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Modelling dependency using GARCH-type models and copulas

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Introduction

- The study of dependence between financial variables using copulas has attracted a lot of attention.
  - Flexibility in the dependence estimation; and
  - Information it gives for investment decision-making.
- Examples:
  - Mensi et al (2016) studied the dynamic linkages between Islamic and conventional sector equity indexes.
  - Hammoudeh et al (2014) studied dynamic dependence of the global Islamic equity index with global conventional equity market indices.

Introduction

- Several ways to estimate dependence: EML, CML, IFM

- IFM approach:

    1. Marginal modelling

    2. Dependence estimation

Introduction

- The incorrect specification of the marginal model will lead to the incorrect parameter estimation of copula model and negligence of some stylized facts of the data set (Ning, 2010).

- Researchers have used the following marginal models:

  - GARCH (Shams & K. Haghighi, 2013; Shams & Zarshenas, 2014; Razak et al., 2016; Chen & Khashanah, 2016; and Aminuddin et al., 2018).

  - GJR-GARCH (Sukcharoen et al., 2014) to account for negative skewness characteristics for most of the return series.

  - APGARCH (Dajcman, 2013)

 - EGARCH (Dajcman, 2013)

Motivation of Study

- There is no consensus on the best marginal model that would result accurate and reliable copula parameter estimates.

- Therefore, this study investigated the effect of various specifications of the marginal models on copula model selection and parameter estimations.

Data

- Daily returns data

- Index: Dow Jones Industrial Average Index (DJI) and Dow Jones United States Islamic Market Index (IMUS)

- Period from 1 January 2007 to 30 Jun 2017

Methodology

- Marginal models: GARCH, IGARCH, EGARCH, GJR-GARCH

- Copula models: There are 234 copulas listed in "VineCopula" package for example Normal copula, clayton copula, t-copula, BB1 copula and BB7 copula.
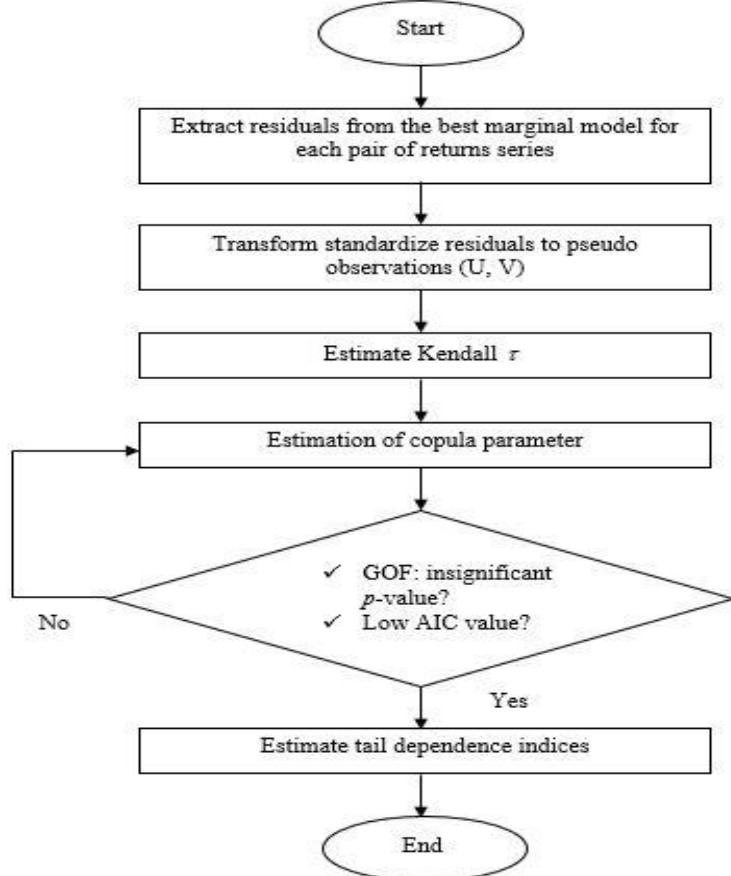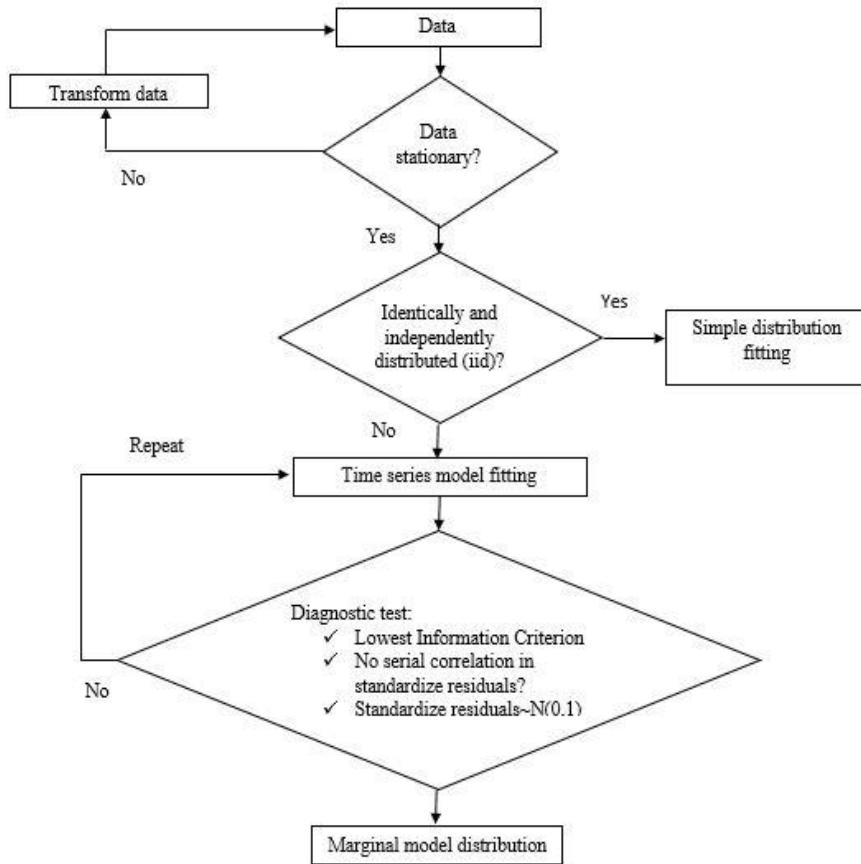
Results : Descriptive Statistics

Stock	DJI	IMUS
Mean	-0.00020	-0.00026
Median	-0.00033	-0.00043
SD	0.01169	0.01219
Skewness	0.09837	0.18528
Kurtosis	13.70156	14.06448
ADF Test (p-value)	0.01	0.01
JB Test	12979.00*	13885.00*

Results: Marginal Model

	GARCH		IGARCH		EGARCH		GJR-GARCH	
	DJI	IMUS	DJI	IMUS	DJI	IMUS	DJI	IMUS
Parameter estimation								
μ	-0.000834**	-0.000886**	-0.000835**	-0.000888**	-0.001110**	-0.001200**	-0.000954**	-0.001011**
	(0.000133)	(0.000129)	(0.000132)	(0.000126)	(0.000165)	(0.000131)	(0.000127)	(0.000126)
φ_1	-0.062505**	0.678823**	-0.062515**	0.678833**	-0.048994*	0.619760**	-0.055794**	0.647684**
	(0.019275)	(0.123457)	(0.019270)	(0.123209)	(0.022917)	(0.044776)	(0.018940)	(0.130110)
θ_1	-	-0.738904**	-	-0.738972**	-	-0.669710**	-	-0.701612**
		(0.113529)		(0.113299)		(0.042996)		(0.121117)
ω	0.000002	0.000002	0.000002	0.000002	-0.031529**	-0.040240**	0.000001	0.000001
	(0.000002)	(0.000002)	(0.000002)	(0.000002)	(0.004265)	(0.003625)	(0.000002)	(0.000003)
α_1	0.155400**	0.146857**	0.156255**	0.147770**	-0.163104**	-0.171420**	0.022338	0.016858
	(0.030137)	(0.030322)	(0.023433)	(0.022697)	(0.014783)	(0.015611)	(0.015752)	(0.025969)
γ_1	-	-	-	-	0.207386**	0.199150**	0.196976**	0.200907**
					(0.007309)	(0.007566)	(0.012880)	(0.029938)
β_1	0.843600**	0.852143**	0.843745	0.852230	0.995677**	0.994550**	0.880928**	0.884361**
	(0.025753)	(0.025604)	(NA)	(NA)	(0.000231)	(0.000259)	(0.027104)	(0.047912)
λ	0.949949**	0.945110**	0.949595**	0.944648**	0.913579**	0.913610**	0.932687**	0.932541**
	(0.022196)	(0.023271)	(0.021875)	(0.022762)	(0.023439)	(0.022594)	(0.021179)	(0.019765)
ν	4.740659**	5.074581**	4.717359**	5.045774**	5.149967**	6.139530**	6.016478**	6.906528**
	(0.566647)	(0.703940)	(0.434221)	(0.531610)	(0.588918)	(0.818241)	(0.333659)	(1.083782)
Diagnostic tests								
Q(10)	0.3963	0.6958	0.3966	0.6954	0.2423	0.2539	0.3129	0.5552
Q(20)	0.2317	0.7353	0.2318	0.7350	0.1216	0.3415	0.1782	0.6252
$Q^2(10)$	0.1050	0.3114	0.1059	0.3136	0.3683	0.2218	0.0676	0.0648
$Q^2(20)$	0.1823	0.5053	0.1825	0.5022	0.4754	0.5409	0.1777	0.3576
LM test	0.0949	0.2496	0.0948	0.2496	0.4459	0.2798	0.0851	0.0713

GARCH-type (Information Criterion)	ARMA(1,1)-GARCH(1,1)	ARMA(1,1)-IGARCH(1,1)	ARMA(1,1)-EGARCH(1,1)	ARMA(1,1)-GJR-GARCH(1,1)
DJI				
AIC	-6.6563	-6.6571	-6.6964	-6.6872
BIC	-6.6410	-6.6440	-6.6790	-6.6698
SIC	-6.6563	-6.6571	-6.6964	-6.6872
HQIC	-6.6508	-6.6523	-6.6901	-6.6809
IMUS				
AIC	-6.5298	-6.5305	-6.5761	-6.5671
BIC	-6.5124	-6.5153	-6.5565	-6.5476
SIC	-6.5298	-6.5306	-6.5761	-6.5672
HQIC	-6.5235	-6.5250	-6.5690	-6.5601

Results : Copula Model

Marginal model	Copula	Parameters	SE	GOF	Lower tail	Upper tail
GARCH-GARCH	BB1	0.76 (3.23)	0.05 (0.08)	0.257	0.75	0.76
IGARCH-IGARCH	BB1	0.76 (3.22)	0.05 (0.08)	0.256	0.75	0.76
EGARCH-EGARCH	t	0.93 (3.48)	0 (0.38)	0.276	0.71	0.71
GJR-GARCH-GJR-GARCH	BB1	0.76 (3.17)	0.05 (0.08)	0.215	0.75	0.76

Conclusion

- The best-fitted marginal models were the EGARCH (1,1)-skewed-t model with ARMA specifications and the t-copula was selected as the most suitable model to represent the dependence structure for DJI-IMUS pair.

- Other marginal models resulted the same selection of best-fitted copula model and similar parameter estimates.

- Parameter values are quite high thus indicating the strong positive linkage between DJI and IMUS returns.

Contribution

- These evidence contribute to the body of knowledge that different input or marginal models leads to different dependence structures thus acknowledging the importance of correct specification of the input model in the study of dependence structures.

- The strong dependence between DJI and IMUS for the recent decade (2007-2017) supports past studies that the Islamic index behave similarly with their conventional counterpart in normal and non-normal market conditions.

THANK YOU!