

# **Modelling Non-Linear, Asymmetric Dependence With Dynamic Copula-Garch Approach A Study Of Pre-Crisis And Post-Crisis Period For The International Stock Market**

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*Dependence structure is a ubiquitous but still not fully understood problem in modern finance. The misinterpretation of linear correlation and the inaccuracy of applying multinormal distribution to model various financial assets return have been emphasized. Copulas became a buzzword since last decade in the field of statistics and finance. It is a generous implement that could be used to construct multivariate distribution; and it is more often applied to investigate the entire dependence structure between variables without the standard multivariate normal independent identically distributed (i.i.d) return distributions restriction. The relationship between different international stock markets is of crucial importance for both financial practitioners and academicians in order to diversify risks. However, measuring and modelling dependence structure become even more complicated when asset returns present nonlinear, nongaussian and dynamic features. In this paper, we firstly investigate volatility spillover effect between different stock indices. Strong lagged volatility of stock market itself and asymmetric spillover effect between different stock markets are found out based on the multivariate GARCH-BEKK model with de-mean log-daily returns as inputs. We advocate two steps copula-garch model to examine the dependence structure. Firstly, we filter log-return daily data using ARMA (1, 1)-GJR (1, 1) model to construct the marginal distributions. Hansen's skewed-t distribution has been employed for the likelihood estimation. Post estimations proved that filter has eliminated auto-correlation of time-series data which are suitable to build up robust models. Secondly, couples of static with*

*constant parameters and time-varying copulas with dynamic parameters are selected as candidates to join the estimated marginal distributions. Kendall's tau ( $\tau$ ) and Spearman's rho ( $\rho$ ) are selected as candidates of rank correlation statistics in our study. Subsequently, the correlation parameters corresponding to each copula are calculated based on the estimated Kendall's  $\tau$ ; whilst some other parameters involved in copulas are computed by Maximum Likelihood Estimation (MLE) method. With the parameters needed for copulas, we calibrate copulas and demonstrate them by density (cumulative density) diagrams. We simulate the equity log-returns and scatterplots using the copulas that we have calibrated. The Akaike information criterion (AIC) and Bayesian information criteria (BIC) method is then adopted to determine which copula provides best fitness to the market data. In general, time varying copulas performance superior to the static copulas. T copula and SJC (Symmetric Joe Clayton) copula with the capability to capture tail dependence are more appropriate for post-crisis period. This reveals that significant asymmetric tail dependence widely exist between different stock market. Finally, some interesting results of comovement between different stock markets are critically discussed.*

Keywords: Copula-garch, dependence structure, time-varying, volatility spillover effect, AIC

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