

Book of Short Papers

SIS 2021



Editors: **Cira Perna, Nicola Salvati and Francesco Schirripa Spagnolo**



Distribuzione Software | Formazione Professionale
Statistica | Economia | Finanza | Biostatistica | Epidemiologia
Sanità Pubblica | Scienze Sociali
www.tstat.it | www.tstattraining.eu

Copyright © 2021

PUBLISHED BY PEARSON

WWW.PEARSON.COM

ISBN 9788891927361

Contents

Preface	XIX
1 Plenary Sessions	1
1.1 Citizen data, and citizen science: a challenge for official statistics. <i>Monica Pratesi</i>	2
2 Specialized Sessions	8
2.1 A glimpse of new data and methods for analysing a rapidly changing population	9
2.1.1 The diffusion of new family patterns in Italy: An update. <i>Arnstein Aassve, Letizia Mencarini, Elena Pirani and Daniele Vignoli</i>	10
2.1.2 Causes of death patterns and life expectancy: looking for warning signals. <i>Stefano Mazzuco, Emanuele Aliverti, Daniele Durante and Stefano Campostrini</i>	16
2.2 Advances in ecological modelling	22
2.2.1 A Bayesian joint model for exploring zero-inflated bivariate marine litter data. <i>Sara Martino, Crescenza Calculli and Porzia Maiorano</i>	23
2.3 Advances in environmental statistics	29
2.3.1 Bayesian small area models for investigating spatial heterogeneity and factors affecting the amount of solid waste in Italy. <i>Crescenza Calculli and Serena Arima</i>	30
2.3.2 A spatial regression model for for predicting abundance of lichen functional groups. <i>Pasquale Valentini, Francesca Fortuna, Tonio Di Battista and Paolo Giordani</i>	36
2.4 Advances in preference and ordinal data theoretical improvements and applications	42
2.4.1 Boosting for ranking data: an extension to item weighting. <i>Alessandro Albano, Mariangela Sciandra and Antonella Plaia</i>	43
2.4.2 An Extended Bradley-Terry Model For The Analysis Of Financial Data. <i>Alessio Baldassarre, Elise Dusseldorp and Mark De Rooij</i>	49

2.5	Business system innovation, competitiveness, productivity and internationalization	55
2.5.1	An analysis of the dynamics of the competitiveness for some European Countries. <i>Andrea Marletta, Mauro Mussini and Mariangela Zenga</i>	56
2.5.2	National innovation system and economic performance in EU. An analysis using composite indicators. <i>Alessandro Zeli</i>	62
2.6	Challenges for observational studies in modern biomedicine	68
2.6.1	Data integration: a Statistical view. <i>Pier Luigi Conti</i>	69
2.6.2	Exploring patients' profile from COVID-19 case series data: beyond standard statistical approaches. <i>Chiara Brombin, Federica Cugnata, Pietro E. Cippà, Alessandro Ceschi, Paolo Ferrari and Clelia di Serio</i>	75
2.6.3	On the statistics for some pivotal anti-COVID-19 vaccine trials. <i>Mauro Gasparini</i>	81
2.7	Data Science for Industry 4.0 (ENBIS)	87
2.7.1	Sample selection from a given dataset to validate machine learning models. <i>Bertrand Iooss</i>	88
2.7.2	Reliable data-drive modelling and optimisation of a batch reactor using bootstrap aggregated deep belief networks. <i>Changhao Zhu and Jie Zhang</i>	94
2.8	Integration of survey with alternative sources of data	100
2.8.1	A parametric empirical likelihood approach to data matching under nonignorable sampling and nonresponse. <i>Daniela Marella and Danny Pfeffermann</i>	101
2.8.2	Survey data integration for regression analysis using model calibration.	107
2.8.3	Latent Mixed Markov Models for the Production of Population Census Data on Employment. <i>Daniela Filippini, Ugo Guarnera and Roberta Varriale</i>	112
2.9	Media, social media and demographic behaviours	118
2.9.1	Monitoring the Numbers of European Migrants in the United Kingdom using Facebook Data. <i>Francesco Rampazzo, Jakub Bijak, Agnese Vitali, Ingmar Weber and Emilio Zagheni</i>	119
2.10	New developments in ensemble methods for classification	125
2.10.1	An alternative approach for nowcasting economic activity during COVID-19 times. <i>Alessandro Spelta and Paolo Pagnottoni</i>	126
2.10.2	Assessing the number of groups in consensus clustering by pivotal methods. <i>Roberta Pappadà, Francesco Pauli and Nicola Torelli</i>	132
2.10.3	Clustering of data recorded by Distributed Acoustic Sensors to identify vehicle passage and typology. <i>Antonio Balzanella and Stefania Nacchia</i>	138
2.11	New developments in latent variable models	144
2.11.1	A Hidden Markov Model for Variable Selection with Missing Values. <i>Fulvia Pennoni, Francesco Bartolucci, and Silvia Pandolfi</i>	145
2.11.2	Comparison between Different Likelihood Based Estimation Methods in Latent Variable Models for Categorical Data. <i>Silvia Bianconcini and Silvia Cagnone</i>	151
2.11.3	A Comparison of Estimation Methods for the Rasch Model. <i>Alexander Robitzsch</i>	157

2.12	New issues on multivariate and univariate quantile regression	163
2.12.1	Directional M-quantile regression for multivariate dependent outcomes. <i>Luca Merlo, Lea Petrella and Nikos Tzavidis</i>	164
2.13	Semi-parametric and non-parametric latent class analysis	170
2.13.1	Stepwise Estimation of Multilevel Latent Class Models. <i>Zsuzsa Bakk, Roberto di Mari, Jennifer Oser and Jouni Kuha</i>	171
2.13.2	Distance learning, stress and career-related anxiety during the Covid-19 pandemic: a students perspective analysis. <i>Alfonso Iodice D'Enza, Maria Iannario, Rosaria Romano</i>	177
2.13.3	A Tempered Expectation-Maximization Algorithm for Latent Class Model Estimation. <i>Luca Brusa, Francesco Bartolucci and Fulvia Pennoni</i>	183
2.14	Statistics for finance high frequency data, large dimension and networks	189
2.14.1	The Italian debt not-so-flash crash. <i>Maria Flora and Roberto Reno'</i>	190
3	Solicited Sessions	197
3.1	Advances in social indicators research and latent variables modelling in social sciences	198
3.1.1	A composite indicator to measure frailty using administrative healthcare data. <i>Margherita Silan, Rachele Brocco and Giovanna Boccuzzo</i>	199
3.1.2	Clusters of contracting authorities over time: an analysis of their behaviour based on procurement red flags. <i>Simone Del Sarto, Paolo Coppola and Matteo Troia</i>	205
3.1.3	An Application of Temporal Poset on Human Development Index Data. <i>Leonardo Salvatore Alaimo, Filomena Maggino and Emiliano Seri</i>	211
3.1.4	The SDGs System: a longitudinal analysis through PLS-PM. <i>Rosanna Cataldo, Maria Gabriella Grassia and Laura Antonucci</i>	217
3.2	Changes in the life course and social inequality	223
3.2.1	Heterogeneous Income Dynamics: Unemployment Consequences in Germany and the US. <i>Raffaele Grotti</i>	224
3.2.2	In-work poverty in Germany and in the US: The role of parity progression. <i>Emanuela Struffolino and Zachary Van Winkle Z.</i>	230
3.2.3	Parenthood, education and social stratification. An analysis of female occupational careers in Italy. <i>Gabriele Ballarino and Stefano Cantalini</i>	236
3.3	Composition in the Data Science Era	242
3.3.1	Can we Ignore the Compositional Nature of Compositional Data by using Deep Learning Approaches? <i>Matthias Templ</i>	243
3.3.2	Principal balances for three-way compositions. <i>Violetta Simonacci</i>	249
3.3.3	Robust Regression for Compositional Data and its Application in the Context of SDG. <i>Valentin Todorov and Fatemah Alqallaf</i>	255

3.4	Evaluation of undercoverage for censuses and administrative data	261
3.4.1	Spatially balanced indirect sampling to estimate the coverage of the agricultural census. <i>Federica Piersimoni, Francesco Pantalone and Roberto Benedetti</i>	262
3.4.2	Next Census in Israel: Strategy, Estimation and Evaluation. <i>Danny Pfeffermann</i>	268
3.4.3	Administrative data for population counts estimations in Italian Population Census. <i>Antonella Bernadini, Angela Chieppa, Nicola Cibella and Fabrizio Solari</i>	274
3.4.4	LFS non response indicators for population register overcoverage estimation. <i>Lorella Di Consiglio, Stefano Falorsi</i>	279
3.5	Excesses and rare events in complex systems	285
3.5.1	Space-time extreme rainfall simulation under a geostatistical approach. <i>Gianmarco Callegher, Carlo Gaetan, Noemie Le Carrer and Ilaria Prosdocimi</i>	286
3.6	Hierarchical forecasting and forecast combination	292
3.6.1	Density calibration with consistent scoring functions. <i>Roberto Casarin and Francesco Ravazzolo</i>	293
3.6.2	Forecasting combination of hierarchical time series: a novel method with an application to CoVid-19. <i>Livio Fenga</i>	298
3.7	Household surveys for policy analysis	304
3.7.1	Did the policy responses to COVID-19 protect Italian households' incomes? Evidence from survey and administrative data. <i>Maria Teresa Monteduro, Dalila De Rosa and Chiara Subrizi</i>	305
3.8	Learning analytics methods and applications	311
3.8.1	Open-Source Automated Test Assembly: the Challenges of Large-Sized Models. <i>Giada Spaccapanico Proietti</i>	312
3.8.2	How Much Tutoring Activities May Improve Academic Careers of At-Risk Students? An Evaluation Study. <i>Marta Cannistra, Tommaso Agasisti, Anna Maria Paganoni and Chiara Masci</i>	318
3.8.3	Composite-based Segmentation Trees to Model Learners' performance. <i>Cristina Davino and Giuseppe Lamberti</i>	324
3.8.4	Test-taking Effort in INVALSI Assessments. <i>Chiara Sacco</i>	330
3.9	Light methods for hard problems	336
3.9.1	Fast Divide-and-Conquer Strategies to Solve Spatial Big Data Problems. <i>Michele Peruzzi</i>	337
3.9.2	Application of hierarchical matrices in spatial statistics. <i>Anastasiia Gorshechnikova and Carlo Gaetan</i>	343
3.10	Management and statistics in search for a common ground (AIDEA)	349
3.10.1	Customer Segmentation: it's time to make a change. <i>Fabrizio Laurini, Beatrice Luceri and Sabrina Latusi</i>	350
3.10.2	Multivariate prediction models: Altman's ZScore and CNDCEC's sectoral indicators. <i>Alessandro Danovi, Alberto Falini and Massimo Postiglione</i>	356
3.10.3	Comparing Entrepreneurship and Perceived Quality of Life in the European Smart Cities: a "Posetic" Approach. <i>Lara Penco, Enrico Ivaldi and Andrea Ciacci</i>	362

3.10.4	The Relationship between Business Economics and Statistics: Taking Stock and Ways Forward. <i>Amedeo Pugliese</i>	368
3.11	Mathematical methods and tools for finance and insurance (AMASES)	373
3.11.1	On the valuation of the initiation option in a GLWB variable annuity. <i>Anna Rita Bacinello and Pietro Millosovich</i>	374
3.11.2	Modern design of life annuities in view of longevity and pandemics. <i>Annamaria Olivieri</i>	380
3.11.3	Risk Management from Finance to Production Planning: An Assembly-to-Order Case Study. <i>Paolo Brandimarte, Edoardo Fadda and Alberto Gennaro</i>	386
3.11.4	Some probability distortion functions in behavioral portfolio selection. <i>Diana Barro, Marco Corazza and Martina Nardonthors</i>	392
3.12	Multiple system estimation	398
3.12.1	Multiple Systems Estimation in the Presence of Censored Cells. <i>Ruth King, Oscar Rodriguez de Rivera Ortega and Rachel McCrea</i>	399
3.12.2	Bayesian population size estimation by repeated identifications of units. A semi-parametric mixture model approach. <i>Tiziana Tuoto, Davide Di Cecco and Andrea Tancredi</i>	405
3.13	Network sampling and estimation	411
3.13.1	Targeted random walk sampling. <i>Li-Chun Zhang</i>	412
3.13.2	Estimation of poverty measures in Respondent-driven sampling. <i>María del Mar Rueda, Ismael Sánchez-Borrego and Héctor Mullo</i>	418
3.13.3	Sampling Networked Data for Semi-Supervised Learning Algorithms. <i>Simone Di Zio, Lara Fontanella, Francesco Pantalone and Federica Piersimoni</i>	423
3.13.4	A sequential adaptive sampling scheme for rare populations with a network structure. <i>Emilia Rocco</i>	429
3.14	New perspectives on multidimensional child poverty	435
3.14.1	Estimating uncertainty for child poverty indicators: The Case of Mediterranean Countries. <i>Ilaria Benedetti, Federico Crescenzi and Riccardo De Santis</i>	436
3.14.2	Child poverty and government social spending in the European Union during the economic crisis. <i>Angeles Sánchez and María Navarro</i>	442
3.14.3	The Children's Worlds Study: New perspectives on children's deprivation research. <i>Caterina Giusti and Antoanneta Potsi</i>	448
3.14.4	The impact of different definition of "households with children" on deprivation measures: the case of Italy. <i>Laura Neri and Francesca Gagliardi</i>	454
3.15	Perspectives in social network analysis applications	460
3.15.1	A comparison of student mobility flows in Erasmus and Erasmus+ among countries. <i>Kristijan Breznik, Giancarlo Ragozini and Marialuisa Restaino</i>	461
3.15.2	Network-based approach for the analysis of LexisNexis news database. <i>Carla Galluccio and Alessandra Petrucci</i>	467
3.15.3	A multiplex network approach to study Italian Students' Mobility. <i>Ilaria Primerano, Francesco Santelli and Cristian Usala</i>	473
3.15.4	Ego-centered Support Networks:a Cross-national European Comparison. <i>Emanuela Furfaro, Elvira Pelle, Giulia Rivellini and Susanna Zaccarin</i>	479

3.16	Statistical analysis of energy data	485
3.16.1	Machine learning models for electricity price forecasting. <i>Silvia Golia, Luigi Grossi, Matteo Pelagatti</i>	486
3.16.2	The impact of hydroelectric storage in the Italian power market. <i>Filippo Beltrami</i>	492
3.16.3	Jumps and cojumps in electricity price forecasting. <i>Peru Muniain, Aitor Ciarreta and Ainhoa Zarraga</i>	498
3.17	Statistical methods and models for the analysis of sports data	507
3.17.1	Football analytics: a Higher-Order PLS-SEM approach to evaluate players' performance. <i>Mattia Cefis and Maurizio Carpita</i>	508
3.17.2	Bayesian regularized regression of football tracking data through structured factor models. <i>Lorenzo Schiavon and Antonio Canale</i>	514
3.17.3	A dynamic matrix-variate model for clustering time series with multiple sources of variation. <i>Mattia Stival</i>	520
3.17.4	Evaluating football players' performances using on-the-ball data. <i>David Dandolo</i>	526
3.18	The social and demographic consequences of international migration in Western societies	532
3.18.1	Employment and job satisfaction of immigrants: the case of Campania (Italy). <i>Alessio Buonomo, Stefania Capecchi, Francesca Di Iorio and Salvatore Strozza</i>	533
3.18.2	Social stratification of migrants in Italy: class reproduction and social mobility from origin to destination. <i>Giorgio Piccitto, Maurizio Avola and Nazareno Panichella</i>	539
3.19	Well-being, healthcare, integration measurements and indicators (SIEDS)	545
3.19.1	A Composite Index of Economic Well-being for the European Union Countries. <i>Andrea Cutillo, Matteo Mazziotta and Adriano Pareto</i>	546
3.19.2	Poverty orderings and TIP curves: an application to the Italian regions. <i>Francesco M. Chelli, Mariateresa Ciommi and Chiara Gagliarano</i>	552
4	Contributed Sessions	558
4.1	Advances in clinical trials	559
4.1.1	Quantitative depth-based [18F]FMCH-avid lesion profiling in prostate cancer treatment. <i>Lara Cavinato, Alessandra Ragni, Francesca Ieva, Martina Sollini, Francesco Bartoli and Paola A. Erba</i>	560
4.1.2	Modelling longitudinal latent toxicity profiles evolution in osteosarcoma patients. <i>Marta Spreafico, Francesca Ieva and Marta Fiocco</i>	566
4.1.3	Information borrowing in phase II basket trials: a comparison of different designs. <i>Marco Novelli</i>	572
4.1.4	Q-learning Estimation Techniques for Dynamic Treatment Regime. <i>Simone Bogni, Debora Slanzi and Matteo Borrotti</i>	578
4.1.5	Sample Size Computation for Competing Risks Survival Data in GS-Design. <i>Mohammad Anamul Haque and Giuliana Cortese</i>	584

4.2	Advances in neural networks	590
4.2.1	Linear models vs Neural Network: predicting Italian SMEs default. <i>Lisa Crosato, Caterina Liberati and Marco Repetto</i>	591
4.2.2	Network estimation via elastic net penalty for heavy-tailed data. <i>Davide Bernardini, Sandra Paterlini and Emanuele Taufer</i>	596
4.2.3	Neural Network for statistical process control of a multiple stream process with an application to HVAC systems in passenger rail vehicles. <i>Gianluca Sposito, Antonio Lepore, Biagio Palumbo and Giuseppe Giannini</i>	602
4.2.4	Forecasting air quality by using ANNs. <i>Annalina Sarra, Adelia Evangelista, Tonio Di Battista and Francesco Bucci</i>	608
4.3	Advances in statistical methods	614
4.3.1	Robustness of Fractional Factorial Designs through Circuits. <i>Roberto Fontana and Fabio Rapallo</i>	615
4.3.2	Multi-objective optimal allocations for experimental studies with binary outcome. <i>Alessandro Baldi Antognini, Rosamarie Frieri, Marco Novelli and Maroussa Zagoraiou</i>	621
4.3.3	Analysis of three-way data: an extension of the STATIS method. <i>Laura Bocci and Donatella Vicari</i>	627
4.3.4	KL-optimum designs to discriminate models with different variance function. <i>Alessandro Lanteri, Samantha Leorato and Chiara Tommasi</i>	633
4.3.5	Riemannian optimization on the space of covariance matrices. <i>Jacopo Schiavon, Mauro Bernardi and Antonio Canale</i>	639
4.4	Advances in statistical methods and inference	645
4.4.1	Estimation of Dirichlet Distribution Parameters with Modified Score Functions. <i>Vincenzo Gioia and Euloge Clovis Kenne Pagui</i>	646
4.4.2	Confidence distributions for predictive tail probabilities. <i>Giovanni Fonseca, Federica Giummolè and Paolo Vidoni</i>	652
4.4.3	Impact of sample size on stochastic ordering tests: a simulation study. <i>Rosa Arboretti, Riccardo Ceccato, Luca Pegoraro and Luigi Salmaso</i>	658
4.4.4	On testing the significance of a mode. <i>Federico Ferraccioli and Giovanna Menardi</i>	664
4.4.5	Hommel BH: an adaptive Benjamini-Hochberg procedure using Hommel's estimator for the number of true hypotheses. <i>Chiara G. Magnani and Aldo Solari</i>	670
4.5	Advances in statistical models	676
4.5.1	Specification Curve Analysis: Visualising the risk of model misspecification in COVID-19 data. <i>Venera Tomaselli, Giulio Giacomo Cantone and Vincenzo Miracula</i>	677
4.5.2	Semiparametric Variational Inference for Bayesian Quantile Regression. <i>Cristian Castiglione and Mauro Bernardi</i>	683
4.5.3	Searching for a source of difference in undirected graphical models for count data – an empirical study. <i>Federico Agostinis, Monica Chiogna, Vera Djordjilovic, Luna Pianesi and Chiara Romualdi</i>	689
4.5.4	Snipped robust inference in mixed linear models. <i>Antonio Lucadamo, Luca Greco, Pietro Amenta and Anna Crisci</i>	695

4.6	Advances in time series	701
4.6.1	A spatio-temporal model for events on road networks: an application to ambulance interventions in Milan. <i>Andrea Gilardi and Riccardo Borgoni and Jorge Mateu</i>	702
4.6.2	Forecasting electricity demand of individual customers via additive stacking. <i>Christian Capezza, Biagio Palumbo, Yannig Goude, Simon N. Wood and Matteo Fasiolo</i>	708
4.6.3	Hierarchical Forecast Reconciliation on Italian Covid-19 data. <i>Andrea Marcocchia, Serena Arima and Pierpaolo Brutti</i>	714
4.6.4	Link between Threshold ARMA and tdARMA models. <i>Guy M�elard and Marcella Niglio</i>	720
4.7	Bayesian nonparametrics	726
4.7.1	Bayesian nonparametric prediction: from species to features. <i>Lorenzo Masoero, Federico Camerlenghi, Stefano Favaro and Tamara Broderick</i>	727
4.7.2	A framework for filtering in hidden Markov models with normalized random measures. <i>Filippo Ascolani, Antonio Lijoi, Igor Pr�unster and Matteo Ruggiero</i>	733
4.7.3	On the convex combination of a Dirichlet process with a diffuse probability measure. <i>Federico Camerlenghi, Riccardo Corradin and Andrea Ongaro</i>	739
4.7.4	Detection of neural activity in calcium imaging data via Bayesian mixture models. <i>Laura D'Angelo, Antonio Canale, Zhaoxia Yu and Michele Guindani</i>	745
4.8	Clustering for complex data	751
4.8.1	Clustering categorical data via Hamming distance. <i>Edoardo Filippi-Mazzola, Raffaele Argiento and Lucia Paci</i>	752
4.8.2	Penalized model-based clustering for three-way data structures. <i>Andrea Cappelozzo, Alessandro Casa, and Michael Fop</i>	758
4.8.3	Does Milan have a smart mobility? A clustering analysis approach. <i>Nicola Cornali, Matteo Seminati, Paolo Maranzano and Paola M. Chiodini</i>	764
4.8.4	A Fuzzy clustering approach for textual data. <i>Irene Cozzolino, Maria Brigida Ferraro and Peter Winker</i>	770
4.8.5	Valid Double-Dipping via Permutation-Based Closed Testing. <i>Anna Vesely, Livio Finos, Jelle J. Goeman and Angela Andreella</i>	776
4.9	Data science for complex data	782
4.9.1	Text mining on large corpora using Taltac4: An explorative analysis of the USPTO patents database. <i>Pasquale Pavone, Arianna Martinelli and Federico Tamagni</i>	783
4.9.2	Emotion pattern detection on facial videos using functional statistics. <i>Rongjiao Ji, Alessandra Micheletti, Natasa Krklec Jerinkic and Zoranka Desnica</i>	789
4.9.3	The spread of contagion on Twitter: identification of communities analysing data from the first wave of the COVID-19 epidemic. <i>Gianni Andreozzi, Salvatore Pirri, Giuseppe Turchetti and Valentina Lorenzoni</i>	795
4.9.4	Composition-on-Function Regression Model for the Remote Analysis of Near-Earth Asteroids. <i>Mara S. Bernardi, Matteo Fontana, Alessandra Menafoglio, Alessandro Pisello, Massimiliano Porreca, Diego Perugini and Simone Vantini</i>	801
4.9.5	Determinants of football coach dismissal in Italian League Serie A. <i>Francesco Porro, Marialuca Restaino, Juan Eloy Ruiz-Castro and Mariangela Zenga</i>	805
4.10	Data science for unstructured data	810
4.10.1	Identification and modeling of stop activities at the destination from GPS tracking data. <i>Nicoletta D'Angelo, Giada Adelfio, Antonino Abbruzzo and Mauro Ferrante</i>	811

4.10.2	A generalization of derangement. <i>Maurizio Maravalle and Ciro Marziliano</i>	817
4.10.3	Analysis of clickstream data with mixture hidden markov models. <i>Furio Urso, Antonino Abbruzzo and Maria Francesca Cracolici</i>	823
4.10.4	Using Google Scholar to measure the credibility of preprints in the COVID-19 Open Research Dataset (CORD-19). <i>Manlio Migliorati, Maurizio Carpita, Eugenio Brentari</i>	829
4.10.5	Mobile phone use while driving: a Structural Equation Model to analyze the Behavior behind the wheel. <i>Carlo Cavicchia and Pasquale Samacchiaro</i>	835
4.11	Demographic analysis	841
4.11.1	Life expectancy in the districts of Taranto. <i>Stefano Cervellera, Carlo Cusatelli and Massimiliano Giacalone</i>	842
4.11.2	Family size and Human Capital in Italy: a micro-territorial analysis. <i>Gabriele Ruii, Marco Breschi and Alessio Fornasin</i>	848
4.11.3	Estimate age-specific fertility rates from summary demographic measures. An Indirect Model Levering on Deep Neural Network. <i>Andrea Nigri</i>	854
4.11.4	Patterns in the relation between causes of death and gross domestic product. <i>Andrea Nigri and Federico Crescenzi</i>	860
4.11.5	Locally sparse functional regression with an application to mortality data. <i>Mauro Bernardi, Antonio Canale, Marco Stefanucci</i>	866
4.12	Environmental statistics	871
4.12.1	A Distribution-Free Approach for Detecting Radioxenon Anomalous Concentrations. <i>Michele Scagliarini, Rosanna Gualdi, Giuseppe Ottaviano, Antonietta Rizzo and Franca Padoani</i>	872
4.12.2	Ecosud Car, a novel approach for the predictive control of the territory. <i>Giacomo Iula, Massimo Dimo, Saverio Gianluca Crisafulli, Marco Vito Calciano, Vito Santarcangelo and Massimiliano Giacalone</i>	878
4.12.3	Effect of ties on the empirical copula methods for weather forecasting. <i>Elisa Perrone, Fabrizio Durante and Irene Schicker</i>	884
4.12.4	Spatio-temporal regression with differential penalization for the reconstruction of partially observed signals. <i>Eleonora Amone and Laura M. Sangalli</i>	890
4.12.5	Sea Surface Temperature Effects on the Mediterranean Marine Ecosystem: a Semiparametric Model Approach. <i>Claudio Rubino, Giacomo Milisenda, Antonino Abbruzzo, Giada Adelfio, Mar Bosch-Belmar, Francesco Colloca, Manfredi Di Lorenzo and Vita Gancitano</i>	895
4.13	Functional data analysis	901
4.13.1	Remote Analysis of Chapas Stops in Maputo from GPS data: a Functional Data Analysis Approach. <i>Agostino Torti, Davide Ranieri and Simone Vantini</i>	902
4.13.2	A Conformal approach for functional data prediction. <i>Jacopo Diquigiovanni, Matteo Fontana and Simone Vantini</i>	907
4.13.3	Block testing in covariance and precision matrices for functional data analysis. <i>Marie Morvan, Alessia Pini, Madison Giacomci and Valerie Monbet</i>	911
4.13.4	Analysing contributions of ages and causes of death to gender gap in life expectancy using functional data analysis. <i>Alessandro Feraldi, Virginia Zarulli, Stefano Mazzuco and Cristina Giudici</i>	917
4.13.5	Supervised classification of ECG curves via a combined use of functional data analysis and random forest to identify patients affected by heart disease. <i>Fabrizio Maturo and Rosanna Verde</i>	923

4.14	Mixture models	929
4.14.1	Alternative parameterizations for regression models with constrained multivariate responses. <i>Roberto Ascari, Agnese Maria Di Brisco, Sonia Migliorati and Andrea Ongaro</i>	930
4.14.2	Spatially dependent mixture models with a random number of components. <i>Matteo Gianella, Mario Beraha and Alessandra Guglielmi</i>	936
4.14.3	Finite mixtures of regression models for longitudinal data. <i>Marco Alfò and Roberto Rocci</i>	942
4.14.4	Mixtures of regressions for size estimation of heterogeneous populations. <i>Gianmarco Caruso</i>	948
4.14.5	Finite mixtures of regressions with random covariates using multivariate skewed distributions. <i>Salvatore D. Tomarchio, Michael P.B. Gallagher, Antonio Punzo and Paul D. McNicholas</i>	954
4.15	New applications of regression models	960
4.15.1	The Shapley-Lorenz decomposition approach to mitigate cyber risks. <i>Paolo Giudici and Emanuela Raffinetti</i>	960
4.15.2	A spatially adaptive estimator for the function-on-function linear regression model with application to the Swedish Mortality dataset. <i>Fabio Centofanti, Antonio Lepore, Alessandra Menafoglio, Biagio Palumbo and Simone Vantini</i>	967
4.15.3	POSetR: a new computationally efficient R package for partially ordered data. <i>Alberto Arcagni, Alessandro Avellone and Marco Fattore</i>	972
4.15.4	Multi Split Conformal Prediction. <i>Aldo Solari and Vera Djordjilović</i>	978
4.15.5	Changes in the consumption of fruits and vegetables among university students during master courses: an analysis of data automatically collected from cashier transactions. <i>Valentina Lorenzoni, Giuseppe Turchetti and Lucio Masserini</i>	984
4.16	New challenges in clustering and classification techniques	990
4.16.1	A Dynamic Stochastic Block Model with infinite communities. <i>Roberto Casarin and Ovielt Baltodano López</i>	991
4.16.2	Cross-Subject EEG Channel Selection for the Detection of Predisposition to Alcoholism. <i>Michela Carlotta Massi and Francesca Ieva</i>	997
4.16.3	Some Issues on the Parameter Selection in the Spectral Methods for Clustering. <i>Cinzia Di Nuzzo and Salvatore Ingrassia</i>	1003
4.16.4	The link-match tale: new microdata from unit level association. <i>Riccardo D'Alberto, Meri Raggi and Daniela Cocchi</i>	1009
4.17	New developments in Bayesian methods	1015
4.17.1	Spatio-temporal analysis of the Covid-19 spread in Italy by Bayesian hierarchical models. <i>Nicoletta D'Angelo, Giada Adelfio and Antonino Abbruzzo</i>	1016
4.17.2	Modelling of accumulation curves through Weibull survival functions. <i>Alessandro Zito, Tommaso Rigon and David B. Dunson</i>	1021
4.17.3	Model fitting and Bayesian inference via power expectation propagation. <i>Emanuele Degani, Luca Maestrini and Mauro Bernardi</i>	1026
4.17.4	Bayesian quantile estimation in deconvolution. <i>Catia Scricciolo</i>	1032
4.17.5	Bayesian inference for discretely observed non-homogeneous Markov processes. <i>Rosario Barone and Andrea Tancredi</i>	1038

4.18	New developments in composite indicators applications	1044
4.18.1	Building composite indicators in the functional domain: a suggestion for an evolutionary HDI. <i>Francesca Fortuna, Alessia Naccarato and Silvia Terzi</i>	1045
4.18.2	Small Area Estimation of Inequality Measures via Simplex Regression. <i>Silvia De Nicolò, Maria Rosaria Ferrante and Silvia Pacei</i>	1051
4.18.3	Relational Well-Being and Poverty in Italy Benessere relazionale e povertà in Italia. <i>Elena Dalla Chiara and Federico Perali</i>	1057
4.18.4	A composite indicator to assess sustainability of agriculture in European Union countries. <i>Alessandro Magrini and Francesca Giambona</i>	1063
4.18.5	Interval-Based Composite Indicators with a Triplex Representation: A Measure of the Potential Demand for the “Ristori” Decree in Italy. <i>Carlo Drago</i>	1069
4.19	New developments in GLM theory and applications	1075
4.19.1	Variational inference for the smoothing distribution in dynamic probit models. <i>Augusto Fasano and Giovanni Rebaudo</i>	1076
4.19.2	Interpretability and interaction learning for logistic regression models. <i>Nicola Rares Franco, Michela Carliotta Massi, Francesca Ieva and Anna Maria Paganoni</i>	1082
4.19.3	Entropy estimation for binary data with dependence structures. <i>Linda Altieri and Daniela Cocchi</i>	1088
4.19.4	A Comparison of Some Estimation Methods for the Three-Parameter Logistic Model. <i>Michela Battauz and Ruggero Bellio</i>	1094
4.19.5	A statistical model to identify the price determinations: the case of Airbnb. <i>Giulia Contu, Luca Frigau, Gian Paolo Zammarchi and Francesco Mola</i>	1100
4.20	New developments in social statistics analysis	1106
4.20.1	Data-based Evaluation of Political Agents Against Goals Scheduling. <i>Giulio D'Epifanio</i>	1107
4.20.2	Local heterogeneities in population growth and decline. A spatial analysis for Italian municipalities. <i>Federico Benassi, Annalisa Busetta, Gerardo Gallo and Manuela Stranges</i>	1113
4.20.3	The assessment of environmental and income inequalities. <i>Michele Costa</i>	1119
4.20.4	Household financial fragility across Europe. <i>Marianna Brunetti, Elena Giarda and Costanza Torricelli</i>	1125
4.20.5	Refugees' perception of their new life in Germany. <i>Daria Mendola and Anna Maria Parroco</i>	1131
4.21	New perspectives in clinical trials	1137
4.21.1	Improved maximum likelihood estimator in relative risk regression. <i>Euloge C. Kenne Pagui, Francesco Pozza and Alessandra Salvan</i>	1138
4.21.2	Development and validation of a clinical risk score to predict the risk of SARS-CoV-2 infection. <i>Laura Savaré, Valentina Orlando and Giovanni Corrao</i>	1144
4.21.3	Functional representation of potassium trajectories for dynamic monitoring of Heart Failure patients. <i>Caterina Gregorio, Giulia Barbati¹ and Francesca Ieva</i>	1150
4.21.4	Effect of lung transplantation on the survival of patients with cystic fibrosis: IMaCh contribution to registry data. <i>Cristina Giudici, Nicolas Brouard and Gil Bellis</i>	1156
4.21.5	Categories and Clusters to investigate Similarities in Diabetic Kidney Disease Patients. <i>Veronica Distefano, Maria Mannone, Claudio Silvestri and Irene Poli</i>	1162

4.22	New perspectives in models for multivariate dependency	1168
4.22.1	Parsimonious modelling of spectroscopy data via a Bayesian latent variables approach. <i>Alessandro Casa, Tom F. O'Callaghan and Thomas Brendan Mur</i>	1169
4.22.2	Bias reduction in the equicorrelated multivariate normal. <i>Elena Bortolato and Euloge Clovis Kenne Pagui</i>	1175
4.22.3	Some results on identifiable parameters that cannot be identified from data. <i>Christian Hennig</i>	1181
4.23	Novel approaches for official statistics	1187
4.23.1	Web data collection: profiles of respondents to the Italian Population Census. <i>Elena Grimaccia, Gerardo Gallo, Alessia Naccarato, Novella Cecconi and Alessandro Fratoni</i>	1188
4.23.2	Trusted Smart Surveys: architectural and methodological challenges at a glance. <i>Mauro Bruno, Francesca Inglese and Giuseppina Ruocco</i>	1194
4.23.3	On bias correction in small area estimation: An M-quantile approach. <i>Gaia Bertarelli, Francesco Schirripa Spagnolo, Raymond Chambers and David Haziza</i>	1200
4.23.4	The address component of the Statistical Base Register of Territorial Entities. <i>Davide Fardelli, Enrico Orsini and Andrea Pagano</i>	1206
4.23.5	A well-being municipal indicator using census data: first results. <i>Massimo Esposito</i>	1212
4.24	Prior distribution for Bayesian analysis	1218
4.24.1	On the dependence structure in Bayesian nonparametric priors. <i>Filippo Ascolani, Beatrice Franzolini, Antonio Lijoi, and Igor Prünster</i>	1219
4.24.2	Anisotropic determinantal point processes and their application in Bayesian mixtures. <i>Lorenzo Ghilotti, Mario Beraha and Alessandra Guglielmi</i>	1226
4.24.3	Bayesian Screening of Covariates in Linear Regression Models Using Correlation Thresholds. <i>Ioannis Ntzoufras and Roberta Paroli</i>	1232
4.25	Recent advances in clustering methods	1238
4.25.1	Biclustering longitudinal trajectories through a model-based approach. <i>Francesca Martella, Marco Alfò and Maria Francesca Marino</i>	1239
4.25.2	Monitoring tools for robust estimation of Cluster Weighted models. <i>Andrea Cappozzo and Francesca Greselin</i>	1245
4.25.3	Co-clustering Models for Spatial Transcriptomics: Analysis of a Human Brain Tissue Sample. <i>Andrea Sottosanti and Davide Risso</i>	1251
4.25.4	Graph nodes clustering: a comparison between algorithms. <i>Ilaria Bombelli</i>	1257
4.26	Social demography	1263
4.26.1	Childcare among migrants: a comparison between Italy and France. <i>Eleonora Trappolini, Elisa Barbiano di Belgiojoso, Stefania Maria Lorenza Rimoldi and Laura Terzera</i>	1264
4.26.2	Employment Uncertainty and Fertility in Italy: The Role of Union Formation. <i>Giammarco Alderotti, Valentina Tocchioni and Alessandra De Rose</i>	1270
4.26.3	Determinants of union dissolution in Italy: Do children matter? <i>Valentina Tocchioni, Daniele Vignoli, Eleonora Meli and Bruno Arpino</i>	1276
4.26.4	Working schedules and fathers' time with children: A Sequence Analysis. <i>Annalisa Donno and Maria Letizia Tanturri</i>	1282
4.26.5	Correlates of the non-use of contraception among female university students in Italy. <i>Annalisa Busetta, Alessandra De Rose and Daniele Vignoli</i>	1288

4.27	Social indicators applications and methods	1294
4.27.1	A logistic regression model for predicting child language performance. <i>Andrea Briglia, Massimo Mucciardi and Giovanni Pirrotta</i>	1295
4.27.2	Subject-specific measures of interrater agreement for ordinal scales. <i>Giuseppe Bove</i>	1301
4.27.3	A Tucker3 method application on adjusted-PMRs for the study of work-related mortality. <i>Vittoria Carolina Malpassuti, Vittoria La Serra and Stefania Massari</i>	1307
4.27.4	Two case-mix adjusted indices for nursing home performance evaluation. <i>Giorgio E. Montanari and Marco Doretti</i>	1313
4.27.5	The ultrametric covariance model for modelling teachers' job satisfaction. <i>Carlo Cavicchia, Maurizio Vichi and Giorgia Zaccaria</i>	1319
4.28	Some recent developments in compositional data analysis	1325
4.28.1	A Robust Approach to Microbiome-Based Classification Problems. <i>Gianna Serafina Monti and Peter Filzmoser</i>	1326
4.28.2	What is a convex set in compositional data analysis? <i>Jordi Saperas i Riera, Josep Antoni Martín Fernández</i>	1332
4.28.3	Compositional Analysis on the Functional Distribution of Extended Income. <i>Elena Dalla Chiara and Federico Perali</i>	1338
4.28.4	Evaluating seasonal-induced changes in river chemistry using Principal Balances. <i>Caterina Gozzi and Antonella Buccianti</i>	1344
4.28.5	Compositional Data Techniques for the Analysis of the Ragweed Allergy. <i>Gianna S. Monti, Maira Bonini, Valentina Ceriotti, Matteo Pelagatti and Claudio M. Ortolani</i>	1350
4.29	Spatial data analysis	1356
4.29.1	Spatial multilevel mixed effects modeling for earthquake insurance losses in New Zealand. <i>F. Marta L. Di Lascio and Selene Perazzini</i>	1357
4.29.2	Weighted distances for spatially dependent functional data. <i>Andrea Diana, Elvira Romano, Claire Miller and Ruth O'Donnell</i>	1363
4.29.3	Spatial modeling of childcare services in Lombardia. <i>Emanuele Aliverti, Stefano Campostrini, Federico Caldura and Lucia Zanotto</i>	1369
4.29.4	On the use of a composite attractiveness index for the development of sustainable tourist routes. <i>Claudia Cappello, Sandra De Iaco, Sabrina Maggio and Monica Palma</i>	1375
4.30	Statistical applications in education	1381
4.30.1	Does self-efficacy influence academic results? A separable-effect mediation analysis. <i>Chiara Di Maria</i>	1382
4.30.2	Statistics Knowledge assessment: an archetypal analysis approach. <i>Bruno Adabbo, Rosa Fabbricatore, Alfonso Iodice D'Enza and Francesco Palumbo</i>	1388
4.30.3	Exploring drivers for Italian university students' mobility: first evidence from AlmaLaurea data. <i>Giovanni Boscaino and Vincenzo Giuseppe Genova</i>	1394
4.30.4	Can Grading Policies influence the competition among Universities of different sizes? <i>Gabriele Lombardi and Antonio Pio Distaso</i>	1400
4.30.5	The class A journals and the Italian academic research outcomes in Statistical Sciences. <i>Maria Maddalena Barbieri, Francesca Bassi, Antonio Irpino and Rosanna Verde</i>	1406
4.31	Statistical methods for finance	1412
4.31.1	Hypotheses testing in mixed-frequency volatility models: a bootstrap approach. <i>Vincenzo Candila and Lea Petrella</i>	1413

4.31.2	Quantile Regression Forest with mixed frequency Data. <i>Mila Andreani, Vincenzo Candila and Lea Petrella</i>	1419
4.31.3	Higher order moments in Capital Asset Pricing Model betas. <i>Giuseppe Arbia, Riccardo Bramante and Silvia Facchinetti</i>	1425
4.31.4	When Does Sentiment Matter in Predicting Cryptocurrency Bubbles? <i>Arianna Agosto and Paolo Pagnottoni</i>	1431
4.32	Statistical methods for high dimensional data	1437
4.32.1	Virtual biopsy in action: a radiomic-based model for CALI prediction. <i>Francesca Ieva, Giulia Baroni, Lara Cavinato, Chiara Masci, Guido Costa, Francesco Fiz, Arturo Chiti and Luca Viganò</i>	1438
4.32.2	Functional alignment by the “light” approach of the von Mises-Fisher-Procrustes model. <i>Angela Andreella and Livio Finos</i>	1444
4.32.3	A screening procedure for high-dimensional autologistic models. <i>Rodolfo Metulini and Francesco Giordano</i>	1450
4.32.4	Covariate adjusted censored gaussian lasso estimator. <i>Luigi Augugliaro, Gianluca Sottile and Veronica Vinciotti</i>	1456
4.32.5	Ranking-Based Variable Selection for ultra-high dimensional data in GLM framework. <i>Francesco Giordano, Marcella Niglio and Marialuisa Restaino</i>	1462
4.33	Statistical methods in higher education	1468
4.33.1	Effects of remote teaching on students' motivation and engagement: the case of the University of Modena & Reggio Emilia. <i>Isabella Morlini and Laura Sartori</i>	1469
4.33.2	A random effects model for the impact of remote teaching on university students' performance. <i>Silvia Bacci, Bruno Bertaccini, Simone Del Sarto, Leonardo Grilli and Carla Rampichini</i>	1475
4.33.3	Multinomial semiparametric mixed-effects model for profiling engineering university students. <i>Chiara Masci, Francesca Ieva and Anna Maria Paganoni</i>	1481
4.33.4	Evaluating Italian universities: ANVUR periodic accreditation judgment versus international rankings. <i>Angela Maria D'Uggento, Nunziata Ribecco and Vito Ricci</i>	1487
4.33.5	Women's career discrimination in the Italian Academia in the last 20. <i>Daniele Cuntrera, Vincenzo Falco and Massimo Attanasio</i>	1493
4.34	Statistical methods with Bayesian networks	1499
4.34.1	Statistical Micro Matching Using Bayesian Networks. <i>Pier Luigi Conti, Daniela Marella, Paola Vicard and Vincenzina Vitale</i>	1500
4.34.2	Modeling school managers challenges in the pandemic era with Bayesian networks. <i>Maria Chiara De Angelis and Flaminia Musella and Paola Vicard</i>	1506
4.34.3	Structural learning of mixed directed acyclic graphs: a copula-based approach. <i>Federico Castelletti</i>	1512
4.34.4	Inference on Markov chains parameters via Large Deviations ABC. <i>Cecilia Viscardi, Fabio Corradi, Michele Boreale and Antonietta Mira</i>	1518
4.34.5	A propensity score approach for treatment evaluation based on Bayesian Networks. <i>Federica Cugnata, Paola M.V. Rancoita, Pier Luigi Conti, Alberto Briganti, Clelia Di Serio, Fulvia Mecatti and Paola Vicard</i>	1524
4.35	Statistical modelling for the analysis of contemporary societies	1530
4.35.1	Social Network Analysis to analyse the relationship between 'victim-author' and 'motivation' of violence against women in Italy. <i>Alessia Forciniti</i>	1531
4.35.2	Satisfaction and sustainability propensity among elderly bike-sharing users. <i>Paolo Maranzano, Roberto Ascari, Paola Maddalena Chiodini and Giancarlo Manzi</i>	1537

4.35.3	Media and Investors' Attention. Estimating analysts' ratings and sentiment of a financial column to predict abnormal returns. <i>Riccardo Ferretti and Andrea Sciandra</i>	1543
4.35.4	Predictions of regional HCE: spatial and time patterns in an ageing population framework. <i>Laura Rizzi, Luca Grassetti, Divya Brundavanam, Alvisa Palese and Alessio Fornasin</i>	1549
4.36	Surveillance methods and statistical models in the Covid-19 crisis	1555
4.36.1	The Italian Social Mood on Economy Index during the Covid-19 Crisis. <i>Alessandra Righi and Diego Zardetto</i>	1556
4.36.2	Modeling the first wave of the COVID-19 pandemic in the Lombardy region, Italy, by using the daily number of swabs. <i>Claudia Furlan and Cinzia Mortarino</i>	1562
4.36.3	Analysing the Covid-19 pandemic in Italy with the SIPRO model. <i>Martina Amongero, Enrico Bibbona and Gianluca Mastrantonio</i>	1568
4.36.4	Intentions of union formation and dissolution during the COVID-19 pandemic. <i>Bruno Arpino and Daniela Bellani</i>	1574
4.37	Time series methods	1580
4.37.1	Bootstrap-based score test for INAR effect. <i>Riccardo Ievoli and Lucio Palazzo</i>	1581
4.37.2	Evaluating the performance of a new picking algorithm based on the variance piecewise constant models. <i>Nicoletta D'Angelo, Giada Adelfio, Antonino D'Alessandro and Marcello Chiodi</i>	1587
4.37.3	Conditional moments based time series cluster analysis. <i>Raffaele Mattera and Germana Scepti</i>	1593
4.37.4	On the asymptotic mean-squared prediction error for multivariate time series. <i>Gery Andrés Díaz Rubio, Simone Giannerini, and Greta Goracci</i>	1599
4.37.5	Spherical autoregressive change-point detection with applications. <i>Federica Spoto, Alessia Caponera and Pierpaolo Brutti</i>	1605
5	Posters	1611
5.1	A method for incorporating historical information in non-inferiority trials. <i>Fulvio De Santis and Stefania Gubbiotti</i>	1612
5.2	Optimal credible intervals under alternative loss functions. <i>Fulvio De Santis and Stefania Gubbiotti</i>	1618
5.3	Statistical learning for credit risk modelling. <i>Veronica Bacino, Alessio Zoccarato, Caterina Liberati and Matteo Borrotti</i>	1624
5.4	Evaluating heterogeneity of agreement with strong prior information. <i>Federico M. Stefanini</i>	1630
5.5	Analysis of the spatial interdependence of the size of endoreduplicated nuclei observed in confocal microscopy. <i>Ivan Sciascia, Andrea Crosino, Gennaro Carotenuto and Andrea Genre</i>	1636
5.6	A Density-Peak Approach to Clustering Graph-Structured Data. <i>Riccardo Giubilei</i>	1642
5.7	The employment situation of people with disabilities in Tuscany, A Survey on the workplace. <i>Paolo Addis, Alessandra Coli and Gianfranco Francese</i>	1648
5.8	Robustness of statistical methods for modeling paired count data using bivariate discrete distributions with general dependence structures. <i>Marta Nai Ruscone and Dimitris Karlis</i>	1654

6	Satellite events	1660
6.1	Measuring uncertainty in key official economic statistics	1661
6.1.1	Uncertainty in production and communication of statistics: challenges in the new data ecosystem. <i>Giorgio Alleva and Piero Demetrio Falorsi</i>	1662
6.1.2	Uncertainty and variance estimation techniques for poverty and inequality measures from complex surveys: a simulation study. <i>Riccardo De Santis, Lucio Barabesi and Gianni Betti</i>	1668
6.1.3	Pandemics and uncertainty in business cycle analysis. <i>Jacques Anas, Monica Billio, Leonardo Carati, Gian Luigi Mazzi and Hionia Vlachou</i>	1674
6.2	Covid-19: the urgent call for a unified statistical and demographic challenge	1680
6.2.1	Environmental epidemiology and the Covid-19 pandemics	1681
6.2.1.1	The Covid-19 outbreaks and their environment: The Valencian human behaviour. <i>Xavier Barber, Elisa Espín, Lucía Guevara, Aurora Mula, Kristina Polotskaya and Alejandro Rabasa</i>	1682
6.2.2	Estimation of Covid 19 prevalence	1686
6.2.2.1	Optimal spatial sampling for estimating the SARS-Cov-2 crucial parameters. <i>Piero Demetrio Falorsi and Vincenzo Nardelli</i>	1687
6.2.2.2	Survey aimed to estimate the seroprevalence of SARS-CoV-2 infection in Italian population at national and regional level. <i>Stefano Falorsi, Michele D'Alò, Claudia De Vitiis, Andrea Fasulo, Danila Filippini, Alessio Guandalini, Francesca Inglese, Orietta Luzi, Enrico Orsini and Roberta Radini</i>	1693
6.2.3	Measuring and modeling inequalities following the Covid-19 crisis	1699
6.2.3.1	COVID-19 impacts on young people's life courses: first results. <i>Antonietta Bisceglia, Concetta Scolorato and Giancarlo Ragozini</i>	1700
6.2.3.2	Exploring Students' Profile and Performance Before and After Covid-19 Lock-down. <i>Cristina Davino and Marco Gherghi</i>	1705
6.2.4	Nowcasting the Covid-19 outbreaks methods and applications	1711
6.2.4.1	Modeling subsequent waves of COVID-19 outbreak: A change point growth model. <i>Luca Greco, Paolo Girardi and Laura Ventura</i>	1712
6.2.4.2	The second wave of SARS-CoV-2 epidemic in Italy through a SIRD model. <i>Michela Baccini and Giulia Cereda</i>	1718
6.2.5	The impact of Covid-19 on survey methods	1724
6.2.5.1	Collecting cross-national survey data during the COVID-19 pandemic: Challenges and implications of data collection for the 50+ population in the Survey of Health, Ageing and Retirement in Europe (SHARE). <i>Michael Bergmann, Arne Bethmann, Yuri Pettinicchi and Borsch-Supan</i>	1725
6.2.5.2	Adapting a Long-Term Panel Survey to Pandemic Conditions. <i>Peter Lynn</i>	1731
6.2.6	Young contributions in Covid-19 statistical modelling	1737
6.2.6.1	Statistical communication of COVID-19 epidemic using widely accessible interactive tools. <i>Marco Mingione and Pierfrancesco Alaimo Di Loro</i>	1738
6.2.6.2	Modelling COVID-19 evolution in Italy with an augmented SIRD model using open data. <i>Vincenzo Nardelli, Giuseppe Arbia, Andrea Palladino and Luigi Giuseppe Atzeni</i>	1744

Analysis of clickstream data with mixture hidden markov models

Analisi dei clickstream data tramite i mixture hidden markov model

F. Urso, A. Abbruzzo, and M.F. Cracolici

Abstract Clickstream data is an important source of information for businesses, however it is not easy to manage this data and also to convert the information coming out from it in competitive advantage is not a trivial task. This study considers the application of mixture hidden Markov models to clickstream data extracted from a travel services company's e-commerce portal. We find clusters related to web users' browsing behaviour and geographical position that provide essential indications for developing new business strategies.

Abstract *I clickstream data sono un'importante fonte di informazioni per l'e-commerce, sebbene non siano semplici da gestire e convertire queste informazioni in un reale vantaggio competitivo non è un compito banale. In questo articolo, consideriamo l'applicazione dei mixture hidden Markov model a dati relativi al flusso di clickstream estratti dal portale e-commerce di un'azienda di servizi turistici. Sono stati individuati cluster relativi al comportamento di navigazione degli utenti e alla loro posizione geografica che forniscono indicazioni importanti per lo sviluppo di nuove strategie di business.*

Key words: Clickstream Data, Online browsing behaviour, Mixture hidden Markov models, Tourism 2.0, Web mining

F. Urso

Department of Economics, Business and Statistics, University of Palermo, Palermo, Italy, e-mail: furio.urso@unipa.com

A. Abbruzzo

Department of Economics, Business and Statistics, University of Palermo, Palermo, Italy, e-mail: antonino.abbruzzo@unipa.com

M.F. Cracolici

Department of Economics, Business and Statistics, University of Palermo, Palermo, Italy, e-mail: mariafrancesca.cracolici@unipa.com

1 Introduction

Analyzing users' browsing behaviour when exploring e-commerce portals allows companies to gain significant advantages, such as the ability to classify potential customers, tailor their offers accordingly, or identify new opportunities that lead to changes in business strategies. Unfortunately, although the analysis of clickstream data provides essential information on the users' movements exploring a website (5; 3; 9; 6), it does not explain the underlying reasons behind their navigation choices. Furthermore, to develop effective marketing strategies, it would be desirable to identify users' subpopulations based on browsing behaviour. For this reason, statistical models with hidden variables such as mixture hidden Markov models (MHMMs) are a suitable tool for the analysis of clickstreams data. They allow to take into account two levels of uncertainty, a latent process whose evolution explains users' motivations to move from one page to another (13; 8; 7), and a hidden variable related to the presence of clusters representing browsing "profiles" (11; 15; 10). Here, we apply the MHMMs to data collected from the e-commerce portal of the PalermoTravel, a company operating in the hospitality sector, to analyze the differences in user behaviour by identifying the navigation profiles.¹ The paper is structured as follows: Section 2 illustrates the mixture of hidden Markov models. In Section 3, we have applied the model to identify browsing behaviour profiles taking into account user information such as geographic location obtained from IP addresses, access devices and access period.

2 Mixture Hidden Markov models

Hidden Markov models (2; 4; 14) allow analyzing time series whose evolution is supposed to depend on a latent Markov process. The mixture hidden Markov models enable to relax the hypothesis of a single population through latent variables that take into account the different longitudinal patterns in the sequences (15), identifying groups (clusters) of sequences assigned with specific probabilities derived from the data (11). This paper focuses on discrete MHMMs where the latent and the response are assumed discrete random variables.

Let $Y_i = (Y_{i1}, Y_{i2}, \dots, Y_{iT})$ be the generic i -th sequence of length T with $\text{card}|Y_i| = R$, $U_i = (U_{i1}, U_{i2}, \dots, U_{iT})$ the i -th hidden random vector with $\text{card}|U_i| = S$ and assume n independent sequences. Let $M = \{M^1, M^2, \dots, M^K\}$ be a set of HMMs, where $\Theta^k = \{\pi^k, A^k, B^k\}$ is the set of parameters for each sub-models M^k , related on each sub-population $k = 1, \dots, K$. For each sequence Y_i , we define the prior cluster probabilities that the model parameters are the ones related to the k -th sub-model M^k as $P(M^k) = w_k$. The log-likelihood is computed as

¹ PalermoTravel is a pseudonym.

Analysis of clickstream data with mixture hidden markov models

$$\ell(\Theta; Y) = \sum_{i=1}^n \log P(Y_i | \Theta) = \sum_{i=1}^n \log \left(\sum_{k=1}^K w_{ik} \sum_u \pi_{u_1}^k b_{u_1}^k(y_{i1}) \prod_{t=2}^T a_{u_{t-1}, u_t}^k b_{u_t}^k(y_{it}) \right), \quad (1)$$

where the hidden state sequences $u = (u_1, u_2, \dots, u_T)$ take all possible combinations of values in the hidden state space S and where y_{it} are the observations of subject i at time t , $\pi_{u_1}^k = P(u_1 = s | \Theta^k)$ with $s \in \{1, \dots, S^k\}$ is the initial probability of the hidden state at time $t = 1$ in sequence u for cluster k ; $a_{u_{t-1}, u_t}^k = P(u_t = j | u_{t-1} = i, \Theta^k)$ with $i, j \in \{1, \dots, S\}$ is the transition probability from the hidden state at time $t - 1$ to the hidden state at t in cluster k ; and $b_{u_t}^k(y_{it}) = P(y_{it} = r | u_t = s, \Theta^k)$ with $s \in \{1, \dots, S\}$ and $r \in \{1, \dots, R\}$ is the probability that the hidden state of subject i at time t emits the observed state at t in cluster k . MHMM can be generalized to include time-constant covariates (15) that can be used to estimate cluster memberships w_{ik} of each sequence according to the following multinomial logistic model

$$w_{ik} = P(M^k | X_i) = \frac{e^{X_i \gamma_k}}{1 + \sum_{j=2}^K e^{X_i \gamma_j}}, \quad (2)$$

where γ_k is the set of coefficients associated with the vector of covariates X_i for observation i and the k -th class, and $\sum_{k=1}^K w_{ik} = 1$. The cluster posterior probabilities $P(M^k | Y_i, x_i)$ are obtained as

$$P(M^k | Y_i, X_i) = \frac{P(Y_i | M^k, X_i) P(M^k | X_i)}{P(Y_i | \Theta, X_i)}, \quad (3)$$

where $P(Y_i | \Theta, X_i)$ is the likelihood of the complete MHMM for subject i . In order to obtain the parameters estimates, the forward-backward algorithm (1; 12) can be used in MHMM context as illustrated by Vermunt et al. (15).

3 Results

MHMM has been used to analyze the difference in browsing behaviour among users of the PalermoTravel website. The data (log files) were collected in 2017 from September to December. They consist of 10,252 user sessions of maximum length $T=20$. These sessions are the sequences of pages viewed from the same IP address in a fixed period. Specifically, we do not consider the page names but their page category, corresponding to the thematic areas of the site: *Homepage*, *Attraction*, *Accommodation*, *Event*, *Experience*, *Service* and *Info* about the company. We consider three time-constant covariates collected from the website log files: IP address geographic area (i.e., Africa, Asia, East Europe, Italy, Latin America, Middle East, North America, North Europe, Oceania, Russia, South Europe), access device distinguishing PC and mobile and access month. These covariates are used to estimate prior cluster probabilities through the multinomial logistic model as in equation 2. Finally, using a selection procedure based on a combination of AIC and entropy, we

have selected the MHMM consists of 4 clusters and different hidden states in each cluster (i.e., 4,5,5,4) by applying a model selection procedure.

As an example, we show in Figure 1 a directed graph representing the path followed by users in cluster 1. Each pie graph represents a hidden state and edges are the transitions between states. Transition probabilities are displayed on the edges. The different colours and sizes of the pie slices represent emission probabilities of observed states (the pages' thematic area). The identified clusters are the following.

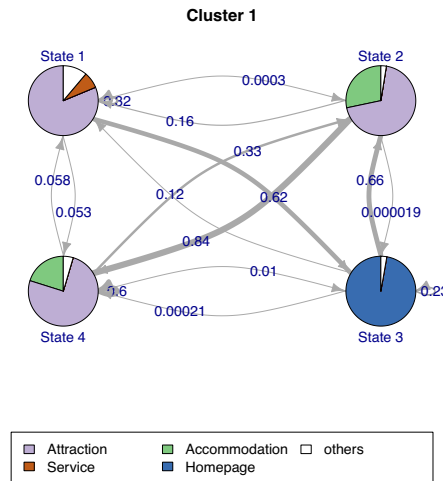


Fig. 1 Cluster 1 hidden Markov process structure. Vertices represent hidden states, edges show the transition probabilities and the slices' color and size show emission probabilities. Emission probabilities lower than 0.05 are classified as "others".

Cluster 1 includes 15% of the sessions and has a high percentage of Northern Europeans who logged in the website from both PC and mobile, especially in October. Users start their session from state 3 (with probability 0.89). This state emits the observed state *Homepage* with probability 0.97. They move to state 2 with probability 0.66, then to state 4 with probability 0.84 and they stay in this state with probability 0.60. These states emit *Attraction* with probability 0.69 and 0.75 respectively. So, users appear to have a particular interest in general information about the region and less interested in the company's products, which is why the cluster was named **Information seeker**.

Cluster 2 (31.3% of the sessions) largely includes Italian, North American and Northern European users who explored the site using mostly their PC in November and December. Users start their session from state 3 with probability of 0.42 and stay in this state with probability 0.92. State 3 emits *Attraction* with probability 0.91. If users start from state 5 (with probability 0.23) they move to state 2 with probability 0.56 and stay in this state with probability 0.75. These two states emit *Event* with probabilities 0.72 and 0.62 respectively. If users start from state 1 with probability

0.19, they stay in this state with probability 0.96. State 3 emits *Accommodation* with probability 0.59. It seems that users primary interest remains viewing tourist attractions. Still, we also note that navigation can view seasonal events (a sign of the desire to select a period of visit) and apartments. This cluster was named **Potential tourist**.

Cluster 3 (41.3% of the sessions) includes the majority of Italians, with accesses mainly from a PC and in September. Users start from state 2 with probability 0.56. This state emits *Homepage* with probability 0.98. Then they move to other states with probabilities not too different. If they start from state 4 with probability 0.25, they will stay in this state with probability 0.95. This state emits *Accommodation* with probability 0.93. Users are interested in viewing and comparing tourism products, with less interest in the information pages presumably having prior knowledge of the Sicily region, so, this cluster was named **Expert tourist**.

Cluster 4 (12.4% of the sessions) includes most Asians and East Europeans and is characterized by the lowest percentage of access via mobile. Users start from state 3 with probability 0.82 and stay in this state with probability 0.89. State 3 emits *Homepage* with probability 0.99. So, they focused only on viewing the home page and move to different areas of the site. This cluster contains an interesting subgroup of users who would stay there if it reached state 2, this state emits *Info* with probability 0.99. This interest in information relating to the tourism company could be attributed to companies interested in partnership relationships. In light of these considerations, this cluster was named **Casual explorer or Potential partner**.

In summary, focusing on the first three profiles as a representation of the user's interest in purchasing a holiday package, we note that most users are categorized in profiles relating to medium and high interest: cluster two (Potential tourist) and cluster three (Expert tourist). Italian users are mostly present in group 3 and scarcely present in the information seeker profile. Users viewing both tourist information and products (cluster two) are mainly North Americans. In contrast, most North European countries are distributed in all first three profiles, making up most profile 1 of information seeker related to a lack of interest in the company's products. Regarding cluster 4, the users are from countries with a greater "cultural distance" from the Italian such as Slavic or Asian countries. Although scarcely present in the sample, these users are all in this profile showing a superficial interest (rarely accessing areas of the site other than the Homepage) or not purchasing oriented (e.g. potential partners). These results highlight that two users' target exploring the website exist, which come out out two different business models i.e. the business-to-consumer (already adopted by the analyzed firm), and the business-to-business.

In light of the above results, the company should consider making the website more attractive to potential customers from non-Western countries and consider selling products and services to other companies.

References

- [1] Baum, L.E., Petrie, T.: Statistical inference for probabilistic functions of finite state markov chains. *The annals of mathematical statistics* **37**(6), 1554–1563 (1966)
- [2] Baum, L.E., Petrie, T., Soules, G., Weiss, N.: A maximization technique occurring in the statistical analysis of probabilistic functions of markov chains. *The annals of mathematical statistics* **41**(1), 164–171 (1970)
- [3] Cadez, I., Heckerman, D., Meek, C., Smyth, P., White, S.: Visualization of navigation patterns on a web site using model-based clustering. In: *Proceedings of the sixth ACM SIGKDD international conference on Knowledge discovery and data mining*, pp. 280–284 (2000)
- [4] Collins, L.M., Wugalter, S.E.: Latent class models for stage-sequential dynamic latent variables. *Multivariate Behavioral Research* **27**(1), 131–157 (1992)
- [5] Cooley, R.W., Srivastava, J.: *Web usage mining: discovery and application of interesting patterns from web data*. Citeseer (2000)
- [6] Das, R., Turkoglu, I.: Creating meaningful data from web logs for improving the impressiveness of a website by using path analysis method. *Expert Systems with Applications* **36**(3), 6635–6644 (2009)
- [7] De Angelis, L., Dias, J.G.: Mining categorical sequences from data using a hybrid clustering method. *European Journal of Operational Research* **234**(3), 720–730 (2014)
- [8] Dias, J.G., Vermunt, J.K.: Latent class modeling of website users' search patterns: Implications for online market segmentation. *Journal of Retailing and Consumer Services* **14**(6), 359–368 (2007)
- [9] Eirinaki, M., Vazirgiannis, M., Kapogiannis, D.: Web path recommendations based on page ranking and markov models. In: *Proceedings of the 7th annual ACM international workshop on Web information and data management*, pp. 2–9 (2005)
- [10] Helske, S., Helske, J.: Mixture hidden markov models for sequence data: The seqhmm package in r. *arXiv preprint arXiv:1704.00543* (2017)
- [11] Van de Pol, F., Langeheine, R.: Mixed markov latent class models. *Sociological methodology* pp. 213–247 (1990)
- [12] Rabiner, L.R.: A tutorial on hidden markov models and selected applications in speech recognition. *Proceedings of the IEEE* **77**(2), 257–286 (1989)
- [13] Scott, S.L., Hann, I.H.: A nested hidden markov model for internet browsing behavior. *Marshall School of Business* pp. 1–26 (2006)
- [14] Vermunt, J.K., Langeheine, R., Bockenholt, U.: Discrete-time discrete-state latent markov models with time-constant and time-varying covariates. *Journal of Educational and Behavioral Statistics* **24**(2), 179–207 (1999)
- [15] Vermunt, J.K., Tran, B., Magidson, J.: Latent class models in longitudinal research. *Handbook of longitudinal research: Design, measurement, and analysis* pp. 373–385 (2008)