parameter dependency, are Gaussian, Gumbel, Frank, Joe, Rotated 180 Clayton-Gumbel and Joe. For two sided parameter estimates, are BB1, BB6, BB7, BB8, Rotated 180 Degree BB1-BB6-BB7 and BB8. Every copulas represented in this article are selected by statistic AIC, SIC and Kendall's Tau.

Table 5. One Parameters of Copulas Models.

	THBRU	THCAM	THSIN	THMAL	THPHI	THLAO	THIND	THMYA
Gaussian								
parameters	0.1981	0.0113	0.2003	0.1893	0.0709	0.0294	0.0157	0.0633
AIC	-6.4548	1.9731	-6.6488	-5.7060	0.9407	1.8172	1.9484	1.1547
SIC	-3.0254	5.4025	-3.2195	-2.2767	4.3701	5.2466	5.3778	4.5840
Kendall's Tau	0.1270	0.0072	0.1284	0.1213	0.0452	0.0187	0.0100	0.0403
Gumbel								
parameters	1.1288	1.0001	1.1321	1.1180	1.0430	1.0205	1.0006	1.0331
AIC	-5.5732	2.0002	-5.8522	-3.8767	1.1146	1.8028	1.9996	1.5119

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	THBRU	THCAM	THSIN	THMAL	THPHI	THLAO	THIND	THMYA
SIC	-2.1439	5.4295	-2.4229	-0.4473	4.5439	5.2322	5.4290	4.9412
Kendall's Tau	0.1141	0.0001	0.1167	0.1056	0.0413	0.0201	0.0006	0.0320
Frank								
parameters	1.0706	0.1176	1.1108	1.0892	0.3783	0.2718	0.0346	0.4857
AIC	-4.7095	1.9129	-5.1760	-5.1835	1.1397	1.5495	1.9923	0.5380
SIC	-1.2802	5.3423	-1.7466	-1.7542	4.5690	4.9788	5.4216	3.9674
Kendall's Tau	0.1176	0.0131	0.1219	0.1196	0.0420	0.0302	0.0038	0.0538
Joe								
parameters	1.1623	1.0001	1.1662	1.1468	1.0566	1.0350	1.0025	1.0394
AIC	-3.6339	2.0001	-3.8151	-1.9358	1.3600	1.7769	1.9983	1.7266
SIC	-0.2046	5.4295	-0.3858	1.4936	4.7893	5.2063	5.4276	5.1559
Kendall's Tau	0.0850	0.0001	0.0869	0.0776	0.0316	0.0198	0.0015	0.0223
Rotated 180 Clayton								
parameters	0.2327	0.0397	0.2363	0.2199	0.1034	0.0776	0.0182	0.0893
AIC	-5.1907	1.7545	-5.3396	-4.1177	0.4221	1.1013	1.9470	0.9056
SIC	-1.7614	5.1839	-1.9103	-0.6883	3.8515	4.5306	5.3764	4.3350
Kendall's Tau	0.1042	0.0195	0.1057	0.0991	0.0491	0.0374	0.0090	0.0428
Rotated 180 Gumbel								
parameters	1.1322	1.0001	1.1350	1.1063	1.0517	1.0010	1.0001	1.0116
AIC	-6.9434	2.0022	-6.9855	-3.8558	0.0367	2.0021	2.0024	1.9368
SIC	-3.5141	5.4316	-3.5561	-0.4265	3.4661	5.4315	5.4317	5.3661

	THBRU	THCAM	THSIN	THMAL	THPHI	THLAO	THIND	THMYA
Kendall's Tau	0.1167	0.0001	0.1189	0.0961	0.0492	0.0010	0.0001	0.0115
Rotated 180 Joe								
parameters	1.1687	1.0001	1.1724	1.1196	1.0655	1.0001	1.0001	1.0001
AIC	-5.2965	2.0027	-5.2258	-1.8710	0.2546	2.0032	2.0025	2.0009
SIC	-1.8672	5.4321	-1.7964	1.5583	3.6840	5.4326	5.4318	5.4302
Kendall's Tau	0.0881	0.0001	0.0898	0.0643	0.0364	0.0001	0.0001	0.0001

Table 6. Two Parameters of Copulas Models.

	THBRU	THCAM	THSIN	THMAL	THPHI	THLAO	THIND	THMYA
BB1								
par. 1#	0.1117	0.0010	0.1102	0.0940	0.0238	0.0010	0.0010	0.0010
par. 2#	1.0813	1.0010	1.0848	1.0751	1.0329	1.0201	1.0010	1.0326
AIC	-4.8564	4.0193	-5.0658	-2.7536	3.0433	3.8244	4.0085	3.5229
SIC	2.0023	10.8780	1.7929	4.1051	9.9020	10.6831	10.8672	10.3816
Kendall's Tau	0.1241	0.0015	0.1263	0.1116	0.0433	0.0202	0.0015	0.0321
BB6								
par. 1#	1.0010	1.0010	1.0010	1.0010	1.0110	1.0334	1.0010	1.0010
par. 2#	1.1281	1.0010	1.1314	1.1173	1.0423	1.0010	1.0010	1.0325
AIC	-3.5653	4.0049	-3.8440	-1.8672	3.1176	3.7775	3.9992	3.5159
SIC	3.2934	10.8636	3.0147	4.9915	9.9760	10.6362	10.8579	10.3746
Kendall's Tau	0.1141	0.0016	0.1166	0.1055	0.0411	0.0199	0.0016	0.0320
BB7								
par. 1#	1.1065	1.0010	1.1092	1.0869	1.0400	1.0346	1.0021	1.0389

	THBRU	THCAM	THSIN	THMAL	THPHI	THLAO	THIND	THMYA
par. 2#	0.1561	0.0010	0.1574	0.1384	0.0396	0.0010	0.0010	0.0010
AIC	-4.9149	4.0186	-5.0732	-2.4425	3.1006	3.7968	4.0071	3.7319
SIC	1.9438	10.8773	1.7855	4.4162	9.9529	10.6556	10.8658	10.5906
Kendall's Tau	0.1219	0.0011	0.1236	0.1063	0.0411	0.0201	0.0017	0.0225
BB8								
par. 1#	6.0000	1.0010	6.0000	3.1239	1.2121	1.1927	1.0010	1.4976
par. 2#	0.1852	0.0010	0.1910	0.3761	0.8173	0.7942	0.0010	0.5867
AIC	-2.6972	3.9999	-3.1526	-3.2519	2.6050	3.0341	3.9999	2.3328
SIC	4.1615	10.8586	3.7060	3.6068	9.4637	9.8928	10.8586	9.1915
Kendall's Tau	0.1170	0.0000	0.1211	0.1194	0.0489	0.0414	0.0000	0.0565
Rotated 180 BB1								
par. 1#	0.1109	0.0385	0.1118	0.1392	0.0561	0.0764	0.0170	0.0880
par. 2#	1.0907	1.0010	1.0926	1.0562	1.0357	1.0010	1.0010	1.0010
AIC	-6.0173	3.7921	-6.0503	-3.3041	1.7117	3.1501	3.9778	2.9275
SIC	0.8414	10.6508	0.8084	3.5546	8.5704	10.0088	10.8365	9.7862
Kendall's Tau	0.1313	0.0199	0.1332	0.1148	0.0608	0.0378	0.0094	0.0431
Rotated 180 BB6								
par. 1#	1.0010	1.0010	1.0010	1.0010	1.0010	1.0010	1.0010	1.0010
par. 2#	1.1314	1.0010	1.1343	1.1056	1.0510	1.0010	1.0010	1.0110
AIC	-4.9373	4.0514	-4.9788	-1.8438	2.0382	4.0548	4.0496	3.9524
SIC	1.9214	10.9101	1.8799	5.0149	8.8969	10.9134	10.9083	10.8111
Kendall's Tau	0.1167	0.0016	0.1189	0.0960	0.0490	0.0016	0.0016	0.0114

	THBRU	THCAM	THSIN	THMAL	THPHI	THLAO	THIND	THMYA
Rotated 180 BB7								
par. 1#	1.1196	1.0010	1.1212	1.0620	1.0491	1.0010	1.0010	1.0010
par. 2#	0.1631	0.0392	0.1652	0.1803	0.0749	0.0771	0.0176	0.0887
AIC	-6.2655	3.7885	-6.2127	-3.1453	1.5196	3.1451	3.9749	2.9292
SIC	0.5932	10.6471	0.6460	3.7134	8.3783	10.0038	10.8336	9.7879
Kendall's Tau	0.1302	0.0198	0.1317	0.1116	0.0617	0.0377	0.0093	0.0430
Rotated 180 BB8								
par. 1#	1.2841	1.0010	1.3241	6.0000	6.0000	1.0010	1.0010	6.0000
par. 2#	0.9555	0.0010	0.9397	0.1873	0.0700	0.0010	0.0010	0.0883
AIC	-4.6030	3.9999	-4.9730	-3.1259	3.1629	3.9999	3.9999	2.5806
SIC	2.2557	10.8586	1.8856	3.7328	10.0216	10.8586	10.8587	9.4393
Kendall's Tau	0.1076	0.0000	0.1133	0.1185	0.0409	0.0000	0.0000	0.0523

Bivariate Independent Test is fully applied to all residual series which was computed by ARMA(1,1)-GARCH(1,1). Parameters from marginal distribution method are showing the high reciprocal correlation between THBRU, THSIN and THMAL to Thailand inflation.

Table 7. Bivariate Marginal Residual Independence Test.

Variables	P-Value
THCAM	0.7350
THBRU	0.0102***
THSIN	0.0080***
THMAL	0.0091***
THPHI	0.4237
THLAO	0.5668
THIND	0.9602
THMYA	0.2008

Source: computed

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

4.6 Modeling Persistence Volatilities

QML estimates are obtained by using Dynamic Conditional Volatility model (Table 8). Only two countries (Myanmar and Vietnam) in AEC that have no both positive and negative effect to Thailand inflation. Also the rest correlations were completely positive based on given historical data. Beta estimate expresses as persistence dynamics of dependency structure, expresses sparsely around 0.019-0.0483. For the short-term dependence structure can be measured by Alpha estimates. The results are surprisingly showing a high dependency between conditional volatilities or residuals of both variables. This leads to two possible hypotheses. First is the short-term correlation of conditional volatilities are highly dependent to each other. Second is the specific of historical data given is unobservable and Dynamic Conditional Correlation method is not appropriate to model short term relationships. Moreover, these results are checked by QM-test, rank based and epsilon Qkm.

Table 8. Dynamic Conditional Correlation and Time Varying Modeling Test.

	THBRU	THCAM	THSIN	THMAL	THPHI	THLAO	THIND	THMYA
Omega	0.7171 a	0.899 a	0.7256 a	0.8260 a	0.8333 a	0.7484 a	0.759 a	0.9200
s.e.	0.2921	0.2021	0.2928	0.4305	0.1910	0.3592	0.3525	0.4268
p-value	0.0010	0.0001	0.0010	0.0001	0.0000	0.0000	0.0009	0.9999
Beta	0.0486 d	0.0306 c	0.0491 a	0.0199 a	0.0736 a	0.0331	0.0483 c	0.0045
s.e.	0.0639	0.0744	0.0622	0.0471	0.0681	0.0624	0.0753	0.0407
p-value	0.0738	0.0481	0.0620	0.1260	0.0004	0.2128	0.0291	0.7745
Alpha	5.01 a	5.01 a	3.01 a	4.6100	4.17 a	4.228 a	4.2018 a	5.0100
s.e.	6.9605	1.1895	9.9868	0.9856	1.3154	0.8879	1.6480	1.0521
p-value	0.0000	0.0000	0.0000	2.2204	0.0000	0.0000	0.0000	1.0000
Q(M) Test	28.6556	34.1252	28.5854	35.1224	40.6070	39.0950	29.6311	0.3405
Rank-based	17.0251	18.4304	17.5654	15.1708	31.5561	13.1985	20.0153	23.9450
epsilon Qk(m)	165.7785	170.3577	165.6991	161.2347	166.3950	123.7345	135.3972	5.1753

Signif. codes: 'a' 0.001 'b' 0.01 'c' 0.05 'd' 0.1

5. Concluding Remarks

Central banks used them as one of tangible policies for an implementation. For the past decade there are many literatures which were aimed to model those relationships between exchange rates and inflations. Almost of those articles were using the tools based on linear correlation model, however, there are some unsatisfied conditions such as misspecification, normality and dynamic time series. To conquer them, parametric copula based GARCH methodology is adapted. Since dependencies are estimated as a constant measure and allow correlation to be calculated for the varying over time. Conditional volatilities can be obtained by bivariate copulas for modeling residual results from ARMA-GARCH series.

The aims of this article are to expose three relationships between AEC exchange rate based on Thai Baht (THB) and Thailand inflation. Those correlations are marginal residual, growth rate dependency and conditional volatility. ARMA(1,1)-GARCH(1,1), fifteen copulas, bivariate independent test and dynamic conditional correlation methods are applied to the article. Furthermore, Box-LJung, AIC, SIC and Kendall Tau can be the representative to prove that these methodologies are suitable to reach the objectives mentioned above. The most fitted copula for THCAM, THBRU, THSIN and THPHI is Rotated 180 Degree Gumbel, Frank copula is for THLAO and THLAO, Gaussian copula for THMAL, and Rotated 180 Degree Clayton copula for THIND based on AIC, SIC and Kendall Tau indicators. In addition, the highest dependency of growth rate is THPHI 1.135, come along with THBRU 1.1322, THLAO 1.0517, THSIN 1.0001, THCAM 1.0001, THMAL 0.1893, THIND 0.0182 and not significant in THMYA for both sides correlations. The strongest to weakest relationship of dependencies of conditional volatilities or dynamic conditional correlation is THIND 0.92, THCAM 0.899, THPHI 0.8333, THMAL 0.826, THLAO 0.7484, THSIN 0.7256 and THBRU 0.7171 for short-term formulations (concluded by Omega in Table 7.), also for the long-term formulations are THBRU 5.01, THIND 5.01, THCAM 5.01, THMAL 4.61, THLAO 4.228, THPHI 4.1 and THSIN 3.01 respectively.

Moreover, specific circumstances can be forecasted by changes in one of those parameters. For instance, when shocks (conditional volatilities) between Brunei-Thai and Cambodian-Thai exchange rate happens, there is slightly short-term correlation to Thailand inflation but for the long-term investigation shows the strongest relationship compared to other AEC countries.

The short-term impacts of volatilities from Indonesia, Cambodian and Philippines have the most influence to inflation. And for long-term correlations are Brunei, Indonesia and Cambodian. The most unexpectable computation is that there is no correlation in Myanmar between growth rate of exchange rate and inflation for every type of parameters (growth rate, residual and conditional volatility), also showed no correlation for both short-term and long-term investigation.

Beyond all computed results written above is “Policy Implication”. Three possible consequences thus can be explained by Copula based GARCH with Dynamic Conditional Correlation method. First, the relationship between error residuals of AEC exchange rates and Thailand inflation is positive. Second, the persistence correlation of conditional volatility of AEC exchange rates and Thailand inflation are sparsely around 0.019-0.0483 and 4.1-5.01 for the short-run and long-term dependency. For the positive correlation can be simply implied that when the AEC exchange rate based on Thai Baht gets higher spot rate. The inflations in Thailand thus grow significantly. In additional, short-run and long-run can be separately correlated in the term of different dynamic dimensional time correlation. Supposed Thailand inflation is 1.5% and Thai government need to create surplus export-import revenue (EXIM) by boosting the export up with lowering THB currency policy. With all computed computations given such that, we can forecast that the inflation could be lower and led to deflation state etc.

With all results above, Bank of Thailand can simultaneously direct the Thailand inflation and AEC country exchange rates for the most balanced and stable equilibrium in both terms of international trade and inflation. Also BOT needs to be aware of those correlations especially when BOT wants to control the exchange rate relationship between all countries in Asian Economic Communities.

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