STATISTICAL MODELING WITH APPLICATIONS 2023

∑tatMod

29-30 September 2023
Bucharest, Romania

A hybrid workshop co-organized by:

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- Artificial Intelligence
- Demography
- Entropy, Divergence Measures and Applications
- Financial Mathematics
- Markov and semi-Markov Processes
- Mathematical Reliability
- Optimization
- Renewable Energy
- Statistical Methods and Applications
- Statistics for Dependent Data
- Stochastic Processes

STATISTICAL MODELING WITH APPLICATIONS 2023

BOOK *of* ABSTRACTS

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ABSTRACTS

Danijel ALEKSIĆ (Univ. of Belgrade, Serbia)
On the asymptotic properties of non-degenerate U-statistics in the presence of MCAR data
joint work with Marija CUPARIĆ, Bojana MILOŠEVIĆ (Univ. of Belgrade, Serbia)

Abstract: In this presentation, we will discuss recent results regarding the asymptotic properties of non-degenerate U-statistics in cases where the data are missing completely at random, and a complete-case approach is employed. As an illustrative example, we will focus on the problem of testing independence using the estimator of Kendall's τ. In this particular context, we will provide limiting results when employing several commonly used imputation methods.

Sorin AVRAM (Center for Demographic Research, INCE & Univ. of Craiova, Romania)
The relationship between demography and economic growth within the urban poles of economic growth. a perspective on the evolution models in the context of the adoption of AI technologies
joint work with Laura ANGHEL (INCE, School of Advanced Studies of the Romanian Academy, Romania)

Abstract: This study analyzes the relationship between demography and economic growth in urban economic growth poles from a possible future where we registered a massive adoption of artificial intelligence technologies. We try to establish the impact of this technological transformation upon the interplay between demographic factors and economic development in major cities. We substantiated our research starting from two basic scenarios. In the case of the optimistic scenario, the use of AI could contribute to economic growth by automating and increasing the efficiency of processes and flows. This intervention would realize a more dynamic economy with more employment opportunities. In a pessimistic scenario, the widespread adoption of AI could generate pressures on the labor market. This pressure could amplify social disparities and influence internal and external migration flows to and from important urban poles. We thus set out to present how public policy and urban planning could respond to these emerging challenges and opportunities, including by adapting education systems and addressing changes in workforce needs. The research findings underscore the need for a proactive, flexible approach to ensure that the relationship between demographics and economic growth in urban poles remains robust and sustainable in the age of advanced technology.

Romain AZAÏS (INRIA Lyon, France)
Estimation in spinal Galton-Watson tree
joint work with Benoît HENRY (IMT Lille Douai, France)

Abstract: We consider a Galton-Watson tree whose birth distribution depends on the hidden type of nodes: normal or special. Every special node gives birth to one special child and a number of normal children whose descendance will be normal. Even in such a very structured two-type population, our ability to distinguish the two types and estimate their birth distribution is constrained by a trade-off between the growth-rate of the population and the similarity of the two birth distributions. Indeed, if the growth-rate is too large, large deviation events are likely to be observed in the sampling of the normal individuals, preventing us from distinguishing them from special ones. The talk will be illustrated by numerical simulations and asymptotic goodness-of-fit tests for surviving subcritical Galton-Watson trees.

Apostolos BATSIDIS (Univ. of Ioannina, Greece)
Size biased samples when modeling extreme phenomena
joint work with Polychronis ECONOMOU (Univ. of Patras, Greece), George TZAVELAS (Univ. of Piraeus, Greece)

Abstract: The present talk deals with two possible sources of bias that arise naturally from the selection procedure when modeling extreme phenomena. More specifically, the first type of bias arises when a size biased sample from a set of maximum values is selected, while the second one occurs when it is observed a random sample of maxima, which are obtained from a series of size biased samples. The concept of weighted distributions is used not only as a method of describing both cases but also as an adjustment methodology. In this context, the unknown population parameters are estimated with the method of maximum likelihood estimators. Finally, the differences between the two types of bias are discussed, while the impact of ignoring the biasness is revealed both theoretically and with the use of numerical examples.

Ioana Antonia BRANEA (Transilvania Univ. of Brasov, Romania)
Missing values imputation in the SEPHAR IV echocardiographic study
joint work with Antonia Teodora MOHAIU (Univ. Politehnica of Bucharest, Romania), Lucian Mihai ITU (Transilvania Univ. of Brasov, Romania), Maria DOROBANTU, Cosmin COJOCARU, Oana Florentina FRONEA, Aura Elena VIJIIAC (Univ. of Medicine and Pharmacy "Carol Davila", Romania), Anamaria VIZITIU (Transilvania Univ. of Brasov, Romania)

Abstract: Due to technical and human errors, data collection is prone to a high ratio of missing entries. With a focus on using the benefits of statistical analysis and

Machine Learning-based algorithms on incomplete medical databases, a mechanism for handling missing values is required. This paper proposes a solution for missing data imputation for the SEPHAR IV echocardiographic study by employing an ensemble technique. The most commonly used missing value imputation algorithms (Mean Imputation, k-Nearest Neighbors, Multiple Imputation by Chained Equations, Expectation Maximization, Iterative Imputer, and DataWig) are studied and applied to a synthetic dataset obtained by randomly deleting information from the complete samples. Qualitative and quantitative analysis of the performances is then used to combine the three best models and determine the final missing values. The proposed ensemble technique outperforms current missing value imputation methods on both numeric and categorical data.

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Flavia CHOROBURA (Univ. Politehnica of Bucharest, Romania)

Coordinate descent methods beyond smoothness and separability

joint work with Ion NECOARA (Univ. Politehnica of Bucharest & ISMMA, Romania)

Abstract: In this work we consider convex nonsmooth optimization problems. We introduce a general smooth approximation framework for the original function and apply random (accelerated) coordinate descent methods for minimizing the corresponding smooth approximations. Our framework covers the most important classes of smoothing techniques from the literature. Based on this general framework for the smooth approximation and using coordinate descent type methods, we derive convergence rates in function values for the original objective. Moreover, if the original function satisfies a growth condition, then we prove that the smooth approximations also inherits this condition and, consequently, the convergence rates are improved in this case. We also present a relative randomized coordinate descent algorithm for solving nonseparable minimization problems with the objective function relative smooth along coordinates w.r.t. a (possibly nonseparable) differentiable function. For this algorithm, we also derive convergence rates in the convex case and under the growth condition for the objective.

Ioana CIOTIR (LMI, INSA Rouen Normandy, France)
The stochastic fast logarithmic equation in Rd with multiplicative Stratonovich noise
joint work with Reika FUKUIZUMI (Research Center for Pure and Applied Mathematics, Tohoku University, Japan), Dan GOREAC (Shandong Univ. Weihai, China & Univ. Gustave Eiffel, France)

Abstract: This paper is concerned with the existence and uniqueness of the solution for the stochastic fast logarithmic equation with Stratonovich multiplicative noise in R^d for d=3. It provides an answer to a critical case (morally speaking, corresponding to the porous media operator ΔX^m for m = 0) left as an open problem in the paper Barbu-Rockner-Russo. We face several technical difficulties related both to the degeneracy properties of the logarithm and to the fact that the problem is treated in an unbounded domain. Firstly, the order in which the approximations are considered is very important and different from previous methods. As a by-product of this choice, leading only to weak convergence of relevant terms, identifying the relevant part of the equation in the domain of the nonlinear operator is more precise. Secondly, the energy estimates needed in the last step can only be achieved with a well-chosen Stratonovich-type rectification of the noise.

Luminița CHIVU (INCE, Romania)
Labour market shortages in Romania. Long-term forecast
joint work with George GEORGESCU (INCE, Romania), Sorin-Marius DINU (INCE, Romania)

Abstract: In this presentation we analyse the issue of labour shortages in the case of Romania against the background of negative demographic and net migration. Our approach is taking into account the determining factors of the labour market in Romania in the long-term, such as GDP growth rate, investments (incremental capital output ratio), labour and capital productivity, total factor productivity, capital intensity, and the demographic profile. We also present a long-term forecast of the labour market supply side based on demographic projections and multivariate functions in order to project activity rate and, respectively, of the labour market demand side based on the Cobb-Douglas production function and multivariate functions in order to project the series for its variables. The results led to the conclusion that, long-term, the labour market shortages in Romania are quantitatively determined by the demographic factors and factor productivity and, qualitatively, by the human capital formation process. The labour market shortages will lead to the need to import labour force from outside the European Union and to develop and implement a public policy suitable for its integration.

Elena Corina CIPU (CiTi, National Univ. of Science and Technology Politehnica Bucharest & INCE, Center for Demographic Research, Romania)
Demographic approaches by Monte Carlo modeling
joint work with Ruxandra Ioana CIPU, Ștefania Maria MICHNEA (CiTi, National Univ. of Science and Technology Politehnica Bucharest, Romania)

Abstract: A broad class of computational algorithms that rely on repeated sampling to obtain numerical results useful for estimating survival chances, economic impact, or demographic patterns that express the dynamics of a population category. Monte Carlo modeling provides a flexible and versatile approach to simulate and analyze complex systems, with wide applicability: Finance and Risk Analysis, Physics and Material Science, Environmental Science, Healthcare and Pharmaceuticals, Energy and Utilities, Urban Planning and Transportation, Demographic studies, etc.
After a description of the method, a study of applicability and robustness is made. Two applications that can highlight the degree of generality, applicability, and robustness of the method are considered. First is connected with the financial and medical efficiency of proton beam therapy. Proton beam therapy is a type of radiation therapy that uses protons to treat different types of malignancies. Data found in research centers that have published patient outcomes can be used in a MC analysis to conclude if proton beam therapy as an oncology treatment is better.
A second study is considered to estimate pay gaps. After finding a representative sample containing the relevant variables that contribute to pay gaps, such as gender, race, experience, education, and job role, MC modeling is used to simulate a range of possible pay gap estimates. Based on the Monte Carlo results, sensitivity analysis to identify which variables have the most significant impact on pay gaps is performed.
Other two important types of demographic approaches using Monte Carlo modeling are household and family structure, essential for planning housing, education, and social services, and uncertainty and sensitivity analysis that help capture the inherent variability in demographic processes.

Doru CONSTANTIN (The National Univ. of Science and Technology Politehnica Bucharest, Pitești University Centre, Romania)
Cumulative paired ϕ-negentropy in ICA model estimation
joint work with Costel BĂLCĂU (The National Univ. of Science and Technology Politehnica Bucharest, Pitești University Centre, Romania)

Abstract: By using the cumulative paired ϕ-entropy, we define a new kind of negentropy and use it in ICA model estimation.

Vlad Raul CONSTANTINESCU (Univ. of Bucharest & ISMMA, Romania) *Interpolation property of shallow neural networks*
joint work with Ionel POPESCU (Univ. of Bucharest & IMAR, Romania)

Abstract: In this work, we prove that in the overparametrized regime, a shallow neural network can interpolate any data set, i.e., the loss function has a global minimum value equal to zero as long as the activation function is not a polynomial of small degree. Additionally, if such a global minimum exists, then the locus of global minima is a manifold. Furthermore, we give a characterization of the Hessian of the loss function evaluated at the global minima, and we provide a practical probabilistic method of finding the interpolation point.

Ernö Robert CSETNEK (University of Vienna, Austria)
Second order dynamics with closed-loop damping
joint work with Hedy ATTOUCH (University Montpellier, France), Radu Ioan BOŢ (University of Vienna, Austria)

Abstract: We analyze the asymptotic behavior of dissipative inertial continuous dynamics where the damping acts as a closed-loop control. The function to be minimized (not necessarily convex) enters the dynamic through its gradient, which is assumed to be Lipschitz continuous on the bounded subsets. We first consider the case where the damping term acts as a closed-loop control of the velocity. We analyze the asymptotic convergence and the convergence rates of the trajectories generated by this system. To do this, we use techniques from optimization, control theory, and PDE's: Lyapunov analysis based on the decreasing property of an energy-like function, quasi-gradient and Kurdyka-Lojasiewicz theory, and monotone operator theory for wave-like equations. Then, we extend the results to the case where an additional Hessian-driven damping enters the dynamic, which reduces the oscillations. This study naturally leads to similar results for the proximal-gradient algorithms obtained by temporal discretization.

Spiros DAFNIS (Univ. of Piraeus & Univ. of the Aegean, Greece)
Improved Shewhart-type control charts with supplementary runs rules
joint work with Theodoros PERDIKIS (Athens Univ. of Economics and Business, Greece), Markos V. KOUTRAS (Univ. of Piraeus, Greece)

Abstract: In this work we introduce new Shewhart-type control charts with supplementary runs rules and study the control charts' characteristics (run length distribution, average run length). An extensive numerical analysis is conducted, and it is shown that the proposed charts significantly improve the chart's detection power, especially for small shifts (increases or decreases) in the process mean.

Guglielmo D'AMICO (Univ. "G. d'Annunzio" of Chieti-Pescara, Italy)
On some measures of poverty dynamics
joint work with Riccardo DE BLASIS (Marche Polytechnic Univ. of Ancona, Italy),
Fulvio GISMONDI ("Guglielmo Marconi" Univ. of Rome, Italy)

Abstract: Poverty measurement is an old research problem that is again of wide interest and has many open problems to be solved. Traditionally, several measures have been proposed to quantify different aspects of poverty. Recently, a stochastic approach to the problem has emerged and led to new results. Basically, it consists of modeling the income evolution of the economic agents according to a continuous-time Markov chain, extending the classical poverty measures into this dynamic framework, and deriving approximate computations of the poverty measures based on probabilistic arguments. The paper reviews such an approach, focusing on the generalization of classical poverty measures into a dynamic setting, and also presents some new measures of interest.

Riccardo DE BLASIS (Marche Polytechnic Univ. of Ancona, Italy)
General state space multivariate Markov chain: a mixture transition distribution approach

Abstract: The multivariate Markov chain model is generally employed to describe the behavior of multiple related categorical data sequences pertaining to many applications, from engineering to economics. However, its practical tractability becomes unfeasible when the number of sequences increases. This issue translates into a high number of parameters to estimate. In order to reduce this value, a mixture transition distribution approach has been proposed; see, e.g., [1]. Moreover, departing from the analysis of categorical data, other authors applied the same methodology to economics and financial problems. In particular, [2] proposed a multivariate Markov stock model using multiple dividends series, while [3] applied a similar approach to financial returns to identify the leadership among price series. Nevertheless, this kind of application requires a discretization of the continuous series in order to be modeled by a multivariate Markov chain. To overcome this limitation, we propose a multivariate Markov chain model with a continuous state space. This approach is based on the Gaussian mixture transition distribution model in [4] and its multivariate vector autoregressive extensions [5]. In addition, we perform an application to financial time series to test the proposed model.

Silvia DEDU (Bucharest Univ. of Economic Studies & Center for Demographic Research, INCE, Romania)
A new estimation approach to loss models and survival models using general information measures
joint work with Vasile PREDA (ISMMA & Center for Demographic Research, INCE & Univ. of Bucharest, Romania), Muhammad SHERAZ (Institute of Business Administration Karachi, School of Mathematics and Computer Science, Pakistan)

Abstract: The aim of this talk consists in developing risk estimation methods for actuarial models involving truncated and censored random variables by using general information measures. The effect of some partial insurance transformations, such as inflation, truncation, and censoring from above and truncation and censoring from below, upon the entropy of losses is investigated in this framework. Representation formulas for the per-payment and per-loss information measures are derived, and various properties and relationships between the associated entropies are described. The information measure of the right-truncated loss random variable corresponding to the per-loss risk model with a given deductible and policy limit is computed for the exponential, Weibull, Chi-Square and Gamma distribution. The properties of the resulting entropies, such as the residual loss entropy and the past loss entropy, are studied, and the combined effect of applying a deductible and a policy limit is analyzed. The general information measure approach for actuarial models involving truncated and censored random variables is new and more realistic, since it allows a greater degree of flexibility and improves the modeling accuracy.
This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS/CCCDI– UEFISCDI, project number PN-III-P4-ID-PCE-2020-1112, within PNCDI III).

Bice DI BASILIO (Univ. "G. d'Annunzio" of Chieti-Pescara, Italy)
A comparative econometric study of liquidity risk via drawdown-based risk measures
joint work with Guglielmo D'AMICO (Univ. "G. d'Annunzio" of Chieti-Pescara, Italy), Filippo PETRONI (Marche Polytechnic Univ. of Ancona, Italy)

Abstract: Trading volumes are a key variable since they measure an asset's liquidity degree. To evaluate the liquidity risk exposure, we analyze the volume drawdown process and crash-recovery measures in rolling-time windows. The time-varying windows shield our financial indicators from the massive amount of volume transactions that characterize the stock market's opening and closing. The empirical study is carried out on a dataset of three Nasdaq-listed assets from April to September 2022. Firstly, we shape all of the volume time series using a weighted-indexed semi-Markov (WISMC) model, as well as the EGARCH and GJR models for comparisons. Next, we calculate drawdown-based risk measures on real and synthetic data. Finally, we employ the Kullback-Leibler divergence to compare real and simulated risk

indicators. Results reveal that the WISMC model reproduces all the drawdown-based risk measures much better than the EGARCH and GJR models do for all stocks.

Konstantinos FLORAKIS (MICS, CentraleSupélec, Univ. Paris-Saclay, France & National and Kapodistrian Univ. of Athens, Greece)
Statistical techniques for predicting water consumption in a hydroponic greenhouse: a case study on tomato plants
joint work with Samis TREVEZAS (National and Kapodistrian Univ. of Athens, Greece), Véronique Le CHEVALIER-LETORT (MICS, CentraleSupélec, Univ. Paris-Saclay, France)

Abstract: This study explores techniques for explaining and predicting daily water consumption by utilizing only easily available meteorological data and the progressively growing records of the water consumption dataset. Further, it investigates the potential contribution of crop models' main concepts in constructing more robust models, even when plant measurements are unavailable. Two strategies were developed for this purpose. The first strategy utilized the Greenlab model, employing reference parameter values from previously published papers and re-estimating, for identifiability reasons, only a limited number of parameters. The second strategy adopted key principles from crop growth models to propose a novel modeling approach, which involved deriving a Stochastic Segmentation of input Energy (SSiE) potentially absorbed by the elementary photosynthetically active parts of the plant. All proposed models were fitted with maximum likelihood estimation and compared in terms of their predictive water consumption patterns with real data from the ecstasis Tomato plant. The results suggest that SSiE models can potentially improve irrigation management through efficient data extraction from greenhouse measurements.

Daniel GAIGALL (Aachen Univ. of Applied Sciences, Germany)
On the applicability of several tests to models with not identically distributed random effects

Abstract: We consider Kolmogorov-Smirnov and Cramér-von-Mises type tests for testing central symmetry, exchangeability, and independence. In the standard case, the tests are intended for the application to independent and identically distributed data with unknown distribution. The tests are available for multivariate data, and bootstrap procedures are suitable to obtain critical values. We discuss the applicability of the tests to random effects models, where the random effects are independent but not necessarily identically distributed and with possibly unknown distributions. Theoretical results show the adequacy of the tests in this situation. The quality of the tests in models with random effects is investigated by simulations.

Empirical results obtained confirm the theoretical findings. A real data example illustrates the application.

Carmen Adriana GHEORGHE (Center for Demographic Research, INCE, Romania & School of Advanced Studies of the Romanian Academy, Romania)
Modeling the Bidirectional Relationship Between Gini Index and Ecosystem Services

Abstract: This study explores the complex and bidirectional relationship between income inequality, as measured by the Gini Index, and ecosystem services. By using multidimensional models of autoregressive vectors, the interaction between the variables is analyzed. Our research explores the impact of income inequality on the provision of ecosystem services and, conversely, how changes in ecosystem services can influence the distribution of income. The analysis uses panel data from various countries, allowing us to fully examine temporal and cross-sectional variation. Preliminary findings suggest that income inequality can have both positive and negative effects on ecosystem services, depending on contextual factors. The possibility of a vicious circle between income inequality and ecosystem services was also investigated, aiming to understand how one variable can reinforce or mitigate changes in the other. The results of this research have significant implications for policymakers, highlighting the need for integrated strategies that address both income inequality and ecosystem conservation.

Carmen Adriana GHEORGHE (Center for Demographic Research, INCE, Romania & School of Advanced Studies of the Romanian Academy, Romania)
Regional Disparities and Determinants of Low Birth Rates in Romania
joint work with Mihaela Hrisanta MOSORA (Bucharest Academy of Economic Studies, Romania) and Alina RĂDOI (Center for Demographic Research, INCE, Romania)

Abstract: This study investigates regional disparities in the birth rate in Romania. By applying Principal Component Analysis (PCA) on economic and social indicators available at the level of territorial administrative units, the main key components that contribute to the observed variations in the birth rate in different regions were identified. Results for Romania were spatially represented using hotspot maps, thus obtaining valuable insights into the complex interaction of factors that influence the birth rate, providing a data-based approach that will serve as a starting point for understanding regional disparities in order to address them in future studies.

Dan GOREAC (Shandong Univ. Weihai, China & Univ. Gustave Eiffel, France)
Linearisation and dual algorithms in reinsurance
joint work with Florin AVRAM (Pau Univ., France), Juan LI (Shandong Univ., China), Boxiang XU (Shandong Univ., China), Xiaoxi WU (Shantou Univ., China)

Abstract: This talk aims at offering a brief presentation of a linear programming method in the mixed (singular/continuous) control problems and ensuing algorithms. The main motivation comes from reinsurance in a model with a capital-depending premium, when dividend payments and capital injections to avoid ruin are allowed. The linearisation is based on variational techniques by interpreting the controlled trajectories as accupation measures. The primal/dual programming is translated into an algorithm on spaces of measures that is efficient with no a priori requirements on the optimal controls. On the one hand, we provide a comparison of the output of our method in terms of the optimal value against two benchmarks. On the other hand, we discuss the improvements of some already existing models when capital injection is introduced. Several cases for the equity cost parameter are discussed, as are the boundary (or limit) situations.

Emmanouil-Nektarios KALLIGERIS (LMRS, Univ. of Rouen–Normandy, France)
Exploring visual-motor skill acquisition dynamics in climbing via drifting Markov models
joint work with Vlad Stefan BARBU (LMRS, Univ. of Rouen–Normandy, France & Center for Demographic Research, INCE, Romania), Guillaume HACQUES, Ludovic SEIFERT (STAPS, Univ. of Rouen–Normandy, France), Nicolas VERGNE (LMRS, Univ. of Rouen–Normandy, France)

Abstract: The progress in climbing tracking technology has created fresh prospects in various fields, encompassing the improvement of visual-motor abilities. This entails the capacity to recognise significant visual cues in the surroundings and control movements to attain a desired outcome. Drifting Markov models present a more adaptable approach to modeling sequence heterogeneities in comparison to conventional Markov chains or hidden Markov models. This study seeks to comprehend skill acquisition processes by analyzing visual-motor behaviour through a combination of eye-tracking and instrumented holds. By utilizing Drifting Markov modeling, the study examines a real-life scenario involving 11 individuals over ten climbing sessions to identify the visual-motor skill acquisition's patterns and dynamics.

Alex KARAGRIGORIOU (Univ. of the Aegean, Greece)
A general modified family of divergence measures for estimating and testing purposes joint work with Christos MESELIDIS

Abstract: The focus in this work is placed on situations where zero frequency cells occur. The modified power divergence family has been introduced, and the minimum modified power divergence estimator together with the associated modified double indexed test statistic (MDITS) are defined and investigated. Asymptotic results are obtained under two situations, namely under model misspecification and when the hypothesized parametric model is correctly specified. The behavior of the proposed family of estimators and test statistics is examined, through an extensive simulation study, not only for the regular case but also when the data are contaminated. Results indicate that, through the proposed methodology, we can derive robust estimators with improved efficiency, and stable test statistics, in terms of size, when the data are contaminated.

Omar KASSI (ENSAI Rennes & CREST, France)
Regularity estimation in multivariate functional data
joint work with Nicolas KLUTCHNIKOFF (IRMAR, Rennes Univ., France), Valentin PATILEA (ENSAI Rennes & CREST, France)

Abstract: Combining information both within and between sample realizations, we propose a simple estimator for the local regularity of surfaces in the functional data framework. The independently generated surfaces are measured with error at possibly random discrete times. Non-asymptotic exponential bounds for the concentration of the regularity estimators are derived. An indicator for anisotropy is proposed, and an exponential bound of its risk is derived. Two applications are proposed. We first consider the class of multi-fractional, bidimensional, Brownian sheets with domain deformation, and study the non-parametric estimation of the deformation. As a second application, we build optimal, bivariate kernel estimators for the reconstruction of the surfaces.

Oana LUPAȘCU-STAMATE (ISMMA, Romania)
Asymptotic behaviour of a one-dimensional avalanche model through a particular stochastic process
joint work with Madalina DEACONU (INRIA Nancy, France)

Abstract: We develop the study of a binary coagulation-fragmentation equation that describes the avalanche phenomena. We construct first an adapted stochastic process and obtain its behaviour to the equilibrium. Our model is based on self-organized critical (SOC) systems and in particular on a simple sand pile model introduced in Bressaud and FourINCE. Furthermore, we derive a stochastic

differential equation for this process and propose a numerical method in order to approximate the solution. The key point of our work is a new interpretation of the avalanche phenomena by handling stochastic differential equations with jumps and the analysis of the invariant behaviour of the stochastic process.

Andreas MAKRIDES (Univ. of the Aegean, Greece)
Competing risks modeling through multistate systems
joint work with Theodora DIMITRAKOPOULOU, Alex KARAGRIGORIOU (Univ. of the Aegean, Greece), Ilia VONTA (National Technical Univ. of Athens, Greece)

Abstract: In this work, we focus on the description of the competing risks model in terms of the Multi-State Systems (MSS) methodology and the associated statistical inference when the sojourn times i.e., the waiting times on each state follow distributions belonging to a general class of distributions that is closed under minima.

Bojana MILOŠEVIĆ (Univ. of Belgrade, Serbia)
On the nonparametric change-point detection for some complex data types

Abstract: In this presentation, we introduce general ideas for constructing change-point tests in sequences of independent and identically distributed (i.i.d.) real-valued random variables. We illustrate these concepts with well-known examples and motivating applications to highlight their significance. Additionally, we show how these concepts can be extended to address complex data types, including matrix-valued random variables and directional data. During the presentation, we highlight existing research directions and discuss potential paths for future research.

Yassine NABOU (Univ. Politehnica of Bucharest, Romania)
Moving higher-order Taylor approximation method for smooth problems
joint work with Ion NECOARA (Univ. Politehnica of Bucharest & ISMMA, Romania)

Abstract: In this paper we develop a higher-order method for solving composite (non)convex minimization problems with smooth (non)convex functional constraints. At each iteration, our method approximates the smooth part of the objective function and of the constraints by higher-order Taylor approximations, leading to a moving Taylor approximation method (MTA). We present convergence guarantees for MTA algorithm for both, nonconvex and convex problems. In particular, when the objective and the constraints are nonconvex functions, we prove that the sequence generated by MTA algorithm converges globally to a KKT point. Moreover, we derive convergence rates in the iterates when the problem's data satisfy the Kurdyka-Lojasiewicz (KL) property. Further, when the objective function is (uniformly) convex and the constraints are also convex, we provide (linear/superlinear) sublinear

convergence rates for our algorithm. Finally, we present an efficient implementation of the proposed algorithm and compare it with existing methods from the literature.

Nikolay NIKOLOV (Institute of Statistics, RWTH Aachen Univ., Germany)
Likelihood-ratio tests for rank data models

Abstract: Rank data commonly arise in situations where a set of individuals or objects need to be ordered in agreement with some criteria. Examples of rankings can be found in various practical problems that occur in biology, psychology, sociology, politics, market research, economics, etc. One approach to analysing rank data is to construct a probability distribution over all possible full rankings. In this talk, likelihood-ratio statistics are considered for testing the goodness-of-fit of distance-based models. In particular, the classical Mallows model (MM) under different measures on permutations, a generalized MM based on Cressie-Read power divergence, and the Marginals model are compared in cases with relatively small numbers of ranked objects. As an illustration, the obtained models and test statistics are applied to two real data examples.

Mihaela-Adriana NISTOR (Univ. of Bucharest, Romania)
Risk measures
joint work with Ionel POPESCU (Univ. of Bucharest & IMAR, Romania)

Abstract: The risk measures are statistical instruments used in predicting the risk and volatility of a portfolio based on historical data. The most popular risk measures are the standard deviation, Sharpe ratio, beta, Value at Risk (VaR), and Conditional Value at Risk (CVaR). What all these have in common is that they are measuring the risk (random variable) with a real number. The downside is that all these classical measures are unable to capture (or predict) the change in the risk regime. Our proposal is a risk measure that is associating to the random variable not a single real value, but a step function. The aim is to capture the magnitude of the risk under different risk regimes. In this presentation, we aim at covering a few theoretical aspects of the proposed risk measure.

Mihaela Georgiana OPREA (Center for Demographic Research, INCE, Romania; School of Advanced Studies of the Romanian Academy)
Labor market and demographic changes: the challenges of an active aging population
joint work with **Mihaela Irma VLĂDESCU** (Center for Demographic Research, INCE, Romania; School of Advanced Studies of the Romanian Academy)

Abstract: The phenomenon of population aging is a global phenomenon that affects almost all European countries, including Romania, where the percentage of elderly

people in the total population has increased rapidly in recent years. This is due, among other things, to high migration, increasing life expectancy, and a steadily declining birth rate. The consequences of this demographic phenomenon are particularly important because the social and economic effects are long-term. Some of the studies in this area have focused on examining the population between the ages of 65 and 74 (young seniors), who can be a labour resource at a time when many countries are facing an acute shortage of human resources. The aim of this study is to analyse the demographic situation in the EU and Romania through a comparative analysis of the number of seniors in the EU countries and in Romania. To get an overview of the evolution of the number of seniors, we analysed a number of indicators, including the share of people aged 65 and over in the total population of the EU-27, the share of employed people aged 65 and over by residence in Romania, the evolution of the employment rate of the population aged 65-74 in Romania, the employed people aged 65 and over by economic activity and residence at the national level. In more developed countries such as Italy, France, Germany and Finland, the share of the elderly population in the total population exceeds 20%, confirming the concern about the phenomenon of demographic aging. At the Romanian level, we have noted a fairly clear demarcation by sector of activity. While agriculture is the predominant activity in rural areas, urban populations often opt for fields that require higher education, such as education and health care. In conclusion, the integration of older people into the labour market, although challenging, can reduce labour shortages and increase the volume of contributions to the state budget, while helping to strengthen social cohesion.

Adina OPRIȘAN (New Mexico State University, USA)
Functional limit theorems for a time-changed Brownian motion

Abstract: Additive functionals and the time-changed method of constructing Markov semigroups are used in the case in which the Laplace operator is multiplied by a state-dependent intensity coefficient. Functional limit theorems, including a large deviation principle on the space of continuous functions, for the normalized time changed Wiener process generated this way will be discussed, with an emphasis on the duality between the large deviations' theory and that of the weak convergence.

Christina PARPOULA (Panteion Univ. of Social and Political Sciences, Greece) *Multiple change-point Google trends analysis for detecting mental health issues and needs in Greece*
joint work with Fotios ANAGNOSTOPOULOS (Panteion Univ. of Social and Political Sciences, Greece)

Abstract: During the pandemic, Greeks were already burdened by the strain of a decade-long financial crisis, inevitably posing a huge cumulative burden on their

mental health. As other discernible population-level changes in mental health have yet to emerge, continued surveillance is warranted. To this end, in this study we employed a multiple change-point detection approach to analyze Google Trends data and assess mental health issues and needs in Greece. Google search data from both pre-and post-financial and pandemic crisis periods (2004-2023) were analyzed to examine the search frequency of specific topics/terms of interest, and estimate statistically significant departures from past norms. The results revealed the superiority of anxiety symptoms' searches over depressive ones, and that Greeks, over the last five years, are increasingly searching for "psychologist", "psychotherapist", "psychiatrist", "neurologist", and treatment practices such as "psychotherapy", "meditation", "anxiolytics" and "antidepressants". Furthermore, we evaluated whether the presence of a trend affects the change-point or viceversa, and some conclusions were drawn regarding the functionality and usefulness of change-point technique in analyzing Google Trends data.

Charalampos D. PASSALIDIS (Univ. of the Aegean, Greece)
Background risk model in presence of heavy tails under dependence
joint work with Dimitrios G. KONSTANTINIDES (Univ. of the Aegean, Greece)

Abstract: We study the asymptotic analysis of the tail distortion risk measures in background risk models under various forms of dependence, with regularly varying risk distributions in each portfolio. Further, we extend Breiman's theorem under the Asimit-Jones dependence structure and we study the new tail expectation of unequal heavy-tailedness portfolios and we study it under strong asymptotic independence. Additionally, we investigate the asymptotic behavior of two weighted random sums, generalizing to dependence among the components in each random vector, under a new dependence structure. Finally, we consider the ruin probability in a bi-dimensional discrete time risk model under dependence with unequal heavy-tailedness.

Florin Marius PAVELESCU (Institute of National Economy, Center for Macro Modelling, INCE, Romania)
On the algebraical properties of the intercept of the simple linear regressions. Implications for estimation methodology

Abstract: In the first part, the paper reveals that the intercept of a simple linear regression acts as a residium of the estimation. Hence, its size is sensibly influenced by the type of the coefficient of determination. There are identified eight types of coefficients of determination. In the second part, the paper determines the modeling factors of statistics of the Student test related to the intercept. Hence, it is recommendable to analyse carefully the size of intercept, firstly considering the

simple mean of the observed values of the dependent variable and then the deviation from the respective mean. Also, the author argues that the size of the statistics of the Student test related to the intercept has to be considered in correlation with the size of the respective statistics related to the explanatory variable.

Alexandru POPA (Univ. Politehnica of Bucharest, Romania)
IP solutions for international kidney exchange programs
joint work with Radu-Stefan MINCU (Univ. Politehnica of Bucharest, Romania), Péter BIRÓ (Institute of Economics, Hungarian Academy of Sciences & Corvinus Univ. of Budapest, Hungary), Márton GYETVAI (Institute of Economics, Hungarian Academy of Sciences & Corvinus Univ. of Budapest, Hungary), Utkarsh VERMA (IIT, India)

Abstract: In kidney exchange programs patients with end-stage renal failure may exchange their willing, but incompatible living donors among each other. National kidney exchange programs are in operation in ten European countries, and some of them have already conducted international exchanges through regulated collaborations. The exchanges are selected by conducting regular matching runs (typically every three months) according to well-defined constraints and optimisation criteria, which may differ across countries. In this work we give integer programming formulations for solving international kidney exchange problems, where the optimisation goals and constraints may be different in the participating countries and various feasibility criteria may apply for the international cycles and chains. We also conduct simulations showing the long-run effects of international collaborations for different pools and under various national restrictions and objectives. We compute the expected gains of the cooperation between two countries with different pool sizes and different restrictions on the cycle-length. For instance, if country A allows 3-way cycles and country B allows 2-way cycles only, whilst the pool size of country A is four times larger than the pool size of country B (which is a realistic case for the relation of Spain and France, respectively), then the increase in the number of transplants will be about 2% for country A and about 37% for country B.

Hajar RAILLANI (ENSA of El Jadida, Morocco & LMN, INSA Rouen Normandy, France)
Disaster modeling with hidden Markov model: application to floods
joint work with Lamia HAMMADI (LabSIPE, ENSA of El Jadida, Morocco & LMN, INSA Rouen Normandy, France), Vlad Stefan BARBU (LMRS, Univ. of Rouen–Normandy, France & Center for Demographic Research, INCE, Romania), Abdessamad EL BALLOUTI (LabSIPE, ENSA of El Jadida, Morocco), Eduardo SOUZA DE CURSI (LMN, *INSA* Rouen Normandy, France)

Abstract: Hidden Markov models (HMMs) are a commonly used tool for sequence modeling, particularly in fields like speech and signal recognition. In this work, we

explore the application of an HMM for flood prediction within the context of humanitarian supply chains. Specifically, our focus is on monitoring and managing populations residing in flood-prone areas that are not under the control of Moroccan authorities. This hard-to-reach population constitutes a big challenge for government, especially in terms of disaster response. Our goal, therefore, is to use a hidden Markov model to understand the fluctuations within this vulnerable population and how they impact observations, namely, the number of deaths due to floods. We apply this model to historical death data of 58 years, and we use the Expectation-Maximization (EM) algorithm to estimate model parameters. This research provides valuable insights into the potential applications of HMMs in disaster management and humanitarian logistics. It highlights the importance of these models in predicting, monitoring, and then protecting vulnerable populations and mitigating the effects of natural disasters in the future.

Anişoara RĂDUCAN (ISMMA, Romania)
A new order relation between random variables applied to an investment problem
joint work with Raluca VERNIC (Ovidius Univ. of Constanta, Romania), Gheorghiță *ZBĂGANU* (ISMMA, Romania)

Abstract: In this paper we define a new preference relation between random variables, some of its characteristics, and also how it is related to other known orders. This new order emerged in an attempt to stochastically solve an investment problem: when is it better (more profitable for the investor) to first invest a larger amount of money and afterwards a smaller one?

Steliana RODINO (ICEADR, INCDSB, Romania)
Applications of system dynamics models for agricultural sector
joint work with Ruxandra POP (ICEADR, Romania)
Abstract: System dynamics (SD) is a modeling methodology used to analyze and simulate complex systems over time. Creating a SD model for agriculture involves defining the key variables, parameters, and relationships within the system and then running simulations to explore the system behavior under various specific conditions. The results of SD model simulation are a valuable tool with friendly graphical presentation for interested stakeholders (decision-makers, farmers, civil society, researchers) in understanding the complex dynamics of agricultural systems. This study will include practical examples of SD models for the agriculture sector, focusing on the circular economy approach.

Răzvan-Cornel SFETCU (Univ. of Bucharest, Romania)
Generalizations of Tsallis entropy
joint work with Vasile PREDA (ISMMA & Center for Demographic Research, INCE & Univ. of Bucharest, Romania)

Abstract: We introduce fractal Tsallis entropy and fractal Tsallis divergence and study some properties of them, such as Shannon-Khinchin axioms, pseudo-additivity, and Lesche stability. Then we generalize LMC complexity measure (LMC is the abbreviation for Lopez-Ruiz, Mancini and Calbert) and define the statistical complexity by using Euclidean and Wooters' distance measures in order to analyze them for two-level systems.

Yousri SLAOUI (LMA, Univ. of Poitiers, France)
Mixture of longitudinal factor analyzers and their application to chronic pain
joint work with Amine OUNAJIM (PRISMATICS Lab, Poitiers Univ. Hospital & LMA, Univ. of Poitiers, France), Pierre-Yves LOUIS (Institut Agro Dijon & IMB, Univ. Bourgogne Franche-Comté, France), Maxime BILLOT (PRISMATICS Lab, Poitiers Univ. Hospital, France), Denis FRASCA (Department of Anaesthesiology and Critical Care, 3 Poitiers Univ. Hospital & INSERM, Univ. of Nantes and Tours, France), Philippe RIGOARD (PRISMATICS Lab & Department of Spine, Neuromodulation and Handicap, Poitiers Univ. Hospital, France)

Abstract: Multivariate longitudinal are used in a variety of research areas not only because they allow to analyze time trajectories of multiple indicators, but also to determine how these trajectories are influenced by other covariates. In this article, we propose a mixture of longitudinal factor analyzers. This model could be used to extract latent factors representing multiple longitudinal noisy indicators in heterogeneous longitudinal data and to study the impact of one or several covariates on these latent factors. One of the advantages of this model is that it allows for measurement non-invariance, which arises in practice when the factor structure varies between groups of individuals due to cultural or physiological differences. This is achieved by estimating different factor models for different Latent classes. The proposed model could also be used to extract latent classes with different latent factor trajectories over time. Other advantages of the model include its ability to take into account heteroscedasticity of errors in the factor analysis model by estimating different error variances for different latent classes. We first define the mixture of longitudinal factor analyzers and its parameters. Then, we propose an EM algorithm to estimate these parameters. We propose a Bayesian information criterion to identify both the number of components in the mixture and the number of latent factors. We then discuss the comparability of the latent factors obtained between subjects in different latent groups. Finally, we apply the model to simulated and real data of patients with chronic postoperative pain.

Yvik SWAN (ULB, Belgium)
Independent additive weighted bias distributions and associated goodness-of-fit tests
joint work with Bruno EBNER (Karlsruhe Institute of Technology, Germany)

Abstract: We use a Stein identity to define a new class of distributions, which we call "independent additive weighted bias distributions". We investigate related L^2-type discrepancy measures, empirical versions of which not only encompass traditional ODE-based procedures but also offer novel methods for conducting goodness-of-fit tests in composite hypothesis testing problems. We determine critical values for these new procedures using a parametric bootstrap approach and evaluate their power through Monte Carlo simulations. As an illustration, we apply these procedures to examine the compatibility of two real data sets with a compound Poisson Gamma distribution.

Roman TENZIN (LMRS, Univ. of Rouen-Normandy, France)
Truncated sequential change-point detection for Markov chains with applications in the epidemic statistical analysis
joint work with Evgenii PCHELINTSEV (International Laboratory of Statistics of Stochastic Processes and Quantitative Finance, National Research Tomsk State Univ., Russia), Serguei PERGAMENCHTCHIKOV (LMRS, Univ. of Rouen-Normandy, France)

Abstract: We consider truncated detection problems for statistical models with dependent
observations given by Bayesian Markov chains for a uniform prior distribution when the number of observations is limited by some known value. To do this, using optimal stopping methods, a new optimal sequential detection procedure is constructed that minimizes the average delay time in the class of sequential procedures with false positive probabilities not exceeding some fixed value. The main difference between the proposed detection procedure and the usual ones is that it is based not on the posterior probabilities but on Shiryaev-Roberts statistics. This makes it possible to provide optimal detection in a non-asymptotic sense over a bounded time interval without using additional unknown parameters, in contrast to the well-known Bayesian procedures based on a priori geometric distribution containing an unknown parameter. Then we apply the constructed procedures to the problem of early detection of the beginning of the spread of the epidemic. To this end, we use two epidemic models: the binomial models proposed by Baron, Choudhary, Yu (2013) and the models based on the Gaussian approximation introduced by Pergamenchtchikov, Tartakovsky, Spivak (2022). The obtained theoretical results are confirmed by numerical simulations through the Monte Carlo method.

Ciprian A. TUDOR (Univ. of Lille, France)
Estimation for the stochastic wave equation with space-time white noise

Abstract: We study the limit behavior of the quadratic variations (in time and in space) of the solution to the linear stochastic wave equation driven by the space-time white noise. We give their limit (almost surely and in $L^2(\Omega)$) and we prove that these variations satisfy, after a proper renormalization, a Central Limit Theorem via Stein-Malliavin calculus. We apply the quadratic variation to define and analyze estimators for the drift parameter of the wave equation. Some facts concerning the nonlinear equation will also be discussed.

Silviu Laurențiu VASILE (ISMMA & Univ. of Bucharest, Romania)
Network anomaly detection based on traffic analysis

Abstract: In many cases, networks are susceptible to traffic anomalies caused by network equipment failures, device restart, or, in some cases, by DDoS attacks. Early detection of
such unusual anomalies in the network is the first step towards a quick recovery and the prevention of future serious problems. In this work, we present a statistical approach to analyze the distribution of network traffic in order to identify normal network traffic behavior. By applying descriptive statistics to network samples at different time intervals, multiple control limits are calculated. These limits are then used as thresholds for future traffic analysis.

Salvatore VERGINE (Univ. "G. d'Annunzio" of Chieti-Pescara, Italy)
Investment valuation for energy communities
joint work with Riccardo DE BLASIS, Graziella PACELLI (Marche Polytechnic Univ. of Ancona, Italy)

Abstract: Community energy is defined as a network where people have ownership or can influence the management of renewable energy sources whose presence is fundamental for the existence of the community. The basic idea consists of the fact that community members can install and share renewable sources and share energy among different buildings. This setting guarantees savings in terms of total costs and photovoltaic capacity.
Furthermore, the inclusion of the battery in the community gives managerial flexibility to users because of the possibility to store the excess energy produced by renewable sources and to use it when it is more cost-convenient. The community management is implemented by considering random demand profiles of each unit belonging to the community connected to the weather conditions and, consequently, to the photovoltaic production. We consider different community sizes with fixed capacities of the community battery and community photovoltaic system. We study

multi-category community aggregation and value the possibility of expanding a pre-existing community based on costs, savings, and electricity price.

Raluca VERNIC (Ovidius Univ. of Constanta, Romania)
Extending composite distributions to the bivariate setting
joint work with Catalina BOLANCÉ (Univ. of Barcelona, Spain)

Abstract: Composite distributions (or two-component spliced distributions) have been intensively studied in the univariate case in connection to data exhibiting extreme values. A composite distribution is defined from different distributions on distinct contiguous intervals, with a heavy-tailed distribution (usually Pareto) modeling the right tail. Extending spliced distributions to the bivariate setting is an open problem; in this work, we discuss two ways of performing this extension. The first way consists of using a bivariate Pareto distribution for values larger than some thresholds and a less heavy-tailed bivariate distribution on the complementary domain (like the bivariate Gumbel or bivariate Lognormal distributions). A second proposal is to use a bivariate Copula that joins composite marginals. In this work, we present the bivariate Farlie-Gumbel-Morgenstern distribution with composite Exponential-Pareto marginals. Some properties of these bivariate distributions are presented, and, since the parameter estimation is not obvious due to the marginal unknown thresholds, estimation procedures are discussed and illustrated on simulated and real data from insurance.

Adrian VIOREL (Babes-Bolyai Univ., Romania)
On a continuous dynamical system version of the nonlinear conjugate gradient system

Abstract: Recently, in an Computational Mechanics article, M. Schneider has introduced a continuous time version of the well-known Fletcher-Reeves Conjugate Gradient nonlinear optimization algorithm. We compare the dynamics generated by this new second order dynamical system with that of the influential asymptotic vanishing damping system that models Nesterov's accelerated gradient at continuous level.

Eirini VOTSI (LMM, Le Mans Univ., France)
On the moments of the time to failure for semi-Markov chains
joint work with Mohamed HAMDAOUI (Lorraine Univ. and Arts et Métiers ParisTech, France), Samis TREVEZAS (National and Kapodistrian Univ. of Athens, Greece)

Abstract: In this paper, we focus on the multiple trajectory case of semi-Markov chains and study estimators of important reliability indicators as well as their

asymptotic properties when the number of trajectories tends to infinity. First, we obtain explicit expressions for the mean and the variance of the time to failure, and then for any factorial moment. Second, we define empirical estimators and study under some conditions their asymptotic properties, such as strong consistency and asymptotic normality. The theoretical results that are obtained enable us to construct confidence intervals for the moments of the first hitting time.

Gheorghiță ZBĂGANU (ISMMA, Romania)
Inequality indices, compatibility conditions

Abstract: We find compatibility conditions between four inequalty indices: R/P 20:20, R/P 10:10, Palma ratio, and Gini index.

Jingqi ZHANG (UTT & École Centrale Marseille & LMAC, UTC, France)
A semi-Markov model with geometric renewal processes
joint work Mitra FOULADIRAD (École Centrale Marseille, France), Nikolaos LIMNIOS (LMAC, UTC, France)

Abstract: We consider a repairable system modeled by a semi-Markov process (SMP), where we include a geometric renewal process for system degradation upon repair, and replacement strategies for non-repairable failure or upon N repairs. First Perez-Ocon and Torres-Castro studied this system and proposed availability calculation using the Laplace Transform. In our work, we consider an extended state space for up and down times separately. This allows us to leverage the standard theory for SMP to obtain all reliability- related measurements such as reliability, availability (point and steady-state), mean times, and rate of occurrence of failures of the system with general initial law. We proceed with a convolutional algebra, which allows us to obtain final closed-form formulas for the above measurements. Finally, numerical examples are given to illustrate the methodology.