Statistical Modeling with Applications

A Conference in honour of Professor Markos V. Koutras

Book of Abstracts

Edited by Ioannis S. Triantafyllou & Alex Karagrigoriou

Department of Statistics & Insurance Science

University of Piraeus

26-28 September 2025

Preface

On behalf of the Organizing Committee, we are delighted to welcome you to the ΣtatMod 2025 Conference, hosted at the University of Piraeus, under the auspices of the Department of Statistics & Insurance Science.

The conference takes place from September 26 to 28, 2025, and brings together researchers, scholars and practitioners from diverse areas of Statistical Modeling. It provides a platform for the presentation of recent advances, the exchange of ideas and the promotion of scientific collaboration.

In line with the conference's scientific scope, presentations will cover a wide range of topics in the fields of Probability, Statistics and related fields. These include, but are not limited to, Markov and semi-Markov processes, nonparametric statistics, stochastic modeling, Bayesian methods, insurance mathematics, design of experiments, theory of runs and scans, reliability modeling, entropy and information measures and machine learning.

ΣtatMod 2025 Conference holds special significance as it is dedicated to honoring Professor Markos V. Koutras on the occasion of his retirement. Professor Koutras has a distinguished academic career, contributing profoundly to the fields of Probability and Statistical Modeling. It is generally acknowledged that Professor Koutras has been an inspiring mentor, collaborator and leader within the statistical community in Greece and internationally. We are especially proud to host this event at the University of Piraeus, where Professor Koutras has served with commitment and excellence throughout his academic tenure.

It is a genuine pleasure for all of us that, during the course of the conference, brief addresses in recognition of Professor Markos V. Koutras will be delivered by eminent scholars, such as Subha Chakraborti, Tasos Christofides, Charalampos Damianou, Georgios Donatos, Aglaia Kalamatianou, Andreas Kyriakousis, Athanasios Kyriazis, Takis Papaioannou, Andreas Philippou and George Roussas.

We extend our sincere gratitude to all participants, speakers and contributors for joining us in commemorating 5 years of successful ΣtatMod conferences and at the same time celebrating Professor Koutras' legacy. We anticipate that the conference will be a stimulating and collegial academic gathering.

We wish you a productive and rewarding conference experience.

On behalf of the Organizing Committee,

Ioannis S. Triantafyllou & Alex Karagrigoriou

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Sheldon Ross, University of Southern California, USA
Peihua Qiu, University of Florida, USA
Min Xie, City University of Hong Kong, Hong Kong

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Uniform integrability of the OLS estimators and the convergence of their moments

Georgios Afendras[1] & **Marianthi Markatou**[2]

[1]Aristotle University of Thessaloniki, Greece

[2]University at Buffallo, U.S.A

gafendra@math.auth.gr; markatou@buffalo.edu

Abstract. In this work, we prove the uniform integrability of the ordinary least squares estimators of a linear regression model, under suitable assumptions on the design matrix and the moments of the errors. Further, we prove the convergence of the moments of the estimators to the corresponding moments of their asymptotic distribution and study the rate of the moment convergence. The canonical central limit theorem corresponds to the simplest linear regression model. We investigate the rate of the moment convergence in canonical central limit theorem proving a sharp improvement of von Bahr's (*Ann. Math. Stat.* 36, 808–818, 1965) theorem.

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Journey log

Vasiliki A. Alexandrou

alexandrou.vassia@gmail.com

Abstract. The presentation provides glances of the journey during my Ph.D. studies under the significant mentoring of Professor Markos V. Koutras, some highlights and back story of our research, as well as how this experience was fundamental for my professional experience and achievements in the industry sector.

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Robust Functional Penalized and Smoothed SIMPLS

Aylin Alin

Department of Statistics, Dokuz Eylul University, Izmir, Türkiye

aylin.alin@deu.edu.tr

Abstract. High-dimensional functional predictors, such as spectroscopic curves, present unique challenges for classical regression techniques. In particular, Partial Least Squares (PLS) Regression, while popular in chemometrics, can yield unstable coefficient estimates when the underlying coefficient function over the predictor domain is smooth yet complex, and they are highly vulnerable to outliers. To address these limitations, we propose a new algorithm "*Robust Functional Penalized and Smoothed SIMPLS (RFPSSIMPLS)*", that systematically addresses these challenges by integrating functional modeling, robust estimation, and adaptive smoothing within the PLS framework.

The proposed algorithm first projects high-dimensional predictor curves onto a B-spline basis, ensuring a flexible yet parsimonious spectral domain representation. Penalization is imposed via a finite difference penalty matrix, enforcing smoothness in the estimated coefficient function. The SIMPLS procedure is made robust through iterative reweighting, down-weighting influential outliers in both predictors and response proposed by Alin & Agostinelli (2017). The number of PLS components and the penalty parameter for smoothness are adaptively selected using cross-validation, enhancing objectivity and predictive performance.

Comprehensive numerical studies with simulated and real spectroscopic data demonstrate that RFPSSIMPLS outperforms classical and existing robust PLS methods in prediction accuracy and robustness to outliers, especially in scenarios with structured contamination and varying signal-to-noise ratios. The algorithm broadly applies to various functional regression problems encountered in chemometrics, biostatistics, and beyond.

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On the E(s^2)-optimality of two-level supersaturated designs constructed from orthogonal arrays with partially aliased interactions

Emmanouil Androulakis & Haralambos Evangelaras

Department of Statistics and Insurance Science, University of Piraeus, Greece

mandroulakis@unipi.gr; hevangel@unipi.gr

Abstract. Wu (1993) introduced a method for constructing two-level supersaturated designs, by augmenting a Hadamard design with n runs and $n-1$ columns, with two-column interactions provided they are partially aliased. Later, Bulutoglu and Cheng (2003) established that this approach yields E(s^2)-optimal designs when certain interaction columns are selected. In this work, we extend their findings by proving that E(s^2)-optimal supersaturated designs can also be obtained using Wu's method when the starting design is a two-level orthogonal array with n runs and $n-1$, $n-2$, or $n-3$ columns, as long as its two-column interactions are partially aliased. Our results rely on the framework of the Generalized Wordlength Pattern and its connection to the concept of J-characteristics.

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Stochastic orders and shape properties for a new distorted proportional odds model

Idir Arab[1], Milto Hadjikyriakou[2] & Paulo Eduardo Oliveira[1]

[1]Department of Mathematics, University of Coimbra, Portugal

[2] School of Sciences, University of Central Lancashire, Cyprus

idir.bhh@gmail.com; MHadjikyriakou@uclan.ac.uk; paulo@mat.uc.pt

Abstract. Building on recent developments in models focused on the shape properties of odds ratios, this work introduces two new models that expand the class of available distributions while preserving specific shape characteristics of an underlying baseline distribution. The first model offers enhanced control over odds and log odds functions, facilitating adjustments to skewness, tail behaviour, and hazard rates. The second model, which broadens flexibility in the shape of odds functions, describes these as quantile distortions. This approach leads to an enlarged log-logistic family capable of capturing these quantile transformations and diverse hazard behaviours, including non-monotonic and bathtub-shaped rates. Central to our study are the shape relations described through stochastic orders; we establish conditions that ensure stochastic ordering both within each family and across models under various ordering concepts, such as hazard rate, likelihood ratio, and convex transform orders.

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A method for Sufficient Dimension Reduction (SDR) in high dimensional settings

Andreas Artemiou

University of Limassol, Cyprus

artemiou@uol.ac.cy

Abstract. Sufficient Dimension Reduction (SDR) is a framework of methods for feature extraction in a supervised setting. This talk presents a combination of our work which is presented in two papers where we proposed two ideas for performing SDR in high-dimensional settings. Both ideas are using principal projections to project the high-dimensional data into lower-dimensional space in the area of Support Vector Machine (SVM)-based SDR.

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Continuous time Semi-Markov Processes for reliability and survival analysis: A Nonparametric Estimation Approach

Chafiâa Ayhar

University Center of El Bayadh Nour El Bachir, Algeria

c.ayhar@cu-elbayadh.dz

Abstract. We consider a semi-Markov process with a finite state space. We propose nonparametric estimators for continuous-time semi-Markov kernel, the semi-Markov transition function, and reliability indicators. We also give asymptotic properties of the above estimators, such as the uniform strong consistency and the asymptotic normality. In addition, a numerical example illustrates the asymptotic properties of the reliability function approximation in a continuous-time semi-Markov process.

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Superefficient estimation of future conditional hazards based on marker information

Dimitrios Bagkavos[1], Alex Isakson[2], Enno Mammen[3], Jens P. Nielsen[2] & Cecile Proust-Lima[4]

[1]Department of Mathematics, University of Ioannina, Greece, [2]Bayes Business School, City, University of London, UK, [3]Institute of Applied Mathematics, Heidelberg University, Germany, [4]Univ. Bordeaux, INSERM, Bordeaux Population Health Research Center, Bordeaux, France.

d.bagkavos@uoi.gr; alex.isakson.2@city.ac.uk; mammen@math.uni-heidelberg.de; Jens.Nielsen.1@city.ac.uk; cecile.proust-lima@u-bordeaux.fr

Abstract. We introduce a new concept for forecasting future events based on marker information. The model is developed in the nonparametric counting process setting under the assumptions that the marker is of so-called high quality and with a time-homogeneous conditional distribution. Despite the model having nonparametric parts it is established herein that it attains a parametric rate of uniform consistency and uniform asymptotic normality. In usual nonparametric scenarios, reaching such a fast convergence rate is not possible, so one can say that the proposed approach is superefficient. These theoretical results are employed in the construction of simultaneous confidence bands directly for the hazard rate. Extensive simulation studies validate and compare the proposed methodology with the joint modeling approach and illustrate its robustness for mild violations of the assumptions. Its use in practice is illustrated in the computation of individual dynamic predictions in the context of primary biliary cirrhosis (PBC) of the liver.

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Hidden Markov Models in Bioinformatics: A personal narrative

Pantelis G. Bagos

University of Thessaly, Greece

pbagos@compgen.org

Abstract. Hidden Markov Models (HMMs) are probabilistic models initially developed for applications in speech recognition, but in the last three decades they became widely used in biological sequence analysis. The most commonly used type of HMM is the profile HMM (pHMM), which is especially useful for multiple sequence alignment and remote homology detection. However, for other applications in biological sequence analysis, the need for HMMs with custom architecture arises, and the use of labeled sequences for training is advisable. These models are usually named Class HMMs (CHMMs). In this work I will present the basic notation for HMMs along with algorithms developed during these years for labeled sequences. I will discuss Maximum Likelihood (ML) and Conditional Maximum Likelihood (CML) estimation, decoding algorithms and decoding under constraints, extensions to the basic assumptions (for instance models allowing conditioning on past observations, and Hidden Neural Networks), and methods for semi-supervised learning. I will also discuss applications of these algorithms in important biological problems, such as the topology prediction of membrane proteins and the prediction of signal peptides, all of which can be fitted with JUCHMME, an open source package developed for handling such problems implementing all the above-mentioned approaches.

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Flexible Modelling of LTRC Data with Covariates

Narayanaswamy Balakrishnan

Department of Mathematics and Statistics, McMaster University, Canada

bala@mcmaster.ca

Abstract. In this talk, I will first provide a detailed introduction to the form of LTRC data and then explain all the complications that arise in analyzing data of such forms. I will then develop some general likelihood-based algorithms for fitting different lifetime models for such data involving covariates, using both parametric and semiparametric forms in terms of cumulative hazard function. I will finally demonstrate the usefulness of the model and also the associated fitting methods with the use of extensive simulation studies as well as two well-known real-life data sets.

A goodness-of-fit test for the geometric maximum compound logistic distribution model

Ludwig Baringhaus & Daniel Gaigall

Leibniz University Hannover, FH Aachen - University of Applied Sciences

lbaring@stochastik.uni-hannover.de; gaigall@fh-aachen.de

Abstract. Based on independent copies of a bivariate random vector (M,N), with positive integer-valued component N, we consider testing the composite hypothesis that (M,N) follows a geometric maximum compound logistic distribution. This distributional model is of interest for example in hydrology, where N models the number of floods, and M the maximum flood water level during a certain time period. The geometric maximum compound logistic distribution is characterized in the sense that a special transform of (M,N) fulfills a specific equation. We suggest a weighted integral of an expression obtained by replacing the function part of this equation by empirical counterparts as test statistic, propose a parametric bootstrap procedure to get critical values, give a thorough discussion that the procedure works, and present a simulation study on its performance. The test is applied to a hydrological data set. A new goodness-of-fit test for the logistic distribution is obtained as a special case of the novel approach.

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Statistical inference under size-biased sampling

Apostolos Batsidis

Department of Mathematics, University of Ioannina, Ioannina, Greece

abatsidis@uoi.gr

Abstract. This talk deals with statistical inference under size-biased sampling. Initially, through motivating examples, the necessity of considering some specific problems is highlighted. Afterwards, using the concept of weighted distributions, our interest is focused on the statistical inference for the expectation of a function of a random vector based on multivariate weighted biased samples and on the hypothesis testing problem of the equality of two populations based on an independent sample and a biased sample drawn from them.

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Optimal and Learning-Based Server Replacement in M/M/1 Queues with Fatigue-Induced Failures

Konstantinos Bekios & Apostolos Burnetas

Department of Mathematics, National and Kapodistrian University of Athens, Greece

kmpekios@gmail.com; aburnetas@uoa.gr

Abstract. We consider an M/M/1 queueing system with an unreliable server whose performance degrades with usage. Specifically, the service rate decreases and the failure rate increases as a function of the number of customers served since the last replacement. The service provider can choose to replace the server at any time by incurring a fixed replacement cost. If the server fails, it is also replaced immediately, but all customers in the queue are lost, incurring an additional abortion cost per customer.

We formulate the problem as a Markov Decision Process (MDP) and analyze both the infinite-horizon discounted cost and long-run average cost criteria. We prove that the optimal replacement policy has a threshold structure, based on the number of completed services and the number of customers waiting. In the second part of the study, we consider the more realistic setting where the failure rate function is unknown. We develop a class of learning-based replacement policies that explore the failure behavior while minimizing cost. Our algorithms are shown to be consistent, in the sense that the average cost converges to the optimal cost under full information. Simulation experiments illustrate the regret performance and convergence behavior of the proposed policies.

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A nonparametric distribution-free test of independence among continuous random vectors based on L_1-norm

Nour-Eddine Berrahou[1], **Salim Bouzebda**[2] & **Lahcen Douge**[1]

[1]Laboratoire de Modélisation des Systèmes Complexes, University Cadi Ayyad

[2]Université de technologie de Compiègne, LMAC

n.berrahou@uca.ac.ma; Salim.Bouzebda@utc.fr

lahcen.douge@uca.ac.ma

Abstract. We propose a novel statistical test to assess the mutual independence of multidimensional random vectors. Our approach is based on the L_1-distance between the joint density function and the product of the marginal densities associated with the presumed independent vectors. Under the null hypothesis, we employ Poissonization techniques to establish the asymptotic normal approximation of the corresponding test statistic, without imposing any regularity assumptions on the underlying Lebesgue density function, denoted as $f(\cdot)$. Remarkably, we observe that the limiting distribution of the L_1-based statistics remains unaffected by the specific form of $f(\cdot)$. This unexpected result contributes to the robustness and versatility of our method. Moreover, our tests exhibit nontrivial local power against a subset of local alternatives, which converge to the null hypothesis at a rate of $n^{-1/2}h_n^{-d/4}$, $d \geq 2$, where n represents the sample size and h_n denotes the bandwidth. Finally, the theory is supported by a comprehensive simulation study to investigate the finite-sample performance of our proposed test. The results demonstrate that our testing procedure generally outperforms existing approaches across various examined scenarios.

Studying Clinical Trials Designs using Markov Chain Embedding

Sotirios Bersimis

Department of Business Administration, University of Piraeus, Greece

sbersim@unipi.gr

Abstract. Adverse events in Phase II comparative clinical trials have often been overlooked in the methodological literature, despite their significant impact on both trial outcomes and ethical considerations. In this work, we investigate a class of comparative sequential designs with bivariate endpoints, which incorporate mechanisms for either early trial termination or the imposition of penalties in response to severe adverse events. The designs are analytically studied through the Markov chain embedding technique, providing a flexible and rigorous probabilistic framework. The proposed class of designs achieves a desirable trade-off: maintaining high statistical power while substantially reducing the expected sample size. This balance supports key ethical principles in clinical research, promoting faster, more informed decision-making and minimizing patient exposure to potentially harmful treatments.

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On the preservation of ageing properties under random maxima

Panayiotis Bobotas[1] & Markos V. Koutras[2]

[1]Department of Mathematics, University of Patras, Greece

[2]Department of Statistics and Insurance, University of Piraeus, Greece

pbobotas@upatras.gr; mkoutras@unipi.gr

Abstract. Bobotas and Koutras (2019) studied the exact distributions of random minimum and maximum of a random sample of continuous positive random variables, when the support of the sample size distribution contains zero, providing a probability model which had not been systematically studied in the literature until then. That work triggered in turn a meticulous study by Bobotas and Koutras (2024) on the preservation of ageing properties such as increasing failure rate (IFR), increasing failure rate average (IFRA), and new better than used (NBU), under random maxima. The results unify, complete, correct, extend and/or generalize existing ones in the literature. As a by-product, the above ageing notions are also introduced for a nonnegative mixed-type random variable.

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Self-Starting Shiryaev (3S): A Bayesian Change Point Model for Online Monitoring of Short Runs

Konstantinos Bourazas[1] & **Panagiotis Tsiamyrtzis**[2,3]

[1] Department of Economics, Athens University of Economics and Business, Greece

[2] Department of Mechanical Engineering, Politecnico di Milano, Italy

[3] Department of Statistics, Athens University of Economics and Business, Greece
kbourazas@aueb.gr; panagiotis.tsiamyrtzis@polimi.it; pt@aueb.gr

Abstract. The Shiryaev's change point methodology is a powerful Bayesian tool in detecting persistent parameter shifts. It has certain optimality properties when we have pre/post-change known parameter setups. In this work we will introduce a self-starting version of the Shiryaev's framework that could be employed in performing online change point detection in short production runs. Our proposal will utilize available prior information regarding the unknown parameters, breaking free from the phase I requirement and will introduce a more flexible prior for change-point parameter, compared to what standard Shiryaev employs. Apart from the on-line monitoring, our proposal will provide posterior inference for all the unknown parameters, including the change point. The modeling will be provided for Normal data, and we will guard for persistent shifts in both the mean and variance. A real data set will illustrate its use, while a simulation study will evaluate its performance against standard competitors.

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On joint discounted densities of the deficit and the number of claims until ruin, assuming dependent claim sizes and inter-claim times

Michael V. Boutsikas & David-Jacob Economides

University of Piraeus, Greece

mbouts@unipi.gr; davoik@unipi.gr

Abstract. We propose a generalization of the Gerber-Shiu function that incorporates the number of claims until ruin under the dependent Sparre-Andersen risk model with the presence of dependence between the claim sizes and the inter-claim times. Using an appropriate change of measure technique based on Esscher transform, we present a connection between already studied Gerber-Shiu functions and the proposed generalized. We also offer a result connecting a special form of the Gerber-Shiu function that depends on the distribution of the deficit at ruin under the new measure. We further employ a Downton-Moran bivariate exponential distribution to describe the dependence structure of our model and we offer explicit formulae for some cases of the Gerber-Shiu functions that include the number of claims until ruin. In addition, we derive a closed formula for the defective discounted joint density of the number of claims until ruin, the deficit at ruin, and the time until ruin.

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On the distribution of the number of success runs in a continuous time Markov chain

Michael V. Boutsikas[1] & Eutichia Vaggelatou [2]

[1]Dept. of Statistics & Insurance Science, University of Piraeus, Greece
[2]Dept. of Mathematics, National and Kapodistrian University of Athens, Greece

mbouts@unipi.gr; evagel@math.uoa.gr

Abstract. We propose a continuous-time adaptation of the well-known concept of success runs by considering a marked point process with two types of marks (success-failure) that appear according to an appropriate continuous-time Markov chain. By constructing a bivariate imbedded process (consisting of a run-counting and a phase process), we offer recursive formulas and generating functions for the distribution of the number of runs and the waiting time until the appearance of the n-th success run. We investigate the three most popular counting schemes: (i) overlapping runs of length k, (ii) non-overlapping runs of length k and (iii) runs of length at least k. We also present examples of applications regarding: the total penalty cost in a maintenance reliability system, the number of risky situations in a non-life insurance portfolio and the number of runs of increasing (or decreasing) asset price movements in high-frequency financial data.

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Entropy Measures in Mortality Modelling

Apostolos Bozikas, Georgios Psarrakos & Peter Hatzopoulos

Department of Statistics and Insurance Science, University of Piraeus, Greece

bozikas@unipi.gr; gpsarr@unipi.gr; xatzopoulos@unipi.gr

Abstract. In this talk, we present some entropy measures derived from changes in the survival function, allowing us to assess the predictability of survival probabilities across various age groups. These entropy measures are then integrated into appropriate mortality frameworks, which include many conventional actuarial models, to evaluate their ability to reflect demographic changes and long-term mortality patterns. The numerical examples illustrate how entropy can enhance mortality modelling, aiming to provide a valuable addition to traditional actuarial approaches for analyzing mortality trends.

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Entropy measures of population dynamics and economic implications

Elena Corina Cipu[1,2,4], **Vasile Preda**[3,4,5] & **Carmen Adriana Gheorghe**[4]

[1]Centre for Research and Training in Innovative Techniques of Applied Mathematics in Engineering "Traian Lalescu" (CiTi), UNSTPB, Romania

[2]Department of Applied Mathematics, Faculty of Applied Sciences, UNSTPB

[3]"Gheorghe Mihoc – Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of the Romanian Academy (ISMMA)

[4]V. Trebici" Center for Demographic Research, "Costin C. Kiritescu" National Institute of Economic Research of Romanian Academy, Romania

[5]Faculty of Mathematics, University of Bucharest, Romania

corina.cipu@upb.ro; vasilepreda0@gmail.com; carmen.adriana@ince.ro

Abstract. Entropy measures provide powerful quantitative tools to assess the uncertainty, diversity, divergence or inequality inherent in dynamics of the population. In this paper there are some specific entropy metrics, such as Keyfitz's entropy and Shannon entropy, that are interpreted as a parameter for the internal state of a system. It is studied how they can be used in the demographic domain to analyze lifespan variability, age structure diversity, the predictability of population aging, migration or heterogeneity of labor force characteristics. Economically, entropy indicators are closely linked to challenges with sustainability, healthcare labor market flexibility, and income inequality. The purpose of this paper is to determine entropy as a parameter for regional demographic dynamics in the Romanian population system and over Europe and connect these indicators with migration, labour force, or education that are relevant for macroeconomic simulations, human capital assessments, and regional development strategies.

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Enhancing Civic Engagement: Behavioral Insights from Young Students

Theodore Chadjipadelis

Aristotle University of Thessaloniki & Hellenic Open University, Greece

chadji@polsci.auth.gr

Abstract. Civic education is fundamental to fostering active, responsible citizens and ensuring the sustainability of democratic societies. This paper presents a didactic intervention implemented in collaboration with secondary schools since 2017. The intervention engages university students in designing and conducting interactive workshops with high school students, using innovative methods such as role-playing, group learning, and scenario-based activities to simulate democratic processes. This year's intervention focused specifically on promoting civic engagement, cultivating a sense of collective responsibility, and encouraging collaboration within democratic frameworks to address disruptive behavior, individualistic - self-centered- attitudes, and violence.

The study analyzes data, exploring the impact of the intervention on their civic awareness, behavioral frameworks, and perceptions of democratic values. Key variables examined include political behavior, interest, mobilization, and attitudes towards collaboration and responsibility. The analysis employs a two-step multivariate methodology, combining Hierarchical Cluster Analysis (HCA) and Factorial Correspondence Analysis (FCA), to identify and visualize patterns in students' responses. The results highlight how the intervention enhanced students' understanding of their roles as citizens, reducing individualistic tendencies and fostering a deeper appreciation for democratic processes and ethical citizenship.

By integrating qualitative observations from the workshops and quantitative insights from the survey, this paper underscores the transformative potential of civic education in shaping the "citizen identity" of young individuals. It offers actionable recommendations for educators and policymakers seeking to address civic disengagement and promote a culture of collaboration and responsibility in democratic societies.

Repeated Measurements Designs: The existence of a control treatment in a model of two treatments

Miltiadis Chalikias

University of West Attica, Greece

mchalik@uniwa.gr

Abstract. It is of interest Repeated Measurement Designs of three treatments, n experimental units and m periods (RMD (t=3, n, m)) when one of the three treatments is a control treatment.

The method of calculating the information matrix is presented, which is used to find optimal designs for estimating the direct and residual effects. The model is similar to that presented by Hedayat and Afsarinejad for the case of the two treatments and the calculation method has been used in the two treatments by Laska and Meisner, Kunert, and Kounias and Chalikias.

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Supervised statistical (machine) learning for domain estimation with business survey data

Vasilis Chasiotis[1], **Nikos Tzavidis**[2], **Chiara Bocci**[3] & **Paul Smith**[2]
[1]Athens University of Economics and Business, Greece
[2]University of Southampton, Southampton, UK
[3]University of Florence, Italy
chasiotisv@aueb.gr; N.TZAVIDIS@soton.ac.uk; chiara.bocci@unifi.it; P.A.Smith@soton.ac.uk

Abstract. We discuss current research on supervised statistical (machine) learning methods (random forests) and extensions to mixed effects random forests (Krennmair & Schmid, 2022), as a flexible method for domain estimation with business survey data. Random forests excel in terms of predictive performance. Automated model-selection and detecting covariate interactions make their use appealing for prediction problems. Mixed effects random forests, however, appear to be going against the algorithmic modelling culture (Breiman, 2001), that treats the prediction mechanism as unknown, and are more in line with the data modelling culture (Efron, 2020). Model-based estimation with business survey data requires careful handling and may include outlier robust estimation, complex modelling of the model variance and use of data-driven transformations. We explore the use of random forest-type algorithms for estimation of finite population parameters. We focus on critically evaluating (a) the role of random effects in machine learning algorithms, (b) the role of data transformations, and (c) whether machine learning algorithms offer protection under misspecification of linear-type models. Small area predictors are derived by using a smearing-type estimator that has been explored in small area and survey estimation before in the context of outlier-robust estimation (Chambers *et al*., 2014). A non-parametric bootstrap MSE estimator is evaluated. We compare machine learning-based predictors to empirical best predictors and outlier robust predictors under a linear mixed model (Smith *et al*., 2021) using real business survey data form Italy. This work aims to inform the discussion on the use of machine learning methods in the production of official statistics.

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Operator norm for random matrices with general variance profile

Dimitris Cheliotis[1] & **Michail Louvaris**[2]

[1]National and Kapodistrian University of Athens, Greece

[2]Yale University, U.S.A

dcheliotis@math.uoa.gr; louvarismixalis@gmail.com

Abstract. We prove the convergence of the operator norm of general variance profile random matrices to the largest element of the support of the limiting empirical spectral distribution under very general assumptions for the variance profile of the matrices. We also prove that it is sufficient for the entries of the matrix to have finite only the \$4\$-th moment or the \$4+\epsilon\$ moment in order for the convergence to hold in probability or almost surely respectively. Our approach covers the cases of random symmetric or non-symmetric matrices whose variance profile is given by a step or a continuous function, random band matrices whose bandwidth is proportional to their dimension, random Gram triangular matrices and more.

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Unasked, Unanswered: The Quiet Power of Interviewers in a Large Panel International Survey

Michail Chouzouris & Platon Tinios

University of Piraeus, Greece

mchouzouris@unipi.gr; ptinios@gmail.com

Abstract. Non-response, whether at the unit or item level, remains a persistent challenge in survey research, particularly in face-to-face interviews addressing sensitive topics such as household income. Refusal or inability to answer can introduce significant biases in statistical inference which can affect policy conclusions. This is especially worrisome in multinational surveys frequently used in the European Union. Although interviewer effects are well-documented, the mechanisms driving these effects are less understood, especially concerning the role of interviewer expectations and intrapersonal skills. This study explores item non-response on income using a unique dataset cataloguing interviewer views and behaviour. In particular, we investigate the influence of interviewer characteristics on item non-response in a large multinational panel survey, the Survey of Health, Ageing and Retirement in Europe (SHARE), emphasizing income-related questions. Drawing on data from SHARE wave 7 and the Interviewer Survey, we, first, investigate the frequency and spread of the item non-response problem across the 22 SHARE countries participating in the interviewer survey and analyze whether characteristics of the interviewer such as sociodemographic traits, survey experience, and psychological attributes can influence response patterns. The first results examine if interviewer attitudes and personal qualities are significantly related to higher response rates. These findings underscore the critical- yet often subtle- role interviewers play in influencing data quality and highlight the importance of incorporating both interpersonal skills and professional competencies in interviewer recruitment and training.

The joys and challenges of the Kolmogorov expected value

Manuela-Simona Cojocea

University of Bucharest, Faculty of Mathematics and Computer Science, Romania

simona.cojocea@fmi.unibuc.ro

Abstract. The Kolmogorov expected value, the population counterpart of the Kolmogorov mean, also known as quasi-arithmetic mean, f-mean or generalized mean, is being constructed for both discrete and continuous random variables. We show how this measure of central tendency is particularly useful for the case of random variables without finite means and we conduct a simulation study which underlines some of the applications and limitations of this type of generalized mean.

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Testing independence in the presence of missing data: high-dimensional case

Marija Cuparić[1], **Bojana Milošević**[1] & **Jelena Radojević**[1,2]

[1]University of Belgrade, Faculty of Mathematics, Serbia

[2]University of Belgrade, Faculty of Civil Engineering, Serbia

marija.cuparic@matf.bg.ac.rs; bojana@matf.bg.ac.rs; jradojevic@grf.bg.ac.rs

Abstract. In this talk, we introduce the problem of testing independence within high-dimensional data and modify a recently proposed Kendall-based statistic to account for missing values in the dataset. In particular, two novel modifications are proposed, and their properties are examined from both theoretical and practical perspectives. The results of a comprehensive empirical study will also be presented. These findings contribute to the development of robust nonparametric tools suitable for modern incomplete data settings.

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Improved Shewhart-type control charts based on weak runs in multistate trials

Spiros D. Dafnis[1], Theodoros Perdikis[2] & Markos V. Koutras[3]

[1]Department of Statistics & Actuarial-Financial Mathematics, University of the Aegean, Greece

[2]Department of Tourism Studies, University of Piraeus, Piraeus, Greece

[3]Department of Statistics and Insurance Science, University of Piraeus, Piraeus, Greece

sdafnis@aegean.gr; theoperdik@unipi.gr; mkoutras@unipi.gr

Abstract. In this work we introduce two new classes of Shewhart-type control charts with supplementary runs rules using a three or four region partition of the observed characteristic's range. The study of the control charts' characteristics (run length distribution, average run length) is carried over by considering an extension of the concept of r-weak runs (which was recently introduced for sequences of binary trials) under a multistate framework. Our numerical experimentation provides useful hints for the implementation of the new control charts by a practitioner and reveals that the proposed charts significantly improve the detection power (as compared to other existing charts) especially for small shifts in the process mean.

On the behavior of the global reaching centrality

Guglielmo D'Amico[1], Riccardo De Blasis[2] & Pegah Mahdavi[3]

[1]Department of Economics, University of Chieti-Pescara, Italy

[2]Department of Management, Marche Polytechnic University, Italy

[3]Department of Neuroscience, University of Chieti-Pescara, Italy
g.damico@unich.it; r.deblasis@univpm.it; pegah.mahdavi@phd.unich.it

Abstract. Many complex systems show hierarchical organization, which means that small groups of nodes tend to connect to each other hierarchically, creating larger groups (Ravasz and Barabási, 2003). This feature is one of the main characteristics of complex networks, both living and artificial (Corominas-Murtra et al., 2013). Hierarchy can be divided into three major types: order, nested, and flow hierarchy. The first is simply an ordered set. The nested one consists of different clusters of nodes organized into levels of hierarchy. Finally, the flow hierarchy includes different layers that can influence others at lower levels (i.e., directed networks) (Mones, 2013). A measure for hierarchy is the global reaching centrality (GRC) (Mones *et al*., 2012) that can be applied to both directed and undirected networks, as well as to weighted and unweighted networks. In particular, for the unweighted network, this measure can be seen as a normalized difference between the maximum and average size of reachable sets of nodes. Some authors explore the flow hierarchy by analyzing the GRC measure in the context of different random networks with no degree correlation, such as hierarchical trees, Erdos–Rényi graph, exponential networks, and scale-free networks. In this work, we further expand the analysis of the behavior of the GRC measure investigating directed and weighted networks with adjacency matrices based on stochastic weight matrices. We explore how the GRC function behaves in the presence of extreme cases with different levels of entropy. Specifically, we assess cases including absorbing nodes or nodes at maximum entropy, i.e., all weights are equally distributed. To this extent, we present several properties of the GRC measure with some numerical examples. Among the potential applications, we include social and economic networks, as well as energy networks, e.g., wind farms or energy communities.

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Reliability Analysis of Energy Communities

Guglielmo D'Amico[1] & Salvatore Vergine[2]

[1]Department of Economics, University G. d'Annunzio of Chieti-Pescara, Italy

[2]Department of Management, Marche Polytechnic University, Italy

g.damico@unich.it; s.vergine@staff.univpm.it

Abstract. Dependability measures are essential for various engineering problems, the one dealing with the planning and development of a wind farm included. In this work, we address the problem of quantifying the mismatch between wind production and energy demand within energy communities through well-known dependability measures, such as reliability and availability functions, and recent metrics such as sequential interval reliability. The integration of battery storage systems is also considered, as it significantly enhances performability metrics by mitigating the variability of wind energy and improving alignment with demand. To achieve this objective, we modeled wind power using the discrete-time semi-Markov process and compared the obtained real wind power and the simulated data to demonstrate the validity of the proposed approach. Furthermore, we test different energy communities by aggregating buildings both randomly selected from the database and correctly chosen by solving an optimization problem that minimizes the mismatch between wind production and cumulative demand. The results show that the proposed model and metrics are suitable for studying wind production in relation to energy demand and provide useful information for the management and design of an energy community.

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Instantaneous Mobility indexes for Markov Reliability Systems applied to Wind-Farm

Guglielmo D'Amico & Filippo Petroni

Dipartimento di Economia, Università 'G. d'Annunzio' Chieti-Pescara, Italy

g.damico@unich.it; filippo.petroni@unich.it

Abstract. The Rate of Occurrence of Failures (ROCOF) is a widely utilized indicator for assessing a system's performance over time, yet it does not fully disclose the instantaneous behavior of a system. This paper introduces new measures to complement the ROCOF, providing a more comprehensive understanding of system reliability, particularly for Markov systems. We define the Rate of Occurrence of Repairs (ROCOR), which quantifies the system's instantaneous tendency to transition from failure to working states, and the Rate of Inoccurrence (ROI), which measures the propensity to remain within the current subset of states (either working or failure) without transitioning out. Explicit expressions for the computation of these rates are derived for Markov systems. Furthermore, a Total Mobility Rate (TMR) is proposed, integrating these individual rates to capture the overall dynamism of the system. The utility of these new indicators is demonstrated through a significant real-world application to wind farm management. The results from the wind farm study show that ROCOR, ROI, and TMR, when used in conjunction with ROCOF, reveal nuanced operational dynamics and reliability characteristics that are not discernible from static measures like Weibull parameters or ROCOF alone. These indicators can distinguish between sites with similar long-term wind profiles by identifying different "reliability logics," such as persistence-driven versus transition-driven behaviors. This enriched, time-dependent perspective provides valuable information for maintenance scheduling, operational strategies, and risk assessment, ultimately enhancing the ability to manage complex systems effectively.

General information measures for loss models and survival models involving truncated and censored random variables

Silvia Dedu[1,2], **Vasile Preda**[2,3,4] & **Muhammad Sheraz**[5]

[1] Department of Applied Mathematics, Bucharest University of Economic Studies, Bucharest, Romania

[2] "V. Trebici" Center for Demographic Research, "Costin C. Kiritescu" National Institute of Economic Research, Romanian Academy, Bucharest, Romania

[3] "Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics, Bucharest, Romania

[4] Faculty of Mathematics and Computer Science, University of Bucharest, Romania

[5] Institute of Business Administration Karachi, Department of Mathematical Sciences, School of Mathematics and Computer Science, Karachi, Pakistan

silvia.dedu@csie.ase.ro; vasilepreda0@gmail.com; msheraz@iba.edu.pk

Abstract. Risk assessment represents an important topic in various fields, since it allows designing the optimal strategy in real-world problems. Information measures can be used to evaluate uncertainty corresponding to phenomena described by random variables. This paper aims to develop an entropy-based approach to risk assessment for actuarial models involving truncated and censored random variables. The research is focused on studying the effect of partial insurance models, such as inflation, truncation and censoring from above and truncation and censoring from below upon the entropy of losses using general information measures. Analytic expressions for the per-payment and per-loss entropies are derived, and the relationship between these measures is investigated. The combined effect of a deductible and a policy limit is also studied. By considering the residual and past entropies for survival models, the entropies of losses corresponding to the proportional hazard and proportional reversed hazard models are derived. The properties of the resulting entropies, such as residual loss entropy and past loss entropy, are investigated as a result of using a deductible or a policy limit. The entropy of losses is computed and illustrated for different distribution models. The detected behavior proves that the general information measures approach for actuarial models involving truncated and censored random variables provides a new and relevant perspective, since it allows a higher flexibility and improves the modeling accuracy.

On reliability evaluation of fuel cell stack system subject to competing failures

Yilser Devrim & Serkan Eryilmaz

Atilim University, Ankara, Turkey

yilser.devrim@atilim.edu.tr; serkan.eryilmaz@atilim.edu.tr

Abstract. A polymer electrolyte membrane fuel cell (PEMFC) stack is an electrochemical system consisting of a specified number of degrading cells. Degradation in the voltage of cells forming the fuel cell causes the performance of the entire fuel cell to decrease. On the other hand, fuel cells are subjected to different types of shock and vibration inherent to the environments where they are utilized. In this context, the reliability assessment of a fuel cell requires a model that takes into account both degradation and shocks. Competing failure processes are suitable for such a model. This study is concerned with the investigation of fuel cell reliability under competing failure processes.

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Stochastic processes with bimodal transition densities: construction and centroid-based analysis

Antonio Di Crescenzo

Dipartimento di Matematica, Università degli Studi di Salerno, Italy

adicrescenzo@unisa.it

Abstract. Various natural phenomena are influenced by random dynamics shaped by opposing forces, leading to behaviors best described by stochastic processes with bimodal transition densities. These densities are often modeled as suitable mixtures.

After a brief review of well-known case studies—such as one- and two-dimensional birth-death processes and one-dimensional diffusion processes—we introduce new constructions of multidimensional diffusion processes characterized by bimodal transition densities, with a particular focus on those derived from the Wiener and the Ornstein-Uhlenbeck processes.

Finally, we investigate centroid-based methods to represent these distributions, highlighting their potential applications in the applied sciences.

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Limit Equilibria in Stochastic Resource Allocation Games

Antonis Dimakis[1] **& Costas Courcoubetis**[2]

[1]Athens University of Economics and Business
[2]Chinese University of Hong Kong - Shenzhen
dimakis@aueb.gr; costas@cuhk.edu.cn

Abstract. Many applications involve repeated interactions between agents who compete for the same resources, as in crowdsourcing and ridehailing platforms, road and communication networks. These are typically modeled as stochastic games involving multiple interacting Markov decision processes, for which equilibrium computation is generally intractable.

We approximate equilibria by analyzing their limit when the number of agents and resources grow proportionally. The limit game is remarkably tractable, as its Nash equilibria coincide with the solutions of a convex optimization problem. Using convex duality, we derive valuable structural insights into these systems: agents earn at least half of what they would under perfect coordination, the joint learning and queueing dynamics are Lyapunov stable, equilibrium approximations can be computed efficiently via fast polynomial-time algorithms. Finally, we note that if agent rewards satisfy *proportional fairness* (Kelly 1997), agents ultimately learn strategies that maximize collective earnings—as if they were perfectly coordinated.

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Some applications of Markov decision processes using stochastic dynamic programming

Theodosis D. Dimitrakos

Department of Mathematics, University of the Aegean, Karlovasi, Samos, Greece

dimitheo@aegean.gr

Abstract. We consider various mathematical models for the optimal control of stochastic processes controlled by a sequence of actions. A process is reviewed at equidistant time points, and the state of the process is observed at each review. After observing the state of the process, a controlling action is taken. The controlled system is a discrete-time Markov Decision Process if (a) the economic consequences of choosing a specific action a, when the state of the process state is i, are represented by an immediate or expected cost $C(i, a)$, which depends only on i and a, and (b) if action a is taken, when the state of the process is i, the next state of the process will be j, with probability $p_{ij}(a)$, which depends only on i, j and a. A policy is any rule of choosing actions at each decision epoch. We seek a policy that, for each initial state of the process, minimizes a predefined function of the expected future cost which predefines the optimality criterion of the problem. The most usual optimality criterion is the minimization of the long run expected average cost per unit time. The Markov decision model is an outgrowth of the Markov model and dynamic programming. Dynamic programming is a recursion procedure for calculating optimal value functions from a functional equation. The models that we briefly present are related with: (i) optimal control of epidemic processes and biological populations, (ii) optimal maintenance and/or replacement of machines or system equipment, (iii) optimal stochastic single vehicle routing problems and (iv) optimal control of emergency medical service systems.

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On various dependence structures in vector-valued reflected autoregressive processes

Ioannis Dimitriou

Department of Mathematics, University of Ioannina, Greece

idimit@uoi.gr

Abstract. In this work, we study Markov-dependent reflected autoregressive processes, and other related models the analysis of which results in a vector-valued fixed-point functional equation of a certain type. In queueing terms, such processes describe the workload just before a customer arrival, which makes obsolete a fraction of the work already present, and where the interarrival time and the service time depend on a common discrete time Markov chain. Our primary aim is to derive the Laplace-Stieltjes transform vector of the steady-state workload via a recursive approach. We consider the following cases: Given the state of the underlying Markov chain a) the interarrival time and the service time are conditionally independent, b) there is also additional dependence based on the Farlie-Gumbel-Morgenstern copula, c) there is a dependence based on a class of multivariate matrix-exponential distributions. The transient analysis of the Markov-modulated reflected autoregressive process with a more general dependence structure is also investigated. Finally, motivated by queueing applications, we will discuss other related Markov-modulated multiplicative Lindley-type recursions.

A Classification and Adversarial Approach on the Under-Sampled UMNIDS Dataset

Christos Douligeris & Iakovos-Christos Zarkadis

University of Piraeus, Greece

cdoulig@unipi.gr; iakovos.zarkadis@gmail.com

Abstract. This research examines firstly the capabilities of machine learning algorithms to solve a classification task, on the under-sampled Unified Multimodal Network Intrusion Detection System dataset, which combines network flow data, packet payload information and contextual features, which makes it ideal for cross-datasets validation. Secondly, with the emerging threats of AI and Machine Learning security issues, which will affect, probably threaten, our privacy, social security, personal rights and freedoms in the upcoming years, we focus on a modern statistic-based approach, Adversarial Learning algorithms to generate data that will be inevitable for an Intrusion Detection System to figure real from fake, highlighting our personal capabilities in order to keep our human identity and emotional intelligence.

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Stein's Method of Moments

Bruno Ebner[1], Adrian Fischer[2], Robert E. Gaunt[3], Babette Picker[1] & Yvik Swan[4]

[1]Karlsruher Institut für Technologie, Germany

[2]University of Oxford, UK

[3]The University of Manchester, UK

[4]Université Libre de Bruxelles, Belgium

bruno.ebner@kit.edu; adrian.fischer@stats.ox.ac.uk; robert.gaunt@manchester.ac.uk; babette.picker@kit.edu; yvik.swan@ulb.be

Abstract. Stein operators allow to characterize probability distributions via differential operators. Based on these characterizations, we develop a new method of point estimation for marginal parameters of strictly stationary and ergodic processes, which we call *Stein's Method of Moments* (SMOM). These SMOM estimators satisfy the desirable classical properties such as consistency and asymptotic normality. As a consequence of the usually simple form of the operator, we obtain explicit estimators in cases where standard methods such as (pseudo-) maximum likelihood estimation require a numerical procedure to calculate the estimate. In addition, with our approach, one can choose from a large class of test functions which allows to improve significantly on the moment estimator. Moreover, for i.i.d. observations, we retrieve data-dependent functions that result in asymptotically efficient estimators and give a sequence of explicit SMOM estimators that converge to the maximum likelihood estimator. Our simulation study demonstrates that for a number of important univariate continuous probability distributions our SMOM estimators possess excellent small sample behavior, often outperforming the maximum likelihood estimator and other widely-used methods in terms of lower bias and mean squared error. We also illustrate the pertinence of our approach on a real data set related to rainfall modelization.

The M/M/1 queue with strategic arrivals who are informed about other arrivals' decisions: Performance evaluation using QBD processes, game-theoretic analysis and implications

Antonis Economou

Department of Mathematics, National and Kapodistrian University of Athens, Greece

aeconom@math.uoa.gr

Abstract. Strategic customer behavior in queueing systems has been studied intensively for more than 50 years. A recurrent theme is this thread of the literature is the study of the impact of information on strategic customer behavior, on the associated social welfare and on the revenue that is generated by a given system.

In the present talk, we will present some recent and ongoing studies that focus on the impact of providing some information to strategic arrivals about other arrivals' decisions. To keep the framework as simple as possible, we will consider the M/M/1 queue as our fundamental stylized model and will present various 2-dimensional continuous-time Markov chains that record the number of customers in the system and the information about recent arrivals' decisions in different cases of information. These Markov chains are QBD processes with special structures that facilitate the efficient calculations of their steady-state distributions and the computations of the equilibrium customer strategies. We will show several theoretical and numerical results. Moreover, we will compare the models with their unobservable and observable counterparts.

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A Novel HydroEconomic - Econometric Approach for Integrated Transboundary Water Management Under Uncertainty

Nikolaos Englezos[1], Xanthi Kartala[2], Phoebe Koundouri[3,6], Efthymios Mike Tsionas[4,5] & Angelos Alamanos[3]

[1]Department of Banking and Financial Management, University of Piraeus, Greece
[2]Department of Statistics, Athens University of Economics and Business, Greece
[3]School of Economics and ReSEES Research Laboratory, Athens University of Economics and Business, Greece
[4]Montpellier Business School, France; [5]Management School, Lancaster University, UK
[6]Department of Technology, Management and Economics, Technical University of Denmark.
englezos@unipi.gr; xkartala@aueb.gr; pkoundouri@aueb.gr; m.tsionas@lancaster.ac.uk; angalamanos@gmail.com

Abstract. The optimal management of scarce transboundary water resources among competitive users is expected to be challenged by the effects of climate change on water availability. The multiple economic and social implications, including conflicts between neighbouring countries, as well as competitive sectors within each country are difficult to estimate and predict, to inform policy-making. In this paper, this problem is approached as a stochastic multistage dynamic game: we develop and apply a novel framework for assessing and evaluating different international strategies regarding transboundary water resources use, under conditions of hydrological uncertainty. The Omo-Turkana transboundary basin in Africa is used as a case study application, since it increasingly faces the above challenges, including the international tension between Kenya and Ethiopia and each individual country's multi-sectoral competition for water use. The mathematical framework combines a hydro-economic model (water balance, water costs and benefits), and an econometric model (production functions and water demand curves) which are tested under cooperative and non-cooperative conditions (Stackelberg "leader–follower" game). The results show the cross-country and cross-sectoral water use—economic trade-offs, the future water availability for every game case, the sector-specific production function estimations (including residential, agriculture, energy, mining, tourism sectors), with nonparametric treatment, allowing for technical inefficiency in production and autocorrelated Total Factor Productivity, providing thus a more realistic simulation. Cooperation between the two countries is the most beneficial case for future water availability and economic growth. The study presents a replicable, sophisticated modelling framework, for holistic transboundary water management. This paper draws on results obtained in DAFNE Horizon 2020 Project: "Decision Analytic Framework to explore the water-energy-food Nexus in complex transboundary water resource systems of fast developing countries".

On some analogies between engineering and biological systems from a reliability engineering point of view

Serkan Eryilmaz

Atilim University, Ankara, Turkey

serkan.eryilmaz@atilim.edu.tr

Abstract. This conceptual work is an attempt to establish some analogies between engineering and biological systems by focusing on specific concepts or topics of reliability analysis. To this end, some basic concepts of reliability engineering are presented and how they can be defined for the human organism and what they correspond to. Further, it is also aimed at establishing an analogy by taking into account the reliability engineering approach, which is greatly influenced by the developments in today's digital technologies, e.g. digital twins.

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A family of three–level orthogonal arrays useful for fitting second order linear models with quantitative factors

Haralambos Evangelaras

Department of Statistics and Insurance Science, University of Piraeus, Greece

hevangel@unipi.gr

Abstract. In this work we explore a family of three–level orthogonal arrays that can be used to efficiently explore linear, quadratic and interaction effects of quantitative factors, using second order linear models. Properties of these designs are discussed, and lists of efficient arrays are given for small run orders.

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A Robust Approach for Variance Component Estimation under Missing Data

Dário Ferreira & Sandra Ferreira

Department of Mathematics and Center of Mathematics and Applications, University of Beira Interior, Portugal

dario@ubi.pt; sandraf@ubi.pt

Abstract. Variance component estimation is vital in linear mixed models but traditional methods struggle with missing data, leading to bias and inefficiency. To address this, we propose the Bayesian-Stochastic Approximation Expectation-Maximization (BSA-EM) method, which combines EM for missing data imputation and BSA for variance estimation with Bayesian regularization and stochastic approximation. Numerical experiments show BSA-EM outperforms existing methods in accuracy, robustness, and efficiency, especially for unbalanced or sparse datasets.

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An Extension of the Weibull Distribution to Accommodate Non-Monotonic Hazard Functions: Properties and Applications

Sandra S. Ferreira & Dário Ferreira

Mathematics Department and Center of Mathematics and Applications,
University of Beira Interior, Covilhã, Portugal
sandraf@ubi.pt; dario@ubi.pt

Abstract. The extensive application of the Weibull distribution in evaluating reliability and survival has motivated statisticians to create improved models. The traditional Weibull distribution has limitations as it can only model failure rates that constantly increase or decrease. In this work, we present an extension to address failure rates that exhibit bathtub-shaped and unimodal behaviors. This extension demonstrates greater adaptability compared to the standard Weibull distribution. The relevance of this proposed distribution is confirmed through the analysis of a real-world dataset, alongside model comparisons and visual aids that reinforce the theoretical basis.

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A Max-type control chart with runs rules for monitoring a shifted exponential process

Konstantinos G. Fountoukidis, Demetrios L. Antzoulakos & Athanasios C. Rakitzis

Department of Statistics and Insurance Science, University of Piraeus, Greece

k.fountoukidis@unipi.gr; dantz@unipi.gr; arakitz@unipi.gr

Abstract. Supplementary runs rules have been used in statistical process control, for normal and non-normal data, to improve the performance of control charts in detecting small to moderate shifts in process parameters. Currently, there is an increasing interest in monitoring shifted (or two-parameter) exponential distributed processes. The shifted exponential distribution is a probability model that is widely used in many practical applications to model time-to-event data. In the present paper we introduce and study a Max-type control chart supplemented with runs rules for simultaneously monitoring the parameters of a shifted exponential process. Using the Markov chain method, we evaluate the run length distribution of the chart and critical measures for assessing its performance for increasing and/or decreasing shifts in process parameters. The performance of the chart is compared with other competitive control charts, such as the SEMLE-Max and the RS-SEMLE-Max. Finally, a real dataset is used to illustrate the implementation of the proposed chart.

Convex distance bounds for the stable central limit theorem via Stein’s method

Robert E. Gaunt & Zixin Ye

University of Manchester, UK

Robert.gaunt@manchester.ac.uk; zixin.ye@postgrad.manchester.ac.uk

Abstract. The stable central limit theorem is a generalisation of the classical central limit theorem that relaxes the finite variance assumption. Quantifying the quality of the distributional approximation of the stable central limit theorem is a fundamental problem in probability, which has seen a number of contributions over years. In particular, there have been recent advances on this problem using Stein's method in which the stable central limit theorem is quantified with respect to Wasserstein-type distances. In this talk, we use Stein's method to derive optimal rates of convergence in the multivariate stable central limit theorem in terms of the convex distance, which is a natural multivariate generalisation of the Kolmogorov distance. Our bounds are derived by combining the recent advances on Stein's method for alpha-stable distributions together with a powerful smoothing technique.

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Composite designs and alternatives for response surface methodology

Stelios D. Georgiou & Stella Stylianou

Department of Mathematical and Geospatial Sciences

School of Science, RMIT University, Australia

Stelios.georgiou@rmit.edu.au

Abstract. Response Surface Methodology (RSM) refers to experimental designs for optimising or developing processes, initially in manufacturing. In this work, new methods are presented for constructing composite designs by modifying both the axial and factorial components to achieve improved D-values and overall design efficiency. One approach introduces an algorithm that replaces the classical axial part in a Central Composite Design (CCD) with flexible structures based on orthogonal designs (ODs), arranged in block formats. This allows the construction of efficient orthogonal designs suitable for sequential experimentation, including cases with odd numbers of factors that were previously not possible to design efficiently. A second approach proposes alternative composite designs using Definitive Screening Designs (DSDs) for the factorial part and standard or block-based orthogonal designs for the axial part. Both methods result in designs with better D-values and lower prediction variance compared to existing designs. The proposed designs are evaluated and compared with known alternatives in the literature, with results summarised in tables for practical application in a wide range of experimental settings.

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A Multiple Testing Approach to Scan Statistics

Joseph Glaz

University of Connecticut, U.S.A.

joseph.glaz@uconn.edu

Abstract. Scan statistics have been extensively used in scientific literature to identify and monitor local changes in model parameters in one or higher dimensional data. In this talk the use of a parametric bootstrap approach via the minimum P-value statistics will be discussed for several topics in statistics. An implementation of a repeated significance test via the minimum P-value statistic for one and two-dimensional normal data will be presented as well. Numerical results will be presented to evaluate the performance of this approach. Open problems will be discussed as well.

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Expected Number of Distinct Patterns in Random Permutations

Anant Godbole

East Tennessee State University, U.S.A.

godbolea@etsu.edu

Abstract. In this talk we will focus on the (difficult to find) expected value of a very interesting random variable X. In the case of random letter generation, $X = X_n$ will denote the number of distinct words of all lengths $1 \leq k \leq n$ found as substrings *or subsequences* of the word. In the case of permutations, X will be the number of distinct *patterns* found in the random permutation in *both the consecutive and non-consecutive cases*. As a result, our study will encompass patterns that occur both consecutively and non-consecutively. This talk contains work done jointly with Biers-Ariel, Borras-Serrano, Byrne, Kelley, Swickheimer, Veimau, and Zhang, and the key references are listed below.

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A General Stochastic Mortality Modelling Framework

Peter Hatzopoulos & Apostolos Bozikas

Department of Statistics and Insurance Science, University of Piraeus, Greece

xatzopoulos@unipi.gr; bozikas@unipi.gr

Abstract. In this talk, we introduce a novel estimation approach based on the following procedure. Firstly, we use appropriate generalized linear models to produce smooth estimates of mortality rates. Next, we apply sparse principal component analysis to derive the corresponding age, period, and cohort factors. The optimal number of these components is determined using the unexplained variance ratio, which helps to maximize the variance explained by the model while also controlling its sparsity. This approach aims to isolate clear and meaningful stochastic components and is tested on empirical mortality datasets.

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On the star order for convolutions of Erlang distributions and tests for the scale of hypoexponential distribution

George Iliopoulos

Department of Statistics and Insurance Science, University of Piraeus, Greece

geh@unipi.gr

Abstract. Some aspects related to the star order for convolutions of Erlang distributions (that is, the dispersive order of their logarithms) are discussed and then used in order to construct efficient tests for the scale parameter of hypoexponential distributions.

Estimating the Probability of Default Cascades in Financial Markets

Dimitris Ioannides
Department of Mathematics, University of Patras
and Department of Economics, University of Macedonia, Greece
dimioan@uom.edu.gr

Abstract. The recent theoretical and empirical literature on financial contagion has Investigated the relationships between the interbank exposure network and the financial stability of the banking system by Glasserman and Young (2015, 2016) for a nice recent surveys).

The financial network has been recognized as a source of financial crisis as shocks, which initially affect only few institutions, and propagate through the entire banking system producing a contagion cascade. The present paper studies the issue of financial contagion assuming that the shocks are random variables. Aim of the present paper is to study the issue of financial contagion assuming that the shocks are random variables. As is pointed in Glasserman and Young (2015) the interconnections among the banks create potential channels for contagion and amplification of the shocks. Contagion occurs when defaults by some banks tiger defaults by other banks through a domino effect, while amplification occurs where contagion stops but the losses among defaulting banks keep escalating because of their indebtedness to one another. They analyzed the probability of default cascades and consequent losses of value that are attributable to network connections by assuming that the shocks random variables follow well known distributions. The contribution of this paper is to extend the results for the modelling of shocks in Gasserman and Young (2016) and the estimation of the probability of default cascades for a more general random variables.

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Reliability assessment of systems equipped with protection blocks under discrete time modeling

Cihangir Kan

Xiían Jiaotong-Liverpool University, Suzhou, China

kancihangir@gmail.com

Serkan Eryilmaz

Atilim University, Ankara, Turkey

serkan.eryilmaz@atilim.edu.tr

Abstract. Protection blocks are frequently used in the design of certain systems as one of the reliability enhancing methods. In a single component system supported by a protection block, the failure rate of the component varies depending on whether the protection block is working or not. The component's failure rate is lower when the protection block is working properly. The protection block also has its own failure rate. In this work, the reliabilities of single unit and multi-component systems equipped with protection blocks are studied by considering the discrete time version of the model that has been previously studied in the literature.

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Some stochastic orders and aging properties of a recent family of continuous univariate distributions

Lazaros K. Kanellopoulos[1], **Spiros D. Dafnis**[1] & **Markos V. Koutras**[2]

[1]University of the Aegean, Greece

[2]University of Piraeus, Greece

lkanellopoulos@aegean.gr; sdafnis@aegean.gr; mkoutras@unipi.gr

Abstract. In this work we extend the aging results of Koutras and Dafnis (2025a) for the recently introduced $D_g^+(h)$ family of continuous univariate distributions. In reliability theory, it is well-known that aging classes and stochastic orders are closely connected. We explore this connection to study stochastic orderings between members of this family, based on the aforementioned aging classes. Furthermore, we provide applications involving actuarial and entropy measures.

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The future of electricity production from renewable sources in Greece using Grey Markov Models

Paraskevi Kapetanopoulou[1] & **Alex Karagrigoriou**[2]

[1]Department of Mechanical Engineering, University of Western Macedonia, Greece

[2]Department of Statistics and Insurance Science, University of Piraeus, Greece

pkapetanopoulou@uowm.gr; alex.karagrigoriou@unipi.gr

Abstract. In 2024, 46.9% of net electricity generated in the European Union came from renewable energy sources. Greece's energy landscape has undergone a significant transformation over the last decade. The country's primary energy production has shifted away from solid fossil fuels towards a greater reliance on renewable energy sources. Using a forecasting model that integrates the Grey system theory with Markov chains, the purpose of this study is to forecast the electricity production in Greece until 2034. The past 25 years, from 2000 to 2024, is taken as the basic data to fit the model. The forecast results have important implications as they can serve as a guide for adjusting current and future policies. The findings also reveal a significant potential for renewable energy sources to increase their share in Greece.

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Statistical inference for a generalized family of divergences with censoring

Alex Karagrigoriou[1], Christos Meselidis[2] & Ilia Vonta[3]

[1]Department of Statistics and Insurance Science, University of Piraeus, Greece

[2]Department for Applied Informatics, University of Macedonia, Greece

[3]Department of Mathematics, National Technical University of Athens, Greece

alex.karagrigoriou@unipi.gr; mesel.chri@gmail.com; vonta@math.ntua.gr

Abstract. Divergence measures are fundamental in statistical inference, serving as key tools for parameter estimation and the development of goodness-of-fit tests. Generalized families of divergence measures, such as the (Φ,α)-power divergence family, can lead to estimators and test statistics that outperform conventional approaches. A crucial challenge in statistical modeling is selecting an appropriate model when dealing with censored data, a frequent issue in survival analysis and reliability studies. This work introduces and analyzes a family of estimators and test statistics derived from the (Φ,α)-power divergence family, specifically designed for censored data schemes. Additionally, a comprehensive simulation study is conducted to assess the effectiveness of the proposed methodology.

Non-parametric random coefficient integer autoregressive models

Dimitris Karlis[1], Naushad Mamode Khan[2] & Vishal Sunecher[2]

[1]Athens University of Economics and Business, Greece

[2]University of Mauritius, Mauritius

karlis@aueb.gr

Abstract. Random coefficient INteger AutoRegressive (RCINAR) models constitute an important extension of the simple INAR model when the thinning parameters are considered to be random. In the present paper we propose the case that the thinning parameter follows a discrete distribution with positive probability to a finite number of points. We provide an EM algorithm to estimate the model while we link the model to the non-parametric Maximum Likelihood estimate of the mixing distribution. The ideas are then extended to the bivariate case where the thinning parameters is now a matrix of random variables. The finite mixture representation helps a lot to account for the extra variability but also extra correlation to the model.

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Uncertainty Quantification for Scalable Reinforcement Learning

Michael N. Katehakis

Department of Management Science and Information Systems, Rutgers University, New Jersey, U.S.A.

mnk@business.rutgers.edu

Abstract. We explore advanced Reinforcement Learning (RL) methodologies for complex MDPs, covering both classical algorithms (Q-Learning, R-Learning, UCB, PSRL) and modern approaches integrating Transformers with uncertainty quantification techniques (Ensembles, Bootstrapped Heads, MC Dropout). These combined approaches enable RL to handle large, continuous state-action spaces by capturing complex dependencies while supporting exploration-exploitation decisions through confidence bounds. Empirical examples demonstrate computational trade-offs and performance advantages of different uncertainty estimation strategies, showing promise for high-dimensional, real-world problems by bridging theoretical guarantees with practical scalability.

Step-Stress Accelerated Life Testing:
New Developments and Trends in Reliability Modeling

Maria Kateri

RWTH Aachen University, Germany

maria.kateri@rwth-aachen.de

Abstract. Accelerated life testing (ALT) is a key method in reliability analysis, applied across various fields such as material science and biomedical research. In step-stress ALT (SSALT) experiments, stress on test units is incrementally varied, typically increased, over time to induce earlier failures. Within a parametric framework, statistical inference methods are employed to estimate the lifetime distribution parameters, which are extrapolated to normal operating conditions based on a stress-parameter relationship. The SSALT model relies on several assumptions, including the timing and nature of stress level changes, the termination criteria for the experiment, and the assumed lifetime distributions of the test units. The associated statistical inference procedures depend on the type of censoring and the method of failure monitoring (i.e., continuous or interval monitoring). This presentation explores SSALT models, focusing on a flexible approach utilizing a general-scale family of distributions. We discuss maximum likelihood and maximum product of spacings estimators for scale parameters in Type-I censored experiments. Furthermore, we extend the analysis to heterogeneous SSALT models, where mixture models are used to account for population variations in aging behavior.

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Ex-post Risk Premia Estimation using Large Cross Sections of Assets: Regularization and Clustering

Soohun Kim[1] & **Georgios Skoulakis**[2]

[1]KAIST, Republic of Korea; [2]University of Piraeus, Greece

soohun.kimi@gmail.com; georgios.skoulakis@unipi.gr

Abstract. Estimating risk premia using large cross sections of stock data and short time series is a challenging exercise due to the severe error-in-variables problem in the noisy beta coefficient estimation. We propose a regularization method for identifying suitable corrections that ensure consistency of the risk premia estimators. The method unifies extant approaches in a coherent framework. In addition, using a clustering approach, we facilitate inference about various asset pricing implications while allowing for realistic non-trivial cross-sectional correlations in the form of industry effects.

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On the family of the γ-order distributions with applications to Physics

Christos P. Kitsos & Ioannis S. Stamatiou

University of West Attica, Greece

xkitsos@uniwa.gr; istamatiou@uniwa.gr

Abstract. The target of this paper is to discuss "daughter distributions" of the family of γ-order Generalized Normal distribution, emerged from the Logarithmic Sobolev Inequalities (LSI). At our paper at the Greek Statistical Conference, in Larisa on April 2025, we focused on:

- γ-order Generalized Lognormal distribution
- γ-order Generalized Chi-square distribution
- γ-order Generalized Chi-γ distribution.

In this paper we focus on three distributions useful in applications, mainly in Physics, namely Maxwell-Boltzmann, Rayleigh and Cauchy (which is also applied in Economics). So, we introduce and discuss:

- γ-order Generalized Maxwell-Boltzmann distribution
- γ-order Generalized Rayleigh distribution
- γ-order Generalized Cauchy distribution.

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Statistical modeling using unreplicated designs

Christos Koukouvinos

Department of Mathematics, National Technical University of Athens, Greece

ckoukouv@math.ntua.gr

Abstract. Unreplicated factorial designs are widely used in screening experiments due to their economic run size. However, they are difficult to analyze because there are no degrees of freedom left to estimate the experimental error. Many methods have been proposed for the analysis of such designs, with Daniel's and Lenth's being the most popular. We present two methods for analyzing unreplicated factorial designs. The first method is based on the representation of the effects on a normal probability plot, while the second takes advantage of the projective property of factorial designs. The presented methods are compared to existing techniques via an extensive simulation study.

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Not all Neighbors Agree: Graph Learning Beyond Homophily

Danai Koutra

University of Michigan, U.S.A.

danae112358@gmail.com

Abstract. Graph neural networks (GNNs) have become a cornerstone of graph-based machine learning, demonstrating strong performance across a variety of applications spanning recommendation systems, molecular analysis, and social networks. While a wide variety of GNN models have been proposed, most of them perform best in graphs that exhibit the property of homophily, in which linked nodes often belong to the same class or have similar features, echoing the adage “birds of a feather flock together”. However, in the real world, there are also many settings where “opposites attract”, leading to networks that exhibit heterophily, in which linked nodes tend to be from different classes (e.g., protein-protein interaction networks or fraud detection scenarios). Moreover, even homophilic networks exhibit local variations in homophily, including strong heterophily.

In this talk, I will present our recent advances in understanding and improving GNNs in the presence of heterophily. I will introduce effective GNN designs for node classification and link prediction and discuss how heterophily relates to core challenges such as over smoothing and robustness. Moving beyond global homophily, I will show how local homophily variations can lead to performance disparities across node groups, ultimately resulting in unfair predictions. Finally, I will present the limitations of standard positional encodings in heterophilic graphs and introduce a variant that improves performance across a range of GNN architectures, including graph transformers.

On a new family of continuous univariate distributions

Markos V. Koutras[1] & Spiros D. Dafnis[2]

[1]University of Piraeus, Greece

[2] University of the Aegean, Greece

mkoutras@unipi.gr; sdafnis@aegean.gr

Abstract. In this work we focus on a recently introduced family of continuous univariate distributions $D_g^+(h)$ which involves two functions, g (generator) and h (parametric part) satisfying appropriate conditions. We study its properties, including aging, tail properties and unimodality, and apply our general results to families of classical distributions, thereof obtaining alternative proofs of well known results. We also discuss how the new framework can be exploited for constructing new distributional models with desirable properties.

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Maximal inequalities for *N*-demimartingales with scan statistic applications

Markos V. Koutras[1] & Demetrios Lyberopoulos[2]

[1]University of Piraeus, Greece

[2] Hellenic Statistical Authority (ELSTAT), Greece

mkoutras@unipi.gr; d.lymperopoulos@statistics.gr

Abstract. Demimartingales have drawn the attention of many researchers during the last decades (see e.g. the pioneering papers of Newman and Wright (1982) and Christofides (2003), where this concept was introduced), since they can be exploited to develop useful tools for dealing with stochastic dependence. Such a structure arises naturally in runs and scans theory; scan statistics are defined as random variables enumerating the moving windows in a sequence of binary outcomes trials that contain a prespecified number of successes.

In this talk, maximal inequalities for nonnegative *N*-demi(super)martingales, developed in Koutras & Lyberopoulos (2017) are first presented. As an application, some bounds for the cumulative distribution function of the waiting time for the first occurrence of a scan statistic in a sequence of independent and identically distributed binary trials are obtained. A numerical study is also carried out to investigate the behavior of the new bounds.

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Optimal choice of next customer in stochastic single vehicle routing problems with pick-up and delivery

Epaminondas G. Kyriakidis[1], **Theodosis D. Dimitrakos**[2] & **Andreas Papasalouros**[3]

[1]Athens University of Economics and Business, Greece

[2,3]University of the Aegean, Greece

ekyriak@aueb.gr; dimitheo@aegean.gr; andpapas@aegean.gr

Abstract. We consider a vehicle routing problem in which a single vehicle starts its route from a depot and visits *N* customers in order to deliver to them new products and to collect expired products. The customers are not serviced according to a predefined sequence. The demands of the customers are assumed to be discrete random variables with known distributions. Actual demands become known only when the vehicle visits them. The vehicle may interrupt its route and go to the depot in order to unload the expired products and to restock with new products. The cost structure includes travel costs between customers and travel costs between each customer and the depot. After the first visit at each customer's site two decisions must be made. The first decision is to choose the next customer that the vehicle will visit. The second decision is to choose how the vehicle will go to the next customer. The problem is to find (i) the minimum total expected cost for servicing all customers and (ii) the optimal decisions that must be made after the first visit at each customer's site. The above problem can be solved by implementing a suitable stochastic dynamic programming algorithm.

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Normal deviation of Gamma Processes in Semi-Markov Random Media

Nikolaos Limnios[1] **& Faiza Fourati**[2]

[1]Université de Technologie de Compiègne, Sorbaonne Université, France

[2]Université de Sciences de Tunis, Tunisie

nikolaos.limnios@utc.fr; fayza.fourati@ipeit.rnu.tn

Abstract. This presentation is a continuation of the paper by Limnios (2025), but now in a semi-Markov environment (see, e.g. Limnios & Fourati (2025). We consider gamma processes of «homogeneous type» in random media represented by semi-Markov processes. We approximate such gamma processes by diffusion processes. First we obtain an averaging result, which will serve as an equilibrium, and then the diffusion approximation. This is a diffusion approximation with equilibrium or a normal deviation of gamma process in semi-Markov random media. The tools used in this case are different from the Markov case because we do not have semigroups. Applications in reliability and statistics are discussed.

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Infinitely Stochastic Micro Reserving

Matúš Maciak[1], Ostap Okhrin[2] & Michal Pešta [3]

[1]Charles University, Prague, Czech Republic
[2]Technical University, Dresden, Germany
[3]Charles University, Prague, Czech Republic

maciak@karlin.mff.cuni.cz; ostap.okhrin@tu-dresden.de; pesta@karlin.mff.cuni.cz

Abstract. Forecasting and risk modelling in general belong to key challenges in both applied and theoretical research. In our work, we introduce a novel parametric approach to stochastic forecasting of future expenses in non-life insurance based on micro-level evolutions of future and past events---so-called granular data. The underlying model is based on a marked, time-varying Hawkes process where the marks themselves are again another time-varying Hawkes processes-which all leads to an infinitely stochastic process at the end. The estimated parameters of the overall model are proved to be consistent and asymptotically normal-both under relatively simple (from the theoretical point of view) and easily verifiable (from the practical point of view) assumptions. The empirical properties are investigated through a simulation study and some illustrations are provided using real data examples.

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On seismic activity and extreme events via semi-Markov modelling with multivariate state space

Andreas Makrides[1] & Alexandra Papadopoulou[2]

[1]Department of Statistics and Actuarial-Financial Mathematics, Lab of Statistics and Data Analysis, University of the Aegean, Greece

[2]Department of Mathematics, Aristotle University of Thessaloniki, Greece

amakridis@aegean.gr; apapado@math.auth.gr

Abstract. A novel idea for modelling extreme events especially focused on seismic activity is presented in this paper. Unlike classical models, the proposed framework incorporates a multivariate state space where each state is defined as a vector encoding both the magnitude of the mainshock and temporal or numerical features of the associated foreshock and/or aftershock sequences. This structure enables a dynamic and data-informed correlation between the mainshock characteristics and the surrounding seismic activity, enhancing the descriptive and predictive power of the model. The semi-Markov structure allows for flexible sojourn time distributions, capturing the non-memoryless nature of seismic transitions. Empirical validation using real earthquake catalogs demonstrates that the model effectively captures key patterns in seismic sequences, offering new insights into the temporal evolution and interdependence of seismic events. This new approach might reveal promising paths for probabilistic seismic hazard analysis and provide additional stochastic tools for thorough investigation of extreme phenomena attributes.

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Edgeworth expansion in a fixed Wiener chaos

Paul Mansanarez[1,2], Guillaume Poly[1] & Yvik Swan[2]

[1]Université de Rennes. France

[2]Université libre de Bruxelle, Belgium

Paul.mansanarez@ulb.be; guillaume.poly@univ-rennes.fr; yvik.swan@ulb.be

Abstract. We investigate Edgeworth expansions for functionals of a Gaussian field. In this setting, powerful tools appear, such as the Malliavin-Stein method. For an element F of the p-th Wiener chaos, there is an optimal bound on the distance in total variation between the law of F and the standard Gaussian distribution, depending on the fourth cumulant of F.

By adding correcting terms to the standard normal, we derive a bound on the total variation distance between the law of F and its so-called Edgeworth expansion: a modified Gaussian measure. The bounds depend only on p and a power of the fourth cumulant of F.

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CUSUM Control Chart for Lifetime Monitoring under Failure Censoring With Replacement

Petros E. Maravelakis

Department of Business Administration,

University of the Piraeus, Piraeus, Greece

maravel@unipi.gr

Abstract. A Cumulative Sum (CUSUM) control chart is a well-established tool for detecting shifts in process parameters—particularly small to moderate shifts—in a timely manner. In this paper, we develop a CUSUM control chart to monitor the lifetime of items under failure censoring reliability tests with replacement. We assume that the lifetimes are exponentially distributed. The performance of the proposed chart is evaluated via its run length properties with a Markov chain methodology. A practical example demonstrates the application of the proposed chart, and comparisons are made with relevant alternative schemes. Finally, conclusions regarding the chart's performance and potential future research are provided.

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Poisson Kernel-Based Inference on the High-Dimensional Sphere

Marianthi Markatou

Department of Biostatistics & Jacobs School of Medicine

University at Buffalo

markatou@buffalo.edu

Abstract. Many applications of interest involve data that can be analyzed as unit vectors on a d-dimensional sphere. Specific examples include text-mining, biology, astronomy and medicine. We present a Poisson kernel-based framework for testing uniformity and clustering on the high-dimensional sphere. We first discuss the class of Poisson Kernel-Based Densities (PKBDs) and study connections of this class with other distributions defined on the d-dimensional sphere. We then present tests of uniformity and an algorithm for clustering on the sphere that is based on a mixture model of PKBDs. We investigate the asymptotic distribution of the tests and the identifiability, convergence properties and operational characteristics of our clustering algorithm. We exemplify the methods via simulations and use of real data.

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On the Accuracy of Deep Learned Parameters of Fractional Processes

László Márkus & Dániel Boros

Institute of Mathematics, Eötvös Loránd University, Budapest, Hungary

laszlo.markus@ttk.elte.hu

Abstract. This research explores the reliability of deep learning—specifically Long Short-Term Memory (LSTM) networks—in estimating the Hurst parameter of fractional stochastic processes. The study focuses on three types of processes: fractional Brownian motion (fBm), the fractional Ornstein-Uhlenbeck process (fOUp), and fractional stable Lévy motion (fsLm). Extensive datasets for fBm and fOUp are generated efficiently, enabling the LSTM network to be trained on a large volume of data within feasible time.

The accuracy of the LSTM's Hurst parameter estimates is evaluated using various performance metrics, including RMSE, MAE, MRE, and the quantiles of absolute and relative errors. The findings show that for fBm and fOUp, the LSTM consistently outperforms traditional statistical methods. However, in certain ranges of the Hurst parameter, relative errors remain notably higher than those of classical estimators.

Regarding the jump process fsLm, the results reveal that the LSTM's performance is limited and does not improve significantly when such processes are included in the training set. The study also explores how training length and the length of the evaluation sequence affect the performance of the LSTM.

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Efficient computation of pattern statistic distributions for many values of input parameters

Donald E.K. Martin

Department of Statistics, North Carolina State University, U.S.A

demarti4@ncsu.edu

Abstract. The topic of the efficient computation of pattern distributions is considered. Efficiency is important because it can facilitate the computation of pattern distributions in cases that are not feasible otherwise. The discussion begins with a review of the Markov-chain-based approach of Fu and Koutras (1994), followed by techniques that can greatly reduce the size of the computation engine in the Markov chain setting (Koutras and Alexandrou 1995; Aston and Martin 2007; Nuel 2008; Martin 2019). In the end, the problem of determining distributions for many values of input probabilities is discussed. It is shown that in some cases, recursive equations can be developed that obviate the need to repeat setting up Markov chains. This can lead to significant reductions in computation time. The method is illustrated on the problem of computing acceptance probabilities in start-up demonstration tests.

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Auxiliary Heating of Nuclear Fusion Plasmas: Surrogate Model Comparison for Uncertainty Quantification and Sensitivity Analysis

Ioannis Mavrogiannis, David Zarzoso, Mitra Fouladirad

[1]Aix Marseille University, France ; [2]CNRS, Centrale Med, France ;

[3]M2P2, Marseille, France

ioannis.mavrogiannis@centrale-med.fr; mitra.fouladirad@centrale-med.fr
david.zarzoso-fernandez@cnrs.fr

Abstract. In a nuclear fusion machine, in order for the gas in the vacuum chamber to reach the plasma state and for fusion reactions to occur, extreme temperatures are required, reaching up to 150 million degrees Celsius. To aid the fusion machines reach and maintain such temperatures, auxiliary heating systems such as the Neutral Beam Injection (NBI) are employed. The NBI heating strongly depends on the ionization process as well as the plasma structure and equilibrium, both of which exhibit uncertainties when measured in real experiments. Therefore, to better infer how the propagation of uncertainties in such a highly complex and non-linear medium, in this work we consider uncertainties in the parametric modeling of the thermal equilibrium and the ionization process of the plasma. The TAPAS code is used for modeling these uncertain phenomena and multiple surrogate models are considered (Polynomial Chaos Expansions, Gaussian Processes) and their accuracy is evaluated on samples drawn with Latin Hypercube Sampling (LHS), in order to fully explore the behavior of the code output on all of the underlying multi-dimensional probability space. Finally, sensitivity analysis (SA) of the output variance is conducted from the Sobol' Indices, for which the PCE allows analytical computation. Sobol' indices rank the contribution of each uncertain parameter to the output variance, as well as that of their interactions.

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System identification via Bayesian nonparametrics

Christos Merkatas[1] & Simo Särkkä[2]

[1] University of the Aegean, Greece

[2] Aalto University, Finland

cmerkatas@aegean.gr; simo.sarkka@aalto.fi

Abstract. In this talk we present a Bayesian nonparametric model for system identification of nonlinear stochastic dynamic systems. We focus on the case where the more common assumptions of Gaussian noise processes are inadequate. By modeling the densities of the noise processes with decreasing weights priors, we achieve accurate inference when the true noise processes depart from normality. A Gibbs sampling algorithm for posterior inference is presented. The method is illustrated in simulated and real time series data.

Some critical aspects of cure rate modeling

Fotios S. Milienos

Department of Sociology, Panteion University of Social and Political Sciences, Greece

milienos@panteion.gr

Abstract. It is now common to assume that many patients, after receiving appropriate treatment, will not experience the same issue again; that a notable proportion of students will drop out and never complete their degrees; or that a significant number of individuals who have committed a crime will never reoffend over the course of their lives. Having said that, modelling time-to-event should not ignore the existence of such individuals/items (known as cured), and this can be done by the theory of cure models (e.g., Peng and Yu 2021). A broad class of cure models is introduced under a competing cause scenario, where every individual has a latent random number of competing causes (risk factors), with each cause being able to produce the event of interest after specific (random) time, called, progression or promotion time. The case where the number of competing causes is equal to zero, corresponds to a cured individual. Statistical models performing well under the existence or not of a cured proportion is then of great importance. In this talk, we discuss some theoretical and practical aspects of such families of models (e.g., Koutras and Milienos 2017, Milienos 2022), focusing on the existence of a destructive process on the initial number of competing causes, model diagnostics and some other open issues in the area.

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Direct methods for variable selection in statistical modeling

Marilena Mitrouli

Department of Mathematics, National and Kapodistrian University of Athens, Greece

mmitroul@math.uoa.gr

Abstract. In linear models usually the solutions are required to be sparse since they identify the most important factors that influence the response of the experiment. For this purpose, regularization techniques are employed and the choice of appropriate values for the added parameters becomes of dominant importance. However, most of the statistical models possess a well conditioned design matrix and according to the discrete Picard condition, regularization is not necessary for their solution. In this work we study the properties of the design matrices which follow a specific correlation structure. According to their generalized condition number we can decide from the beginning if regularization is needed or not for the solution of the least squares problem. Furthermore, we will describe some direct methods which behave well for the under study statistical models in terms of the required sparsity in the computed solutions.

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Split-plot experiments in pharmaceutical industry

Kalliopi Mylona

Department of Mathematics, King's College London, London, UK

kalliopi.mylona@kcl.ac.uk

Abstract. We will present how the optimal design methodology can be used to complex pharmaceutical experiments. Our aim was to investigate the response surface in relation to numerous experimental conditions, while also making high-quality predictions in the experimental region. We included optimality criteria for the fitted model inference and prediction quality. We discuss the choice of the design and some of the obtained outcomes. This talk is based on joint works with M. Otava, Janssen Pharmaceutical Companies of Johnson & Johnson, and O. Egorova, A. Olszewska and B. Forbes, Institute of Pharmaceutical Science, KCL.

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Bivariate autoregressive model for ordinal time series

Anna Nalpantidi & Dimitris Karlis

Athens University of Economics and Business, Greece

analpa@aueb.gr; karlis@aueb.gr

Abstract. We present a bivariate vector valued DAR(1) model for ordinal time series. The so called Bivariate DAR(1) (BDAR(1)) model assumes that each time series follows its own univariate DAR(1) model with dependent random mixtures and dependent innovations. The joint distribution of random mixtures which are expressed by Bernoulli vectors are proposed to be defined through copulas. The same holds for the joint distribution of innovation terms. Some properties of the model are also provided. A simulation study indicates that model provides robust estimates even in case of moderate number of observations. Then, a real data application for illustrating the proposed model and some of its special cases are presented. The application focuses on jointly modelling the unemployment state of Slovakia and Czechia based on data of unemployment rate from Eurostat for each quarter for the period 1998 to 2023, while forecasting is also included. Finally, possible extensions of the model are discussed.

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Tests for Homogeneity of Component Lifetime Distributions Based on System Lifetime Data

Hon Keung Tony Ng

Department of Mathematical Sciences, Bentley University, Waltham, MA, U.S.A.

tng@bentley.edu

Abstract. In system reliability engineering, systems are made up of different components, and these systems can be complex. For various purposes, engineers and researchers are often interested in the lifetime distribution of the system as well as the lifetime distribution of the components that make up the system. In many cases, the lifetimes of an *n*-component coherent system can be observed, but not the lifetimes of the components. In recent years, parametric and nonparametric inference for the lifetime distribution of components based on system lifetime lifetimes has been developed. In this talk, we discuss the problem of testing the homogeneity of component lifetime distributions based on system lifetime data with known system signatures. Existing test procedures for the homogeneity of component lifetime distributions based on complete system lifetime data are reviewed. Then, several nonparametric testing statistics based on the empirical likelihood method are proposed for testing the homogeneity of two or more component lifetime distributions. Both complete and Type-II censored system lifetime data will be considered. The performance of the proposed empirical likelihood ratio tests is compared with other parametric and nonparametric tests in the literature. Finally, some concluding remarks and possible future research directions are provided.

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A new approximation for the Weibull renewal function

Christos G. Papadopoulos & Konstadinos Politis

Department of Statistics and Insurance Science, University of Piraeus, Greece

cpapadopoulos@unipi.gr; kpolitis@unipi.gr

Abstract. Renewal processes are a class of stochastic processes that, apart from their theoretical interest, find applications in several other stochastic models, e.g. in actuarial science, queueing theory and reliability theory. The quantity of most interest in a renewal process is the renewal function, for which, however, there is no closed formula in general. Several attempts have been made to approximate this function; a widely used method is the Riemann-Stieltjes (RS) algorithm of Xie (1989). Particularly for the Weibull distribution, which is of interest in reliability theory, approximations for the renewal function have been proposed by Constantine & Robinson (1997) using power series and, more recently, by Jiang (2010, 2022). In the present paper, a new approximation is proposed, based on the lower bound for the renewal function given in Politis & Koutras (2006). Numerical studies indicate that the new method performs favorably against other approximations, over a large range of parameters for the Weibull distribution.

This work has been partly supported by the University of Piraeus Research Center.

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A Stochastic SPIR Model with Particle Filtering for Estimating Epidemic Dynamics

Vasileios E. Papageorgiou[1], **Irene Votsi**[2] & **George Tsaklidis**[3]

[1,3]Department of Mathematics, Aristotle University of Thessaloniki, Greece

[2]Laboratoire LIEC, CNRS, Université de Lorraine, Metz, France

vpapageor@math.auth.gr; eirini.votsi@univ-lorraine.fr; tsaklidi@math.auth.gr

Abstract. In epidemiology, accurately evaluating epidemic events deserves particular attention, where numerous studies have proposed stochastic models and descriptors to assess the phenomenon's severity. However, most of these models assume constant epidemic dynamics, which limits their accuracy for real-time forecasting. In this paper, we introduce an SPIR (Susceptible, Presymptomatic, Infectious, Removed) model based on a three-dimensional Markov chain. Within this framework, we define stochastic descriptors such as the total number of infections, the time at which a specific number of deaths occurs, and the number of infections caused by presymptomatic or infectious individuals. We also propose a novel approach that enhances estimation precision by employing an expanded state-space model with time-varying parameters. This dynamic method is compared with the standard fixed-parameter approach by analyzing two key descriptors: the total number of infections and the time to the first death, using 2022 mpox data from Ghana. Moreover, the contribution of presymptomatic and infectious individuals to disease transmission is examined. Incorporating time-varying parameter estimation through filtering techniques improves the accuracy of epidemiological descriptors and enables more realistic modeling of outbreaks.

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Bayesian inference and Cure Rate Models

Panagiotis Papastamoulis[1] & **Fotios S. Milienos**[2]

[1]Department of Statistics, Athens University of Economics and Business, Greece

[2]Department of Sociology, Panteion University of Social and Political Sciences, Greece

papastamoulis@aueb.gr; milienos@panteion.gr

Abstract. The family of cure models provides a unique opportunity to simultaneously model both the proportion of cured subjects (those not facing the event of interest) and the distribution function of time-to-event for susceptibles (those facing the event). In practice, the application of cure models is mainly facilitated by the availability of various R packages. However, most of these packages primarily focus on the mixture or promotion time cure rate model. This article presents a fully Bayesian approach implemented in R to estimate a general family of cure rate models in the presence of covariates (Papastamoulis and Milienos, 2024b). It builds upon the work by Papastamoulis and Milienos (2024a) by additionally considering various options for describing the promotion time, including the Weibull, exponential, Gompertz, log-logistic and finite mixtures of gamma distributions, among others. Moreover, the user can choose any proper distribution function for modeling the promotion time (provided that some specific conditions are met). Posterior inference is carried out by constructing a Metropolis-coupled Markov chain Monte Carlo (MCMC) sampler, which combines Gibbs sampling for the latent cure indicators and Metropolis-Hastings steps with Langevin diffusion dynamics for parameter updates. The main MCMC algorithm is embedded within a parallel tempering scheme by considering heated versions of the target posterior distribution.

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Model averaging in the Wasserstein space and applications in claim size distribution estimation

Georgios I. Papayiannis

Department of Statistics and Insurance Science, Risk Management and Insurance Laboratory, University of Piraeus, Greece

gpapagiannis@unipi.gr

Abstract. The task of model averaging in the space of probability models, and in particular within the Wasserstein space, is considered. The concept of Fréchet-Wasserstein barycenter is employed and combined with Tikhonov-type regularizations, resulting to effective model averaging schemes for distributional data. Consistency properties of the proposed schemes with respect to the empirical evidence availability are established within the variational framework of Γ-convergence. The proposed aggregation schemes are implemented to a challenging problem, that of estimating the claim size distribution for insurance portfolios where heavy tail behaviour features are displayed.

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Dynamic parameter tuning for optimal detection of changes in a signal

Christina Parpoula

Department of Psychology, Panteion University of Social and Political Sciences, Athens, Greece

chparpoula@panteion.gr

Abstract. Change-point analysis plays an important role in modern time series research. In this work, we assume that a stream of process data fluctuates around an underlying signal, and we aim to perform a posteriori detection and inference of abrupt level shifts. To reduce computational complexity, we employ a dynamic programming approach. The proposed method provides a practical, data-driven strategy for optimally segmenting the time series and fine-tuning key parameters—specifically, the maximum number of segments to consider and the minimum allowable segment length. This approach strikes a balance between robustness considerations and optimality and is applicable to a wide range of real-world scenarios where detecting significant level shifts in signal processing and time series analysis is essential. The method is evaluated through extensive simulations, and key findings are discussed.

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Improved estimation of location parameters of two exponential distributions with ordered scale

Lakshmi Kanta Patra[1], Constantinos Petropoulos[2], Shrajal Bajpai[1] & Naresh Garg[3]

[1]Department of Mathematics, Indian Institute of Technology, Bhilai,
[2]Department of Mathematics, University of Patras, Greece,
[3]Statistics and Mathematics unit, Indian Statistical Institute Delhi, India

lkpatra@iitbhilai.ac.in; shrajalb@iitbhilai.ac.in; costas@math.upatras.gr; nareshng@iitk.ac.in

Abstract. In the usual statistical inference problem, we estimate an unknown parameter of a statistical model using the information in the random sample. A priori information about the parameter is also known in several real-life situations. One such information is the order restriction between the parameters. This prior formation improves the estimation quality. In this paper, we deal with the component-wise estimation of location parameters of two exponential distributions studied with ordered scale parameters under a bowl-shaped affine invariant loss function. We have shown that several benchmark estimators, such as maximum likelihood estimators (MLE), uniformly minimum variance unbiased estimators (UMVUE), and best affine equivariant estimators (BAEE), are inadmissible. We have given sufficient conditions under which the dominating estimators are derived. Finally, we perform a simulation study to compare the risk performance of the improved estimators.

On Multiparameter *q*-Stirling Numbers

Violetta E. Piperigou[1] & Malvina Vamvakari[2]

[1]Department of Mathematics, University of Patras, Greece

[2]Department of Informatics & Telematics, Harokopio University of Athens, Greece

vpiperig@math.upatras.gr; mvamv@hua.gr

Abstract. During the 1980s and early 1990s, the "School of Athens" devoted considerable attention to the study of Stirling numbers of various kinds and their applications in probability models. Motivated by these studies, we consider q-analogues of multiparameter Stirling numbers and discuss related multivariate discrete q-distributions.

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Negative probability and signed probability distributions: simulation and some applications

Igor Podlubny

Technical University of Kosice, Slovakia

Igor.podlubny@tuke.sk

Abstract. Negative probability and signed probability distributions (with positive and negative probabilities) are not yet well-known even to specialists in probability, statistics, and stochastic processes. In this rapid-fire talk these notions will be presented and explained. Several methods for the simulation of signed probability distributions will be presented along with their software implementation and illustrated on selected examples. This talk is based on the joint results with N. Leonenko (Cardiff University).

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Particle swarm optimization convergence

Ionel Popescu, Alexandra Andriciuc & Iulian Cîmpean

University of Bucharest, Romania
and
Institute of Mathematics "Simion Stoilow" of the Romanian Academy, Romania

ionel.popescu@fmi.unibuc.ro; alexandra.andriciuc@drd.unibuc.ro;

iulian.cimpean@imar.ro

Abstract. We will present an analysis of the convergence of the PSO algorithm and the corresponding region of the convergence for this.

Approximations for the distribution of scan statistics and applications

Cristian Preda[1] & **Alexandru Amarioarei**[2]

[1]University of Lille, France and Institute of Statistics and Applied Mathematics of the Romanian Academy, Bucharest, Romania

[2]University of Bucharest and National Institute of Research and Development for Biological Sciences, Bucharest Romania.

cristian.preda@univ-lille.fr; alexandru.amarioarei@fmi.unibuc.ro

Abstract. Viewed as the maximum of a one dependent stationary sequence of random variables, the scan statistics distribution is approximated under different models of generating data (dependance and distribution). Sharp bounds are also provided analytically and illustrated through extensive simulations. The results obtained in one dimension are extended to multidimensional setting with a particular focus on two and three dimensional scan. Related problems to scan such as the longest success run, the longest increasing run and waiting time statistics.

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Projective Shape Analysis for Spatial Orientation in Virtual Environments

Mihaela Pricop Jeckstadt[1], **Alexander Garthe**[2], **Victor Patrangenaru**[3] & **Robert Paige**[4]

[1]University Politehnika of Bucharest, Romania

[2]Deutsches Zentrum für Neurodegenerative Erkrankungen, Dresden, Germany

[3]Florida State University, U.S.A

[4]Missouri University of Science and Technology, U.S.A

Mihaela.Pricop@upb.ro

Abstract. In this talk, we introduce and develop a projective shape analysis for the study of cognitive abilities evaluated based on learning behaviour in the DSNT (Dresden Spatial Navigation Task) virtual navigational experiment. DSNT adapts the classical water maze test for humans and was developed at DZNE (The Research Institute for Neurodegenerative Diseases from Dresden, Germany). This new mathematical modelling of the spatial orientation and learning is based on recent concepts in object-oriented data analysis like extrinsic covariance and extrinsic cross-covariance as well as novel statistical testing methods for random objects on manifolds. Additionally, new numerical algorithms will be developed, studied and finally implemented in an open-source mathematical software like R and will be used to evaluate our conclusions and to present the data visually.

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Lindley-type weighed distributions with applications to Actuarial and Risk Management

Georgios Psarrakos

University of Piraeus, Greece

gpsarr@unipi.gr

Abstract. In this talk, a family of weighted distributions is proposed, whose Lindley (see Lindley, 1958) distribution is a member. For the construction of this family a positive parameter to add flexibility, say $\theta > 0$, is used. Applications to premium principle are obtained, since the parameter θ give more flexibility to an actuary to control the degree of risk aversion. This approach complements the study of flexibility on the modified variance premium initiated in Goovaerts et al. (2001). Furthermore, the role of θ is investigated in risk management, by comparing it with the Probability Equivalent Level between Value-at-Risk and Expected Shortfall (PELVE).

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Online Monitoring of Dynamic Data Streams Using Transparent Sequential Learning

Peihua Qiu

Department of Biostatistics

University of Florida, U.S.A.

pqiu@ufl.edu

Abstract. In fields such as air pollution surveillance and additive manufacturing, online monitoring of data streams poses unique challenges. The in-control (IC) distributions of these data often evolve over time due to seasonality and other factors, making standard statistical process control (SPC) charts difficult to apply. Traditional SPC methods rely on the assumption that IC observations are independent and identically distributed across time—an assumption that frequently fails in these contexts. In this talk, we present our recent methods developed under the transparent sequential learning framework for monitoring dynamic data streams. These methods are designed to accommodate time-varying IC distributions, serial correlation, high dimensionality, and nonparametric data structures.

A Comparative Study of Control Charts with Individual Observations for Monitoring Shifted Exponential Processes

Athanasios C. Rakitzis, Demetrios L. Antzoulakos, Konstantinos G. Fountoukidis

University of Piraeus, Department of Statistics and Insurance Science

arakitz@unipi.gr, dantz@unipi.gr, k.fountoukidis@unipi.gr

Abstract. The shifted (or two-parameter) exponential distribution is a well-known distribution employed in the analysis of lifetime data with a warranty period. Apart from that, it is useful in modeling survival data with some flexibility due to its two-parameter representation. Control charts for monitoring a process that is modeled as a shifted exponential distribution have been studied quite extensively in the recent literature. In this work, we introduce different types of one-sided control charts for individual observations such as Shewhart, CUSUM and EWMA, and compare their performance in terms of their run length distribution, for several out-of-control situations in a shifted exponential process. The numerical results show that there is not a unique chart that outperforms uniformly all other charts, so the most appropriate charts are suggested, depending on the magnitude of shifts in process parameters. Also, we provide empirical rules for the statistical design of each chart under investigation.

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Higher order derivatives of Stein's solution and the Integrated Pearson family

Ferdinand Rapin & **Yvik Swan**

Université libre de Bruxelles (ULB), Belgium

ferdinand.rapin@ulb.be; yvik.swan@ulb.be

Abstract. Stein's method is a well-known collection of tools allowing to assess proximity between distributions. We study the properties of iterated derivatives of the solution f_h to the Stein equation under regularity conditions on the target distribution. We present a new analytic representation of the higher order derivatives of f_h and prove that when the target distribution belongs to the Integrated Pearson family, the n -th derivative of f_h only depends on the $(n-1)$-th derivative of h, completing results offered by Döbler, Gaunt & Vollmer (2017).

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First Ahead by at least *k* Multinomial Game

Sheldon M. Ross

Department of Industrial and Systems Engineering, University of Southern California, Los Angeles, U.S.A.

smross@usc.edu

Abstract. Multinomial trials having probabilities $p_1, p_2, \ldots, p_n$ are observed until one of the outcomes, called the winning outcome, has occurred at least k more times than each of the others. Supposing that $p_1 = max_i p_i$, $p_n = min_i p_i$, we prove that the probability that outcome 1 wins is at least $p_1^k / \sum_{j=1}^{n} p_j^k$, whereas the probability that outcome n wins is at most $p_n^k / \sum_{j=1}^{n} p_j^k$. When $p_i = v_i / \sum_{j=1}^{n} v_j$, we show that the probability that outcome i wins is an increasing function of v_i.

Usage of novel bivariate distributions and clustering concept to construct multivariate semiparametric control charts

Elisavet M. Sofikitou

elisavet.sofikitou@gmail.com

Abstract. This work deals with the construction of several control charts using two different approaches: new bivariate distributions and clustering. The first part of the presentation focuses on presenting the basic concepts of the Theory of Order Statistics and their Concomitants, as well as the Theory of Copulas. Subsequently, new distributions for bivariate order statistics and enumerating variables for them are introduced. The new results are used to construct bivariate semiparametric control charts and are applied to establish expressions for their characteristics, i.e. operating characteristic function and (false) alarm rate. The proposed schemes are capable of detecting mean and/or variability shifts of the underlying process. Their key advantage is that they can be exploited as fully nonparametric monitoring schemes and they can be easily extended to higher dimensions.

In the second part of the presentation, a new methodology is proposed which leverages the ideas from Clustering and Statistical Process Control to develop new control charts for mixed-type data. This new class of multivariate control charts exploits the distances to the centroids of the interval/ratio measurements to construct an artificial intelligent, univariate kernel density estimator and treats the categorical characteristics as multinomial random variables. Under this set-up, the reference and the test sample are represented by two multi-dimensional clusters. These novel schemes are capable of the simultaneous monitoring of interval/ratio and categorical scale variables.

The performance of the all the aforementioned control charts is discussed and evaluated on the basis of their characteristics, while their applicability is demonstrated using real-world data.

Mathematical models in infectious diseases as a tool to inform policy decisions

Vana Sypsa

Department of Hygiene, Epidemiology and Medical Statistics,
Medical School, National and Kapodistrian University of Athens, Greece

vsipsa@med.uoa.gr

Abstract. During an epidemic, there is often interest to estimate key epidemiological parameters, frequently from limited available data, and to assess the impact of various interventions when randomised controlled trials are not feasible. In this presentation, I will discuss how mathematical models have been used to reconstruct an HIV outbreak among people who inject drugs in Athens and to assess the impact of implemented interventions, to explore the impact of social distancing measures during the COVID-19 pandemic and to model the transmission of antibiotic resistant bacteria in the healthcare setting.

AI-informed Non-linear Cox Model for Survival Analysis of Running-Related Injuries

Katarzyna Szczerba[1,2], Christophe Ley[1] & Laurent Malisoux[3]

[1]University of Luxembourg, Luxembourg

[2]Information Technology for Translation Medicine, Luxembourg

[3]Luxembourg Institute of Health, Luxembourg

katarzyna.szczerba@uni.lu; christophe.ley@uni.lu; laurent.malisoux@lih.lu

Abstract. The Cox proportional hazards model is the most commonly used method for multivariate survival analysis. Despite its many advantages, such as simplicity and interpretability, it has a serious drawback: it fails to capture non-linear relationships. In this paper, we propose AI informed Non-linear Cox Model, a method that uses insights from a highly predictive machine learning model, extracted with an interpretable machine learning tool, to integrate non-linear relationships into the traditional Cox model.

On simulated data with a deliberately introduced non-monotonic relationship between the predictor and the outcome variable, the AI-informed Cox model outperformed the traditional proportional hazards Cox model. Its concordance index was also comparable to that of the best-performing machine learning model - gradient boosted Cox model. Similar results were observed when the models were applied to runners dataset.

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Unified management of interacting operations in degrading and adaptive production systems

Konstantinos A. Tasias

Department of Mechanical Engineering, University of Western Macedonia, Greece

ktasias@uowm.gr

Abstract. In adaptive production systems, performance degradation over time introduces complex challenges in ensuring operational reliability while simultaneously meeting production and quality targets. Traditional decision-making approaches often optimize maintenance, production, inventory, and quality control policies in isolation, overlooking their complex interdependencies and the cumulative effect of degradation on system performance. This presentation proposes a unified control framework that integrates these process aspects within a reliability-aware decision-making context. The approach captures the interactions among equipment condition, process variability, and system responsiveness, aiming to optimize overall performance under uncertainty. By modeling the dynamic evolution of system states and incorporating flexible production capabilities, the model enables proactive interventions that mitigate failure risks and enhance system availability. This work contributes to the development of reliability-based strategies within data-driven manufacturing environments.

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Hidden Drifting Markov Models: Theory, Inference, and Simulation-Based Evaluation

Aguêmon Léon Tehungue[1], Vlad Stefan Barbu[1,2,3] & Nicolas Vergne[1]

[1]LMRS, University of Rouen - Normandy, France

[2]Centre for Demographic Research "Vladimir Trebici", Romania

[3]"Costin C. Kiritescu" National Institute of Economic Research of Romanian Academy, Bucuresti, Romania

aguemon.tehungue@univ-rouen.fr; vladstefan.barbu@univ-rouen.fr; nicolas.vergne@univ-rouen.fr

Abstract. This presentation focuses on the modeling and analysis of time series data with latent structures using Hidden Drifting Markov Models (HDMMs). We begin with a theoretical overview of HDMMs, highlighting their key components and probabilistic assumptions. We then detail two core inference methods: the Expectation-Minimization (EM) algorithm for parameter estimation, and the Modified Viterbi algorithm for decoding the least risks sequence of hidden states. Numerical simulations on synthetic data are used to demonstrate the practical implementation and performance of these techniques. This work emphasizes the ability of HDMMs to uncover hidden temporal patterns and the role of EM and Modified Viterbi algorithms in effective model fitting and interpretation.

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Gaussian Invariance in Markov Chain Monte Carlo

Michalis K. Titsias[1], Angelos Alexopoulos[2], Siran Liu[3] & Petros Dellaportas[2,3]

[1]Google DeepMind, UK

[2]Athens University of Economics and Business, Greece

[3]University College London, UK

mtitsias@gmail.com; angelos@aueb.com; siran.liu.21@ucl.ac.uk; petros@aueb.gr.

Abstract. We develop sampling methods, which consist of Gaussian invariant versions of *RWM*, *MALA* and second order Hessian or Manifold *MALA*. Unlike standard *RWM* and *MALA*, we show that Gaussian invariant sampling can lead to ergodic estimators with significantly improved statistical efficiency. This is because Gaussian invariance has the remarkable property that allows us to derive exact analytical solutions to the Poisson equation for Gaussian targets. Then, these analytical solutions can be used to construct efficient and easy-to-use control variates for variance reduction of estimators under any intractable target. We demonstrate the new samplers and estimators in several examples, including high-dimensional targets in latent Gaussian models where we compare against several advanced methods and obtain state-of-the-art results.

Joint modelling of longitudinal and competing-risk data under failure cause and non-informative right censoring

Christos Thomadakis[1,2], **Loukia Meligkotsidou**[3], **Constantin T. Yiannoutsos**[4] & **Giota Touloumi**[1]

[1]Department of Hygiene, Epidemiology and Medical Statistics, Medical School, National and Kapodistrian University of Athens, Greece

[2]Department of Statistics, Athens University of Economics and Business, Greece

[3]Department of Mathematics, National and Kapodistrian University of Athens, Greece

[4]Department of Biostatistics and Health Data Science, Indiana University, U.S.A

cthomadak@aueb.gr; meligots@math.uoa.gr; cyiannou@iu.edu; gtouloum@med.uoa.gr

Abstract. In our motivating example of jointly modelling CD4 count evolution and competing risks (death and disengagement from care) in a resource-constrained setting, misclassification of death is a concern. This can be addressed using data from double sampling, a random subset of disengaged patients whose true vital status was actively ascertained. Further complexity arises when individuals silently transfer to other programs, which would be treated as non-informative censoring but is not reported to the original program. We propose a joint model for longitudinal markers and competing risks that accounts for misclassified failure causes and censoring indicators. A linear mixed model was used for the marker trajectory, $y_i(t) = m_i(t) + \varepsilon_i(t)$, and cumulative incidence functions were modelled using a generalized odds-rate transformation, $F_{ik}(t) = 1 - \left[1 + c_k \int_0^t h_{0k}(s) \exp\{\gamma_k^T w_{ik} + \alpha_k m_i(s)\} ds\right]^{-1/c_k}$, depending on marker values and baseline covariates. Misclassification probabilities were estimated by assuming that true event types are observed only in the double sample, while reported causes are available for all. We show that, unlike settings with correctly classified censoring, the conditional probability of failure types also depends on the censoring hazard. Thus, we included a proportional hazards model for censoring. Bayesian inference was performed using a hybrid MCMC algorithm with data augmentation. Simulations mimicking the motivating study confirmed that ignoring "silent" transfers leads to biased association parameters and population-level CIFs. Application to East Africa IeDEA data supported these findings.

Joint modeling of longitudinal (bio)markers and visiting process to dynamically predict time-to-next visit: identifying individuals more prone to disengage from care

Giota Touloumi, Achilleas Stamoulopoulos & Christos Thomadakis
Dept of Hygiene, Epidemiology and Medical Statistics, Medical School, NKUA
gtouloum@med.uoa.gr; achilleasst@med.uoa.gr; cthomadak@med.uoa.gr

Abstract. In chronic diseases, regular visits enable the assessment of disease progression and/or treatment effectiveness. In HIV studies, extended intervals between visits have been shown to be associated with adverse outcomes (viral load relapse, antiretroviral therapy interruption). Prediction of next visiting time can be a useful tool in identifying those more prone to disengage from care. As visiting times vary substantially both, between and within individuals, patients' characteristics such as longitudinal (bio)markers history and past visiting patterns have to be taken into account when dealing with the prediction of future visiting times. In this study, we propose a model for the joint analysis of a longitudinal continuous (bio)marker and the visiting process. A linear mixed-effects model is employed for the (bio)marker sub-model and a proportional hazards model for the gap times, conditional on a scalar random effect, for the visiting process sub-model. The two sub-models are linked through correlated normally distributed random effects leading to a relatively simple marginal likelihood that requires one-dimensional integration, irrespective of the number of the random effects that will be used in the longitudinal data sub-model; a property that is retained also for multiple longitudinally measured (bio)markers. The model is used to derive subject-specific dynamic predictions for the time of the next visit as well as for the probability of the time of the next visit exceeding a prespecified cut-off (e.g. 1.5 years), conditioning on subject's previous gap times and (bio)marker history. The performance of the proposed methodology is assessed through simulation, and it is applied to data of people living with HIV from the Athens Multicenter AIDS Cohort Study (AMACS).

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Finite multi-time Markov Renewal chains – Algebraic properties and computational issues

Samis Trevezas & Leonidas Kordalis

Department of Mathematics, National and Kapodistrian University of Athens, Greece

strevezas@math.uoa.gr; lkordali@math.uoa.gr

Abstract. A new extension of the Markov Renewal theory in discrete time is introduced by allowing time to evolve in multiple dimensions. The resulting chains are referred to as multi-time Markov Renewal chains and the associated semi-Markov chains as multi-time semi-Markov chains. When time is multidimensional interesting phenomena arise, such as zero-time events for the marginal semi-Markov chains. As a first step in theoretical development, the state space is assumed to be finite. The flexibility of Markov renewal theory is still present in multiple time dimensions by allowing the sojourn times in the different states of the system to be arbitrarily selected from a multidimensional discrete distribution. Some basic definitions and properties of this new class are given, including the multi-time Markov renewal equations. The computational complexity for computing the convolution product and the convolutional inverse of multi-time matrix sequences is very high, and we discuss the possibility to apply appropriately the Fast Fourier Transform for matrix sequences to reduce the computational cost. Some applications of this theoretical framework are discussed.

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The signature of coherent systems: A probabilistic tool for Reliability Modeling

Ioannis S. Triantafyllou

Department of Statistics & Insurance Science, University of Piraeus, Greece

itriantafyllou@unipi.gr

Abstract. In the present work, the signature vector of a coherent system consisting of independent and identically distributed components is investigated. The signature is closely related to many well-known reliability, a fact turning it to a very important tool for studying the performance of a reliability model and comparing structures between each other. First, a brief presentation of certain fundamental results concerning the system's signature is provided. Among other aspects, the discussion includes certain methods for computing the coordinates of the signature, as well as the relationship between the signature vector and the lifetime of the underlying system. In addition, some recent advances are also provided for specific members of the class of the consecutive-type systems.

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Directional data analysis: spherical Cauchy or Poisson kernel-based distribution?

Michail Tsagris[1], Panagiotis Papastamoulis[2] & Shogo Kato[3]

[1]Department of Economics, University of Crete, Gallos Campus, Rethymnon, Greece

[2]Department of Statistics, Athens University of Economics and Business, Athens, Greece

[3]Institute of Statistical Mathematics, Tokyo, Japan

mtsagris@uoc.gr; papastamoulis@aueb.gr; skato@ism.ac.jp

Abstract. In 2020, two novel distributions for the analysis of directional data were introduced: the spherical Cauchy distribution and the Poisson kernel-based distribution. This paper provides a detailed exploration of both distributions within various analytical frameworks. To enhance the practical utility of these distributions, alternative parametrizations that offer advantages in numerical stability and parameter estimation are presented, such as implementation of the Newton-Raphson algorithm for parameter estimation, while facilitating a more efficient and simplified approach in the regression framework. Additionally, a two-sample location test based on the log-likelihood ratio test is introduced. The maximum likelihood discriminant analysis framework is developed for classification purposes, and finally, the problem of clustering directional data is addressed, by fitting finite mixtures of Spherical Cauchy or Poisson kernel-based distributions. Empirical validation is conducted through comprehensive simulation studies and real data applications, wherein the performance of the spherical Cauchy and Poisson kernel-based distributions is systematically compared.

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Study of a homogeneous Markovian compartmental model as a viscoelastic medium

George Tsaklidis

Department of Mathematics, Aristotle University of Thessaloniki, Greece

tsaklidi@math.auth.gr

Abstract. The evolution of a homogeneous Markovian system, which constitutes a compartment model, of fixed size is explained by the theory of continuous medium. The flow of the members of the Markovian system is assumed to take place as a flow of elementary particles in a continuous medium. The existence of asymptotic behavior of the Markovian model is explained by the flow of a viscoelastic medium, which has the characteristic of deceleration of motion due to the combination of spring damping (according to Hooke's law) and hydraulic damping due to viscosity. The Kelvin-Voight model and the Maxwell model are considered. The energy of such an HMS is studied in the context of the aforementioned consideration.

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Volatility properties for the general price index of the Athens stock exchange

Eleni Tsami[1], **Petros Skiadas**[1] & **Andreas Rokopanos**[2]

[1]University of Piraeus, Greece

[2]University of Western Macedonia, Greece

etsami@unipi.gr; pskiadas13@gmail.com; a.rokopanos@gmail.com

Abstract. The Athens Stock Market (ASE) has gained much of the attention of economic researchers in recent years, due to the economic crisis in Greece and the extreme prices and phenomena it presents. In general, stock markets do not always react in a rational way, as they are characterized by periods of high volatility where uncertainty due to unpredictable factors (such as political instability, etc.) makes its appearance.

The volatility of a time series of financial data is one of the most important issues in the field of finance and expresses the degree of change in its values over time. The measure to estimate volatility is the standard deviation of the prices. Key properties -characteristics of volatility are thin/thick tails, volatility clustering, leverage effect and long memory.

In this paper we try to captured and analyze the volatilities properties for the General Price Index of the ASE. We use the daily closed prices of the General Price Index of the ASE for the period 2024 – 2025 and in order to include and cover the above, we use different volatility models such as, the GARCH models.

A Quantitative Assessment of Extreme Freight Rates in Shipping

Vangelis Tsioumas[1] & Yiannis Smirlis[2]

[1]Department of Maritime Studies, University of Piraeus, Piraeus, Greece

[2]Department of Economics, University of Piraeus, Piraeus, Greece

vtsioumas@unipi.gr; smirlis@unipi.gr

Abstract. The shipping freight markets are characterized by periods of high volatility. Unusual market conditions or "black swan events" are typically associated with extreme deviations of freight rates from their mean values. This study focuses on the dry bulk sector and offers a stochastic assessment of extreme freight rates using Extreme Value Analysis (EVA). The dataset comprises daily observations of the Baltic Exchange Dry Index (BDI), which serves as a proxy for freight rates on key trade routes of bulk carriers. Following the Block-Maxima approach, this study develops a stochastic model for the highest monthly BDI values by testing the fit of the Generalized Extreme Value (GEV) distribution to the data and estimating its parameters. Based on this model, the corresponding probabilities are calculated for an indicative list of possible BDI peaks. The findings of this research shed light on the statistical properties of extreme freight rates and inform operational decisions under high uncertainty.

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Bayesian Signature Authenticity Validation

Lampis Tzai[1,2], **Ioannis Ntzoufras**[2], **Franco Taroni**[1] & **Silvia Bozza**[1]

[1]School of Criminal Justice, University of Lausanne, Switzerland

[2]Department of Statistics Athens University of Economics and Business, Greece

[3]Department of Economics, Ca' Foscari University of Venice, Italy

ntzoufras@aueb.gr

Abstract. This work presents a novel, multidisciplinary approach that aims to the identification of valid and useful patterns in handwriting examination via Bayesian modelling. Starting from a sample of characters selected among 13 French native speakers, an accurate loop reconstruction can be achieved by means of Fourier analysis. The contour shape of handwritten characters can be described by means of the first four couples of Fourier coefficient and by the surface. Two modelling approaches are considered for such handwritten features: (a) a two-level random effects model proposed by Bozza *et al.* (2008) and (b) a Bayesian MANOVA model.

For both models, two different Bayesian versions with different prior specifications are considered: a conjugate approach and an independent prior approach. The latter version of these two models is of primary interest because it can incorporate the between writers variability, which is a peculiar distinguishing element between writers, and which is not modelled otherwise. On the other hand, however, this approach does not allow the marginal likelihood to be obtained in closed form, and Monte Carlo methods must be implemented for its estimation.

The Bayes factor is calculated to compare the performance of the proposed models and to evaluate their efficiency for discriminating purposes. Bayesian MANOVA showed an overall better performance, both in terms of stronger evidence and discriminatory capacity. Finally, a sensitivity analysis to the elicitation of the prior distribution modelling the within writers' variability is performed.

Ruin probabilities in the Sparre Andersen model: A change of measures approach

Spyridon M. Tzaninis & Apostolos Bozikas

Department of Statistics and Insurance Science, University of Piraeus, Greece

stzaninis@unipi.gr; bozikas@unipi.gr

Abstract. Let (Ω,Σ,P) be a probability space. It is well-known that, for given compound renewal process S under P (P-CRP for short), exact expressions for the ruin probability exist only in some special cases, e.g. when the claim size distribution is a phase-type distribution. If we are interested in an exact figure for the ruin probability, the only available method seems to be simulation. However, a crude Monte Carlo simulation is not, in general, suitable for this problem, as the indicator function of the ruin event cannot be directly simulated. Moreover, existing Importance Sampling techniques fail in the presence of heavy-tailed distributions. To address this issue, we prove, under a mild assumption, a characterization of the class of all probability measures Q on the domain of P, that preserve the structure of S and so that ruin occurs Q-almost surely. The above characterization leads to a general formula for the computation of the ruin probability via simulation.

A way of eliminating a nuisance parameter with the plug-in method utilizing an independent sample

George Tzavelas

Department of Statistics and Insurance Science, University of Piraeus, Greece

tzafor@unipi.gr

Abstract. The estimation of the structural parameter in the presence of a nuisance parameter is an old and challenging problem. The usual estimating method is the plug-in likelihood method, using the same data set for estimating both the structural as well as the nuisance parameters. The aim of this paper is to provide an optimal estimating function for the estimation of the parameter of interest using the plug-in method, when an estimator for the nuisance parameter is available independent of the sample used to estimate the structural parameter.

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Bias correction in random effects models with sparse binary responses

Vassilis G.S. Vasdekis & Antonia K. Korre

Department of Statistics, Athens University of Economics and Business, Greece

vasdekis@aueb.gr; ant_korre@yahoo.com

Abstract. Sparse correlated binary data are frequently encountered in many applications involving either rare event cases or small sample sizes. In this study we consider correlated binary data and a logit random effects model framework. We discuss h-likelihood estimates and how the computational procedure is affected by sparseness. We propose an adjustment to the fitting process that involves the adaption of the regression calibration method to the estimation of random effects. Using this adjustment, we correct for the bias in the random effects estimates resulting in better properties for the fixed effects estimates of the model. This is supported by the results of the simulation study and is illustrated through a meta-analysis data set.

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The impact of the COVID-19 pandemic on the life expectancy of the population of Greece at national and regional level: 2020-2022

Georgia Verropoulou[1], Cleon Tsimbos[1] & Yannis Psycharis[2]

[1] Department of Statistics and Insurance Science, University of Piraeus, Greece
[2] Department of Economic and Regional Development, Panteion University, Greece
gverrop@unipi.gr; cleon@unipi.gr; psycharis@panteion.gr

Abstract. The onset of COVID-19 in Greece caused a significant effect on the mortality and morbidity of the population and created major problems for the country's health services. In this work, we construct Life Tables by Cause of Death with particular reference to COVID-19 to estimate the impact of the pandemic on the life expectancy of the population; the analysis is performed at national and regional level, considering the 13 administrative regions of the country. For the purposes of the study, we employ population counts based on the 2021 census and diagnosed deaths due to COVID-19, compiled by the National Organization of Public Health (EODY) during the period October 2020 to March 2022.The results show that the pandemic shrank the life expectancy of the country's population by 2.1 years; the effect was greater for men (2.3 years) and slightly smaller for women (1.9 years). At regional level,_the impact of the pandemic on life expectancy was less important in the islands (1 year or less) while it was particularly pronounced in the regions of Macedonia, Thessaly and Thrace, where life expectancy at birth was apparently reduced by at least 2.1 years. Future research will focus on the interpretation of these early results employing socioeconomic attributes and on assessing the interaction between COVID-19 mortality and selected causes of death which tend to shape observed health-related outcomes.

Forecasting Models for Energy Demand

Veronica Vigna, **Riccardo De Blasis** & **Graziella Pacelli**

Department of Management, Marche Polytechnic University, Italy

v.vigna@univpm.it; r.deblasis@univpm.it; g.pacelli@univpm.it

Abstract. This study presents a comparative analysis of forecasting models applied to hourly electricity demand data in Italy. Accurate energy demand forecasting is crucial in today's context, where energy systems are undergoing a deep transformation toward sustainability, efficiency, and resilience. Anticipating consumption patterns is essential for grid stability, economic planning, and the integration of renewable energy sources.

We evaluate the performance of traditional econometric models and compare them with methods based on grey system theory. In particular, we apply a dynamic GM(1,1) grey model and enhance its predictions by correcting residual errors through a Markov chain-based adjustment.

The models are tested on real hourly electricity load data from the Italian market. Forecasting accuracy is assessed using standard metrics, providing a comprehensive view of each model's predictive capabilities.

Results highlight the effectiveness of grey model, especially when integrated with probabilistic refinements, in delivering reliable short-term energy demand forecasts.

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Comparative Private Health Insurance Indices: International Experience and Proposals for the Greek Case

Panos Xenos[1] & **George Messinios**[2]

[1]Department of Statistics & Insurance Science, University of Piraeus

[2]Department of Informatics, National and Kapodistrian University of Athens

pxenos@unipi.gr; gmessinios01@gmail.com

Abstract. In this paper, an international overview of private health insurance indices is made, which can be used to update the premiums of long-term health insurance contracts. We compare the accuracy of indices based on the change in medical inflation and on the use of specific insurance products. Then, we evaluate the corresponding index of IOBE (Foundation for Economic and Industrial Research) and propose an alternative way of constructing indices for the Greek case.

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Some probability and statistical issues in reliability the era of AI

Min Xie

City University of Hong Kong, Hong Kong

minxie@cityu.edu.hk

Abstract. For complex systems, network reliability and probabilistic models have been studied by leading scholars such as Prof Koutras. Much of the works are still relevant today. Statistical modelling and process monitoring will continue to be important research problems. In the era of wide-spread use of artificial intelligence, systems have become even more complex and the dynamic nature through learning process, new issues need to be considered as well, In this talk, we will discuss some probability models and statistical issues related to system reliability modelling, analysis and some quality engineering problems. We will also share some of our views and research in this direction.

Coverage Processes with Infinitely Divisible Marginals and the Ornstein – Uhlenbeck Process

Michael A. Zazanis & George Makatis

Department of Statistics, Athens University of Economics and Business, Greece

zazanis@aueb.gr; makatis@aueb.gr

Abstract. In this paper we define a class of coverage processes with infinitely divisible marginals and a particular type of correlation structure that can be thought of as generalizations of the classical Ornstein - Uhlenbeck process and which include coverage processes such as the M/GI/∞ process. We show how such processes arise naturally as limits of superpositions of independent ON/OFF Markov processes with different parameters by formulating an appropriate limit theorem.

The characteristic function of the finite dimensional distributions of the proposed family of processes has the form

$$\log \phi_n(\theta_1, \dots, \theta_n; t_1, \dots, t_n) = \sum_{1\le i\le j\le n} \psi(\theta_i + \cdots + \theta_j) \\ \times \left[H(t_j - t_{i-1}) - H(t_j - t_i) - H(t_{j+1} - t_{i-1}) + H(t_{j+1} - t_i)\right]$$

where $\psi(\theta)$ is the characteristic exponent of an infinitely divisible distribution and H is a convex distribution function on $[0, \infty)$ with $H(0) = 0$. In particular, when $\psi(\theta) = -\frac{\theta^2}{2}$ and $H(t) = 1 - e^{-t}$, $t \ge 0$, the above expression reduces to the characteristic function of the finite dimensional distributions of the classical Ornstein – Uhlenbeck Process.

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The Sackin index and depth of leaves in generalized Schröder trees

Panpan Zhang[1], Hosam Mahmoud[2]

[1]Vanderbilt University Medical Center, [2]George Washington University

panpan.zhang@vumc.org; hosam@gwu.edu

Abstract. Schröder trees are biological models of evolution, with internal nodes having two or three children. We generalize the model to grow from an arbitrary stochastic process of independent nonnegative integers (not necessarily identically distributed). We call such a process the building sequence. We study the depth of leaves and the Sackin index for some specific building sequences, such as constant additions, Bernoulli, and Poisson-like models. We include an example that shows that the methods can be extended to exchangeable sequences.

Stochastic epidemic models

Stelios Zimeras & K. Papadopoulou

Department of Statistics and Actuarial-Financial Mathematics,

University of the Aegean, Greece

zimste@aegean.gr

Abstract. The emergence and spread of infectious diseases is a complex phenomenon that depends on various factors, such as the environment, interactions between individuals, and population dynamics. Mathematical models play an important role in epidemiology, as they help to understand and predict the spread of diseases, representing the complex interactions that lead to their emergence and development. Stochastic approaches are particularly useful when the spread of disease does not follow predetermined patterns and the random nature of interactions plays a decisive role. This can be seen in diseases such as influenza, where the infection of an individual depends on the presence of other infected individuals in the population. Stochastic models are distinguished into three methods for constructing stochastic epidemiological models that are directly related to the deterministic corresponding models mentioned: Discrete Time Markov Chain, DTMC, Continuous Time Markov Chain, CTMC, Stochastic Differential Equation, SDE. In this work we are interesting for the SDE epidemic models. SDEs describe the evolution of epidemiological parameters through functions affected by stochastic components, such as random noise and fluctuations. Stochastic Differential Equations (SDEs) are a particularly useful tool in the study of the spread of infectious diseases, as they incorporate randomness into the dynamics of transmission and recovery. This approach allows for a more realistic depiction of the behavior of epidemics and more accurate predictions. In this section, we focus on two main SDE models applied to epidemics: the SDE SIS model and the SDE SIR model.

Is still the normality assumption meaningful in inference? The case of Gaussian estimation

Konstantinos Zografos

University of Ioannina, Greece

kzograf@uoi.gr

Abstract. This talk is based on a recent work by Castilla and Zografos (2022) and it presents an estimation procedure which can provide an alternative in cases where the data are coming from an intractable model and, at the same time, outliers pervade the available set of observations. The estimation procedure, which is proposed to meet both these cases, combines Zhang's (2019) Gaussian estimation with minimum density power divergence estimation (MDPDE), introduced in the paper by Basu et al. (1998) (cf. also Basu et al., 2011). Applications of the presented procedure in specific models, like the Poisson-lognormal model, will be briefly discussed.

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