Workshop on Advances in Applied Probability, Copenhagen, 24 September 2020

- The workshop will be held at the building of the Royal Danish Academy of Sciences and Letters, H. C. Andersens Boulevard 35, on 24 September.
- Participation is for invited speakers and guests who have registered for this event with Jorge Yslas at jorge@math.ku.dk
  In particular, if a guest wants to have lunch this should be reported to Jorge as well. Due to Corona restrictions the number of participants is restricted to 20.

Schedule (tentative)

09:00-09:45 Soeren Asmussen (Aarhus University)

09:45-10:30 Jorge Yslas (Copenhagen University)

Coffee

11:00-11:45 Hansjoerg Albrecher (University of Lausanne)

11:45-12:30 Martin Bladt (University of Lausanne)

Lunch+coffee

13:30-14:15 Nicolas Meyer (University of Copenhagen)

14:15-15:00 Johannes Heiny (Ruhruniversitaet Bochum)

Abstracts

Gram-Charlier Methods, Regime-Switching and Stochastic Volatility in Financial Lévy models

Søren Asmussen

Aarhus University, Denmark

The Gram-Charlier expansion of a target density $f(x)$ is an L_2-convergent series $f(x) = \sum_0^\infty c_n p_n(x) f^*(x)$ in terms of a reference density $f^*(x)$ and its orthonormal polynomials $p_n(x)$.We implement this for the density of a regime-switching Lévy process at a given time horizon T. The main step is the evaluation of moments of all order of $f(x)$ in terms of model primitives, for which we give a matrix-exponential representation. A number of numerical examples, in part involving pricing of European options, are presented. The traditional choice of $f^*(x)$ as normal with same mean and variance as $f(x)$ does not work beyond the regime-switching Black-Scholes model, and instead $f^*(x)$ is typically taken as normal inverse Gaussian. Similar analysis is given for time-changed Lévy processes modelling stochastic volatility. Joint work with Mogens Bladt.

Fitting inhomogeneous phase-type distributions to data

Jorge Yslas

University of Copenhagen, Denmark

A phase-type distribution is the distribution of the time until absorption of a time-homogeneous Markov jump process defined on a finite state-space where one of the states is absorbing, and the rest are transient. Phase-type distributions have been employed in various contexts since they often provide exact, or even explicit, solutions to important problems in complex stochastic models, this is the case, for example, in renewal theory, queueing theory, and risk theory. Moreover, they form a dense class in the class of distributions on the positive reals. However, one of the main concerns on the use of phase-type models in applications is that, by construction, phase-type tails are always light (Exponential type), making them less suitable where heavy tails are present. Recently, the class of inhomogeneous phase-type distributions was introduced in Albrecher and Bladt [Journal of Applied Probability, 56(4):1044-1064, 2019] as a dense extension of classical phase-type distributions, which leads to more parsimonious models in the presence of heavy tails. In this talk, we propose a fitting procedure for this class to given data. We furthermore consider an analogous extension of Kulkarni's multivariate phase-type class to the inhomogeneous framework and study parameter estimation for the resulting new and

flexible class of multivariate distributions. The performance of the algorithms is illustrated in several numerical examples.

On the profitability of selfish blockchain mining under consideration of ruin

Hansjörg Albrecher

University of Lausanne, Switzerland

Mining blocks on a blockchain equipped with a proof of work consensus protocol is known to be resource-consuming. A miner bears the operational cost, mainly electricity consumption and IT gear, of mining, and is compensated by a capital gain when a block is discovered. In this talk we quantify the profitability of mining when the possible event of ruin is also taken into consideration. This is done by formulating a tractable stochastic model and using tools from actuarial ruin theory and analysis, including the explicit solution of a certain type of advanced functional differential equation. The expected profit at a future time point is determined for the situation when the miner follows the protocol as well as when he/she withholds blocks. The obtained explicit expressions allow to analyze the sensitivity with respect to the different model ingredients and to identify conditions under which selfish mining is a strategic advantage. The talk is based on joint work with P.O. Goffard.

Recent advances in large sample correlation matrices and their applications

Johannes Heiny

Ruhr University Bochum, Germany

Many fields of modern sciences are faced with high-dimensional data sets. In this talk, we investigate the spectral properties of large sample correlation matrices. First, we consider a p-dimensional population with iid coordinates in the domain of attraction of a stable distribution with index $\alpha \in (0, 2)$. Since the variance is infinite, the sample covariance matrix based on a sample of size n from the population is not well behaved and it is of interest to use instead the sample correlation matrix R. We find the limiting distributions of the eigenvalues of R when both the dimension p and the sample size n grow to infinity such that $p/n \to \gamma$. The moments of the limiting distributions $H_{\alpha,\gamma}$ are fully identified as the sum of two contributions: the first from the classical Marchenko-Pastur law and a second due to heavy tails. Moreover, the family $\{H_{\alpha,\gamma}\}$ has continuous extensions at the boundaries $\alpha = 2$ and $\alpha = 0$ leading to the Marchenko-Pastur law and a modified Poisson distribution, respectively. A

simulation study on these limiting distributions is also provided for comparison with the Marchenko-Pastur law.

In the second part of this talk, we assume that the coordinates of the p-dimensional population are dependent and $p/n \leq 1$. Under a finite fourth moment condition on the entries we find that the log determinant of the sample correlation matrix R satisfies a central limit theorem. In the iid case, it turns out the central limit theorem holds as long as the coordinates are in the domain of attraction of a stable distribution with index $\alpha > 3$, from which we conjecture a promising and robust test statistic for heavy-tailed high-dimensional data. The findings are applied to independence testing and to the volume of random simplices.

Tail inference for high-dimensional data

Nicolas Meyer

University of Copenhagen, Denmark

Identifying directions where exceptional events occur is one of the major problems of multivariate extreme value theory. From a theoretical point of view most of the information concerning such events is contained in the spectral measure which appears as the limit of the angular component of regularly varying random vectors. Estimating this measure is a delicate point especially in high dimension. In this presentation we introduce a dimension reduction method based on the Euclidean projection onto the simplex. This gives rise to the notion of sparse regular variation. The first part of the talk is dedicated to theoretical results for sparsely regularly varying random vectors. In a second part, we develop a statistical approach based on model selection to identify groups of coordinates that are likely to be extreme simultaneously. We illustrate our method on simulated and real-world data.

Time series copula models using d-vines and v-transforms: an alternative to GARCH modelling

Martin Bladt

University of Lausanne, Switzerland

An approach to modelling volatile financial return series using d-vine decompositions combined with uniformity preserving transformations known as v-transforms is proposed. By generalizing the concept of stochastic inversion of v-transforms, models are obtained that can describe both stochastic volatility in the magnitude of price movements and serial correlation in their directions. In combination with parametric marginal distributions it is shown both in-sample and for forecasting that these models can rival and sometimes outperform well-known models in the extended GARCH family.