Book of Abstracts

37th International Conference on Mathematical Methods in Economics 2019

České Budějovice | September 11–13, 2019

WEDNESDAY September 11, 2019

8:30		F	Registration
10:00	10:15	F3	Opening Ceremony
10:15	11:30	F3	*Plenary Session (chair: Miloš Kopa)*
	Ronald Hochreiter		From AI and Data Science back to Operations Research and Financial Modeling
11:30	13:00	menza	Lunch
13:00	14:40		Parallel Sessions
		F2	*C Multiple Criteria Decision Making (chair: Jaroslav Ramík)*
	Jan Rydval		Sensitivity Analysis of Priorities of Project Team Roles Using the ANP Model
	Marika Hrubešová		Is it possible to use multi-criteria decision making methods for demographic ageing typology?
	Petr Fiala		Project portfolio designing under risk
	Jaroslav Ramík		Desirable Properties of Weighting Vector in Pairwise Comparisons Matrix
		F3	*F1 Portfolio Selection (chair: Van Quang Tran)*
	Adam Borovička		Methodological framework for 'passive' and 'active' approach to the investment portfolio making
	Miloš Kopa		Second order stochastic dominance constraints in decision dependent randomness portfolio optimization problems
	Renata Dudzińska-Baryla		Problem of trade-offs between portfolio's mean, variance and skewness as a goal programming model
	Juraj Pekár		Portfolio selection model based on Drawdown risk measure with Different Inputs
	Van Quang Tran		Portfolio optimization with VaR and CVaR: the case of Gold and Euro currency
		F4	*E1 Econometric Modeling and Applications (chair: Daniel Němec)*
	Nikola Kaspříková		Cost analysis of rectifying acceptance sampling plans
	Simona Macková		Spatial Panel Data Analysis: Did the Economic Structure in Germany Changed?
	Daniel Němec		Estimating the Laffer Curve for Slovakia: A DSGE Approach
		F5	*S1 Statistical and Econometric Methodology (chair: Michal Černý)*
	Jan Kalina		Implicitly Weighted Robust Estimation of Quantiles in Linear Regression
	Jan Tichavský		A Nonparametric Bootstrap Comparison of Variances of Robust Regression Estimators
	Matúš Porázik		Statistical Inference for Logistic Model: Comparison of Alternative Approaches
	Michal Černý		Variability of interval-valued data: A refined analysis of an NP-hard problem
		F6	*T1 Transportation and Routing Problems (chair: Jan Pelikán)*
	Jan Pelikán		Vehicle routing problem with loading time window
	Dana Figurová		Cooperative Vehicle Routing Problem with non-transferable pay-off and its benefits
	Tereza Nehézová		Robust optimization approach in traveling salesman problem
	Dušan Teichmann		Transportation Problem with Time Windows
14:40	15:10	F1	Coffee Break

15:10	16:30		Parallel Sessions
		F2	*D1 Data Envelopment Analysis (chair: Jana Klicnarová)*
		Josef Jablonský	Inverse data envelopment analysis models: comparison of multi-objective optimization approaches
		Eva Štichhauerová	The Evaluation and Selection of Suppliers: DEA Approach
		Michal Pieter	Quantification of differentiating power in Network DEA
		F3	*F2 Financial Analysis (chair: Oldřich Faldík)*
		Jiří Witzany	The Problem of Back-test Overfitting in Quantitative Trading
		Stanislava Dvořáková	Analysis of multiple economic internal rate of return
		Oldřich Faldík	Analysis of unit trust funds and the creation of a descriptive model, with emphasis on the risk-factor and the return of in
		F4	*E2 Econometric Modeling and Applications (chair: Jana Klicnarová)*
		Petra Tomanová	Property and Violent Crime: Evidence from the Czech Republic
		F5	*M Miscellaneous Mathematical Techniques (chair: Emília Draženská)*
		Helena Myšková	Tolerance solvability of interval max-min matrix equations
		Jaromír Kukal	Voigt distribution and its heavy-tail modeling ability for cryptocurrencies
		Ladislav Lukáš	Dynamic AD-AS macroeconomic model of Mankiw type with generalized expectations
		Emília Draženská	Crossing numbers of join product of several graphs on 6 vertices with path using cyclic permutation
		F6	*Z1 Fuzzy Modeling (chair: Monika Molnárová)*
		Simona Hašková	Profitability Estimation of Long-Term Projects in Terms of Uncertainty of Inputs
		Aleš Kresta	Sales Prediction Applying Linguistic Fuzzy Logic Forecaster
		Ján Plavka	Weak tolerance and possible interval supereigenvectors in fuzzy algebra
		Monika Molnárová	Fuzzy interval Monge matrices with respect to robustness
16:30	17:00	F1	Coffee Break
17:00	18:30	F3	Business Meeting of the Czech Society for Operations Research
19:00	22:00	menza	Welcome Evening

8:30		F	Registration
8:50	10:50	F3	*PhD Student Competition*
	Petra Zýková		Dynamic efficiency analysis of German NUTS 2
	Tomáš Rusý		Interest Rate Modelling: Maximum Likelihood Estimation of One-Factor Short-Rate Models
	Petra Tomanová		Price Clustering Phenomenon
	Xiaoshan Feng		An Empirical Analysis of Macroeconomic and Bank Performance Factors Affecting Credit Risk in Banking for The Central
	Anlan Wang		Applications of Mathematical Optimization Approaches to Portfolio
	Michal Škoda		Evaluation of a Crisis Situation Based on Incomplete and Unsound Data
8:50	10:10		Parallel Sessions
		F2	*F3 Decision Making in Finance (chair: Michal Houda)*
	Adéla Špačková		Tariff analysis in a motor hull insurance portfolio
	Oldřich Faldík		Decision-making support as part of the sustainable investment in unit trust funds
		F4	*E3 Econometric Modeling and Applications (chair: Michaela Chocholatá)*
	Michaela Chocholatá		School Performance and Various Socioeconomic Factors: A GWR Approach for Slovak Data
	Petra Vašaničová		Business environment and its relations within Travel and Tourism Competitiveness Index
	Martina Kuncová		Electricity Consumption Cost for Households in the Czech Republic Based on the High and Low Tariff Rates Ratio – Optim
	Ondřej Šimpach		Analysis of production function of agricultural holdings
		F5	*N Network Models (chair: Robert Hlavatý)*
	František Koblasa		Adaptive population techniques in Evolution Algorithms
	Marek Kvet		Identification of the Maximal Relevant Distance in Emergency System Designing
	Martin Pech		The identification of the Key players in the supply chain network
	Robert Hlavatý		An alternative approach towards dealing with uncertainty in project time analysis
		F6	*O Mathematical Optimization (chair: Michal Fendek)*
	Karel Sladký		Second Order Optimality in Semi-Markov Decision Processes
	Vlasta Kaňková		Mean-Risk Optimization Problems via Scalarization, Stochastic Dominance, Empirical Estimates
	Michal Fendek		Optimality conditions in behavior optimization model of consumers in the network industries markets
10:10	10:40	F1	Coffee Break

10:40	12:00		Parallel Sessions
		F2	*D2 Data Envelopment Analysis (chair: Lucie Chytilová)*
	Miroslav Žižka		Inter-Branch Comparison of Cluster Company Performance Using Malmquist Index
	Natalie Pelloneová		Influence of Membership in the Moravian Aerospace Cluster on the Financial Performance of its Members: Malmquist
	Lucie Chytilová		Energy Efficiency Comparison of EU28 Countries Based on Various Undesirable Outputs of Air Emissions
		F4	*E4 Econometric Modeling and Applications (chair: Jaroslav Sixta)*
	Petr Volf		An application of the Cox regression model with time dependent parameters to unemployment data
	Andrea Čížků		Relationship between Output and Unemployment
	Jakub Bechný		Labour market frictions and vacancies: small open economy DSGE model
	Jaroslav Sixta		Multiplication effects of social and health services
		F5	*F4 Financial Analysis of Exchange Markets (chair: Hana Dvořáčková)*
	Jan Kodera		Determination of exchange rate returns dynamic with recurrence analysis
	Tomáš Oravec		Czech Economy under Foreign Exchange Intervention Regimes
	Michal Dominik Stasiak		Trend analysis with use of binary representation
	Hana Dvořáčková		Experimental finance: the Gender Differences in the Disposition Effect Bias
		F6	*S2 Statistical and Econometric Methodology (chair: Jiří Hozman)*
	Jiří Georgiev		Forecasting Inflation in Small Open Economies
	Stavros Athanasiadis		European insurance market analysis via functional data clustering techniques
	Vladimír Holý		A Note on Method of Moments Estimation of Ornstein-Uhlenbeck Process Using Ultra-High-Frequency Data
	Jiří Hozman		Review of several numerical approaches to sensitivity measurement of the Black-Scholes option prices
12:00	13:00	menza	Lunch
13:45	20:00		Conference Trip & Dinner (Kleť Mountain)

FRIDAY September 13, 2019

8:15		F	Registration
8:30	9:50		Parallel Sessions
		F2	*P Project Management (chair: Igor Krejčí)*
	Igor Krejčí		The Dynamics of Work Effort in Project Management
	Helena Brožová		Task threatness matrix in the Project management
	Petr Kučera		Critical mass task identification in projects
	Jan Rydval		Semantic Model of Project Management in Corporate practice
		F3	*E5 Computational Econometrics (chair: Radim Remeš)*
	Radmila Krkošková		Analysis of labour market development in the Czech Republic
	Pavel Pražák		Least Squares Method With Equality Constraints and Polynomial Approximation of Lorenz Curve
	Radim Remeš		The use of belief function theory in recommendation based on a similarity diffusion
	Renata Klufová		Local Action Groups in the Czech Republic and their assessment
		F4	*E6 Econometric Modeling and Applications (chair: Ondřej Badura)*
	Tomáš Ťoupal		Possible Statistical Comparison of Two Time Series
	Lukáš Veverka		Analysis of TV advertisement
	Ondřej Badura		Relative Income in Durable and Non-Durable Consumption Function: Cross-Sectional Study
		F5	*Z2 Fuzzy Numbers (chair: Tomáš Talášek)*
	Krzysztof Piasecki		The relation "greater than or equal to" for trapezoidal ordered fuzzy numbers
	Anna Łyczkowska-Hanćkowiak		The Jensen's ratio determined by oriented fuzzy discount factor
	Tomáš Talášek		Comparison of similarity measures for generalized trapezoidal fuzzy numbers
9:50	10:20	F1	Coffee Break
10:20	11:15	F3	*Plenary Session (chair: Petr Fiala)*
	Gustav Feichtinger		The Mathematics of Ageing
11:15	11:20	F3	Farewell Ceremony
11:20	13:00	menza	Lunch

Plenary Sessions

From AI and Data Science back to Operations Research and Financial Modeling

Ronald Hochreiter

Presented by: **Ronald Hochreiter**

Financial organizations require various quantitative tools to reduce the complexity of the quantitative decision process - especially in the age of Big Data. The recent AI hype led many people to believe that a responsible mathematical modeling of the underlying (financial and economical) problems can be safely outsourced to machines. One has to be forgiving because through Social Media and other non-peer-reviewed media channels Artificial Intelligence (AI) promised to change the world (once again). Data Scientists who integrate AI methods into business processes are one of the most sought-after group of experts at the moment - regardless whether they understand the thematic challenge or not. Within the last few years classical Machine Learning technologies which were around for at least 20-30 years regained enormous popularity due to fascinating applications which are facilitated by Deep Learning which is based on Artificial Neural Networks. The hugely increased computing power especially due to the availability of GPUs allows for massively deep Neural Networks being fit to Big Data problems. However there are actually two main types of AI problems. The first one includes Robotics, Industry 4.0 and Internet of Things (IoT) and considers technological elements which basically either work or fail. The second one is concerned with erratic structures like humans (customers, clients, employees, ...), financial markets and meteorological data. Consider a simple but telling example where the same human customer might behave differently in the morning and in the afternoon due to how lunchtime was perceived which makes it difficult to use plain pattern-matching methods. In this lecture we contrast these two areas and show that in the area of Robotics a rather plain machine-only, self-learning AI approach might be successful while in the other one - which is extremely important for the whole field of Banking and Finance - the emphasis has to be put on human creativity when applying AI technologies. In the latter case methods of Operations Research, Econometrics and other mathematical sound approaches to solving quantitative decision problems have shown to be of much more use by cleverly integrating Human Intelligence into the modeling process. It is time to renew the fascination of Computational Management Science without using AI jargon - this talk aims to provide some relevant pointers to use for this talk.

The Mathematics of Ageing

Gustav Feichtinger, Dieter Grass, Maria Winkler-Dworak

Presented by: **Gustav Feichtinger**

Age is a crucial variable in social sciences and particularly in population dynamics. In the first part of this paper, a two-state optimal control model is proposed to explain the substantial variations of scientific production over the life cycle of researchers. We identify conditions under which typical hump-shaped age-specific´patterns of scientific production turn out to be optimal for individual researchers. The second part of the paper deals with the ageing of learned societies. In a nutshell, the dilemma of a learned society is that keeping young, i.e. electing young entrants, has the drawback of reducing the replacement rate of members. It turns out that electing a mix of young and old members delivers the optimal solution of the problem, i.e. guaranteeing a young age structure, while ensuring a high recruitment rate.

Keywords: Age-structured models • optimal control • scientific production over the life cycle • optimal recruitment of learned societies.

Parallel Sessions

WEDNESDAY September 11, 2019

C Multiple Criteria Decision Making

Sensitivity Analysis of Priorities of Project Team Roles Using the ANP Model

Jan Rydval, Jan Bartoška, Tereza Jedlanová

Presented by: **Jan Rydval**

The article describes the use of sensitivity analysis in the Analytical Network Process (ANP) for analysing how the priorities of the project team roles change when changing the priorities of individual project documents. Model of Analytical Network Process is used for prioritization of the elements of the soft structure of projects. This soft structure is created using the semantic networks, which are based on the Work Breakdown Structure and the RACI matrix. Prioritization of the soft structure elements, of the project team roles in communication or in documents creation in the project management, is the key to the successful project completion. Sensitivity analysis of the project team roles seems to be an essential part of approaches to increase the success of a project. The results of the sensitivity analysis show the stability of the weights of the individual roles due to the change in weights of the individual project documents.

Keywords: Project Management • Analytic Network Process • Sensitivity Analysis • Unweighted Supermatrix • Limit Supermatrix

Is it possible to use multi-criteria decision making methods for demographic ageing typology?

Jana Klicnarová, Renata Klufová, Marika Hrubešová

Presented by: **Marika Hrubešová**

Demographic ageing is a global phenomenon. With trends continuing towards the contraction of working life, severe imbalances may occur in individual life cycles, in the structure of the workforce, and in socioeconomic provision for an ageing population. The paper focuses to demonstrate the usage of multi-criteria

decision making methods for the typology of south bohemian municipalities according to its demographic ageing. Weighted Sum Approach is applied to chosen demographic and socio-economic criteria in order to describe the process of demographic ageing in South Bohemia.

Project portfolio designing under risk

Petr Fiala, Renata Majovská

Presented by: **Petr Fiala**

Project portfolio designing is a dynamic multi-criteria decision-making problem under risk. The paper presents an approach for dynamic project portfolio management based on the Analytic Network Process (ANP) model. The ANP model consists of four basic clusters (projects, resources, criteria, time) with their elements and influences. An important factor of the proposed ANP model is time. The ANP method is suitable for the determination of priorities in network systems where there are different types of dependencies between the elements of the system. In each time period, the portfolio of projects is reviewed in line with the strategic objectives of the organization. Management may decide to initiate new projects, but it is not so easy to predict what new projects will appear in the future. The organization must decide under risk whether to assign all available resources to present proposals or to reserve a portion of the funds unused for some time and wait for better alternatives that may occur later. We propose to use a decision tree with multiple criteria and interactive multi-criteria analysis for solving this problem.

Desirable Properties of Weighting Vector in Pairwise Comparisons Matrix

Jaroslav Ramík

Presented by: **Jaroslav Ramík**

The aim of this paper is to show a new categorization of inconsistent pairwise comparisons matrices (PCM) proposed with respect to a satisfaction/violation of selected PCM properties, such as the fundamental selection (FS) condition, preservation of order preference (POP) condition, preservation of order of intensity of preference (POIP) condition, and reliability priority condition (RP). A new non-linear optimization problem for finding the weights (i.e. priority vector) satisfying the aforementioned conditions is proposed such that the distance between the given PCM matrix and the ratio matrix composed of the weights function is minimized. Moreover, we presented important examples of alo-groups where the above optimization problem for finding the desirables weights can be solved by standard optimization methods.

Keywords: AHP • pairwise comparisons • pairwise comparisons matrix • ranking of variants • vector of weights • unimodality

F1 Portfolio Selection

Methodological framework for 'passive' and 'active' approach to the investment portfolio making

Adam Borovička

Presented by: **Adam Borovička**

The (optimization) approach to an investment portfolio making can be classified as 'passive' and 'active'. The 'passive' form is methodologically represented by using a well-known mean-variance model including standardly two criteria – return and risk. The 'active' approach provides a more complex portfolio selection process. Then other evaluating investment criteria (cost, market mood, etc.) are considered. Additional investor's preferences can be also formulated, i.e. an explicit specifica-tion of the criteria importance or a determination of the goal (required) values of the portfolio characteristics. All these aspects can be satisfactorily taken into account through an interactive multiple objective programming method. This method is de-veloped on the basis of a well-known STEP method. Advantages and pitfalls of the proposed methodological concept are empirically demonstrated on real-life making a portfolio of open unit trusts offered by Česká spořitelna. Both portfolio making processes are empirically analyzed and compared.

Keywords: 'active' approach • mean-risk model • multi-objective • open unit trust • 'passive' approach • portfolio making

Second order stochastic dominance constraints in decision dependent randomness portfolio optimization problems

Miloš Kopa

Presented by: **Miloš Kopa**

The paper deals with stochastic portfolio optimization problems which maximize a given functional under second - order stochastic dominance constraints in presence of endogenous randomness. Endogenous randomness (or decision dependent randomness) means that the probability distribution of asset returns may depend on the decision variables, i.e. on the weights associated to the assets. This may occur typically in the high frequency trading or in the illiquid markets, when a massive investment of one investor may attract others investors, at least for a small time period. Firstly, we modify the classical second-order stochastic dominance relation between returns of two given portfolios for the case with endogenous randomness of returns. Secondly, we apply this new constraint to the portfolio optimization problem.

Problem of trade-offs between portfolio's mean, variance and skewness as a goal programming model

Renata Dudzińska-Baryla, Donata Kopańska-Bródka, Ewa Michalska

Presented by: **Renata Dudzińska-Baryła**

The assumption regarding a symmetrical distribution of the rate of return in the Markowitz portfolio selection model is unrealistic and has no empirical evidence. Thus the higher order moments of the portfolio's return should be taken into account. Investors prefer high values for odd moments and low ones for even moments. In this paper, we consider the goal programming model in which the weight of each goal represents the investor preference towards mean, variance and skewness of the portfolio's return. Our aim is to analyse the portfolios from the trade-off lines (frontiers) determined for various weights. The empirical study is based on quotations of stocks listed on the Warsaw Stock Exchange.

Portfolio selection model based on Drawdown risk measure with Different Inputs

Juraj Pekár, Ivan Brezina, Marian Reiff

Presented by: **Juraj Pekár**

In addition to assets selection based on expected returns and financial indicators, the Investor in the decision-making process on investment strategy faces the question of how to implement portfolio diversification. Portfolio theory deals with this issue, with aims to find a mix of assets with the optimization models of expected return and risk criteria. Generally, these models result in a set of effective portfolios, from which the decision maker, based on additional information, selects the best alternative. The paper deals with the model in which the risk of DrawDown is used. The starting point is known model from the literature with assumptions of known cumulative yield values and the maximum possible loss of capital for the constructed portfolio. This means that the decision maker implements a portfolio based on the yield maximization criterion, with a known maximum possible loss of capital. However, the required minimum yield value may also be known in practice. Based on this idea, a modification of the model is constructed in which, unlike the original model, the input that represents the value of the minimum yield is altered and the aim is to minimize the risk.

Portfolio optimization with VaR and CVaR: the case of Gold and Euro currency

Jiří Málek, Van Quang Tran

Presented by: **Van Quang Tran**

The correlation between the gold price and the USD/EUR exchange rate is often negative with some exceptions in shorter periods. Hence, gold is known to be used as a useful tool to secure dollar deposits. This paper examines the portfolio optimization possibility using VaR and CVaR as risk measures. We use the t-distribution and the NIG distribution as well as the normal distribution as a comparative benchmark to approximate the empirical probability distribution. We construct several portfolios with various composition of gold and assets denominated in euro. First, parameters of all candidate distributions are estimated. Then, the risk measures of these portfolios are computed. We also repeat this procedure for those periods with highest positive and negative correlation. The obtained results show that it is possible to determine the optimal structure of these portfolios with VaR and CVaR as a risk measure.

Keywords: Portfolio optimization • VaR and CVaR • Parameter estimation • Gold price • EURUSD exhange rate

E1 Econometric Modeling and Applications

Cost analysis of rectifying acceptance sampling plans

Nikola Kaspříková

Presented by: **Nikola Kaspříková**

The paper addresses the LTPD acceptance sampling plans for the inspection by variables minimizing the mean inspection cost per lot of the process average quality when the remainder of the rejected lots is inspected by attributes. The sampling plans based on the EWMA statistic may bring significant savings in the mean inspection cost per lot of the process average quality over the originally designed plans by Dodge and Romig for the inspection just by attributes. The extent of the savings is dependent, among other parameters, on the cost of inspecting an item by variables and the cost of inspecting the item by attributes. The break even value of the quotient of the cost of inspecting an item by variables and the cost of inspecting the item by attributes is calculated and analysed for the plans, comparing the situation with known standard deviation and the situation with the unknown standard deviation of the quality characteristics. This value may be used to make the decision whether to use the variables or the attributes sampling plan in a concrete situation in practice. The calculations can be performed with the free LTPDvar extension package for the R software.

Keywords: acceptance sampling • inspection by variables • cost optimization

Spatial Panel Data Analysis: Did the Economic Structure in Germany Changed?

Simona Macková

Presented by: **Simona Macková**

One of the strongest business drivers in Europe is Germany. Its economy is growing and being progressive in the past years even if it had to deal with the reunion in 1990. That time former western Germany was economically much stronger and had to support the weaker eastern part for a very long time. The gap between these two parts has definitely been narrowing but does it still exist or is the gap already bridged? Are the parts of Germany equal or did the inequality persist or transformed? The spatio-temporal nature of macroeconomic drivers and their dependencies should not be neglected. This contribution focuses on the spatio-temporal aspects and tries to observe and analyse the economic development of the country. Cartograms are an irreplaceable tool of spatial econometrics and are used to capture the economic situation and development in time graphically. The paper uses analysis of data divided into NUTS-3 regions. As a measure of prosperity gross domestic product, unemployment rate, level of university education or diversity of industry are used. To evaluate assumptions about changes of economical structure, spatial econometric models suited for panel data are employed.

Keywords: spatial econometrics • spatial panel data • economic structure

Estimating the Laffer Curve for Slovakia: A DSGE Approach

Daniel Němec, Vlastimil Reichel, Jakub Chalmoviánský, Jana Balážová

Presented by: **Daniel Němec**

The goal of this paper is to quantify the impact of alternative tax adjustments on government tax revenues and the size of the shadow economy in Slovakia. Our approach uses a small dynamic stochastic general ekvilibrium (DSGE) model consisting of both formal and informal sectors of the economy. Using the quarterly data for the Slovak economy from 2000 to 2017 we estimate a linearised form of the DSGE model. Based on our parameter estimates, we perform a set of simulation using the non-linear form of the underlying DSGE model to evaluate the effects of changes in the corporate tax rate, personal income tax rate, social security tax rate, and in the probability of tax control. These effects are evaluated with regards to the changes in steady-state values of the output in the official economy, total tax revenues, and the size of the shadow economy. The corresponding Laffer curves show strong responses in the size of the underground economy when the corporate tax rates or personal income tax rates are growing. On the other hand, the increase of the social security tax rates causes only small growth in the share of the shadow economy without negative effects on government tax revenues.

Keywords: underground economy • DSGE model • tax system • Laffer curve • Slovakia

S1 Statistical and Econometric Methodology

Implicitly Weighted Robust Estimation of Quantiles in Linear Regression

Jan Kalina, Petra Vidnerová

Presented by: **Jan Kalina**

Estimation of quantiles represents a very important task in econometric regression modeling and the standard regression quantiles machinery is well developed with numerous econometric applications. Although regression quantiles are commonly known as robust tools, they are vulnerable to the presence of leverage points in the data. We propose here a novel approach for the linear regression based on a specific version of the least weighted squares estimator, together with an additional estimator based only on observations between two different novel quantiles. Numerical computations reveal the new methods to perform comparably to standard regression quantiles, if the data are not contaminated by outliers. However, the new methods seem much more robust on a simulated dataset with severe leverage points. The new methods are also conceptually simple and comprehensible.

Keywords: regression quantiles • robust regression • outliers • leverage points

A Nonparametric Bootstrap Comparison of Variances of Robust Regression Estimators

Jan Kalina, Nicole Tobišková, Jan Tichavský

Presented by: **Jan Tichavský**

While various robust regression estimators are available for the standard linear regression model, there have not been sufficient comparisons of the performance of individual robust estimators over real or simulated datasets. In general, a reliable robust estimator of regression parameters should be not only consistent but at the same time should have a relatively small variability, i.e. the variances of individual regression parameters should be small. The aim of this paper is to compare the variability of S-estimators, MM-estimators, least trimmed squares, and least weighted squares estimators. While they all are consistent under general assumptions, the asymptotic covariance matrix of the least weighted squares remains infeasible, because the only available formula for its computation depends on the unknown random errors. Thus, we take resort to a nonparametric bootstrap comparison of variability of different robust regression estimators. It turns out that the best results are obtained either with MM-estimators, or with the least weighted squares with suitable weights; the latter estimator is especially recommendable for small sample sizes.

Keywords: Robustness • Linear regression • Outliers • Bootstrap • Least weighted squares

Statistical Inference for Logistic Model: Comparison of Alternative Approaches

Matúš Porázik, Petra Tomanová

Presented by: **Matúš Porázik**

When working with data sets that do not meet ideal model assumptions, we encounter problems with statistical inference. These problems are more prominent in nonlinear regression models where the nonlinear function of the estimated parameters in the form of so-called marginal effects is typically of interest. The aim of the paper is to describe the basic approaches to calculating standard errors and confidence intervals for estimated parameters of logistic regression and then to compare the accuracy of the individual approaches using Monte Carlo experiments on suitably selected examples. The data are generated in a way that when estimating the nonlinear regression models we encounter issues such as the presence of outliers or violation of assumptions imposed on error term.

Keywords: Bootstrap • Logistic model • Logit • Maximum likelihood • Monte Carlo • Quasi maximum likelihood • Sandwich

Variability of interval-valued data: A refined analysis of an NP-hard problem

Michal Černý

Presented by: **Michal Černý**

This talk contributes to the analysis of computational complexity of statistical procedures for processing interval-valued data. Evaluation of a tight upper bound for the sample variance of an interval-valued dataset is known to be NP-hard. We refine recent results on probabilistic analysis of this problem. Namely, under a natural data-generating stochastic model, we derive new tail bounds for high computation times. The results show that although the problem is NP-hard in the worst case, such cases are encountered very rarely. This is an important message for practice since it shows that the problem is "almost always" efficiently solvable and thus it makes sense to implement the method in statistical packages for interval data.

Keywords: interval data • nonconvex quadratic programming • average complexity • tail probability bounds

T1 Transportation and Routing Problems

Vehicle routing problem with loading time window

Jan Pelikán

Presented by: **Jan Pelikán**

The vehicle routing problem (VRP) is a standard task solving distribution of goods

from the center to customers. There are a number of modifications, such as VRPs with time windows, VRPs with the external carrier, VRP with heterogeneous fleet etc. This contribution contains a new VRP modification, a dynamic delivery problem, i.e. the problem of delivering goods within a certain time interval. Customer´s time window relates to the time for loading customer´s demand. The time of loading the customer´s demand on a vehicle and therefore the time of exit the depot and start the route from depot to customers of the vehicle must be within the time interval (window) of all these customers. Travel time from the depot to customer and the unloading time are not considered and do not effect to the optimal solution. A mathematical model is presented and a savings heuristic is modified for this problem. An illustrative example is attached.

Keywords: dynamic vehicle routing problém • savings heuristic • integer programming

Cooperative Vehicle Routing Problem with non-transferable pay-off and its benefits

Dana Figurová, Zuzana Čičková

Presented by: **Dana Figurová**

The benefits of cooperative behaviour can be observed in several ways. This contribution is dedicated into the distribution, especially the variant of Vehicle Routing Problem. In general, cooperative games can be divided into two groups according to its pay-off distribution: games with transferable and non-transferable pay-off. In this paper, we will deal with non-transferable pay-off in the case of mutual cooperation of the players, when these pay-offs are tied to the individual players and cannot be transferred to other players. It is considered the distribution system with customers who are assigned to an individual depots and the owners of individual depots (players) can cooperate in coalition to reach the savings of transport costs as well as the savings from mutual use of vehicles. The cooperation allows sharing customer's service and in that way it could bring the benefits from merging the transport requirements of individual players.

Keywords: cooperative game • Vehicle Routing Problem • non-transferable pay-off

Robust optimization approach in traveling salesman problem

Tereza Nehézová

Presented by: **Tereza Nehézová**

Travelling salesman problem is considered one of the greatest mathematical questions of today. It is defined as finding the shortest Hamiltonian path in a graph while visiting all vertices just once. This paper deals with travelling salesman problem while considering some parts of its mathematical model to be uncertain. In simple travelling salesman problem all the route evaluations are known, but in reality it is a common practice that evaluations of routes can be unknown or uncertain. Uncertainty in optimization models can be handled by using stochastic

optimization. In this paper we show how to use robust optimization approach towards modelling uncertainty. The robust approach allows an optimization model to remain relatively simple while finding a robust-optimal solution. It also allows to identify deviations of deterministic values. The way of incorporating of robust aspects in the travelling salesman problem is described in detail and shown on an example in the end.

Keywords: traveling salesman problem • robust optimization • uncertainty

Transportation Problem with Time Windows

Dušan Teichmann, Michal Dorda, Denisa Mocková, Alexandra Dvořáčková

Presented by: **Dušan Teichmann**

In the transportation problem we decide about amounts of the commodity transported between the individual sources and destinations so that the total transportation costs are as minimal as possible. However, in real distribution systems which can be optimised by using the transportation problem some time constraints may arise. The time constraints may be defined for the sources or for the destinations; the constraints can be represented for example by opening hours of the sources or the destinations. Another time factor which may play an important role in the optimisation process is represented by time durations of different operations which vehicles transporting the commodity must undergo in the distribution system – we can mention for example loading times, unloading times and so on. The basic transportation problem cannot deal with the additional time constraints. In the modified model we do not want to minimise only the total transportation costs but also additional costs resulting from delay times of the vehicles waiting for unloading. Such modification of the transportation problem can be named as the transportation problem with time windows.

Keywords: Transportation problem • Time windows • Linear programming

D1 Data Envelopment Analysis

Inverse data envelopment analysis models: comparison of multi-objective optimization approaches

Josef Jablonský

Presented by: **Josef Jablonský**

In traditional data envelopment analysis (DEA) models, the efficiency of a decision making unit (DMU) is evaluated relatively with respect to other elements of the set of homogeneous units based on the values of multiple inputs and multiple outputs. These models assign maximum efficiency score to the units lying on the efficient frontier derived by the model. The inefficient units have worse efficiency score that the efficient ones. Inverse DEA models deal with different tasks.

Typical problems, in this case, are as follows. If the inputs of a unit under evaluation increase (decrease) how much the outputs have to decrease (increase) to maintain the current level of efficiency, or if the outputs decrease (increase) how much the inputs must change to efficiency score remains unchanged. The paper discusses various approaches to solve these problems and compares the results for different groups of DEA models. They are typically based on multiple objective linear programming methodology. A simple numerical example illustrates the presented approaches and their results.

Keywords: data envelopment analysis • multi-objective optimization • inverse DEA • efficiency

The Evaluation and Selection of Suppliers: DEA Approach

Natalie Pelloneová, Eva Štichhauerová

Presented by: **Eva Štichhauerová**

Evaluation and selection of potential suppliers is an essential part of effective management of the current dynamic and global supply chains and is also widely discussed in the literature. Both evaluation of suppliers and selection of the best ones represent a significant and complex decision of the strategic importance that requires careful consideration of different performance criteria and attributes. One of the techniques that can be used for the evaluation and selection of suppliers is the data envelopment analysis (DEA) which uses mathematical programming to evaluate the performance of a set of homogeneous units, considering several inputs and outputs. The presented paper deals with the use of input-oriented BCC model for evaluation and subsequent selection of suppliers in the selected company. The paper is divided into three parts. The first part of the paper is devoted to the literary research focused on the use of DEA method in the evaluation and selection of suppliers. In the second part, the use of the proposed method is demonstrated on an example. The main results are summarized in the conclusion.

Keywords: Data Envelopment Analysis • DEA • supplier selection • supplier evaluation • supplier efficiency • pure technical efficiency

Quantification of differentiating power in Network DEA

Michal Pieter

Presented by: **Michal Pieter**

Network Data envelopment analysis (NDEA) allows one to analyze the internal structure of DMUs, thus better modeling the reality of the system. While the purpose of this is to better discriminate between the DMUs, the complexity of the model must also be taken into account. Common sense dictates that increasingly complicated models bring only diminishing returns after a certain point. And while the complexity of two models can be compared relatively easily, to determine which one is better suited, it is just as crucial to compare their power

to differentiate between the DMUs. This paper thus looks at ways in which the differentiating power of NDEA models can be quantified for a given set of DMUs and then weighted against the complexity of those models. This approach is then tested on a small set of NDEA models of various complexity, as well as traditional, black-box DEA, all applied on a sample dataset.

Keywords: Network DEA • Data envelopment analysis • Complexity • Differentiating power • Quantification

F2 Financial Analysis

The Problem of Back-test Overfitting in Quantitative Trading

Jiří Witzany

Presented by: **Jiří Witzany**

Quantitative investment strategies are often selected from a broad class of candidate models estimated and tested on historical data. Standard statistical technique to prevent model overfitting such as out-sample back-testing turns out to be unreliable in the situation when selection is based on results of too many models tested on the holdout sample. There is an ongoing discussion how to estimate the probability of back-test overfitting and adjust the expected performance indicators like Sharpe ratio in order to reflect properly the effect of multiple testing. We propose a consistent Bayesian approach that consistently yields the desired robust estimates based on an MCMC simulation. The approach is tested on a class of technical trading strategies where a seemingly profitable strategy can be selected in the na?ve approach.

Keywords: Multiple testing • investment strategy • cross-validation • overfitting • backtest • Sharpe ratio • MCMC

Analysis of multiple economic internal rate of return

Stanislava Dvořáková, Petr Jiříček

Presented by: **Stanislava Dvořáková**

The paper will deal with variants of finding the multiple economic internal rates of return of investment projects with a subsidy from public sources. The multiple economic internal rates of return are roots of the polynomial function that describes the investment project. We use the Descrates rule saying that the number of positive real roots of a polynomial is equal to the maximum of the number of the sign variations. The simulations will correspond to gradual changes of the subsidy amounts and the changes of cash flows in individual investment project phases. The simulations will result in displaying functional dependencies of economic internal rates of return on multi-parametric project changes. Then the extreme values and limits of these functional dependencies will be analysed.

Analysis of unit trust funds and the creation of a descriptive model, with emphasis on the risk-factor and the return of investments

Oldřich Trenz, Oldřich Faldík, Sylvie Formánková, Jan Kolomazník, David Schubert, Daniela Kolomazníková

Presented by: **Oldřich Faldík**

The article deals with the data analysis of unit trust funds from the EU with ESG evaluation (environment, social responsibility and corporate governance), whilst attempting to categorize these funds from selected viewpoints. Emphasis is placed on identifying their risks, liquidity and profitability, and this in connection with socially responsible investment (SRI) [1], a component of sustainable investment (SI) which the ESG evaluation itself is a part of. ESG factors are part of the description of non-financial influences on long-term risk management and the expected return on investment [2]. An analysis of the current approaches to evaluating investments shows that the key barrier in the transitions to SI is not taking into account the ESG factors. A part of the article is also an analysis of the present state in the field of sustainable investments, the creation of one's own descriptive model, which takes into account ESG factors in the form of managing long-term risks and expected return on investments [3].

E2 Econometric Modeling and Applications

Property and Violent Crime: Evidence from the Czech Republic

Jakub Škrobánek, Petra Tomanová

Presented by: **Petra Tomanová**

This paper is focused on analysis of monthly time series of registered violent crime in four selected Czech regions between years 2009 – 2016. The data were obtained from the Police of the Czech Republic and the Police Presidium. Due to the difficulty of obtaining data from the Police Presidium, the dataset and the subsequent analyses of the Czech criminality can be viewed as unique. The main purpose of this paper is to examine state and trend development of the overall violent crime in the Czech Republic with the main focus on Moravian-Silesian Region, Ústí nad Labem Region, Central Bohemian Region and Prague using methods based on time series decomposition. The average violent crime in the monitored period was roughly 50 % higher in the Moravian-Silesian Region and Ústí nad

Labem Region compared to Prague and the Central Bohemian Region which can be explained by unemployment. Moreover, we have found that there is a downward trend in crime throughout the year.

Keywords: monthly time series • trend • criminality

M Miscellaneous Mathematical Techniques

Tolerance solvability of interval max-min matrix equations

Helena Myšková

Presented by: **Helena Myšková**

Behavior of discrete event systems, in which the individual components move from event to event rather than varying continuously through time, is often described by systems of linear equations or by matrix equations in max-min algebra. Max-min algebra is an algebraic structure, in which classical addition and multiplication are replaced by maximum and minimum, respectively. Max-min equations have found a broad area of applications in causal models which emphasize relationships between input and output variables. They are used in diagnosis models or models of non-deterministic systems. Many practical situations can be described using max-min matrix equations. It often happens that a max-min matrix equation with exact data is unsolvable. Therefore, we replace matrix elements with intervals of possible values. In this way, we obtain an interval matrix equation. We can define several types of solvability of interval max-min matrix equation. In this paper, we shall deal with the possibly tolerance and strongly tolerance solvability of interval max-min matrix equations. We prove the necessary and sufficient conditions which can be verified in polynomial time.

Keywords: max-min algebra • interval matrix • matrix equation • interval matrix equation • tolerance solvability

Voigt distribution and its heavy-tail modeling ability for cryptocurrencies

Jaromir Kukal, Van Quang Tran

Presented by: **Jaromír Kukal**

Voigt distribution is a convolution of a Cauchy distribution and a Gaussian distribution. This distribution has been so far widely used in technical disciplines. The inclusion of the Cauchy distribution into the mixture makes it a possible alternative for modeling heavy tail properties commonly present in financial data. In our contribution, the closed form of distributional characteristics of the distribution like characteristic function, probability density function (PDF) and cumulative distribution function (CDF) is derived. Due to their numerical complexity, these functions do not provide any practical usage for the maximum likelihood estimation (MLE) of its parameters. Therefore, we propose the use of Fast Fourier Trans-

form (FFT) to make the parameter estimation via MLE technique more numerically feasible. This approach is then verified on the returns of cryptocurrencies which tend to have more heavy tails than those of ordinary heavy tail distributions. The results we obtained with this method are quite interesting.

Keywords: Voigt distribution • Statistical characteristics • Fast Fourier transform • MLE parameter estimation • Cryptocurrencies

Dynamic AD-AS macroeconomic model of Mankiw type with generalized expectations

Ladislav Lukáš

Presented by: **Ladislav Lukáš**

The paper deals with formulation of discrete dynamic AD-AS macroeconomic model of Mankiw type. First, we discuss all macroeconomic structural equations in Mankiw setting. There are the following ones – the demand for goods and services, the Fisher equation expressing real interest rate, the Phillips curve expressing the inflation, adaptive expectation expressing expected inflation, and the monetary-policy rule expressing the nominal interest rate. Next, we focus our main attention to various general possibilities to handle expected inflation. One of the basic general expectations is formed as convex combinations of past inflations, which are discussed in detail together with numerical comparisons of results. We present the numerical implementation of dynamic AD-AS macroeconomic model of Mankiw type both with classical and generalized expectations in Mathematica.

Keywords: discrete dynamic AD-AS model • expected inflation • convex combination of past inflations • numerical implementation in Mathematica

Crossing numbers of join product of several graphs on 6 vertices with path using cyclic permutation

Emília Draženská

Presented by: **Emília Draženská**

Let G be a simple graph with vertex set $V(G)$ and edge set $E(G)$. The crossing number, $\mathrm{cr}(G)$, of a graph G is the minimum number of edge crossings in a good drawing of G in the plane. In general, compute the crossing number for a given graph is a very difficult problem. It has been proved that this problem is NP–complete. The crossing numbers of a few families of graphs are known. One of them are join products of special graphs. The join product of two graphs G_1 and G_2, denoted $G_1 + G_2$, is obtained from the vertex-disjoint copies of G_1 and G_2 by adding all edges between $V(G_1)$ and $V(G_2)$. Let D_n is a discrete graph, P_n is a path and C_n is a cycle on n vertices. Values of crossing numbers of the join products of graph G with, D_n, P_n or C_n are known for several graphs G. In the paper, we extend known results concerning crossing numbers for join of graphs of order six with paths P_n.

Z1 Fuzzy Modeling

Profitability Estimation of Long-Term Projects in Terms of Uncertainty of Inputs

Simona Hašková

Presented by: **Simona Hašková**

One of the criteria underlying the decision concerning acceptance or rejection of a project is the internal rate of return (IRR). The project is acceptable if the discount rate applied is lower than the IRR. We focus on the project of innovative commodity production whose consumption is of interest to the government. The need for a large initial investment and the high production costs do not stimulate a sufficient demand to guarantee an adequate IRR. Therefore, such a project is subsidized. Given the ambiguity about the amount of investment, future market price and demand, only the intervals of these values can be estimated. Concurrently, any relevant reason to prefer a particular value does not exist. We consider this situation as uncertain on the input side of the evaluation process, with the IRR on the output side being consequently uncertain. A tool to answer the question of whether the system of subsidies is adequate is the fuzzy approach. The electric car production project analysis shows that this approach provides superior information, which helps the investor e.g., to assess the degree of competitiveness of a project given to the alternative yield rate.

Sales Prediction Applying Linguistic Fuzzy Logic Forecaster

Aleš Kresta, Jan Kubečka, Tomáš Tichý

Presented by: **Aleš Kresta**

In this contribution, we focus on sales prediction by means of Linguistic Fuzzy Logic Forecaster (LFL-Forecaster). To be more specific, we compare the accu-racy of the prediction obtained by means of this method and the prediction ac-curacy of standard approaches such as extrapolation of the time series and time series decomposition into trend and seasonal component. As the benchmark, we also apply the prediction based on the last known sales and average sales in the previous period. The LFL-forecaster combines the fuzzy transform technique to extract the trend part with fuzzy natural logic in order to forecast future values. Both methods apply the principles of fuzzy sets. From the obtained results, we demonstrate that for selected time series of sales the LFL-Forecaster provides the most accurate prediction in the out-of-sample period, however even this method is prone to the changes in the length of input data and structural breaks.

Weak tolerance and possible interval supereigenvectors in fuzzy algebra

Ján Plavka

Presented by: **Ján Plavka**

A fuzzy algebra is a triple $(B, \oplus, \otimes)$, where $(B, \leq)$ is a nonempty, bounded, linearly ordered set and $a \oplus b = \max\{a, b\}$, $a \otimes b = \min\{a, b\}$ for $a, b \in B$. A vector x is said to be a λ-eigenvector of a square matrix A if $A \otimes x = \lambda \otimes x$ for some $\lambda \in B$. To solve supereigenproblem for some $\lambda \in B$ means to find a solution x of $A \otimes x \geq \lambda \otimes x$, x is called supereigenvector. In [1] the properties of supereigenvectors are described, the values λ associated with supereigenvectors are characterized and efficient algorithms for checking all equivalent conditions are introduced. This contribution investigates the properties of matrices and vectors with interval coefficients. In addition, a complete solution of the weak tolerance and possible interval supereigenproblem in fuzzy algebra is presented.

Fuzzy interval Monge matrices with respect to robustness

Monika Molnárová

Presented by: **Monika Molnárová**

Periodic properties of interval Monge matrices over max-min algebra (fuzzy matrices) are studied. The max-min algebra is an extremal algebra with operations maximum and minimum. An interval matrix A over fuzzy algebra (a matrix with inexact data) is a set of matrices given by a lower bound matrix and an upper bound matrix. We can use two concepts to define robustness of an interval matrix. First, we consider the possible robustness, if there is at least one robust matrix A in A. Second, we consider universal robustness, if all matrices from A are robust. Equivalent conditions for possible robustness and universal robustness as well, were proved. However, the suggested procedures for general cases do not guarantee whether the Monge property or can be exponentially large [6]. In this paper we prove sufficient conditions for possible robustness and universal robustness of interval Monge matrices as well for the case, if the lower bound matrix is trivial. Moreover, equivalent conditions for possible robustness and universal robustness of interval Monge matrices for the case, if the lower bound matrix is nontrivial, were proved.

THURSDAY September 12, 2019

PhD Student Competition

Dynamic efficiency analysis of German NUTS 2

Petra Zýková

Presented by: **Petra Zýková**

The paper deals with efficiency analysis of German NUTS 2 (Nomenclature of Territorial Units for Statistics). The aim is to find the most efficient and ranking NUTS 2 German units between the years 2008 – 2016. Germany is divided into 38 NUTS 2 regions. The efficiency analysis is based on an application of data envelopment analysis (DEA) models. This paper uses dynamic DEA models window analysis that is one of the tools for dealing with time factor in DEA. The data set contains information about the NUTS 2 for nine following years. There are used two inputs – employment (thousand hours worked) and gross fixed capital formation (million Euro) and one output – gross domestic product (million Euro).

Keywords: data envelopment analysis • time series • Germany

Interest Rate Modelling: Maximum Likelihood Estimation of One-Factor Short-Rate Models

Tomáš Rusý, Kamil Kladívko

Presented by: **Tomáš Rusý**

The maximum likelihood method is known to be efficient at estimating fully parametric models. One-factor short-rate models belong to this class, but surprisingly the maximum likelihood method is not extensively used for estimating them. We believe it is a consequence of the current method's failure to determine the value of the short rate without justifying the calculation procedure, which often leads to a poor fit of the observed curve, making it difficult to interpret. In this paper, we propose a way to consider all observed yields at one time and extract the value of the short rate jointly from the entire yield curve. This could be done thanks to a general description of the construction of the likelihood function of a time series of observed yields. The method identifies the models under the real-world measure and hence it is suited not only for pricing, but also for prediction of interest rates. We illustrate the use of such an approach on the popular Hull - White model.

Keywords: Interest rate modelling and forecasting • Hull-White model • Risk-neutral measure • Real-world measure

Price Clustering Phenomenon

Petra Tomanová

Presented by: **Petra Tomanová**

This paper studies the price clustering phenomenon which refers to an excessive occurrence of transaction prices at certain fractions or digits. The source of the phenomenon are traders who execute the transaction in multiples of dimes (10 cents – the second digit is 0) or nickels (5 cents – the second digit is 0 or 5). First, the paper summarizes the state of the art on the price clustering phenomenon from its first observation at the NYSE in 1962 by M. F. M. Osborne, through the year 1994 when price clustering phenomenon has drawn much attention due to the study of NASDAQ stocks of Christie and Schultz, till the most recent papers on clustering phenomenon. Second, the paper contributes to the knowledge by investigating the (conditional) probabilities of prices which evinces bumpy behavior due to the price clustering phenomenon. Our findings are useful in parametric modeling of high-frequency prices with discrete values. In empirical study, we focus on stocks traded on NYSE and NASDAQ exchanges.

Keywords: NASDAQ • NYSE • price clustering • price modeling

An Empirical Analysis of Macroeconomic and Bank Performance Factors Affecting Credit Risk in Banking for The Central European Countries

Xiaoshan Feng

Presented by: **Xiaoshan Feng**

This paper provides empirical results of the macroeconomic and bank performance determinants which affect credit risk in banking for the Central Europe-an Countries. Using time series data from 2002 to 2016 for Austria, the Czech Republic, Germany, Hungary and Poland. In this study, we apply fixed effect panel data regression to figure out how banks' non-performing loans are influenced by macroeconomic factors and bank performance indicators. Through econometric verification, the valid estimation shows empirical results that macroeconomic and bank performance factors do have significant impact on credit risk. GDP growth rate, share price indices, and return on assets are negatively related to the increasing of NPL ratio, while better banks'assets quality is following with lower exchange rate, harmonized consumer price index and unemployment rate.

Keywords: Econometric analysis • Panel data regression • Credit risk • Non-performing loans • Macroeconomic variables • Bank performance indicator • Central Europe

Applications of Mathematical Optimization Approaches to Portfolio

Anlan Wang

Presented by: **Anlan Wang**

In this paper the portfolio optimization problem is solved by applying mathematical optimization approaches. We apply the naive strategy to obtain a portfolio with equal weights. The efficient portfolios are also obtained by considering the standard deviation and the mean absolute deviation as a risk measure separately. In our empirical analysis, based on the in-sample data, we construct the efficient frontiers by applying the Mean Variance approach and the Mean Absolute Deviation approach, and then we make the back-test of these efficient portfolios in the out-of-sample period to verify whether the strategies obtained by the optimization approaches work efficiently. In the back-test, the main performance measure of the portfolio is the Maximum Drawdown. To make the verification conclusive, we also generate random-weights portfolios and make hypothesis tests. By comparing the results, we conclude that for both of Mean Variance approach and Mean Absolute Deviation approach, they each have three portfolios with efficiency in our empirical analysis.

Evaluation of a Crisis Situation Based on Incomplete and Unsound Data

Michal Škoda

Presented by: **Michal Škoda**

This paper deals with evaluation of a crisis situation caused by natural disasters and/or accidents in the first moments after the situation occurs. The correct and timely evaluation of a crisis situations is essential, which is very easy to understand, but not so easy to achieve. Especially in situations where the decision maker has limited information and the consequences of a wrong decision can be disastrous. The proposed approach was created to help to evaluate a crisis situation with high accuracy when using incomplete and unsound data. The entire approach is based on fuzzy set theory, which is widely used in representing uncertain knowledge. The paper also focuses on the choice of suitable scales and method of fuzzification and defuzzification that should be used in this kind of evaluation.First, fuzzy linguistic scales and criteria are chosen. After this a crisis situation is evaluated based on the chosen criteria. Based on ?-level cut the completeness and soundness of data is taken into account. At the end, the defuzzification is done and the situation is ranked.

F3 Decision Making in Finance

Tariff analysis in a motor hull insurance portfolio

Adéla Špačková

Presented by: **Adéla Špačková**

The Non-life insurance pricing is determinated by multiplication of claim frequency and claim severity. The subject of the contribution is tariff analysis, where each empirical model is compared and the categorical model is going to be compare with continous model. The results of this contribution can be interesting and it can con-tribute to a deeper understanding of this problem and importance of the tariff anal-ysis. All empirical models are estimated on the real-world sample data of czech in-surance company collected during the years 2005-2010. Estimation is performed by using generalized linear models. Regression analysis allows the identification of the risk factors and the prediction of the expected frequency of claims given the char-acteristics of policyholders. It depends on many individual rating factors (e.g. based on individual characteristics of vehicle and driver). The aim of this paper is to find out ideally suited model for estimation claim frequency and point out the im-portance of tariff analysis.

Keywords: tariff analysis • generalized linear models • claim frequency • individual rating factors

Decision-making support as part of the sustainable investment in unit trust funds

Oldřich Trenz, Oldřich Faldík, Sylvie Formánková, Jan Kolomazník, František Ostřížek

Presented by: **Oldřich Faldík**

The article deals with decision-making support in the field of sustainable investment in unit trust funds with an ESG evaluation, in accord with socially responsible investment (SRI). The individual methods, which take into account the analysis of long-term risks in conjunction with the expected investment return, will be analyzed and concretized. This will be complemented with the description of the present state in the field of sustainable investing [1]. The applied methods will include the quantitative measurement of risks where we will analyze the dependence of profitability and sustainability in the form of a selective portfolio theory (Markowitz) [2]. Furthermore, the Data Envelopment Analysis (DEA) method will be implemented, and this in order to contrast the relationships between profitability, risk-management and sustainable development [3]. Last but not least, a formalization of the relation of the risk involved and the investment returns will be done, with the aid of a select artificial intelligence method. The results will be used for the support of the decision-making process in the field of unit trust investments.

Keywords: sustainable investing • sustainability • SRI • decision making • funds

E3 Econometric Modeling and Applications

School Performance and Various Socioeconomic Factors: A GWR Approach for Slovak Data

Michaela Chocholatá

Presented by: **Michaela Chocholatá**

To ensure the high quality of education process, to enhance the level of knowledge and skills as well as to eliminate the regional disparities in pupil's learning effectiveness and in school performance belong to the main objectives of the national development strategy in Slovakia. This paper deals with the regional performance of primary schools in Slovakia assessed by the external testing of pupils of the 5th year of primary schools on knowledge of mathematics and national language. The regional school performance is further analysed based on the average percentage Maths scores achieved in 2018. Besides revealing the regional spatial patterns in school performance the main aim of this paper is oriented on both the global and local regression analysis assessing the impact of selected socioeconomic factors (average nominal monthly wage, unemployment rate and index of economic dependence of young people) onto the average percentage Maths scores across the Slovak districts. The classic global regression analysis is followed by local regression analysis based on the geographically weighted regression approach which enables to catch the spatial variations in the modelled relationship.

Keywords: school performance • socioeconomic factors • geographically weighted regression

Business environment and its relations within Travel and Tourism Competitiveness Index

Eva Litavcová, Petra Vašaničová

Presented by: **Petra Vašaničová**

Economic dataset concerning The Travel and Tourism Competitiveness Index (TTCI) published by World Economic Forum consists of 14 characteristics (pillars) of tourism competitiveness. Pillars, which are composed of 90 subpillars, are divided into 4 main subindexes. Business Environment (BE) pillar (consisted of 12 subpillars) is the part of Enabling Environment subindex. To increase the country's tourism competitiveness, state of the business environment is an important piece of information for potential investors. The aim of this paper is to model Business Environment as a response of 13 other pillars of the TTCI from year 2017. We used regression quantiles and lasso estimates for modelling. In resulting tables is shown, which of 13 pillars are in relation to Business Environment on different quantile levels. For the median of BE, the strongest relationship was proven with HRL (Human Resources and Labour Market). Other statistically significant relationships were verified with other eight pillars, one of them is ATI (Air Transport Infrastructure) for example.

Electricity Consumption Cost for Households in the Czech Republic Based on the High and Low Tariff Rates Ratio – Optimization Model

Martina Kuncová, Jana Sekničková

Presented by: **Martina Kuncová**

The electricity market in the Czech Republic started its transformation and liberalization in the year 2002. Since 2006 also households can choose its electricity supplier and the product offered by a supplier. Although Energy Regulatory Office (ERU) offers the online calculator to compare the electricity consumption cost of the given household, the choice of products is still wide, and the conditions and formula for the electricity consumption cost are hardly understandable. The online calculator assumes an estimation (kWh) for the consumption in the high and low tariff rate. As in the real-life situation, it is just a rough estimate, the final product choice could be wrong, and the expected annual electricity consumption costs might be different than the real ones. Based on our previous analyses of the D25d distribution rate best product selection (for the given household), the optimization model is created to find for what ratio of the high and low tariff rates the given product is the cheapest one. Data are taken from the ERU for the years 2017 and 2018 where 60 products of 29 suppliers are offered for each year and each of the 3 distribution regions (PRE, CEZ, E.ON).

Analysis of production function of agricultural holdings

Marie Šimpachová Pechrová, Ondřej Šimpach

Presented by: **Ondřej Šimpach**

Agricultural holdings differ in their production amount due to the size, different yields, technology or weather conditions. The aim of the paper is to find appropriate model for modelling the production function that would account for this heterogeneity and to find the main determinants of the agricultural production. There are panel data available (2 268 observations for 2014–2017), so fixed versus random effects model are considered, compared and tested to choose appropriate model. Cobb-Douglas production function was modelled. The production of farm (sales of own products and services) was explained by the consumption of material, capital, number of employees, and acreage. Results of fixed effects model were not economically meaningful. Hausmann test proved that random effects model is preferred. Increase of consumed material by 1 % caused the increase of production by 0.52 %, of tangible long-term assets by 0.17 %, increase of number of employees by 0.01 %, and of land by 0.02 %. The production of Czech agricultural holdings is influenced the most by the amount of consumed material, while

the number of employees and acreage are less significant.

Keywords: agriculture • fixed effects model • panel data • random effects model

N Network Models

Adaptive population techniques in Evolution Algorithms

František Koblasa, Miroslav Vavroušek

Presented by: **František Koblasa**

Evolution algorithms are one of the most popular optimization techniques for its ability to solve wide field of general combinatorial problems. They are simple to implement and use as its mechanisms are logical and untestable due to its natural and common sense. However its optimization results as well as timespan are heavy dependent on setting searching parameters as crossover, mutation rates, population size etc. Setting those parameters requires intuition and experience and is also beneficial to change them during optimization as necessity to exploit and explore changes during optimization. Those are the reasons why nowadays research in the field of Evolutionary Computing is focusing more and more on the adaptive operator control. This article is focusing on part of adaptive parameter control which is known not only as responsible for quality of results but also for optimization time. The research is focusing on population sizing schemes together with selection and elimination procedures. It is reviewing known techniques and presenting original solution. Those techniques are then tested on known theoretical job shop scheduling problems and their efficiency is discussed.

Keywords: Evolution algorithms • Selection • Population size • Elimination • Job shop scheduling

Identification of the Maximal Relevant Distance in Emergency System Designing

Marek Kvet, Jaroslav Janáček

Presented by: **Marek Kvet**

Emergency service system structure is determined by deployment of given number of service center locations. The objective is to minimize the average response time of system users. Advanced exact methods for obtaining the optimal deployment of the service centers are based on exploitation of a radial model of the location prob-lem. The efficiency of this approach is strongly influenced by the number of con-sidered zones, which is proportional to the maximal relevant distance. The maximal relevant distance in the solved location problem is the maximal distance between user and possible service center locations, which must be taken into account unless the solving process losses the optimal solution. The paper deals with the methods of the maximal relevant distance determination in the location problems, where the system disutility of a user is proportional to the

distance from the user location to the nearest located service center. We also enrich the paper with a study of the prob-lems, in which the generalized disutility is considered. The generalized disutility of a user takes into account distances to more than one nearest located service centers.

Keywords: Emergency service system design • radial approach • maximal relevant distance

The identification of the Key players in the supply chain network

Jaroslava Pražáková, Martin Pech

Presented by: **Martin Pech**

Regarding to the future challenges, another aspect of supply chains needs to be mentioned. Network design decisions have a significant impact on performance and flexibility within the supply chain networks. In this paper, we used various methods suitable for external analysis of automotive industry network that can identify the key players of the network. Exponential Non-Discriminative Snowball Sampling was used as a method for network construction; existence of each 70 nodes and 110 links (based on information flow) was verified using the real suppliers or customers relationship. Then, the analysed network is specified by the basic whole network measures. The results of whole network measures clue method selection used in the next step of the network analysis. The core and periphery was identified using the Core Periphery Model. Within the core part of the network, key players were divided into hubs and authorities through other network characteristics of closeness, information centrality, etc. The node fragmentation level determines the importance of each node for network structure and financial stability.

Keywords: supply chain network • network analysis • core periphery model • fragmentation • network stability

An alternative approach towards dealing with uncertainty in project time analysis

Robert Hlavatý, Helena Brožová

Presented by: **Robert Hlavatý**

Critical path method is a fundamental tool of time analysis in project planning. Due to its deterministic nature, it does not reflect any aspects of uncertainty that might occur in the actual real-world applications. The ways of embedding uncertainty into mathematical model of project time analysis have been widely used, in its basic form represented by probabilistic approach of PERT or GERT. We introduce an alternative viewpoint on uncertainty appearing in activity length evaluation. First, the stated problem is formulated as a longest path problem in directed acyclic graph in the form of mixed integer linear program. Further on, we take an advantage of two different robust formulations that allow to identify critical scenarios in case any deviations from deterministic values of activity lengths should

appear. It turns out that different concepts of robustness must be used depending whether the length of an activity was prolonged or contracted. The resulting scenarios show the worst-case situations with the deviations considered while it is possible to identify those activities that bear somewhat higher potential of criticalness towards the total project length.

Keywords: critical path method • robust optimization • criticalness • worst-case scenario

O Mathematical Optimization

Second Order Optimality in Semi-Markov Decision Processes

Karel Sladký

Presented by: **Karel Sladký**

Semi-Markov decision processes can be considered as an extension of Markov reward models. Unfortunately, traditional optimality criteria as long-run average reward per time may be quite insufficient to characterize the problem from the point of a decision maker. To this end it may be preferable if not necessary to select more sophisticated criteria that also reflect variability-risk features of the problem. Perhaps the best known approaches stem from the classical work of Markowitz on mean-variance selection rules, i.e. we optimize the weighted sum of average or total reward and its variance. Such approach has been already studied for very special classes of semi-Markov decision processes, in particular, for Markov decision processes in discrete- and continuous-time setting. In this note these approaches are summarized and possible extensions to a wider class of semi-Markov decision processes is discussed. Attention is mostly restricted to uncontrolled models in which the process is aperiodic and contains a single class of recurrent states.

Keywords: semi-Markov processes with rewards • discrete- and continuous-time Markov reward chains average reward and variance over time • risk-sensitive optimality • policy iterations

Mean-Risk Optimization Problems via Scalarization, Stochastic Dominance, Empirical Estimates

Vlasta Kaňková

Presented by: **Vlasta Kaňková**

Many economic and financial situations depend simultaneously on a random element and on a decision parameter. Mostly it is possible to influence the above mentioned situation by an optimization model depending on a probability measure. We focus on a special case of one-stage two-objective stochastic "Mean-Risk problems". Of course to determine optimal solution simultaneously with respect to the both criteria is mostly impossible. Consequently, it is necessary to employ

some approaches. Two of them are very-well known; first is based on a scalarizing technique and the second is based on the stochastic dominance. First of them has been suggested by Markowitz. The second approach is based on the second order stochastic dominance. The last corresponds (under some assumptions) to partial order in the set of the utility functions. The aim of the contribution is to deal with the both above mentioned approaches. At first we repeat their properties and further we try to suggest possibility to improve the solution simultaneously with respect to the both criteria. However, we focus mainly on the case when probability characteristics have to be obtained on the data base.

Keywords: mean-risk problem • Markowitz approach • second order stochastic dominance • empirical estimates

Optimality conditions in behavior optimization model of consumers in the network industries markets

Michal Fendek, Eleonora Fendeková

Presented by: **Michal Fendek**

Equilibrium on the network industries market, as well as on any market, is being created based on the level of demand and supply on relevant market. Currently a significant attention in scholarly discussions on various levels is being paid to the subject of network industries. It is understandable as network industries in fact ensure the production and distribution of energy sources that play a key role in an effective operation of the developed economies. We will point out certain features of network industries market where the consumer usually is not able to substitute a product of network industry with other product of appropriate characteristics in a short time period, thus considering the product being exclusive. This exclusivity can be formally represented in the utility function and other related analytical tasks. In this paper, we will discuss the analysis of microeconomic optimization models of consumers and producers behavior on the network industries market, i.e. the analysis of demand and supply phenomena on this specific market. For the optimization problems, we will formulate the Kuhn-Tucker optimality conditions and we will study their interpretation options.

Keywords: network industries market • utility maximization model • optimality conditions

D2 Data Envelopment Analysis

Inter-Branch Comparison of Cluster Company Performance Using Malmquist Index

Miroslav Žižka

Presented by: **Miroslav Žižka**

The article evaluates the differences between the financial performance of clus-

tered companies in two sectors for the period of 2009-2016. The first sample consists of 16 member companies that form the core CLUTEX cluster of technical textiles. The second sample includes 22 subjects representing NANOPROGRESS - cluster core of nanotechnology. Financial performance development was analyzed using the Adjacent Malmquist Index based on window scores. Window score values were obtained using DEA. Staff number, total assets and a long-term capital were used as model inputs. The economic value added was the model output. For each sample, the Malmquist Index and its components were determined - technical efficiency change and technological change. For scale efficiency, models with both constant and variable returns to scale were applied. The results of the analysis show that the average annual growth in company performance in the nanotechnology cluster is significantly higher than in the case of the textile cluster. In the nanotechnology cluster, the main source of performance growth is the improvement of internal technical efficiency.

Keywords: Adjacent Malmquist Index • economic value added • financial performance • cluster of technical textiles • cluster of nanotechnology

Influence of Membership in the Moravian Aerospace Cluster on the Financial Performance of its Members: Malmquist Index Approach

Natalie Pelloneová, Eva Štichhauerová

Presented by: **Natalie Pelloneová**

This contribution deals with the influence of membership of a business entity in a cluster organisation on its financial performance. The aim is to verify the hypothesis that the membership in a cluster organisation is connected with increasing financial efficiency of its members in time. In the research sample are included nine charter members of the Moravian Aerospace Cluster. The data are collected for years 2009-2016. For the assessment of financial performance the data envelopment analysis method is applied with two inputs and one output. For inputs were chosen the assets and long-term capital, the economic value added (EVA) was used as the output. Since the EVA achieves both positive and negative values, the variant of radial measure was used. For each company from the sample were calculated the values of the Malmquist index. With help of MI it was possible to quantify the total factor productivity change and to decompose it to technological change and technical efficiency change. The development of the indicators was monitored in time. In conclusion, the results of the research are discussed.

Keywords: cluster • data envelopment analysis • economic value added • financial performance • Malmquist index • Moravian Aerospace Cluster

Energy Efficiency Comparison of EU28 Countries Based on Various Undesirable Outputs of Air Emissions

Lucie Chytilová, Jana Hančlová

Presented by: **Lucie Chytilová**

This paper presents an assessment and comparison of energy efficiency of EU28 countries in reference period 2008–2014. Cross-country comparison is based on Data Envelopment Analysis (DEA) using directional distance function (DDF). DEA model includes air emissions as undesirable outputs in the various forms (nitrogen oxides, carbon dioxide and particulates smaller than 2.5 or 10). The preliminary findings resulted in rank and evaluation of surveyed European Member States by energy efficiency and moreover the paper discuss the influence of different types of air emissions to the level of efficiency.

Keywords: data envelopment analysis • directional distance function • air emissions

E4 Econometric Modeling and Applications

An application of the Cox regression model with time dependent parameters to unemployment data

Petr Volf

Presented by: **Petr Volf**

The contribution deals with the application of statistical analysis of the process of events, with the intensity described by a generalized version of the Cox regression model. Namely, as in certain cases the impact of covariates may change in time, then the model with time dependent parameters should be used. A method of model components non-parametric estimation is presented, the flexibility of result is assessed with a goodness-of-fit test based on martingale residuals. The application deals with the real data representing the job opportunities development and reduction, during a given period. They record, after an initial interval of stable growth, the period of changes characterized by the increased employees fluctuation and staff reduction. It is due the non-stable conditions in the company that the risk of leaving the company is changing. In particular, the risk of older persons increases (which could be taken as a feature of discrimination), while the fluctuation concerns more the people with shorter time with company. Both these covariates are considered and their impact to the risk analyzed.

Keywords: survival analysis • Cox model • unemployment data

Relationship between Output and Unemployment

Andrea Čížků

Presented by: **Andrea Čížků**

The paper models relation between output and unemployment known as Okun's law for Germany (1991Q1-2017Q4) and Spain (1995Q1-2017Q4) by applying unobserved components methodology. The model is estimated by maximizing the likelihood function which is constructed by applying Kalman filter algorithm. Cycli-cal unemployment rate turned out to be driven to a great extent by cyclical proper-ties of output. Estimated Okun's law coefficients for Germany are in line with other empirical studies. Nonetheless, much higher influence of output gap on unemploy-ment rate gap is detected for Spain indicating substantial heterogeneity regarding the strength of the Okun's law among individual European countries.

Keywords: Okun's law • unobserved components • Kalman filter • maximum likelihood

Labour market frictions and vacancies: small open economy DSGE model

Jakub Bechný, Osvald Vašíček

Presented by: **Jakub Bechný**

The goal of this paper is to incorporate job vacancies into a small open economy dynamic stochastic general equilibrium model with involuntary unemployment. The observed vacancies are introduced into the model by using a variant of matching function. The model is estimated by using a Bayesian approach and 16 observed variables from 2001Q1 to 2018Q4 for the Czech economy. The observed vacancies allow us to identify hiring cost shock which has a moderate impact on inflation. However, the observed vacancies do not improve the overall predictive ability of the model, since the model over-predicts the vacancies' volatility.

Keywords: Bayesian estimation • DSGE model • labour market • predictive ability • recursive forecasts • small open economy • vacancies

Multiplication effects of social and health services

Jaroslav Sixta, Jakub Fischer

Presented by: **Jaroslav Sixta**

The paper deals with expenditures on social and health services in the Czech economy. This study is aimed at expenditures of Czech households and their impact measured by the input-output analysis. We use the key principles given by Leontief production function and multipliers derived from static input-output model. We focus mainly on the impact on gross value added, gross domestic product and employment. The structural impacts on the Czech economy is estimated for different scenarios. These scenarios results from changing share of older people re-

quiring these services. In the current demographic situation, the Czech Republic will be facing ageing and similar studies should contribute to the debate for the preparation for demographic ageing. The potential of use of input-output analysis is huge but it is rarely used for similar purposes in the Czech Republic. However, we also do not hide limitations of input-output analysis, as well.

Keywords: Input-Output • Ageing • Health • Social • Services

F4 Financial Analysis of Exchange Markets

Determination of exchange rate returns dynamic with recurrence analysis

Jan Kodera, Van Quang Tran

Presented by: **Jan Kodera**

Theorists as well as practitioners have been trying hard to identify regular patterns in fluctuations of exchange rate returns for long time. However, their investigation has often been conducted with traditional econometric technique. In the last few decades, non-linear methods of time series analysis have started being employed to examine behavior of economic and financial systems. These techniques have often been applied on processes which are so far considered to be stochastic. In this contribution, first, we use visual recurrence analysis (VRA) to graphically detect patterns and structural changes hidden in financial data. Then these hidden patterns and structures will be quantified by using recurrence quantification analysis (RQA). These two nonlinear time series methods will be applied to determine hidden patterns and structures of fluctuations of exchange rate returns present in the time series over the last 20 years.

Keywords: Visual Recurrence Analysis • Quantification Recurrence Analysis • Exchange Rate Dynamic • Nonlinear Time Series Analysis

Czech Economy under Foreign Exchange Intervention Regimes

Tomáš Oravec, Osvald Vašíček

Presented by: **Tomáš Oravec**

After the economic recession with continued monetary policy easing, many European central banks have been forced to implement unconventional monetary policy instruments. In the case of the Czech economy, depreciation of domestic currency on foreign exchange market has been employed while maintaining nominal exchange rate against euro no stronger than the announced level. In the submitted paper, we inspect the small open Czech economy under several intervention regimes within DSGE model with occasionally binding constraints (OBC). In particular, we examine commitment, managed floating and real exchange rate rule intervention regimes in the economy constrained by zero lower bound at the

same time. We provide economic behavior for individual foreign exchange interventions based on impulse responses framework. We present responses to positive as well as negative unanticipated shocks hitting the economy.

Trend analysis with use of binary representation

Michal Dominik Stasiak

Presented by: **Michal Dominik Stasiak**

One of the basic methods of technical analysis is the trend analysis. There are many indicators that allow for a current trend detection and parameter specification based on the candlestick chart representation. Because the use of candlestick representation is characterised by lower informative value, i.e. leads to a loss of information about the course trajectory, better modelling effects can be obtained by using a binary representation. The binarization algorithm transforms the course represented by tick data into a corresponding binary sequence. In the article we propose algorithm allowing for a detection of current trend and specification of its parameters using binary representation. As a result of the algorithm performance we obtain, for each change in the binary representation, the type of the current trend and its parameters, resulting in a so-called binary-trend representation of a course trajectory. In the article we also include an exemplary statistical analysis of trends, performed based on historical tick data from a six-year period (2013-2019), for AUD/NZD currency pair. In order to execute the research a dedicated software was created in MQL4 and C++.

Experimental finance: the Gender Differences in the Disposition Effect Bias

Hana Dvořáčková

Presented by: **Hana Dvořáčková**

The disposition effect has been described in the stock-investing context as a behavioral tendency of investors to hold on to losing stocks for too long and sell winning stocks too soon. In this paper it is examined whether the disposition effect bias is different for males and females. The experimental data set was collected by Jochec during years 2009 to 2015, students were trading under standardized rules. In this paper the holding periods of profitable and unprofitable trades were tested and compared. Significant difference in the length of trades and also in the risk ap-proach of males and females.

S2 Statistical and Econometric Methodology

Forecasting Inflation in Small Open Economies

Jiří Georgiev

Presented by: **Jiří Georgiev**

Inflation forecasts are a crucial part of economic decision-making.The predictive capabilities of multivariate autoregressive models and their non-linear extensions for inflation forecasting on data of selected small open economies within the European Union are examined in this paper.With the introduction of non-linearity and with the growth of dimensions, the number of estimated coefficients is growing rapidly.Therefore, the models are more flexible and have the potential to capture even more complex relationships, but the risk of overfitting is increasing.The predictive performance of vector autoregressive model (VAR), Factor-Augmented VAR (FAVAR) model and feedforward neural network estimated with various settings and different regularization approaches are compared.Simple autoregressive model is used as a benchmark and errors are calculated by rolling windows with short forecasting horizon.

Keywords: VAR • FAVAR • feedforward neural network • inflation

European insurance market analysis via functional data clustering techniques

Stavros Athanasiadis, Tomáš Mrkvička

Presented by: **Stavros Athanasiadis**

Insurance penetration as a high-level indicator of an insurance market's development exhibits significant variations over time across countries. Cross-country comparisons on the link between insurance and economic growth are better off when insurance development homogeneity is present. Motivated by this evidence, this study is aimed to provide a data-driven and meaningful clustering of European countries in terms of their insurance penetration rates that are considered as functions (curves). The ultimate goal is the extraction and visualization of the representative curves that characterize the homogeneous clusters of European insurance market. To this end, we apply functional data clustering methods that fall into three major categories: distance-based methods, filtering methods, and adaptive methods. The data consist of insurance penetration rates sampled from 34 European countries and observed between 2004 and 2016; that is before, during and post-financial and sovereign debt crises. Our results - the clusters- are analyzed from a qualitative point of view, detecting visually whether they are distinguishable and preserve the magnitude and shape of the cluster member curves.

Keywords: Insurance • Insurance penetration • Time series data clustering • Functional data clustering

A Note on Method of Moments Estimation of Ornstein-Uhlenbeck Process Using Ultra-High-Frequency Data

Vladimír Holý

Presented by: **Vladimír Holý**

Stock prices, foreign exchange rates and commodity prices are recorded with each transaction or bid/ask offer resulting in intraday ultra-high-frequency data. Such time series have a very fine time scale and several distinctive characteristics including irregularly spaced observations and the presence of the market microstructure noise. When time series also exhibit mean-reverting behavior, the Ornstein-Uhlenbeck process with continuous values and continuous time can be used to model them. We propose an estimator of the Ornstein-Uhlenbeck process for irregularly spaced observations contaminated by the independent white noise. The estimator is based on the method of moments and utilizes the sample mean, the sample variance and the autocovariance function approximated by the least squares method. The advantage of the method of moments is that it does not require the underlying distribution to be specified. In a simulation study, we compare the proposed method of moments estimator with the maximum likelihood estimator.

Keywords: Ornstein-Uhlenbeck Process • Ultra-High-Frequency Data • Market Microstructure Noise • Method of Moments

Review of several numerical approaches to sensitivity measurement of the Black-Scholes option prices

Jiří Hozman, Tomáš Tichý, Dana Černá, Aleš Kresta

Presented by: **Jiří Hozman**

The efficient and robust numerical pricing of options plays an important role in financial engineering. Since the option price value depends on several underlying parameters, it is desired to know, apart from its value, also how the option price is sensitive to the changes in the underlying parameters, such as asset prices, volatilities, interest rates and times to maturity. These sensitivity measures are named after Greek letters and simply called the Greeks of an option. In this contribution, we provide a review and comparison of several approaches tested on the well-known benchmark of the Black–Scholes model for plain vanilla options. Specifically, we present three methodological concepts arising from finite differences, the discontinuous Galerkin approach and wavelet method. The potential of each of the approaches is demonstrated within a simple empirical study with emphasis to the number of basis functions. From the practical point of view we evaluate the options at several underlying nodes and compare these values to the reference and analytical ones. Simultaneously we investigate the convergence property and orders of the schemes presented.

Keywords: option pricing • Black-Scholes equation • finite differences • discontinuous Galerkin method • wavelet method

FRIDAY September 13, 2019

P Project Management

The Dynamics of Work Effort in Project Management

Dominik Škoda, Igor Krejčí

Presented by: **Igor Krejčí**

The paper deals with the application of system dynamics to explain the principles of work effort development in project management. The paper follows the previous research in the field that focused on the modelling of the work effort, however, incorporated functions that lack the explanatory function, do not pass the dimensional analysis and work mainly as a black box. Among others understanding the project as a dynamic complex system means understanding its feedback structure of interconnections between its elements and characteristics, the nonlinearity of cause and effect and delays. The simulation model comprehends the modelling structures that represent effects of initial motivation, understanding and the adaptation of the perceived project difficulty and time demandingness parameters, procrastination and fatigue. As a result, phenomena such as student syndrome and Parkinson's law described in the project management literature are possible to simulate and interpret. The last part of the paper shows the basic simulation scenarios of behaviour and work effort development that depicts the possibility of parameter settings and calibration of the management flight simulator.

Keywords: Computer simulation • Project management • Scenarios • System dynamics • Work effort

Task threatness matrix in the Project management

Helena Brožová, Jan Rydval, Petra Pavlíčková, Tomáš Šubrt

Presented by: **Helena Brožová**

The main aim of the project management is to ensure the successful completion of a project which consists of many tasks. The success of a project depends on many constraints as scope, time, quality, budget and allocation of necessary recourses. The crucial question is to find out the tasks which can cause the delaying of a project time or failure of the objectives of project. To find out these tasks is necessary to analyze all project tasks and to determine their threatness in relation to the project objectives.In this paper we analyze project task using the criticalness potential defining the criticalness of tasks and using the failureness potential defining the possibility of various tasks failure. Criticalness potential of task has broader meaning then critical task, it means evaluation of time, topological, slack, cost and work criticalness of task using multiple decision-making methods. Failureness of tasks is analyzed using fuzzy linguistic terms and the proper fuzzy linguistic scale. The aggregation of the evaluation of these two po-

tentials expresses the tasks threatness assessment which can be displayed in the task threatness matrix.

Critical mass task identification in projects

Tomáš Šubrt, Jan Bartoška, Petr Kučera

Presented by: **Petr Kučera**

Critical Mass is a term that refers to some project activities which, even though not on the Critical Path, are very risky for in time project completion. Tasks potentially involved in critical mass are generally small, low priority, miscellaneous work, not linked to many others. A difference between activities on the Critical Path and those comprising a Critical Mass is that Critical Path activities must be completed as scheduled, in order to achieve the target completion date. Critical Mass activities generally have plenty of float or slack and can be executed just about any time and in any order. The aim of our paper is an identification of these activities based on quantitative indicators and to propose early warning system for project managers based on quantitative indicators, that such tasks exist and that they need to be financed and monitored. Our approach is an extension and modification of multi-criteria approach to activities criticalness and their expansion. As the tasks potentially involved in critical mass are inadequately resourced, we will also pay attention to resource utilization indicators and factors limiting resource motivation to work on critical mass tasks.

Semantic Model of Project Management in Corporate practice

Jan Bartoška, Tereza Jedlanová, Jan Rydval

Presented by: **Jan Rydval**

The article proposes the use of semantic networks and analytical network analysis (ANP) methods for quantification of the "soft" structure of a project in corporate organization. The semantic project networks are derived based on the organization structure and on the life cycle of projects. Their subsequent quantification using the ANP method creates the basis for analysis of the project roles and analysis of their individual relationship to organization units. Although the project roles during manage of projects are the key to the success, an approach to quantify and analyse to their impact and influence in project organization structure has not been introduced yet. Semantic networks can be used to manage projects to illustrate and quantify links between internal and external objects of the project environment – project goals, project outputs, project documents, etc. The paper suggests a new approach to identifying and quantitating project roles in the project organization management. The article contains case study of ap-

plication of semantic model of project management in commercial organization from bank sector.

Keywords: Project Management • Corporate Organization • Semantic Networks • Stakeholder Management • Analytic Network Process • Human Resource Project Management • Multi-criteria Decision Making • Case Study

E5 Computational Econometrics

Analysis of labour market development in the Czech Republic

Radmila Krkošková

Presented by: **Radmila Krkošková**

This article deals with an analysis of the relationship between the unemployment rate and the number of vacancies in the labour market. This relationship can be characterized by the Beveridge curve. The article explores, whether there is a long-term or short-term relationship between variables. Furthermore, this relationship in the labour market is expanded with the impact of the rate of the unemployed earning unemployment benefit, the rate of unemployed graduates and the rate of unemployed women. The vector error correction model was used for this purpose to determine both long-term and short-term causal relationships. To create the resulting model, the econometric methodology was used, namely unit root tests, Granger causality for the determination of statistically significant relationships, information criteria, and the Johansen cointegration test. The data used have the character of quarterly time series in the period from 2002Q1 to 2018Q4. EViews software version 9 was used for the calculations.

Keywords: ADF test of stationarity • Beveridge curve • cointegration test • Johansen test • labour market • VECM

Least Squares Method With Equality Constraints and Polynomial Approximation of Lorenz Curve

Pavel Pražák, Kateřina Frončková

Presented by: **Pavel Pražák**

The least square method is frequently and successfully used in different econometric problems. Usually, no restrictions on data sets are considered. The only problem with a constraint is the problem where a linear model through the origin is solved. Nevertheless, there are approximation problems with more data restrictions. For instance, the Lorenz curve is a curve through two points (0,0) and (1,1). In this case, it could be useful to have a least square method subject to constraints. In this paper, two possible solutions to the problems with natural data restrictions are introduced. First, it is showed that the constrained problem with two boundary values can be transformed into the classical least square problem and a special form of the normal equation is derived. A more general problem

is then introduced and the Lagrange multiplier method is used to develop a different form of the normal equation. Finally, a polynomial approximation of the Lorenz curve for the Czech Republic income data is introduced.

Keywords: approximation • Lorenz curve • least square method • normal equation • optimization

The use of belief function theory in recommendation based on a similarity diffusion

Ladislav Beránek, Radim Remeš

Presented by: **Radim Remeš**

At present, recommendation systems are integral part of recommendation systems in e-business. In these systems, collaborative filtering technology is an important method for assessing user preferences by using user feedback data and is widely used. Diffusion-based recommendation based on diffusion phenomenon is an important method in collaborative filtering recommendation for processes that can be modelled by a bipartite network, e.g., processes which can represent behavior between users and e-shops. Diffusion-based recommendation algorithms calculate the similarities between users and make recommendations only regarding implicit feedback but neglect the benefits of explicit feedback which is formed by texts written by users during feedback process next to evaluation by certain amount of points (implicit feedback). These texts can be however a significant element in recommendation systems. This paper proposes a combined diffusion similarity model for the integration of explicit feedback and implicit feedback based on Dempster-Shafer theory. The experimental results show that the proposed solution gives good results compared to other algorithms.

Keywords: Recommendation system • E-business • Network • Diffusion • Collaborative filtering

Local Action Groups in the Czech Republic and their assessment

Renata Klufová, Jana Klicnarová

Presented by: **Renata Klufová**

The LEADER programme supports the endogenous and also neo-endogenous development of rural regions through a bottom-up and an integrated approach implemented by the Local Action Groups (LAGs). The evaluation of LAGs' effectiveness in achieving the programme's objectives has already been discussed by the scientific community. The aim of the paper is to assess and create a typology of LAGs in the Czech Republic according to the factors linked to the individual features of LAG and to its organizational background as well as to the success in achieving subsidies.

Keywords: rural development • LEADER • LAGs • quantitative analysis

E6 Econometric Modeling and Applications

Possible Statistical Comparison of Two Time Series

Tomáš Ťoupal

Presented by: **Tomáš Ťoupal**

The most often discussed problem is the comparison of two time series (for example financial or non-financial time series). The proposed approach can be assessed on the base of knowledge of the set of past values and the assumption that there is no significant change in the used probability model. The presented paper is motivated by the approach of positive and quadrant dependence. There is a "power of matching" between two time series, which can be measured (or estimated) in many ways. The problem may occur with their non-stationarity. One solution to this problem can be the quantification of preserving (or not preserving) probability of a monotone relationship. It means the probability that the values of the first time series are increasing and the values of the second time series are also increasing and similarly for consistent decreases. One measure for this quantification is proposed here followed by application on real data sets (Prague Stock Exchange) to estimate the price of one asset depending on the price of another asset.

Keywords: Statistical comparison • Coefficient of concordance • Dependence • Time series • Prague Stock Exchange

Analysis of TV advertisement

Lukáš Veverka, Lukáš Frýd

Presented by: **Lukáš Veverka**

Evaluation of advertising campaigns is a crucial part of the workload ofthe marketing department as the company needs to calculate whether the investmentin advertising is profitable. Here we propose a new data-driven method for evaluating marketing campaigns, in particular, we study the effect of TV advertisement on the sales of cough medicine on a weekly basis. The exact sales data are hard to obtain as the dataset carries sensitive information, therefore we use Google Trends as a proxy variable. Moreover, as the sales are heavily influenced by the seasonality, the Fourier transformation is used to decompose the time series. The presence of a carry-over effect is also tested since marketing communication might affect sales with a delay. The results of the proposed method are promising and the method allows to determine the return on investment.

Keywords: Data-driven marketing • Fourier transformation • Carry-over effect • Google Trends

Relative Income in Durable and Non-Durable Consumption Function: Cross-Sectional Study

Ondřej Badura

Presented by: **Ondřej Badura**

Since the life cycle hypothesis the consumption theory has been understood as the theory of utility streaming from consumption of goods and services at the time of its purchase. In this sense the consumption of durable goods is actually not a consumption, but rather a kind of investment. Although this statement seems to be clear and logic, for the sake of simplicity many empirical studies ignore this fact and assume the same structural patterns for both durable and non-durable consumption function. But can we actually simplify household consumption behaviour that much at the first place? Does this equivalence hold also for the interdependent con-cept of consumption and utility?The aim of this work is to make a little contribution in answering these questions by estimating the consumption functions of durables and non-durables separately focusing on the influence of relative income. The regression analysis of the cross-sectional dataset of Czech households reveals that while relative income is the key determinant of non-durable consumption function, its influence is strongly insignifi-cant in the durable consumption behaviour.

Keywords: Consumption • Durables • Non-durables • Relative income • Cross-sectional regression

Z2 Fuzzy Numbers

The relation "greater than or equal to" for trapezoidal ordered fuzzy numbers

Krzysztof Piasecki, Anna Łyczkowska-Hanćkowiak, Aleksandra Wójcicka-Wójtowicz

Presented by: **Krzysztof Piasecki**

The ordered fuzzy number (OFN) is defined as a pair of fuzzy number and its orientation. Any OFN is interpreted as imprecise number with additional information about the location of the approximated number. Each positively oriented OFN is interpreted as an imprecise real number described by the linguistic variable "about or slightly above". Each negatively oriented OFN is interpreted as an imprecise real number described by the linguistic variable "about or slightly below". Here, we restrict our considerations to the case of trapezoidal OFN. The main goal of this paper is to introduce the preorder "greater than or equal to on the space of all OFNs. This relation is defined as an extension of analogous relations on the space of all fuzzy numbers. All properties of the introduced relation have been investigated on the basis of the revised Kosiński's theory of OFNs. It is shown here that in the above way this relation has been defined unambiguously as fuzzy

ones. In addition, it is proven that the obtained relationship is independent on the orientation of the compared OFNs. The results obtained will be useful for formulating optimization tasks using numbers.

Keywords: disorientation • fuzzy number • fuzzy relation • ordered fuzzy number • preorder

The Jensen's ratio determined by oriented fuzzy discount factor

Anna Łyczkowska-Hanćkowiak

Presented by: **Anna Łyczkowska-Hanćkowiak**

The analysis presented in this paper regards the security of a present value given as an ordered fuzzy number. The present value was estimated in an imprecise manner and supplemented by the forecast of its coming changes. A discount factor of such security is an ordered fuzzy number of the orientation identical to the oriented present value that determines it. All classical methods of portfolio analysis are based on the definition of the return rate. In the case of securities with a fuzzy present value, a discount factor is a better tool for portfolio analysis than the return rate. It implies the chosen methods of management of securities should be revised and transformed to methods based on a discount factor. This would enable the use of those methods in the case of a financial instrument of the oriented fuzzy present value. This paper presents example results of the realization of such a postulate. The main aim of the paper is to generalize Jensen's ratio to a case of investment recommendations management formulated for a security characterized by an oriented discount factor. A five-degree rating scale was used. The whole deliberation is illustrated by broad numerical examples.

Keywords: Jensen's ratio • ordered fuzzy number • fuzzy oriented discount factor

Comparison of similarity measures for generalized trapezoidal fuzzy numbers

Tomáš Talášek, Jan Stoklasa

Presented by: **Tomáš Talášek**

In the last ten years, several new similarity measures for generalized trapezoidal fuzzy numbers were proposed in the literature. These similarity measures differer in the combination of properties of fuzzy numbers that are taken into consideration (e.g. center of gravity, height, area, perimeter, distance of significant values, etc. of the compared fuzzy numbers). The performance of these similarity measures was, so far, investigated only on several specifically chosen examples. A thorough comparison of the performance of these different similarity measures is still not available in the literature. This paper investigates the relationships between the new similarity measures using a numerical experiment. The effect of the different heights of the compared generalized fuzzy numbers is also considered. As such, the paper provides first insights into the shared features of the similarity measures.

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