UNIVERSITÄT SALZBURG

Salzburg Workshop on Dependence Models & Copulas

Workshop booklet

September 19 - 22, 2016
Salzburg, Austria

Foto: Tourismus Salzburg

Enjoy your days in Salzburg!

Local organization:
Andrea Baumgartner, Beatrice Haring, Noppadon Kamnitui, Raoul Kutil, Sarah Lederer Manuela Schreyer

Workshop chairs:
Fabrizio Durante (IT)
Wolfgang Trutschnig (AT)

Contents

Conference Location

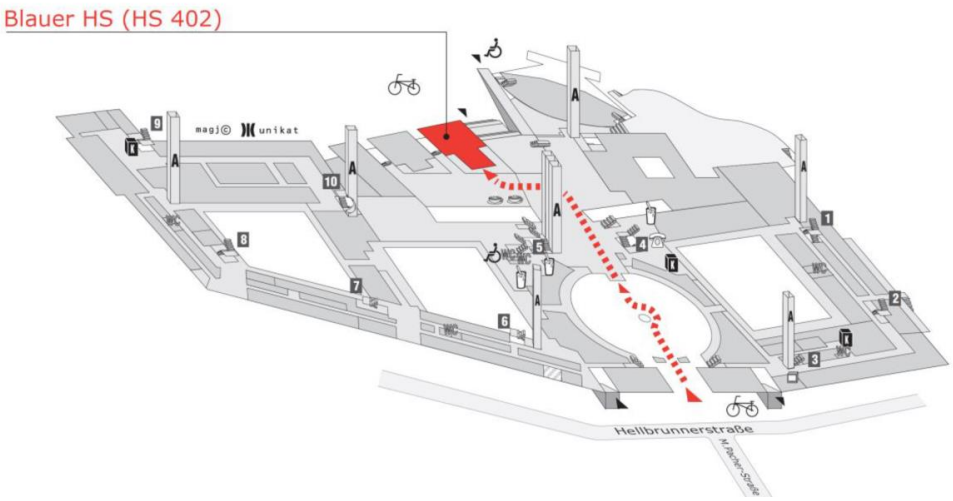
The conference is taking place in the Faculty of Natural Sciences (NAWI) of the University of Salzburg, in the lecture room 402 (Blauer HS). The address is:

Hellbrunner Str. 34
5020 Salzburg, Austria
Phone (Department of Mathematics): +43 662 8044 5302

City map: Salzburg

Detailed plan: Faculty of Natural Science

ground floor



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General Information

Registration

Registration opens on Monday September 19, from 8:00 to 9:00 in front of lecture room 402 (Blauer HS).

Internet Access

WLAN is available at the campus via eduroam and Plus_Event (username: DMC, password: Wua2eiCh, SSID: Plus_Event)

Lunch

During lunch there will be a separated area in the mensa for the workshop participants. Please hand in your lunch ticket at the register.

Coffee Breaks

Refreshments and coffee will be served during the coffee breaks in the foyer in front of the lecture room 402 (Blauer Hörsaal).

Conference Picture

The conference pictures will be taken on Tuesday at 12:00 am. before Lunch.

Social Dinner

The social dinner will take place on Tuesday at 6:30 pm in the restaurant *Paracelsusstube, Stiegl-Brauwelt*. The address is:

Stiegl-Brauwelt
Bräuhausstraße 9
5020 Salzburg

There will be a bus transfer from the Faculty of Natural Science (NAWI) of the University to the restaurant at 5:50 pm and back at 10:00 pm.

Local Transportation

To reach the conference location, take the bus lines 3 or 8 (get off at the bus stop "Faistauergasse"). The timetable of bus line 3 will be handed to you with the conference folder. From the bus stop "Faistauergasse" walk straight ahead in the outbound direction, until you reach the next traffic light, then turn right onto "Michael-Pacher-Straße", and walk straight on until you reach the large yellow building.

Restaurants

There are many good restaurants in Salzburg. Therefore we can only list a small selection: (reservation is recommended)

Upmarket Austrian cuisine

Arthotel Blaue Gans
Getreidegasse 41–43
Phone: +43 662 84 24 91-0

K+K Restaurant am Waagplatz
Waagplatz 2
Phone: +43 662 84 21 56

Restaurant Wasserfall
Linzer Gasse 10
Phone: +43 662 87 33 31

International restaurants

Trattoria Domani
Kaigasse 33
Phone: +43 662 84 27 43

Lemonchilli
Nonntaler Haupstraße 24
Phone: +43 662 84 25 58

L'Osteria
Dreifaltigkeitsgasse 10
Phone: +43 662 87 06 58 10

Traditional Austrian cuisin

Augustinerbräu
Lindhofstraße 7
Phone: +43 662 43 12 46

Gablerbräu
Linzer Gasse 9
Phone: +43 662 88 965

Restaurant Stieglkeller
Festungsgasse 10
Phone: +43 662 84 26 81

Restaurant Triangel
Wiener Philharmonikergasse 7
Phone: +43 662 84 22 29

Zum fidelen Affen
Pristerhausgasse 8
Phone: +43 662 87 73 61

Program

Monday

Time	Speaker	Title of the talk
08:00-09:00		*Registration*
09:00-09:15		*Opening*
09:15-10:15	Plenary Talk Irène Gijbels	Conditional copulas: inference for no covariates effect
10:15-10:35		*Coffee break*
10:35-12:40	Nonparametric methods for copulas *(organizer & chair: Axel Bücher)*	
10:35-11:00	Betina Berghaus	Weak convergence of the empirical copula process with respect to weighted metrics
11:00-11:25	François Portier	On the weak convergence of the empirical conditional copula under a simplifying assumption
11:25-11:50	Bruno Rémillard	Copulas for Discrete or Mixed Data and Applications
11:50-12:15	Noël Veraverbeke	Nonparametric estimation of copulas by the Bernstein method
12:15-12:40	Axel Bücher	Detecting breaks in the dependence of multivariate extreme-value distributions
12:40-13:30		*Lunch break*
13:30-15:35	(Copula) Models for Extremal events *(organizer: Elena Di Bernardino & chair: Johanna G. Nešlehová)*	
13:30-13:55	Julie Carreau	Extra-parametrized extreme-value copula: an extension to a spatial framework
13:55-14:20	Olivier Faugeras	Copulas and discrete distributions
14:20-14:45	Olivier Lopez	Semiparametric conditional copula estimation in a bivariate censoring framework
14:45-15:10	Veronique Maume-Deschamps	Copula's approximations: application to quantile estimation
15:10-15:35	Didier Rullière	On some tail dependence transformations of multivariate Archimedean copulas
15:35-16:00		*Coffee break*
16:00-17:00	Plenary Talk Erich Peter Klement	Ultramodular binary copulas: results and constructions
17:00-18:15	Contributed Sessions 1 *(chair: Veronique Maume-Deschamps)*	
17:00-17:25	Hans de Meyer	A method to construct radially symmetric trivariate copulas
17:25-17:50	Klaus D. Schmidt	On Copulas and Order Statistics
17:50-18:15	Martynas Manstavičius	Bounds for the Clayton copula

Tuesday

Time	Speaker	Title of the talk
09:00-10:00	Plenary Talk Matthias Scherer	Copulas of class $\mathcal{G}$: Properties, Constructions, Applications
10:00-10:20		*Coffee break*
10:20-12:00	On theoretical issues concerning copulas and their estimation *(organizer & chair: Piotr Jaworski)*	
10:20-10:45	Jean-David Fermanian	Tests of simplified assumption for conditional copulae
10:45-11:10	Christian Genest	Modeling dependence by random scaling
11:10-11:35	Johanna G. Nešlehová	Multivariate max-id copulas with ℓ_1-norm symmetric exponent measure
11:35-12:00	Piotr Jaworski	On truncation invariant copulas and their estimation
12:00-12:15		*Workshop Photo*
12:15-13:10		*Lunch break*
13:10-14:50	Dependence and Risk Measures *(organizer & chair: Maria Rita Iacò)*	
13:10-13:35	Valeria Bignozzi	Diversification limit of var under dependence uncertainty
13:35-14:00	Corina Costantinescu	Bonus-Malus principles in insurance portfolios
14:00-14:25	Alfred Müller	Expectiles, Omega Ratios and Stochastic Ordering
14:25-14:50	Stefan Thonhauser	Extremal limits of equidistributed sequence
14:50-15:10		*Coffee break*
15:10-16:10	Plenary Talk Roger B. Nelsen	Dependence Modeling with Copulas
16:10-17:50	Contributed Sessions 2 *(chair: Betina Berghaus)*	
16:10-16:35	Sebastian Fuchs	Copula–induced Measures of Concordance
16:35-17:00	Roberta Pappadà	Graphical Copula tools for detecting tail dependence
17:00-17:25	Songkiat Sumetkijakan	Implicit Dependence Copulas
17:25-17:50	Mickaël De Backer	Semiparametric Copula Quantile Regression for Complete or Censored Data
17:50		*Bus Transfer to Stiegl Brewery*
18:30		*Conference Dinner*
22:00		*Bus Transfer back to NAWI*

Wednesday

Time	Speaker	Title of the talk
09:00-10:40	Estimating Copulas *(organizer & chair: Ostap Okhrin)*	
09:00-09:25	Jan Górecki	Estimation of Hierarchical Archimedean Copulas Based on Kendall's Tau and Goodness of Fit
09:25-09:50	Alexander Ristig	Penalized Estimation of Hierarchical Archimedean Copula
09:50-10:15	Anastasia Tetereva	Clustering estimator of the HAC for high-frequency data
10:15-10:40	Nathan Uyttendaele	Building conditionally dependent parametric one-factor copulas
10:40-11:00		*Coffee break*
11:00-12:40	Dependence Models, Copulas and R *(organizer & chair: Fabrizio Durante)*	
11:00-11:25	Marta Di Lascio	A conditional copula-based imputation technique
11:25-11:50	Thomas Nagler	VineCopula: An R package (not just) for inference of vine copula models
11:50-12:15	Christian Schellhase	Vines Estimation for Mixed Data using Penalized Splines
12:15-12:40	Simon Trimborn	gofCopula: Goodness-of-Fit Tests for Copulae
12:40-13:30		*Lunch break*
13:30-15:10	Advances in copula theory and its applications *(organizer & chair: Carlo Sempi)*	
13:30-13:55	Enrique de Amo Artero	Copulas with given sections
13:55-14:20	Giovanna Nappo	Reliability Systems and signature-related classes of copulas
14:20-14:45	Mauro Piccioni	On the Relation Between Load-Sharing Dependence Models and Conditional
14:45-15:10	Gianfausto Salvadori	A Copula framework for assessing Hazard Scenarios and Failure Probabilities
15:10-15:35		*Coffee break*
15:35-16:35	Plenary Talk Ludger Rüschendorf	Risk bounds with partial dependence information
16:35-18:15	Contributed Sessions 3 *(organizer & chair: Jean-David Fermanian)*	
16:35-17:00	Marta Nai Ruscone	Using Mixture of Vine Copulas for Clustering
17:00-17:25	Hideatsu Tsukahara	The Empirical Beta Copula
17:25-17:50	Fabian Spanhel	Modeling the serial dependence of financial returns with copulas
17:50-18:15	Pavel Krupskiy	Factor Copula Models for Spatial Data

Thursday (*Newcomers day*)

Time	**Speaker**	**Title of the talk**
09:00-10:15	Newcomer Sessions 1 *(chair: Alfred Müller)*	
09:00-09:25	Thomas Mroz	Distributions with fixed marginals maximizing the mass of the endograph and the graph of a function
09:25-09:50	José De Jesús Arias García	A method to construct radially symmetric trivariate copulas
09:50-10:15	Noppadon Kamnitui	Idempotence in some standard classes of copulas
10:15-10:35		*Coffee break*
10:35-12:15	Newcomer Sessions 2 *(chair: Matthias Scherer)*	
10:35-11:00	Nicole Barthel	Vine copula based inference of multivariate event time data
11:00-11:25	Matthias Killiches	Block-Maxima of Vine Copulas
11:25-11:50	Malte S. Kurz	Testing the simplifying assumption in high-dimensional vine copulas
11:50-12:15	Dominik Müller	Representing sparse Gaussian DAGs as sparse R-vines allowing for non-Gaussian dependence
12:15-13:15		*Lunch break*
13:15-13:45	Poster Session	
	Hugo Brango	Skew-type Marshall-Olkin Copula
	Simon Chatelain	Archimax Copulas
	Nico Katzke & Nicolaas J. Odendaall	Modelling increased return dependence globally structures of mining companies
	Nikolai Kolev	Skew-type Bivariate Lack of Memory Property
	Andreas Mändle	Multivariate goodness of fit assessment by extension of univariate EDF tests
	Elisa Perrone	Geometry of discrete copulas for weather forecasting
	Burcu Hudaverdi Ucer	A New Nonparametric Estimation for Bivariate Pickands Dependence Function
13:45-15:00	Newcomer Sessions 3 *(chair: Carlo Sempi)*	
13:45-14:10	Fatima Palacios-Rodríguez	Return level estimators based on Extreme Value Theory
14:10-14:35	Manuela Schreyer	The region determined by Kendall's tau and Spearman's rho
14:35-15:00	Anna Zaremba	Non-Parameteric Gaussian Process Vector Valued Time Series Models and Testing For Causality
15:00-15:30		*Coffee break*
15:30		*Discussion, Open problems, Future directions*

Abstracts

Plenary Speakers

Invited Sessions

Contributed Sessions

Poster Session

*...early stage researchers

Plenary Speakers

Conditional copulas: inference for no covariates effect

Irène Gijbels Marek Omelka Noël Veraverbeke

Abstract

In dependence modelling using conditional copulas, one often imposes the working assumption that the covariate(s) influences the conditional copula solely through the marginal distributions. This so-called (pairwise) simplifying assumption is, for example, often made in vine copula constructions. Two important questions then arise: (i) how to test whether such a simplifying assumption is valid or not?; (ii) if the assumption holds, how to estimate efficiently the conditional copula? In this talk the main focus is in testing whether this assumption holds or not. A brief discussion of available tests is given. We present some nonparametric tests for testing the null hypothesis of the simplifying assumption, and study their asymptotic behaviours, under the null hypothesis and under some local alternatives. The emphasis is on tests which are fully nonparametric in nature: not requiring choices of copula families nor knowledge of the marginal distributions. The finite-sample performances of the discussed tests are investigated via a simulation study. A real data application illustrates the use of the tests.

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Ultramodular binary copulas: results and constructions

Erich Peter Klement

Abstract

We discuss some properties of ultramodular binary copulas. In general, the ultramodularity of a real function is a stronger version of both its convexity and its supermodularity (the latter property being always satisfied in the case of a binary copula).

In a statistical sense, ultramodular binary copulas are related to random vectors whose components are mutually stochastically decreasing with respect to each other. Analytically speaking, an ultramodular binary copula is characterized by the convexity of all of its horizontal and vertical sections.

Among other results, we give a characterization of the additive generators of Archimedean ultramodular binary copulas, and we propose two constructions for binary copulas:

- the first one being based on ultramodular aggregation functions,
- the other one showing the special role of ultramodularity and Schur concavity for a product-like composition of binary copulas being again a binary copula.

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Dependence Modeling with Copulas

Roger B. Nelsen

Abstract

Copulas have proven to be remarkably useful for modeling dependence in a variety of settings. In this talk we will survey important aspects of the theory of copulas that make them well suited for dependence modeling. We will discuss methods for constructing one and two parameter families, dependence properties (e.g., tail dependence), applications (e.g., extreme value theory, Schur-constant survival models), simulation techniques, etc. We will also discuss cautions about and limitations to the use of these copulas. We conclude with several open problems.

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Risk bounds with partial dependence information

Ludger Rüschendorf

Abstract

We describe several approaches to improve risk bounds for aggregated portfolios of risks based on marginal information. By a series of recent papers it has become clear that the dependence uncertainty on the aggregated risks based on marginal information only is typically too wide to be acceptable in applications.

Several approaches to reduce DU-uncertainty have been developed recently to include partial dependence information in order to reduce the model uncertainty. These include higher order marginals, global variance or higher order moment bounds, positive or negative dependence restrictions and structural information given by common risk factors (partially specified risk factor models). Several applications show that these improved risk bounds may lead to results acceptable in praxis.

The talk is based on joint work with P. Embrechts, G. Puccetti, C. Bernard, S. Vanduffel R. Wang , D. Small and D.Manko.

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Copulas of class $\mathcal{G}$: Properties, Constructions, Applications

Jan-Frederik Mai Steffen Schenk Matthias Scherer

Abstract

We consider the family of d-variate copulas, denoted "class $\mathcal{G}$", that is obtained by ordering, distorting, and multiplying the arguments $u_1, \ldots, u_d$, i.e.

$$(u_1, \ldots, u_d) \mapsto \prod_{k=1}^{d} g_k(u_{[k]}), \quad u_{[1]} \leq \ldots \leq u_{[d]},$$

with suitable distortion functions $g_k : [0,1] \to [0,1]$ for $k = 1, \ldots, d$. A full analytical characterization is achieved and a stochastic interpretation is found that links this family of multivariate distribution functions to exchangeable, exogenous shock models. A second stochastic model of "de Finetti-type", based on increasing additive processes, is established. The considered family of copulas comprises some interesting subfamilies. Among these are exchangeable Marshall–Olkin copulas, Sato copulas (providing a "Kimberling-type" copula-characterization of self-decomposable probability laws on the positive real axis), and Dirichlet copulas that implicitly appear in Bayesian statistics. A third – and for sampling applications most efficient – stochastic representation is derived that can be considered a conditional sampling representation. We conclude with applications in risk management.

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Invited Sessions

Weak convergence of the empirical copula process with respect to weighted metrics

Betina Berghaus Axel Bücher Stanislav Volgushev

Abstract

The empirical copula process plays a central role in the asymptotic analysis of many statistical procedures which are based on copulas or ranks. Among other applications, results regarding its weak convergence can be used to develop asymptotic theory for estimators of dependence measures or copula densities, they allow to derive tests for stochastic independence or specific copula structures, or they may serve as a fundamental tool for the analysis of multivariate rank statistics. This talk is concerned with weak convergence of the empirical copula process (for observations that are allowed to be serially dependent) with respect to weighted supremum distances. The usefulness of this result is illustrated by an application to estimation procedures for the Pickands dependence function arising in multivariate extreme-value theory.

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Detecting breaks in the dependence of multivariate extreme-value distributions

Axel Bücher Paul Kinsvater Ivan Kojadinovic

Abstract

In environmental sciences, it is often of interest to assess whether the dependence between extreme measurements has changed during the observation period. In this talk, we propose a statistical test that is particularly sensitive to such changes. The resulting procedure is also extended to allow the detection of changes in the extreme-value dependence under the presence of known breaks in the marginal distributions. Simulations are carried out to study the finite-sample behavior of both versions of the proposed test. Illustrations on hydrological data sets conclude the talk.

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On the weak convergence of the empirical conditional copula under a simplifying assumption

François Portier Johan Segers

Abstract

When the copula of the conditional distribution of two random variables given a covariate does not depend on the value of the covariate, two conflicting intuitions arise about the best possible rate of convergence attainable by nonparametric estimators of that copula. In the end, any such estimator must be based on the marginal conditional distribution functions of the two dependent variables given the covariate, and the best possible rates for estimating such localized objects is slower than the parametric one. However, the invariance of the conditional copula given the value of the covariate suggests the possibility of parametric convergence rates. The more optimistic intuition is shown to be correct, confirming a conjecture supported by extensive Monte Carlo simulations by I. Hobaek Haff and J. Segers [Computational Statistics and Data Analysis 84:1–13, 2015] and improving upon the nonparametric rate obtained theoretically by I. Gijbels, M. Omelka and N. Veraverbeke [Scandinavian Journal of Statistics 2015, to appear]. The novelty of the proposed approach lies in the double smoothing procedure employed for the estimator of the marginal cumulative distribution functions. Under mild conditions on the bandwidth sequence, the estimator is shown to take values in a certain class of smooth functions, the class having sufficiently small entropy for empirical process arguments to work. The copula estimator itself is asymptotically undistinguishable from a kind of oracle empirical copula, making it appear as if the marginal conditional distribution functions were known.

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Copulas for Discrete or Mixed Data and Applications

Christian Genest Johanna G. Nešlehová Bruno Rémillard

Abstract

In this talk, we will introduce the multilinear empirical copula for discrete or mixed data and its asymptotic behaviour will be studied. Note that no jittering is involved. This result will then be used to construct inference procedures for multivariate data. Applications for testing independence will be presented.

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Nonparametric estimation of copulas by the Bernstein method

Noël Veraverbeke

Abstract

In this talk we discuss the asymptotic properties of the so-called Bernstein estimation method for bivariate copulas. This smoothing method approximates the copula function $C(u, v)$ by a polynomial of degree m in (u, v). Asymptotics are considered as the sample size n and the degree m both tend to infinity. The estimator for the copula C leads in a natural way to a corresponding estimator for the density c of C. We also consider parallel results for the first order partial derivative of C. This then leads to new estimators for the conditional distribution function and conditional density function and important functionals such as regression and quantile functions.

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Extra-parametrized extreme-value copula : an extension to a spatial framework

Julie Carreau Gwladys Toulemonde

Abstract

Extreme-value copulas are justified by the theory of multivariate extremes. However, most high-dimensional copulas are too simplistic for applications. Recently, a class of flexible extreme-value copulas was put forward by combining two extreme-value copulas with a weight parameter in the unit hyper-cube.
In a multisite study, the copula dimension being the number of sites, this extra-parametrized approach quickly becomes over-parametrized. In addition, interpolation is not straightforward. The aim of this work is to extend this approach to a spatial framework. By taking the weight parameter as a function of covariates, model complexity is reduced. Moreover, the model is defined at every point of the space and can be interpreted in terms of distances.
We focus on the spatial extension based on Gumbel copulas and describe its possible extremal dependence structures. The proposed spatial model is applied on synthetic and precipitation data in the Mediterranean area.

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Copulas and discrete distributions

Olivier P. Faugeras

Abstract

We study copulas associated with discrete multivariate distributions. In a first part, we show how to use probabilistic techniques (maximal coupling) to give a positive answer to some delicate issues related to the convergence of genuine empirical copula functions and some corresponding measures of dependence, under the very weak hypothesis of ergodicity of the sample, a framework which encompasses most types of serial dependence encountered in practice. In a second part, we discuss and illustrate the mathematical, statistical and epistemological issues and pitfalls involved in using parametric copula models for making inference from discrete data.

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Semiparametric conditional copula estimation in a bivariate censoring framework

Olivier Lopez Yohann Le Faou

Abstract

In this work, we study the dependence structure between two random variables subject to censoring. In our framework, the dependence parameter is allowed to depend on covariates. The procedure we develop is a M-estimation approach, combined with kernel smoothing procedures. We derive asymptotic representations of the conditional copula parameter and investigate their limit behavior. Our work is motivated by insurance applications where a dependence of the lower tail of the distribution is investigated.

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Copula's approximations: application to quantile estimation.

Andrés Cuberos Esterina Masiello
Véronique Maume-Deschamps.

Abstract

Estimating quantiles of aggregated variables (mainly sums) is crucial in risk management for many application fields such as finance, insurance, environment... This question has been widely treated but new efficient methods are always welcome; especially if they apply in (relatively) high dimension. We propose an estimation procedure based on the checkerboard copula. It allows to get good estimations from a (quite) small sample of the multivariate law and a full knowledge of the marginal laws. This situation is realistic for many applications. Estimations may be improved by including in the checkerboard copula some additional information (on the law of a sub-vector or on tail probabilities).

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On some tail dependence transformations of multivariate Archimedean copulas

Elena Di Bernardino Didier Rullière

Abstract

We discuss the impact of two classes of transformations on the multivariate tail dependence coefficients of some copulas. The considered transformations both act within the class of Archimedean copulas and allow to build generators exhibiting any chosen tail dependence coefficients.
The first investigated class of transformations relies on functions composition. We focus on the case where the transformed copula exhibits some regular variation properties. We investigate the behaviour of these coefficients in cases that are close to tail independence. Some results are also given under specific conditions involving regularly varying hazard rates of components of the transformation.
The second investigated class of transformations is built in order to ensure the validity of the transformed Archimedean generator. We discuss properties of these transformations, and present some numerical illustrations showing that the transformation can improve both likelihood and tail dependence on a given data.

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A conditional copula-based imputation technique

F. Marta L. Di Lascio Simone Giannerini

Abstract

We present a copula-based imputation method for multivariate missing data with generic patterns and complex dependence structure. The method is based on the conditional density functions of the missing variables given the observed ones. 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. We describe both the analytic and the semiparametric version of the 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, we present a comparison with classical imputation methods. We have implemented and made available the method through the R package `CoImp`. 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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VineCopula: An R package (not just) for inference of vine copula models

Thomas Nagler

Abstract

In vine copula models, the dependence of a multivariate random vector is described using only bivariate copulas as building blocks. Due to their flexibility, vine copula models have gained tremendous popularity amongst academics and practitioners. A key factor for this success has been the R package *VineCopula*. Its main purpose is to provide tools for dependence modeling with vines — including methods for estimation, model selection, and simulation. But there is more: since bivariate copulas are the main ingredient of a vine copula, the package also offers numerous features for bivariate dependence modeling. In this talk, we give an overview of the package's functionality and examples of its use.

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Vines Estimation for Mixed Data using Penalized Splines

Christian Schellhase Göran Kauermann

Abstract

The talk presents the estimation of nonparametric vines for mixed data using penalized B-splines. We estimate each pair-copula density of the vine in a flexible, that is semi-parametric way by refraining from any strong parametric assumptions on the structure of the pairs, using penalized B-splines. The estimation of probability mass functions in the context of copulas is easily done using constant B-splines, whose nodes are placed at the jump points of the empirical cumulative distribution function of some ordinal data. The independence of the constant B-splines from each other ensures the applicability. Our pair-copula for ordinal data is following the theoretical ideas of checkerboard copulas and subcopulas. The entire approach allows to fit distributions for mixed data, for instance fitting log-linear graphical models. The estimation of distributions for mixed data is implemented in a R-package, which is interesting for e.g. calculating counterfactual distributions.

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gofCopula: Goodness-of-Fit Tests for Copulae

Simon Trimborn Ostap Okhrin Shulin Zhang
Qian M. Zhou

Abstract

We present a new "fire-and-forget" `gofCopula` R-package for Good-ness-of-Fit (GoF) tests for copulae. Current strand of literature proposes a big list of different tests having same H_0 hypothesis, but with, obviously, different H_1 alternatives. This leads to the fact that different tests have different properties, especially in capturing error of the second type. In this work we discuss important and most powerful tests from recent literature and show their implementation in the R-package. Our intention was to make at most user friendly package in which in the unified framework many GoF for copulae have been gathered including most recent PIOS and hybrid tests. Because of bootstrapping procedure in finding the p-values most of tests are very time consuming, therefore special function for prediction time needed to accomplish computations has been introduced. Another advantage of the package, that it allows for parallel computation which saves time for the user. The list of other functions makes this package very attractive for the practitioners.

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Diversification limit of var under dependence uncertainty

Valeria Bignozzi Tiantian Mao Bin Wang Ruodu Wang

Abstract

In this talk we present some recent mathematical developments in the field of Risk Aggregation under Model Uncertainty. We investigate the asymptotic behaviour of the portfolio diversification ratio based on Value-at-Risk under dependence uncertainty, which we refer to as "worst-case diversification limit". In the case of regularly varying margins, we provide explicit values for the worst-case diversification limit; we show that under the framework of dependence uncertainty the worst-case diversification limit is significantly higher compared to classic results obtained in the literature of multivariate regularly varying distributions. The results carried out in this paper bring together extreme value theory and dependence uncertainty, two popular topics in the recent study of risk aggregation.

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Bonus-Malus principles in insurance portfolios

Corina Constantinescu Weihong Ni

Abstract

In this talk we will discuss a few collective risk models with dependence structures that mimic Bonus Malus principles in insurance portfolios.

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Expectiles, Omega Ratios and Stochastic Ordering

Alfred Müller

Abstract

In this paper we introduce the *expectile order*, defined by $X \leq_e Y$ if $e_\alpha(X) \leq e_\alpha(Y)$ for each $\alpha \in (0,1)$, where e_α denotes the α-expectile. We show that the expectile order is equivalent to the pointwise ordering of the Omega ratios, and we derive several necessary and sufficient conditions. In the case of equal means, the expectile order can be easily characterized by means of the stop-loss transform; in the more general case of different means we provide some sufficient conditions. In contrast with the more common stochastic orders such as $\leq_{st}$ and $\leq_{cx}$, the expectile order is not generated by a class of utility functions and is not closed with respect to convolutions. As a byproduct of our analysis, we also provide a formula to recover a distribution from its expectile curve. As an illustration, we compare the $\leq_{st}$, $\leq_{icx}$ and $\leq_e$ orders in the family of Lomax distributions.

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Extremal limits of equidistributed sequence

Maria Rita Iacò Stefan Thonhauser Robert F. Tichy

Abstract

In the research field on equidistributed sequences one recently became interested on extremal limits of the form

$$\lim_{N\to\infty} \sum_{n=1}^{N} c(x_n, y_n),$$

where x_n, y_n are equidistributed sequences. Naturally, such questions can be linked to the problem of maximizing

$$\int_{[0,1]^2} c(x,y)\gamma(dx,dy)$$

over the set of probability measures γ on the unit square with uniform marginals, which is the classical optimal transport problem. In this talk I will illustrate how such question arise in the theory of equidistributed sequences and how the theory of optimal transport can be used to give straightforward proofs of results from this number theoretic field. Furthermore one can deal with problems, which could not be handled in this context before.

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Tests of simplified assumption for conditional copulae

Alexis Derumigny Jean-David Fermanian

Abstract

Under the so-called simplified assumption" (SA), conditional copulae do not depend on their conditioning subsets. We propose several non-parametric and parametric tests of this commonly used assumption. The former ones are based on some comparisons between empirical counterparts under or without (SA), or are based on a particular independence property. The latter ones are obtained though usual distances between nonparametrically and parametrically estimated distributions or densities. The consistency and the power of such tests are evaluated by simulation, through some adapted bootstrap procedures.

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Modeling dependence by random scaling

Christian Genest

Abstract

Random scaling is a natural way of modeling latent risk factors. Many broad classes of dependence models are of this form, e.g., Archimedean, elliptical, and extreme-value copulas. New tractable models based on this paradigm will be introduced. Their properties will be described, and their use for modeling dependent risks and large losses in insurance will be highlighted.

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On truncation invariant copulas and their estimation

Piotr Jaworski

Abstract

The turmoil on financial markets, which we observe during last years, emphasize the necessity of considering models that can serve to estimate better the occurrence of extremal events. One of the approaches is based on the study of truncated copulas i.e the copulas of conditional distribution when we condition one of variables to lie above or below some threshold. To make the model feasible we approximate truncation copulas by the limits for extremal thresholds. Such limits if exist must be truncation invariant. In my talk I will discuss several ways of estimating the truncation limits.

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Multivariate max-id copulas with ℓ_1-norm symmetric exponent measure

Johanna G. Nešlehová

Abstract

Members of the well-known family of bivariate Galambos copulas can be expressed in a closed form in terms of the univariate Fréchet distribution. This formula extends to any dimension and can be used to define a whole new class of tractable multivariate copulas that are generated by suitable univariate distributions. In this presentation, I will derive the necessary and sufficient conditions on the underlying univariate distribution that ensure that the resulting copula indeed exists. I will also show that these new copulas are in fact dependence structures of certain max-id distributions with ℓ_1-norm symmetric exponent measure. Basic dependence properties of this new class will be investigated along with an efficient algorithm for random number generation. This is joint work with Christian Genest and Louis-Paul Rivest.

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Estimation of Hierarchical Archimedean Copulas Based on Kendall's Tau and Goodness of Fit

Jan Górecki Marius Hofert Martin Holeňa

Abstract

Kendall's tau is a measure of concordance that has been successfully used for estimation of the parameters and the structure of hierarchical Archimedean copulas (HACs). However, particularly for the estimation of the structure of HACs, there has not been presented any theoretical proof justifying the published approaches based on Kendall's tau. In the talk, we will introduce a theorem showing that the structure of a HAC can be recovered just from the corresponding Kendall correlation matrix. Then, applicability of an approach based on the theorem will be illustrated on simulation studies in high dimensions, e.g., for $d = 100$. Moreover, enhancing the approach by goodness-of-fit statistics, it will be shown on another simulation study that even a HAC involving more than one Archimedean family of generators can also be successfully estimated, including the structure, which has not yet been reported in the literature.

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Penalized Estimation of Hierarchical Archimedean Copula

Ostap Okhrin Alexander Ristig

Abstract

We propose an estimation procedure for hierarchical Archimedean copula which builds on a non-concave penalized likelihood. In particular, we estimate the parameters and aggregate the structure of hierarchical Archimedean copula simultaneously by implicitly imposing a penalty on the structure. This can be interpreted as penalizing a diversified dependence structure in favor of equi-dependence while accounting for the curvature of the likelihood function and the variability of the parameters respectively. The asymptotic properties of our estimation and data-driven aggregation technique are derived and small sample properties are illustrated in a simulation study.

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Clustering estimator of the HAC for high-frequency data.

Ostap Okhrin Anastasija Tetereva

Abstract

Paper introduces a computationally simple estimator for the multivariate hierarchical Archimedean copulae. It is proposed to estimate the structure and the parameters of a copula simultaneously based on the correlation matrix only. The advantage of the average correlation estimator is the significant reduction of the computational costs and that it can be used in cases when the maximum likelihood type estimation can not be performed. Extensive simulation studies show the superior performance and the low computational costs of the proposed estimator in comparison to the benchmark models.
In the case of high-frequency data, the proposed algorithm enables the estimation based on the realized covariance matrix. The application of the estimator to the one-day-ahead Value at Risk prediction using high-frequency data gives rise to the hierarchical realized copula (RHAC). The RHAC exhibits good forecasting properties for a multivariate portfolio in comparison to the dynamic copula and realized covariance models and does not suffer under the curse of dimensionality.

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Building conditionally dependent parametric one-factor copulas

Nathan Uyttendaele Gildas Mazo

Abstract

So far, one-factor copulas induce conditional independence with respect to a latent factor. In this talk, these one-factor copulas are extended through two representations allowing for a varying conditional dependence structure. Estimation issues are discussed, as well as how to distinguish between conditionally independent and conditionally dependent one-factor copulas, thanks to a novel statistical test which does not assume any parametric form for the conditional dependence structure.

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Copulas with given sections

Enrique de Amo Artero

Abstract

Very recently, the problem of finding a copula when it is known on a given subset of its domain has gained special attention. In this communication we survey several papers that have provided successfully their different attempts.

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Reliability Systems and signature-related classes of copulas

G. Nappo F. Spizzichino

Abstract

Let S be a (binary) reliability system made up with n (binary) components. The *structure-function* $\phi : \{0,1\}^n \to \{0,1\}$ of S describes the state of S corresponding to the vector $(y_1, ..., y_n)$ of the states of the single components, i.e.,

$$y_S = \phi(y_1, ..., n_n) \in \{0,1\}.$$

It is commonly assumed that ϕ is non-decreasing, and

$$\phi(0, ..., 0) = 0, \ \phi(1, ..., 1) = 1,$$

Letting $T_1, T_2, ..., T_n$ be the (random) *failure times* of the components, we assume

$$P\{T_i \neq T_j\} = 1, \quad i \neq j,$$

and look at T_S, the lifetime of S, as a function of $\mathbf{T} \equiv (T_1, T_2, ..., T_n)$.
Let $\overline{\mathbf{G}}$ denote the vector of marginal survival functions for $\mathbf{T}$ and K its survival copula, then $\overline{F}_{T_S}(t)$, the survival function of the system, is a functional of ϕ, K, and $\overline{\mathbf{G}}$.
Within this framework, the *probability-signature* $\mathbf{p} \equiv (p_1, ..., p_n)$ is of interest, where

$$p_k := P\{T_S = T_{(k)}\}, k = 1, ..., n.$$

and $T_{(1)}, ..., T_{(n)}$ are the order statistics of $\mathbf{T}$.
We concentrate attention on the special case when the lifetimes are **identically distributed** and preliminary prove that, for any fixed ϕ, $\mathbf{p} = \mathbf{p}(\phi, K)$ only depends on K and ϕ. There may exist other n-dimensional copulas C such that $\mathbf{p}(\phi; C) = \mathbf{p}(\phi; K)$, then we consider the equivalence classes

$$\mathcal{C}_K^{\phi} = \{C | \mathbf{p}(\phi; C) = \mathbf{p}(\phi; K)\}$$

and show several related properties. In particular we point out relations between $\mathcal{C}_K^{\phi}$ and symmetry properties of ϕ.

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On the Relation Between Load-Sharing Dependence Models and Conditional Independence

M. Piccioni F. Spizzichino

Abstract

We consider n lifetimes $T_1, ..., T_n$ with an absolutely continuous joint distribution. Such a distribution can be characterized in terms of the family of the *multivariate conditional hazard rates*, where $\lambda_j(t|(i_1, ..., i_k); t_1, ..., t_k)$ is given by

$$\lim_{h \downarrow 0} \frac{1}{h} P\left(T_j < t + h | T_{i_m} = t_m, m = 1, \ldots, k, T_l > t, l \notin \{i_1, ..., i_k\}\right),$$

for any $\{i_1, ..., i_k\} \subset \{1, ..., n\}, j \notin \{i_1, ..., i_k\}, 0 < t_1 < ... < t_k < t$.
Our attention is concentrated on the so-called *Load-Sharing* models, characterized by the condition that, for any $t > 0, j$ and $(i_1, ..., i_k)$, $\lambda_j(t|(i_1, ..., i_k); t_1, ..., t_k)$ does not depend on $(t_1, ..., t_k)$.
In the talk, we first point out the significance of these models in different applied fields (such as Reliability and Credit Risk) and discuss to which extent they are able to describe direct interactions between risks of failure or default.
A seemingly different pattern of dependence is the one triggered by the presence of common non-observable factors as, in particular, it happens in conditional independence models.
From this perspective, it is of interest to analyze when it is possible to describe Load-Sharing models also under the form of conditional independence. In the second part of the talk, some related results and relevant examples will be presented.

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A Copula framework for assessing Hazard Scenarios and Failure Probabilities

G. Salvadori F. Durante C. De Michele M. Bernardi L. Petrella

Abstract

Several international guidelines have recently recommended to individuate appropriate/relevant Hazard Scenarios in order to tame the consequences of (extreme) natural phenomena. In particular, the scenarios should be multivariate, taking into account the fact that several not independent variables may be simultaneously at play.

In this work, it is shown how a Hazard Scenario can be identified in terms of (i) a specific geometry and (ii) a suitable probability level. Several scenarios, as well as a Structural approach, are presented, and due comparisons are carried out.

In addition, it is shown how the Hazard Scenario approach illustrated here is well suited to cope with the notion of Failure Probability, a tool traditionally used for design and risk assessment in engineering practice. All the results outlined throughout the work are based on the Copula Theory, which turns out to be a fundamental theoretical apparatus for doing multivariate risk assessment.

Suitable indications for the practical application of the techniques outlined in the work are given, and two case studies illustrate the procedures discussed.

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Vine copula based inference of multivariate event time data

Nicole Barthel Claudia Czado Yarema Okhri

Abstract

Studying realized volatility based on high-frequency data is of particular interest in asset pricing, portfolio management and evaluation of risk. We propose an approach for dynamic modeling and forecasting of realized correlation matrices that allows for model parsimony and automatically guarantees positive definiteness of the forecast. We use the one-to-one relationship between a correlation matrix and its associated set of partial correlations corresponding to any regular vine specification. Being algebraically independent the partial correlations of the vine do not need to satisfy any algebraic constraint such as positive definiteness. We present several selection methods to choose, among the large number of vines, the vine structure best capturing the characteristics of the multivariate time-series of the correlation parameters. The individual partial correlation time-series are studied using ARFIMA and HAR models to account for long-memory behavior. The dependence between assets is flexibly modeled using vine copulas that allow for nonlinearity and asymmetric tail behavior. Correlation point forecasts are obtained as nonlinear transformation of the forecasts for the partial correlation vine. The usefulness of the methodology is investigated in a one-day ahead forecasting framework comparing existing methods based on a model confidence set approach.

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Semiparametric Copula Quantile Regression for Complete or Censored Data

M. De Backer A. El Ghouch I. Van Keilegom

Abstract

When facing multivariate covariates, general semiparametric regression techniques come at hand to propose flexible models that are unexposed to the curse of dimensionality. In this work a semiparametric copula-based estimator for conditional quantiles is investigated for complete or right-censored data. In spirit, the methodology is extending the recent literature on copula-based regression models, as the main idea consists in appropriately defining the quantile regression in terms of a multivariate copula and marginal distributions, hereby making use of the advantages of copulas in dependence modelling. In addition, and contrary to the initial suggestion in the literature, a semiparametric estimation scheme for the multivariate copula density is studied, motivated by the possible shortcomings of a purely parametric approach and driven by the regression context. The resulting quantile regression estimator has the valuable property of being automatically monotonic across quantile levels, and asymptotic normality for both complete and censored data is obtained under classical regularity conditions. Finally, numerical examples as well as a real data application are used to illustrate the validity and finite sample performance of the proposed procedure.

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A method to construct radially symmetric trivariate copulas

José De Jesús Arias García Hans De Meyer Bernard De Baets

Abstract

We recall the concept of radial symmetry of a random vector, its probabilistic interpretation and highlight that for continuous random vectors, the property of radial symmetry can be fully characterized by the marginal distributions of the random variables and the copula associated to their joint distribution function. Additionally, we show that the n-dimensional extension of the Frank 2-copula, which is obtained by applying the associativity property of Archimedean 2-copulas, is no longer radially symmetric for $n \geq 3$, showing that jointly requiring associativity and radial symmetry is too restrictive in higher dimensions.
In order to extend the number of radially symmetric 3-copulas in literature, we propose a method to construct a 3-dimensional symmetric function that is radially symmetric, using two symmetric 2-copulas, with one of them being also radially symmetric. We study the properties of our construction method for some families of copulas, and provide several examples in which our construction method yields a 3-copula. Finally, we discuss a possible generalization of our construction method for dimensions $n \geq 4$.

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Copula–induced Measures of Concordance

Sebastian Fuchs

Abstract

We study a group of transformations mapping the collection of all copulas (of fixed but arbitrary dimension) into itself. These transformations may be used to construct new copulas from a given one or to prove that certain real functions on the unit cube are indeed copulas.
Applying this group, we then propose a concise definition of a measure of concordance for copulas. This definition, in which the axioms are formulated in terms of two particular subgroups of the group, provides an easy access to the investigation of invariance properties of a measure of concordance. In particular, it turns out that for copulas which are invariant under a certain subgroup the value of every measure of concordance is equal to zero.
In addition, we discuss a class of measures of concordance in which every element is defined as the expectation with respect to the probability measure induced by a fixed copula having an invariance property with respect to two subgroups of the group. This class is rich and includes the well–known examples Spearman's rho and Gini's gamma.

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Curved splicing of copulas

Tarad Jwaid Hans De Meyer Bernard De Baets

Abstract

First, we generalize the notion of symmetry (resp. opposite symmetry) of a bivariate copula to a more general notion of symmetry of a bivariate function (on the unit square) w.r.t. an increasing (resp. decreasing) permutation φ of the unit interval. Except for the two classical cases mentioned, no bivariate copula can be symmetric in the more general sense, and we show how to quantify this lack of symmetry. Second, calling $F(x, \varphi(x))$ the φ-section of a bivariate function, we identify the conditions a function g must satisfy in order to be the φ-section of a copula. Finally, given two copulas F and G with the same φ-section, inspired by the mentioned notion of symmetry, we provide sufficient conditions so that curved splicing (a generalization of the splice and opposite splice construction method) yields a copula.

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Idempotence in some standard classes of copulas

Noppadon Kamnitui Wolfgang Trutschnig

Abstract

We extend and sharpen some results concerning the notion of idempotence in some standard classes of copulas as recently given in (1). In particular we show that in the class of extreme-value copulas, in the class of Bernstein copulas and in some special class of copulas represented by measure-preserving transformations only the usual suspects are idempotent, namely Π and M. Additionally, we prove that idempotent strict Archimedean copulas necessarily have full support.

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Block-Maxima of Vine Copulas

Matthias Killiches Claudia Czado

Abstract

We examine the dependence structure of componentwise finite block-maxima of multivariate distributions and provide a closed form expression for the corresponding copula density. Once a copula has been specified, this allows the treatment of block-maxima of any finite block-size. We show that the partial derivatives appearing in the copula density of the block-maxima can be obtained by only one-dimensional integration for three-dimensional vine copulas. We look at certain vine copula specifications and examine how the density of the block-maxima behaves for different block-sizes. Additionally, a real data example from hydrology is considered. Block-maxima are used in the development of extreme-value theory for multivariate normal distributions. In this context, a particular scaling of each variable as well as the correlation matrix is necessary in order to obtain a non-trivial limiting distribution when the block-size goes to infinity. This scaling is applied to different three-dimensional vine copula specifications.

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Factor Copula Models for Spatial Data

Pavel Krupskiy Raphaël Huser Marc G. Genton

Abstract

We propose a new copula model that can be used with replicated spatial data. Unlike the multivariate normal copula, the proposed copula is based on the assumption that a common factor exists and affects the joint dependence of all measurements of the process. Moreover, the proposed copula can model tail dependence and tail asymmetry. The model is parameterized in terms of a covariance function that may be chosen from the many models proposed in the literature, such as the Matérn model. For some choice of common factors, the joint copula density is given in closed form and therefore likelihood estimation is very fast. In the general case, one-dimensional numerical integration is needed to calculate the likelihood, but estimation is still reasonably fast even with large data sets. We use simulation studies to show the wide range of dependence structures that can be generated by the proposed model with different choices of common factors. We apply the proposed model to spatial temperature data and compare its performance with some popular geostatistics models.

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Testing the simplifying assumption in high-dimensional vine copulas

Malte S. Kurz Fabian Spanhel

Abstract

In almost all applications of vine copulas, it is assumed that the data generating process satisfies the simplifying assumption, i.e., every conditional copula in a vine collapses to an unconditional copula. So far, tests for the simplifying assumption have been limited to three-dimensional vine copulas. Testing the simplifying assumption in high-dimensional vine copulas is a difficult task, because tests are based on estimated data and amount to checking constraints on high-dimensional distributions. We propose a novel testing procedure which utilizes decision trees to mitigate the curse of dimensionality by searching the possibly strongest deviation from the simplifying assumption. The proposed test is computationally feasible for high-dimensional (e.g., $d = 50$) data sets. Its finite sample performance is analyzed in an extensive simulation study. To demonstrate the applicability of our test, we investigate whether the simplifying assumption is reasonable in practical applications.

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Bounds for the Clayton copula

Martynas Manstavičius Remigijus Leipus

Abstract

The multivariate Clayton copula (also known as Mardia–Takahashi–Clayton–Cook–Johnson copula)

$$C_\theta(u_1,\dots,u_n)=\Big(\sum_{i=1}^n u_i^{-\theta}-n+1\Big)_+^{-1/\theta},\qquad (u_1,\dots,u_n)\in[0,1]^n,$$

where $a_+:=\max\{a,0\}$, $\theta>0$ if $n\geq 3$ and $\theta\in[-1,0)\cup(0,+\infty)$ if $n=2$, is interesting as it can model various kinds of dependence, ranging from comonotonicity in the limit as $\theta\to\infty$, independence if $\theta\downarrow 0$ (also if $\theta\uparrow 0$) and countermonotonicity if $\theta=-1$. It is well known that $C_\theta(u_1,\dots,u_n)\geq\Pi(u_1,\dots,u_n):=\prod_{i=1}^n u_i$ if $\theta>0$. On the other hand, $C_\theta(u_1,u_2)\leq u_1u_2$ if $\theta\in[-1,0)$. We provide two new upper bounds on $C_\theta(u_1,\dots,u_n)$ if $\theta>0$ and a lower bound in the case $\theta\in[-1,0)$. The obtained bounds have an attractive probabilistic interpretation related to the modelling of some negative dependence structures.
To be more explicit, for a vector $\mathbf{x}=(x_1,\dots,x_n)\in\mathbf{R}^n$, $n\geq 2$, let $x_{(1)}\leq\cdots\leq x_{(n)}$ be the components of $\mathbf{x}$ in increasing order. We have

Theorem 1. Let $\theta>0$. Then for any $(u_1,\dots,u_n)\in[0,1]^n, n\geq 2$,

(i) $C_\theta(u_1,\dots,u_n)\leq\theta(1-u_{(1)}-u_{(2)})+(1+\theta)u_{(1)}u_{(2)}$;

(ii) $C_\theta(u_1,\dots,u_n)\leq\Pi(u_1,\dots,u_n)\exp\{\theta\ln u_{(1)}\ln u_{(2)}\}$.

In the case $\theta\in[-1,0)$ and $n=2$, we have

Theorem 2. For any $\theta\in[-1,0)$,

$$C_\theta(u_1,u_2)\geq\theta(1-u_1-u_2)+(1+\theta)u_1u_2,\quad (u_1,u_2)\in[0,1]^2.$$

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Distributions with fixed marginals maximizing the mass of the endograph and the graph of a function

Thomas Mroz

Abstract

For given distribution functions F, G we consider the problem of maximizing the probability of the event $X \leq Y$ within the class of all two-dimensional distribution functions having F and G as marginals. Translating to the copula setting, we not only solve the much more general problem of finding $\sup_{A \in \mathcal{C}} \mu_A(\Gamma^{\leq}(T))$, where $\mathcal{C}$ is the family of all two-dimensional copulas and $\Gamma^{\leq}(T)$ is the endograph of some measurable (and not necessarily non-decreasing) function $T\colon [0,1] \to [0,1]$, but also prove the existence of a copula A_T such that $\mu_{A_T}(\Gamma^{\leq}(T)) = \sup_{A \in \mathcal{C}} \mu_A(\Gamma^{\leq}(T))$ and show how to construct it. Furthermore, we look at the closely related problem of determining $\sup_{A \in \mathcal{C}} \mu_A(\Gamma(T))$, where $\Gamma(T)$ is the graph of some measurable function $T\colon [0,1] \to [0,1]$ and give a characterization of all measurable functions $T\colon [0,1] \to [0,1]$ for which $\sup_{A \in \mathcal{C}} \mu_A(\Gamma(T)) = \sup_{A \in \mathcal{C}} \mu_A(\Gamma^{\leq}(T))$.

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Representing sparse Gaussian DAGs as sparse R-vines allowing for non-Gaussian dependence

Dominik Müller Claudia Czado

Abstract

Modelling dependence in high dimensional systems has become an increasingly important topic. Most approaches rely on the assumption of a joint Gaussian distribution such as statistical models on directed acyclic graphs (DAGs). They are based on modelling conditional independencies and are scalable to high dimensions. In contrast, vine copula based models can accommodate more elaborate features like tail dependence and asymmetry. This flexibility comes however at the cost of exponentially increasing complexity for model selection and estimation. We show a connection between these two model classes by giving a novel representation of DAG models in terms of sparse vine models. Therefore we can exploit the fast model selection and estimation of sparse DAGs while allowing for non-Gaussian dependence in the vine models. We demonstrate for a high dimensional data set that this approach outperforms standard methods for vine structure estimation.

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Using Mixture of Vine Copulas for Clustering

Marta Nai Ruscone

Abstract

Finite mixtures are often used to perform model based clustering of multivariate datasets. In real life applications data may exhibit complex nonlinear form of dependence among the variables. Moreover, the individual variables (margins) may follow different distribution families. Nevertheless, most of the existing mixture models are unable to accommodate these two aspects of the data, so, in order to reveal and fully understand the complex and hidden dependence patterns in multivariate data, we propose a mixture model of multivariate densities having D-vine representations. This model de-couples the margins and their dependence structure, making it possible to describe the margins by using different distribution families, including non-Gaussian ones. Again, many possible dependence structures can be studied using different copulas. Parameter estimates from simulated and real datasets finally show the suitability of the proposed procedure.

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Return level estimators based on Extreme Value Theory

Fatima Palacios-Rodríguez Elena Di Bernardino

Abstract

We consider a risk vector $\mathbf{X} = (X_1, \ldots, X_d)$ with associated multivariate critical layer at level $\alpha \in (0,1)$ denoted as $\partial L(\alpha)$. Let $T_i := [X_i \,|\, \mathbf{X} \in \partial L(\alpha)]$ be a conditional random variable for a fixed α. The proposal of this work is to provide a nonparametric estimator for the return level $x^i_{p_n}$ of T_i when $p_n \to 0$, as the sample size $n \to +\infty$, by using Extreme Value Theory (EVT). In order to achieve this goal, we develop an extrapolation technique by assuming an Archimedean copula as dependence structure for $\mathbf{X}$ and the von Mises condition for marginal X_i. The main result is the Central Limit Theorem of our estimator for $p = p_n \to 0$, as n tends towards infinity. In addition, the performance of the proposed estimator is evaluated on simulated data. Finally, we apply our estimator for a real rainfall dataset.

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Graphical Copula tools for detecting tail dependence

Roberta Pappadà

Abstract

In the analysis of many phenomena (for instance, in finance and environmental sciences), a crucial task is the study of the joint behavior of the involved random variables, especially when dealing with tail-dependent risks. Due to their ability to capture complex dependencies, copulas are largely used in applied sciences and several tools are available for the selection of a suitable parametric model. However, there is still need for investigation of tools for the evaluation and selection of alternative copula models. A copula-based graphical tool which allows us to visualize the fit of a whole collection of multivariate copulas at once will be presented. It will be illustrated how such tool can be used to shed light on the problem of classifying copulas according to some desirable characteristics of practical relevance, especially when tail dependence properties are of primary interest. The proposed tool can be used in the first step of model building, since it allows comparison of a large number of possible parametric families and provides valuable indications for the choice of a suitable copula model.

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On Copulas and Order Statistics

Sebastian Fuchs Klaus D. Schmidt

Abstract

For a random vector $X = (X_1, \ldots, X_n)$ with an arbitrary distribution function F and univariate marginal distributions functions $F_1, \ldots, F_n$, we consider the problem of how to transform a copula representation

$$F(x) = C(F_1(x_1), \ldots, F_n(x_n))$$

of F into a copula representation

$$F_{:n}(x) = C_{:n}(F_{1:n}(x_1), \ldots, F_{n:n}(x_n))$$

of the distribution function of the order statistic $X_{:n} = (X_{1:n}, \ldots, X_{n:n})$ of X. Extending results of Navarro and Spizzichino [2010] by dropping their assumption that $F_1, \ldots, F_n$ are continuous, we provide two general principles for the construction of a copula $C_{:n}$ representing $F_{:n}$. In the case $F_1 = \ldots = F_n$ and for certain copulas C we obtain an explicit formula for $C_{:n}$. To complete the discussion, we also present formulae for the distribution functions $F_{1:n}, \ldots, F_{n:n}$.

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The region determined by Kendall's tau and Spearman's rho

Manuela Schreyer Roland Paulin Wolfgang Trutschnig

Abstract

Kendall's τ and Spearman's ρ are, without doubt, the two most famous nonparametric measures of association/concordance. Given random variables X, Y with continuous distribution functions F and G respectively, Spearman's ρ is defined as the Pearson correlation coefficient of the $\mathcal{U}(0,1)$-distributed random variables $U := F \circ X$ and $V := G \circ Y$, whereas Kendall's τ is given by the probability of concordance minus the probability of discordance.

It is well known and straightforward to verify (Nelsen, 2007) that, Kendall's tau $\tau(X,Y)$ and Spearman's rho $\rho(X,Y)$ only depend on the underlying (uniquely determined) copula A of (X,Y). Considering that τ and ρ quantify different aspects of the underlying dependence structure (Fredricks and Nelsen, 2007) a very natural question is how much they can differ, i.e. if $\tau(X,Y)$ is known which values may $\rho(X,Y)$ assume and vice versa. The *classical τ-ρ region* Ω_0 goes back to the well-known universal inequalities between τ and ρ by Daniels (1950) and Durbin and Stuart (1951) respectively. Daniels' inequality is known to be sharp (Nelsen, 2007) whereas Durbin and Stuarts' inequality is only known to be sharp at some special points. Although both inequalities are known since the 1950s and the interrelation between τ and ρ has received much attention also in recent years (see Fredricks and Nelsen (2007)), the *exact τ-ρ region* $\Omega = \{(\tau(A), \rho(A)) : A \in \mathcal{C}\}$ is still unknown ($\mathcal{C}$ denoting the family of all two-dimensional copulas).

Using properties of shuffles of copulas and tools from combinatorics we solved the sixty year old question about the exact τ-ρ region Ω. In particular, we proved that the inequality established by Durbin and Stuart in 1951 is not sharp outside a countable set, give a simple analytic characterization of Ω in terms of a continuous, strictly increasing piecewise concave function, and show that Ω is compact and simply connected but not convex.

The results also imply the surprising fact that for each point $(x,y) \in \Omega$ there exist mutually completely dependent random variables X, Y for which $(\tau(X,Y), \rho(X,Y)) = (x,y)$ holds.

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Modeling the serial dependence of financial returns with copulas

Fabian Spanhel

Abstract

We investigate to what extent stylized facts of financial returns, such as the martingale difference property, volatility clustering and the leverage effect, can be characterized in terms of copulas. We derive sufficient and necessary conditions for a conditionally symmetric martingale difference sequence in terms of copulas. These conditions reveal that the only possible martingale difference sequence that can be generated by commonly used copula families is a sequence of independent random variables. We then focus on the construction of copula-based first-order Markov processes that exhibit volatility clustering. For this purpose, we introduce two dependence properties that are sufficient for a positive correlation between squared (or absolute) symmetric random variables or an increasing transition variance in the absolute value of one conditioning variable. Moreover, several construction methods of copulas with the desired dependence properties are presented and compared. Finally, we explore the construction of higher-order Markov processes that exhibit volatility clustering. An application of the copula-based time series models to the returns of three major stock indices and one currency exchange rate documents the competitiveness with established GARCH models.

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Implicit Dependence Copulas

Songkiat Sumetkijakan

Abstract

A copula of continuous random variables X and Y is called an *implicit dependence copula* if there exist functions α and β such that $\alpha(X) = \beta(Y)$ almost surely, which is equivalent to C being factorizable as the $*$-product of a left invertible copula and a right invertible copula. Every implicit dependence copula is supported on the graph of $f(x) = g(y)$ for some measure-preserving functions f and g but the converse is not true in general.

We give characterizations of copulas with such supports in terms of the non-atomicity of two newly defined associated σ-algebras and in terms of their Markov operators. As an application, we show that some copulas with fractal supports are implicit dependence copulas. Their left invertible and right invertible factors are also computed explicitly.

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The Empirical Beta Copula

Johan Segers Masaaki Sibuya Hideatsu Tsukahara
Nathan Uyttendaele

Abstract

Given a sample from a multivariate distribution F, the uniform random variates generated independently and rearranged in the order specified by the vector of ranks look like a sample from the copula of F. This idea led us to define the empirical beta copula, which turned out to be a particular case of the empirical Bernstein copula. The advantage is that we do not need any smoothing parameter and that it is extremely simple to simulate a sample from the empirical beta copula. We give a condition for a Bernstein transformation to be a copula, by which we see that the empirical beta copula is always a genuine copula. Furthermore, we establish nonrestrictive assumptions under which the standard asymptotic results hold for the empirical beta/Bernstein copula. Our Monte Carlo simulation study shows that the empirical beta copula outperforms the empirical copula in terms of the bias and the integrated mean squared error, and that in several cases, its performance is still significantly better than the empirical Bernstein copula with optimal smoothing rate.

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Non-Parameteric Gaussian Process Vector Valued Time Series Models and Testing For Causality

Anna Zaremba Gareth W. Peters Tomoko Matsui

Abstract

We develop new classes of non-parameteric multivariate time-series models based on Multi-Output Gaussian Processes. These describe relationships between a current vector of observations and the lagged history of each marginal time series. We encode a linear serial dependency structure through a covariance function and introduce a more complex dependence structure using copulas to couple each marginal process.

Within this class of models our primary goal is to detect causality and to study the interplay between the causal structure and the dependence structure. To perform the testing we consider several families of causality testing and develop compound tests which first require estimation/calibration of the mean and covariance functions parametrizing the non-parametric vector valued time series. Our approach allows very general non-linear dependence and causal relationships which are not often considered in classical parametric time-series models, including causality in higher order information and joint extreme dependence features.

We provide a generic framework which can be applied to a variety of different problem classes and discuss a number of examples to illustrate the ideas developed.

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Poster Session

Skew-type Marshall-Olkin Copula

Hugo Brango Nikolai Kolev

Abstract

We introduce a modification of the Marshall-Olkin's (MO) bivariate exponential distribution as follows

$$S_{X_1,X_2}(x_1,x_2) = \exp\{-\lambda_1 x_1 - \lambda_2 x_2 - \lambda_3 \max(x_1, \omega x_2)\}, \quad (1)$$

for all $x_1, x_2 \geq 0$, where $S_{X_1,X_2}(x_1,x_2) = P(X_1 > x_1, X_2 > x_2)$, $\omega > 0$ and $\lambda_i > 0$, $i = 1,2,3$. The marginals in (1) are exponentially distributed with parameters $\lambda_1 + \lambda_3$ and $\lambda_2 + \omega\lambda_3$. One can recognize that there exists a positive mass concentrated along the line $L_\omega : \{x_1 = \omega x_2\}$ through the origin $(0,0)$ in R^2_+. The additional parameter ω in (1) can be interpreted as a skew parameter. Obviously, the classical MO model results substituting $\omega = 1$ in (1).

The survival copula $\overline{C}(u,v)$ corresponding to (1) is given by

$$\overline{C}(u,v) = uv \min\{u^{-\phi_1}, v^{-\phi_1\phi_2(\omega)}\}, \quad (u,v) \in [0,1]^2, \quad (2)$$

where $\phi_1 = \frac{\lambda_3}{\lambda_1+\lambda_3}$ and $\phi_2(\omega) = \frac{\omega(\lambda_1+\lambda_3)}{\lambda_2+\omega\lambda_3}$.

We show that the Pearson's correlation coefficient of (1) is less than the Spearman's rho of the associated skew-type MO survival copula (2), regardless of parameters. This implies that distribution (1) contradicts the Lancaster's phenomena stating that any nonlinear transformation of variables decreases the correlation in absolute value.

We will discuss properties of model (1) and will demonstrate its advantage in analysis of classical data sets.

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Archimax Copulas

Simon Chatelain

Abstract

This poster presents Archimax copulas, a generalization of both extreme-value and Archimedean copula families. Other than its inherent flexibility, this family has interesting properties. Notably, under conditions of regular variation, the maximum and minimum domains of attraction can be established. These results motivate the use of Archimax copulas for modeling dependence in a context of extreme values. Moreover Archimax copulas admit an interesting stochastic representation which is also presented. Under the same conditions of regular variation on the Archimedean generator mentioned before as well as regularity assumptions on the Pickands dependence function, we are able to show weak convergence of the empirical copula process with respect to weighted metrics. This allows us to establish the convergence of estimators of the Pickands dependence function around which we can construct confidence bands. A joint estimation procedure of both functional parameters is then proposed for the bivariate setting, followed by simulation results.

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Modelling increased return dependence structures of mining companies globally

Nico Katzke Nicolaas Johannes Odendaal

Abstract

Over the last few years a growing literature has highlighted the great homogeneity between share price returns globally following the global financial risis of 2008. In this paper we highlight the increased level of comovement between mining stocks globally, both within and between geographically separated stock markets. This follows as uncertainty over global economic growth precipitated a large sell-off of commodities, causing negative revaluations of mining stocks globally. In this study we explore the changing nature of both inter- and intra national mining company returns since 2003, using Vine Copula techniques. These models allow for the modelling of complex dependency structures that provide deep insight into the level and changing nature of multivariate co-dependency. Our study considers the weekly returns of mining companies from 10 stock universes across the development spectrum. The findings suggest that mining stock return co-dependency have increased significantly in the last decade, which highlights the limited scope for asset managers to diversify across the sector globally. This has significant implications for stock exchanges that have large mining companies and are highly exposed to global commodity price fluctuations, particularly as global commodity prices look to remain volatile in the immediate future.

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Skew-type Bivariate Lack of Memory Property

Nikolai Kolev Hugo Brango

Abstract

We introduce a modification of the bivariate lack of memory property (BLMP) defined by the functional equation

$$S_{X_1,X_2}(x_1+\omega t, x_2+t) = S_{X_1,X_2}(x_1,x_2)\, S_{X_1,X_2}(\omega t, t) \tag{3}$$

for all $x_1, x_2, t \geq 0$, where $S_{X_1,X_2}(x_1,x_2) = P(X_1 > x_1, X_2 > x_2)$ and $\omega > 0$. The parameter ω in (1) can be interpreted as a parameter of skewness. One will get the classical BLMP functional equation by letting $\omega = 1$ in (1).

Characterizations, properties and applications of the novel bivariate memory-less notion will be discussed. In particular, the functional equation (1) has as solutions bivariate continuous distributions with non-exponential marginals. The skew-type BLMP given by (1) implies restrictions on the associated marginal distributions. Starting from pre-specified marginals we offer a procedure to build a wealth of bivariate continuous non-negative distributions possessing a skew-type BLMP. The methodology will be illustrated by examples.

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Multivariate goodness of fit assessment by extension of univariate EDF tests

Andreas Mändle

Abstract

Modeling dependence, e.g. in the context of risk management in finance and insurance, involves making distributional assumptions for multivariate data. In contrast to the classical assumption of a Gaussian distribution, it has been frequently observed that in practice tails are heavy and extremes appear in clusters, indicating tail dependence. Therefore there is often uncertainty if a specific distributional assumption can actually be justified.
In the univariate case popular methods for testing the goodness of fit are the EDF tests based on the CramÃľr-von Mises, Kolmogorov-Smirnov and Anderson-Darling statistics, where the latter test is known especially for its strong power, when there are deviations in the tails of a distribution. For settings, where the multivariate goodness of fit, i.e. the goodness of fit of the marginal distributions together with their common dependence structure, have to be jointly assessed, extensions to the multivariate case have been suggested: These include the results on the multivariate Kolmogorov-Smirnov test by (2), the generalized CramÃľr-von Mises test described in (1) and the Anderson-Darling extension from (3).
To deliver a comparison of these statistics, especially in the bivariate case, results from a simulation study will be presented, stressing the strengths and specific properties of the tests. Special attention will be given to their sensitivity regarding deviations in mean, scale and dependence structure.

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Geometry of discrete copulas for weather forecasting

Elisa Perrone Caroline Uhler

Abstract

In this work we present a geometric approach to describe families of discrete copulas through the properties of their associated polytopes. As an example, we discuss the polytope of ultramodular discrete copulas, i.e., discrete restrictions of ultramodular copulas. We introduce the concept of ultramodularity in the discrete setting and characterize the polytope of ultramodular discrete copulas by its defining halfspaces. In addition, we analyze the volume of this polytope and its vertices. Finally, we present an application of the proposed approach to weather forecasting. In particular, we show how the limitations of empirical postprocessing methods of numerical weather ensemble forecasts in the presence of ties can be overcome by understanding the geometry of the space of discrete copulas.

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A New Nonparametric Estimation for Bivariate Pickands Dependence Function

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Abstract

Pickands dependence function which characterizes the extreme value copulas is widely used to model the extreme events. In this study, we propose a new nonparametric approach to estimate Pickands dependence function by using Bernstein copula. Pointwise estimation procedure with a visual tool is provided for investigating the extreme-value dependence structure. This new Bernstein approximation has flexible form. For the low level of dependence and polynomial degree, the proposed estimator has a better result. Also when the degree of dependence is increased, then the polynomial degree should be increased for a better fit.
These new points can serve to estimate the unknown Pickands dependence function. Kernel Regression method is used to derive an intrinsic estimator that leads to an extremeness test by a bootstrap procedure. The performance of the estimator is given by a simulation study. Test results mainly show that the estimator has a better performance than the conventional estimator.

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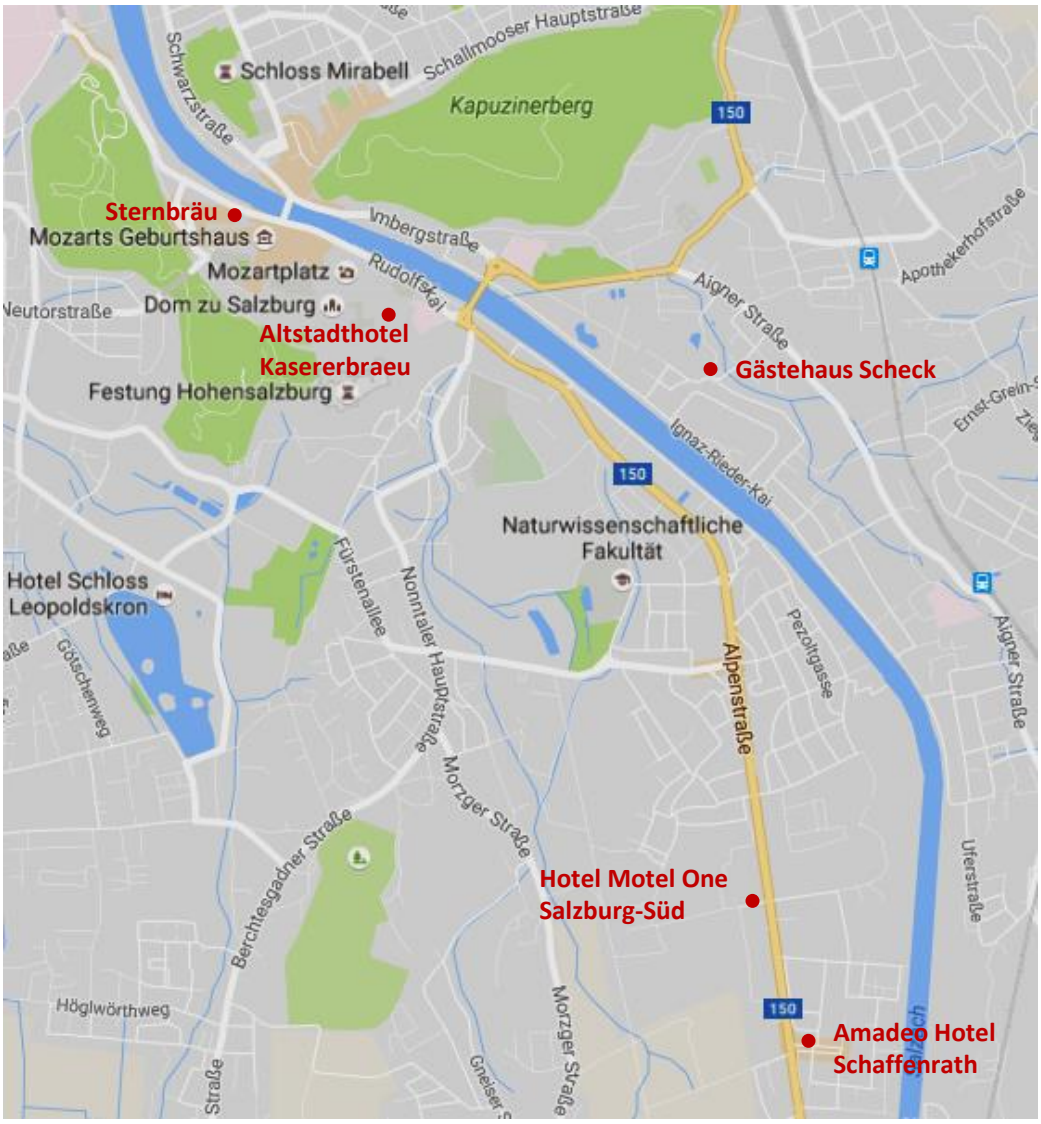
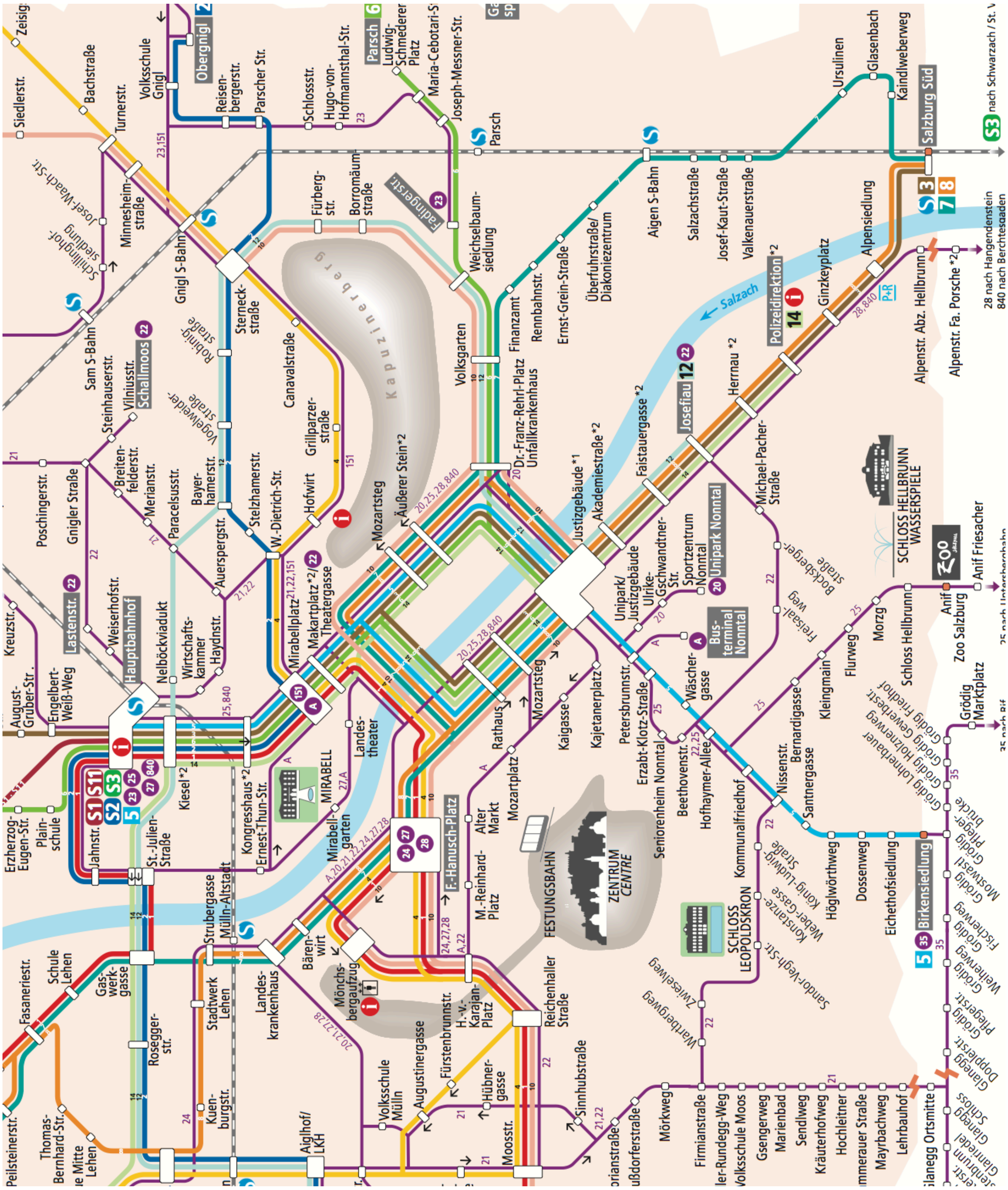
Locations



Bus-lines

Bus stops

Amadeo Hotel Schaffenrath & Ginzkeyplatz
Hotel Motel One & Polizeidirektion
Naturwissenschaftliche Fakultät & Faistauergasse
Gästehaus Scheck & Finanzamt
Altstadthotel Kasererbräu & Justizgebäude
Sternbräu & Ferdinand-Hanusch-Platz
Schloss Mirabell & Mirabellplatz



Hauptbahnhof
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MIRABELL
Mirabellplatz
Makartplatz
Hanuschplatz
Mozartsteg
Rathaus
Justizgebäude
Akademiestraße
Josefiau
Polizeidirektion
Alpensiedlung
Ginzkeyplatz
Parsch
Gnigl S-Bahn
Sam S-Bahn
Aigen S-Bahn
Schallmoos
Lastenstr.
Obergnigl
Landeskrankenhaus
Mönchsbergaufzug
Reichenhaller Straße
Birkensiedlung
Unipark Nonntal
Zoo Salzburg
Anif Friesacher
Volksgarten
Finanzamt
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