INNOVATIONS IN INSURANCE, RISK- & ASSET MANAGEMENT

APRIL 05 – 07, 2017

CONFERENCE AT THE TECHNICAL UNIVERSITY OF MUNICH

ORGANIZED BY

Technische Universität München

Chair of Mathematical Finance

SUPPORTED BY

KPMG Center of Excellence in Risk Management

Eine Einrichtung der TUM – gefördert von der KPMG AG Wirtschaftsprüfungsgesellschaft

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Imputation of complex dependent data: a copula-based approach

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Missing data occur in almost all the surveys and data collections. In risk management, for example, an institution might not have enough data to estimate risk components, like the probability of default, and some reconstruction methods should be used. Handling missing data requires resorting to imputation methods since restricting the analysis to complete cases leads to loss of precision and invalid inferences [5]. The choice of the most appropriate imputation method depends on many elements. We present an imputation method that can be used when the focus in on the multivariate dependence structure of the data generating process. The method, called CoImp [1, 2], is based on the copula function [6] and makes it possible to impute multivariate missing data with generic patterns and complex dependence structure. The CoImp is a stochastic single imputation method and employs conditional density functions of the missing variables given the observed ones to fill in each missing (multivariate) value. These functions can be derived analytically once parametric models for the margins and the copula are specified. When analytical derivations are not feasible, the margins are estimated non-parametrically through local likelihood methods [4]. We describe both the analytic and the semiparametric version of the copula-based imputation method and investigate their performance in terms of preservation of both the dependence structure and the microdata through Monte Carlo studies. Moreover, the method has been implemented and made available through the R package `CoImp` [3]. We provide an illustration of how to handle the imputation through the R package, i.e. a description of its main functions, their output and usage on real data sets.

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[3] Di Lascio, F.M.L., Giannerini, S. (2016) CoImp: copula based imputation method, R Software Package available on the CRAN at `http://cran.r-project.org/web/packages/CoImp/index.html`.

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Non-linear Dependence Structure of Cyber Risk

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Many experts claim that cyber risks are correlated, but so far only little empirical evidence exists. We consider 3,327 data breach events in the time period 2005 to 2016 and identify a non-linear dependence between different types of attacks and different types of industries by applying the pair copula methodology. Different from the literature in data breach modeling, this study conducts the distribution fitting for frequency and severity on monthly and quarterly bases. In order to detect the best fit method for the dataset, we implement two pair copula estimations both with parametric copula functions and with nonparametric copula with Bernstein polynomials as a comparison study. We find that nonparametric pair copula structure with Bernstein polynomials is the better model based on AIC to describe the potential lower tail dependence between different attacks and industries. Our findings are important for risk managers and actuaries working on the implementation of cyber insurance policies. We illustrate the usefulness of our results in two applications on risk measurement and pricing by employing the collective risk model with monthly and quarterly risk arrivals.