Mathematical Methods in Economics

MME 2023

Book of Abstracts of the

41st International Conference on

Mathematical Methods in Economics

Czech Society for Operations Research

Prague University of Economics and Business

Book of Abstracts of the
41st International Conference on Mathematical Methods in Economics

September 13–15, 2023

Prague, Czech Republic

41st International Conference on Mathematical Methods in Economics

September 13–15, 2023

Hosted by the Prague University of Economics and Business, Faculty of Informatics and Statistics

Winston Churchill Square 1938/4, 130 67 Prague 3, Czechia

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- Imposition of a formal embargo on contributions from an individual in the proceedings for a defined period.

Foreword

We are delighted to present to you the Book of Abstracts, which have collected the best selected contributions presented at the 41st International Conference on Mathematical Methods in Economics organized by the Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Econometrics, under the auspices of the Czech Society for Operations Research, the Slovak Society for Operations Research, and the Czech Econometric Society. The conference was held in Prague from September 13 to 15, 2023.

This traditional meeting brings together academicians and professionals interested in the theory and applications of operations research and econometrics. It serves as a significant event in the field. This year, we welcomed more than 110 researchers from 8 countries who also served as discussants of the papers and helped to improve the quality of the research results presented during the conference days. The contributions followed new trends in econometrics and operations research and built bridges between researchers, academicians, and practitioners in the industrial and institutional sectors, sharing recent theoretical and applied results. The wide range of topics presented at the conference demonstrates the importance of using mathematical methods in many fields of economics.

We hosted two distinguished plenary speakers who contributed to the conference program with their speeches. Prof. Dimitris K. Despotis (University of Piraeus, Greece) gave a talk on Network Data Envelopment Analysis with a focus on the prevalent methodological approaches and some recent developments. Prof. Miloš Kopa (Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic) presented recent research on Decision Making in Finance via Stochastic Dominance. Moreover, special attention was paid to two sections collecting the best student talks submitted to the PhD student competition organized by the Czech Society for Operations Research. We congratulate the winner – Mgr. Jana Junová (Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic), and the other laureates.

Finally, we would like to express our deep thanks to the organizers, all the reviewers, and the members of the scientific committee for their contribution to the successful organization of this high-level scientific conference.

Prague, September 2023

Miloš Kopa

Contents

A Consensual Coherent Priority Vector of Pairwise Comparison Matrices in Group Decision-Making

David Bartl[1], Jaroslav Ramík[2]

Abstract. The Analytic Hierarchy Process (AHP) is a method proposed to solve complex multi-criteria decision-making problems. Pairwise comparison methods are often used in AHP to derive the priorities of the successors of an element in the hierarchy. In this paper, we are concerned with group decision-making; that is, given n objects, such as criteria and/or variants, let m decision makers evaluate the n objects (pairwise) with respect to a criterion. The task is then to find a consensual priority vector of the m given $n \times n$ reciprocal pairwise comparison matrices. Recalling several desirable properties of the priority vector – consistency, intensity, and coherence – we consider the weakest one of the three, i.e. coherence, in the rest of the paper. In other words, given m coherent priority vectors, each provided by a decision maker of the group, the purpose is to find a single consensual priority vector of the group. To cope with this task, we propose a grade to measure the consensuality of a priority vector. We thus obtain an optimization problem, whose solution yields an optimal consensual ranking of the n given objects.

Keywords: multi-criteria group decision-making, pairwise comparison matrices, consensual priority vector, coherence, Analytic Hierarchy Process (AHP)

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Three-Parameter Lognormal Curves Combined with the Quantile Method of Parameter Estimation as Models of Salary Distribution

Diana Bílková[1]

Abstract. The main objective of this paper is the construction of salary distribution models through three-parameter lognormal curves in combination with the quantile method of point parameter estimation. Salary distribution models are constructed separately for men and women and according to educational attainment. An important aim is to capture the development of salary distributions over time during the period 2014–2020 and the specification of the typical shape of these models for individual categories of employees. The data for this research was taken from the Czech Statistical Office.

Keywords: three-parameter lognormal curve; quantile parameter estimation method; salary distribution model

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Strategic Management DSS Preferences Evaluation Method Using ANP – Application of Behavioral Economics

Petra Bláhová[1], Jan Rydval[2], Helena Brožová[3]

Abstract. The increasing volume of information and rapid digitalization creates a constantly changing environment where the ability to make effective and timely decisions becomes crucial. Enabled by the development of information technologies, decision support systems (DSS) became an essential tool in this environment. Although the DSS is known to improve organizational performance and success, strategic management DSS use is less than optimal, and intuitive expert estimation and knowledge is preferred. To improve the level of DSS use and DSS acceptance, the paper proposes a method for evaluating senior managers' preferences for DSS capabilities in the context of behavioral economics (BE) heuristics and cognitive bias, and in the context of selected strategies. Proposed method is based on the Analytic Network Process (ANP) suitable for complex decision-making problems, with multiple criteria and alternatives considering the influence of objective and subjective factors.

This paper uses the ANP model to evaluate DSS benefits and capabilities in terms of both decision elements and cognitive bias. The proposed model is flexible regarding selected elements, allowing application in any organization that needs to evaluate its management decision style and the complexity of managers' preferences before proposing the DSS framework. Sensitivity analysis results seem to be an essential part of increasing the understanding of the success of DSS acceptance as such analysis allows to find out how the importance of each element of the DSS changes as the preferences of each element of the ANP decision model increase.

Keywords: ANP, DSS preferences evaluation, strategic management decisions, sensitivity analysis, BE, cognitive bias

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Portfolio Selection under Unstable Dynamics Using the Fuzzy Concept Operating with a Triplet of Moving Characteristics

Adam Borovička[1]

Abstract. Investment portfolio selection can be a very tortuous journey in which an investor faces a number of challenges. Asset prices can move very volatile. At the same time, it is usually possible to trace a certain trendiness in their behavior, which is due, among the other things, to their autocorrelation. The dynamics of development is not stable, it changes (unpredictably) over time. The phenomenon of such uncertainty is caused by the difficulty of predicting the evolution of prices which can be influenced by a variety of factors. To make a representative investment decision, the uncertainty, or an unstable dynamic environment must be taken into account. For this purpose, a methodological procedure integrating the fuzzy concept operating with a triplet of moving characteristics is proposed. Firstly, the continuity, trendiness is reflected by the moving elements, i.e. minimum, average and maximum of the returns. Secondly, the dynamics of the development is identified by means of an average indicator calculated as the triangular fuzzy number whose parameters are derived from the moving investment characteristics. Thirdly, the unstable dynamics, or uncertainty, is measured by the absolute deviation concept which practically quantifies the level of risk associated with the asset. The proposed concept of unstable dynamics is integrated into an investment portfolio making procedure relying on the fuzzified KSU-STEM method. The usefulness of the developed tool is demonstrated on the Czech open unit trust market. Portfolio can be formed according to the investor's preferences in a dynamically evolving environment, which significantly contributes to the adoption of a comprehensive, personally related investment decision.

Keywords: fuzzy, moving, portfolio selection, uncertainty, unit trust, unstable dynamics

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An Analysis of Populist Attitudes Using SEM Models

Slávka Bozděchová[1]

Abstract. In this paper, I investigate the character of people who vote for a populist party. My goal is to understand their success during the recent elections. In the 2017 elections, the so-called populist parties achieved unexpected electoral success. In this article, I deal with the question of what factors (individual, contextual) influence the decision to vote for so-called populist parties. Using structural equation models popular in the social and behavioral sciences, I estimate causality between observed and latent variables. The latent variable is perceived in the work as a variable that contains populist attitudes.

I focus on two populist parties in this paper in particular: „Svoboda a přímá demokracie" from Czech Republic and „Alternative für Deutschland" from Germany. I show that regions with a low population density and a higher number of unemployed people have the greatest influence on attitudes towards populism. Support for populist attitudes is also associated with negative attitudes towards groups (migrants and minorities).

Keywords: populism, structural equation modeling, populist attitudes

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Maintenance Scheduling for Production Units with Machine Failures

Martin Branda [1]

Abstract. We consider problems where identical independent machines process a given set of jobs with prescribed starting times and uncertain finishing times due to machine failures. We assume that maintenance of the machine can be performed for a price and that this maintenance can influence positively the reliability of the machines. So it reduces the possible failures. We provide a stochastic optimization formulation of the problem with endogenous uncertainty and discuss its possible reformulation as a deterministic mixed integer programming problem. We show that this reformulation can be solved efficiently to optimality for smaller instances of the problem.

Keywords: Scheduling, maintenance, stochastic optimization, engogenous uncertainty, mixed integer programming

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ANP Model for Suggestions on whether to Lead a Project Agile or Waterfall

Matej Brnka[1], Jan Rydval[2], Petra Pavlickova[3]

Abstract. In projects, a massive amount of money is often involved, and proper project management contributes to project success and efficient spending of money. Nowadays, two approaches to project management are commonly used and inherit the whole process from initial analysis, design, and implementation to delivery. In the traditional approach (waterfall), each phase follows the previous one, and the next phase cannot start before the previous is completed. It means the customer gets the final product at the end of the project. The agile approach is based on the principle of iterative time and incremental product, which must be functional. The customer gets functional parts of the product during the project and can provide feedback to the supplier.

The paper discusses selecting a project management style based on multi-criteria decision-making using the Analytic Network Process (ANP). The ANP model's structure and its clusters' composition come out on the international project management standard PRICNE 2 ® Agile. The composition of the clusters and the individual decision criteria correspond with the individual attributes of the project hexagon (project constraints like time, cost, scope, benefit, risk and quality), the attributes of the project team (size, location, communication, working style) and the characteristics of the project team members (T-shape, Pi-shape, I-shape, X-shape) and the overall project focus, from IT projects, through marketing to industrial projects. The model results in suggestions for the project manager on how to approach the management of the project or its parts.

Keywords: Agile, Analytic Network Process, PRINCE 2, Project, Project Management, Project Team

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Mathematical Modeling of Ground Handling Process for Cargo Aircraft

Jakub Cíleček [1], Dušan Teichmann [2], Polina Yuryevna Koriukina [3], Cong Thanh Luu [4]

Abstract. Aircraft ground handling is a process involving a large number of sub-activities. Its basic task is to ensure the check-in of the aircraft after arrival and before departure. The ground handling of aircraft requires a whole range of resources. Most often, these are personnel and technical resources, the maintenance of which is financially very expensive. From an operational point of view, it is important that the ground handling of a specific aircraft takes place as efficiently as possible. The effectiveness of ground handling is quantified by its time-consuming nature. It is required that the ground handling takes as little time as possible. The presented article is devoted to the issue of managing the ground handling of cargo aircraft using network analysis methods in the conditions of Ostrava International Airport.

Keywords: ground handling, aircraft, cargo, project management, critical path method

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Wavelet Method for Valuation of Options on Investment Project Expansion

Dana Černá[1]

Abstract. The paper addresses the pricing of options to expand, which are types of real options that allow expanding an investment project at a future date. Under the assumption that the underlying commodity price follows a geometric Brownian motion, the model for the valuation of the expansion option can be represented by a partial differential equation of the Black-Scholes type. Unlike options in finance, however, in the case of real options, there is no analytic solution, the payoff function itself is computed as a solution to a differential equation, and appropriate boundary functions have to be determined. The paper introduces the model for pricing expansion options and proposes a wavelet-based method for its numerical solution. The method employs the Crank-Nicolson scheme combined with the Galerkin method using a cubic spline wavelet basis. Numerical experiments are performed for the benchmark problem in the iron-ore mining industry. From a numerical point of view, the advantages are the higher-order convergence rate and the small number of iterations needed to resolve the problem with the required accuracy.

Keywords: real option, option to expand, cubic spline, wavelet, high-order convergence

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Will This Manuscript Turn into an Influential Paper?

Černý Michal [1], Lucie Dvořáčková [2]

Abstract. The influence of an academic paper is usually measured by the number of citations. However, when a paper is young (freshly published, or yet a manuscript or preprint), there exist no citations at all. We present a model for estimation of future potential impact of a young paper based on text mining techniques. We assume that a paper is represented by its abstract, which is vectorized by the Word2Vec methodology, and then a neural network is trained on the CORD database of previously published biomedical papers for which citation data is already available. Although this is a black-box model, we give interpretability to the predictor (this is the crucial step of our work). We create artificial abstracts made of a single word, or an n-tuple of words with a low n, and ask the trained model whether or not such an expression itself is classified as potentially highly influential. This produces ranking of words (or expressions, or n-grams) w.r.t. their potential contribution to the future high impact of a paper in the abstract of which the words are present. This is especially interesting when, say, a pair of expressions from two different scienfitic disciplines appears to influential, such as a combination of concepts from pharmacy and material engineering. Thus, the method has a potential to discover new and sometimes unexpected possibly influential interdisciplinary research topics. The talk is based on the work [T. Kliegr, M. Joachimiak, M. Černý, L. Dvořáčková, V. Sklenák: Explainable detection of future impactful biomedical research articles and entities, available as preprint] and contributes to the previous research on a similar topic, see e.g. [V. Tshitoyan, J. Dagdelen, L. Weston et al. (2019): Unsupervised word embeddings capture latent knowledge from materials science literature, Nature 571(7763).]

Keywords: scientometrics, text mining, interpretable machine learning

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Statistical Analysis of Brand Marketing

Andrea Čížků[1]

Abstract. The goal of the paper is to investigate brand marketing strategy for different generations of consumers. Brand marketing strategies aims to be more personalized as different types of customers perceive the brand value differently. Specifically, generational approach is applied and sources of brand value are analyzed across different generations of customers. Questionnaire survey data focused on identification of sources of brand value across different generations are statistically analyzed by applying chi-squared tests within contingency tables. The results show that (1) generational aspects play an important role in brand marketing strategy as the perceived source of the brand value turned out to be dependent on consumers' age, (2) this dependence is quite stable over time.

Keywords: generational stratification, brand value, contingency table, chi-squared test

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Network Data Envelopment Analysis: The Prevalent Methodological Approaches and Some Recent Developments

Dimitris Despotis [1]

Abstract. Network data envelopment analysis (NDEA) is an extension of standard data envelopment analysis (DEA) that models the efficiency assessment of DMUs by considering their internal structure. While in standard DEA the DMU is regarded as a single process, in NDEA the DMU is viewed as a network of interconnected sub-processes (stages, divisions), where the flow of the intermediate products (measures) is essential in the efficiency assessment. In the prevalent conventional methodological approaches to NDEA, the sub-processes are assumed as distinct entities with distinct inputs and outputs. Thus, each sub-process has its own production possibility set (PPS), which can be derived axiomatically from a set of assumptions using the minimum extrapolation principle. The PPS of the overall system is defined as the composition of the individual PPSs. We outline in this presentation the basic NDEA methods established in the literature, and we discuss their limitations, merits, and drawbacks.

A fundamental property connecting the system with the divisional efficiencies is that a system is overall efficient if and only if its divisions are all efficient. In NDEA, regardless of the method used, there are cases where none of the observed DMUs is rendered overall efficient, as corroborated by real-world case studies. This deviation from the DEA standards is the motivation to present an alternative, non-conventional, approach to address it in the frame of two-stage processes. The two-stage process is considered as a system that can be viewed in two perspectives depending on the role of the intermediate measures: the system as producer and as consumer of the intermediates. As the recently proposed approach is based on standard DEA, it satisfies the basic desirable properties. The fundamental NDEA property, that the overall system is efficient if and only if both perspectives are efficient, is met. The efficient frontier of the system is explicitly defined by the overall efficient observed DMUs and the inefficient DMUs are projected on the efficient frontier of the system. A convergent procedure is presented for this purpose. The proposed models are equivalently expressed in both the multiplier and the envelopment forms due to strict primal-dual correspondence and can operate under both constant and variable returns-to-scale assumptions.

Keywords: data envelopment analysis, network data envelopment analysis, two-stage processes

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Computational Aspects of Data Envelopment Analysis

Martin Dlouhý[1]

Abstract. The data envelopment analysis is a well-known non-parametric method of efficiency evaluation. The large number of production units in data envelopment analysis leads to extensive computations because one linear program has to be solved for each production unit. The objective of this paper is to summarise the current body of knowledge on computational aspects of data envelopment analysis. We can distinguish three main groups of approaches. Firstly, the preprocessing methods that can quickly classify or score a production unit without solving a linear program. Secondly, the linear programming methods aim to reduce the computational requirements of solving linear programs by accelerating their performance or extracting opportunistic information for classification from them. Thirdly, the big data methods deal with the computational challenges when large sets of production units are present. The computational experiments have shown that the savings achieved by applying some procedures can be significant.

Keywords: data envelopment analysis, convex hull

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Economic Dependency in Slovakia

Tomas Domonkos [1], Stefan Domonkos [2]

Abstract. We estimate the economic impact of ageing in Slovakia from 2015 till 2050. We express this impact using a set of dependency measures derived from the Slovak National Transfer Accounts and relevant demographic projections. Our results reveal that the economic dependency and public sector dependency will increase in the future. The source of this increase is predominantly ageing, while the contribution of the youth dependent population to its dynamics is negligible. We additionally show what impact can be expected from future increases in the retirement age on the economic dependency and public sector dependency ratios.

Keywords: NTA,ageing,economic dependency

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The Crossing Numbers of Cartesian Product of Paths and Cycles with Several 8-vertex Graphs

Emília Draženská [1]

Abstract. The crossing number of a graph G is the minimum number of edge crossings over all drawings of G in the plane. Garey and Johnson have proved that compute the crossing number for a given graph is a very difficult problem, it is NP–complete problem, in general. There are several classes of graphs for which crossing numbers have been studied. The main aim of the paper is to establish the crossing numbers of the Cartesian products of the paths and cycles on n vertices with several connected graphs on eight vertices.

Keywords: graphs, drawings, crossing numbers

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Traffic Flow Control Using Tecnomatix Plant Simulation

Jan Fábry[1], Ondřej Kopčan[2]

Abstract. The traffic jams that form as a result of poor control of traffic flows cause delays in the delivery of materials and goods, delays of public transport, but also a high production of emissions and noise. The paper focuses on the issue of traffic flow control at intersections. Computer simulation is a suitable tool for performing the analysis of traffic flow problems to find the efficient solution. In many cases it is necessary to decide on the type of intersection for certain location. As the alternatives, non-signalized or signalized crossroad can be considered, or roundabout can be built. We created several simulation models in Tecnomatix Plant Simulation software to run computer experiments. In case of signalized intersections, experiments for intervals setting were executed.

Keywords: traffic flow, non-signalized intersection, signalized intersection, traffic lights, roundabout, computer simulation, Tecnomatix Plant Simulation software

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Model of a Network Industry

Petr Fiala[1]

Abstract. Behaviour in network industries is an important subject of intensive economic research. The analysed model of a network industry is based on the coopetition concept, where players are networks that compete and networks consist of a supplier and producers who may or may not cooperate with the supplier. The effects that arise depending on cooperation and competition in networks are analysed. This simplified situation allows greater transparency of results. Cournot oligopoly model serves as a basis that is analysed as a game where strategic decisions are based on output. The other approach is based on negotiations between suppliers and non-cooperating producers. Supply prices are negotiated between the supplier and individual producers. The negotiation process can be modelled by a simultaneous biform game with a combination of cooperative and non-cooperative approaches. The model is simple, but it still allows to make important managerial implications.

Keywords: network industry, game theory, coopetition

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Historical Calibration of SVJD Models with Deep Learning

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Abstract. We propose how deep neural networks can be used to calibrate the parameters of Stochastic-Volatility Jump-Diffusion (SVJD) models to historical asset return time series. 1-Dimensional Convolutional Neural Networks (1D-CNN) are used for that purpose. The accuracy of the deep learning approach is compared with machine learning methods based on shallow neural networks and hand-crafted features, as well as with commonly used statistical approaches such as MCMC, Quasi-MLE, and Particle Learning. The deep learning approach is found to be highly robust as well as highly accurate, outperforming the shallow machine learning based methods, and achieving performance on par with MCMC, which is the most accurate out of the classical approaches. Among the practical advantages of the deep learning approach is its speed in situations when the parameter estimation needs to be done repeatedly for large number of time series. The second major advantage is that the approach is fully generic and can be applied to any SVJD model, including the ones for which no efficient MCMC algorithms exist.

Keywords: SVJD models,stochastic volatility,deep learning,convolutional neural networks,MCMC

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Two-stage Efficiency Analysis Pitfalls

Lukáš Frýd[1], Ondřej Sokol[2]

Abstract. DEA is one of the two main estimators of technical efficiency and is thus a popular tool in policy analysis of agricultural, environmental and other policies. Associated with these policies is the so-called two-stage efficiency analysis, where the first stage estimatesDEAefficiency and the second stage estimates the effect of selected policy variables on DEA efficiency from the first stage. Although there is a large body of theoretical work dealing with the statistical properties of the DEA estimator, how to measure the inputs and outputs to the DEA model and the sensitivity in the second stage is completely neglected. We show that differently approximated albeit highly correlated basic inputs lead to specific technical efficiencies. This heterogeneity also leads to heterogeneity of results in the second stage of the analysis. Policy analysis built on a two-stage approach not only cannot be easily compared with each other, but may lead to erroneous decisions.

Keywords: data envelopment analysis, input measurement, efficiency analysis

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Economic Perspective of Smart System for Waste Collection

Taťána Funioková[1], Petr Kozel[2], František Zapletal[3]

Abstract. Smart cities use modern information technologies to improve the quality of life of their residents and to become attractive to other entities as well. One of the areas that is essential for every municipality and where there is room for the application of modern approaches is waste collection. This article aims to extend the concept presented by [11]. Using mathematical programming methods in combination with financial analysis, a thorough analysis of the viability of the smart system is carried out with regard to fluctuations in requirements during the year. Next, an economic analysis is performed that compares the smart system with a traditional system with fixed collection. The results showed that the smart system would impact each resident groups differently: the costs for companies and couples will increase, on the other hand, the companies would reach substantially greater level of comfort. For most families, the costs would be reduced and the comfort increased.

Keywords: Smart city, waste collection, optimisation, linear programming

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DEA Methodology as a Tool for Determining the Efficiency of Public Transport in South Moravian Region

Nino Gochitidze[1]

Abstract. This paper discusses the possibility to apply DEA methodology for determining the efficiency of public transport. There are 673 municipalities in the region connected by municipal and private transport companies in a unified mode. According to the latest data, transported passengers among region have increased from 118 to 828 million of passengers-kilometers during the period 2004–2019, while in the city of Brno from 344 to 403 million passengers. Along with the increase in the flow of passengers, the criteria for efficiency evaluation also changes.

The aim of this contribution is to (i) identify the main evaluation criteria of transport efficiency for passengers based on a pilot survey in the region, (ii) identify a set of feasible transportation alternatives, and (iii) by using Data envelopment analysis (DEA), find an efficient transport design and discuss the suitability of the method for the transportation problem.

Keywords: Public Transport, South Moravian Region, DEA, Efficiency

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Assessing the Scientific Perception of Several Professions through Quantitative Methods

Sandra González-Gallardo[1], Maria Isabel Sánchez-Rodríguez [2], Ana B. Ruiz[3], Mariano Luque [4]

Abstract. This work analyses how scientific a variety of professions belonging to fields of science, social science and pseudoscience are considered in Spain. Professions related to scientific knowledge are highly valued, especially those related to life and the natural world such as physicians, scientists or researchers. However, other professions in the social sciences or humanities have considerably lower scientific recognition. In this sense, the scientificity of a profession is a term that refers to the quality of the scientific procedure followed, which is best when the procedure and its results are objective, impartial and neutral. Firstly, regression binary logistic models are used on a set of explanatory variables (related to scientific culture, politics, education, and sociodemographic characteristics) to estimate the scientificity level of the professions considered. This provides a perception of the relative impact of the predictors on the professions' scientificity. Then, based on the significance of each previous regression coefficient, a multiobjective optimization problem is built with the aim to improve the perception of these professions. The results are very promising and indicate the policies to be followed to increase the scientificity levels of the professions under study.

Keywords: logistic regression, multiobjective optimization, scientific perception

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Testing the Stability of the Result of Composite Indicator Obtained by the Model Benefit of the Doubt

Jakub Hanousek[1]

Abstract. This article deals with a composite indicator based on the "Benefit of the Doubt". The model of the "Benefit of the Doubt" is based on a non-parametric method called data envelopment analysis. The selection of appropriate and relevant criteria that are included in the Benefit of the Doubt model is an important part of the analysis. This article measures the correlation between all criteria and then between the ranking of composite indicators. The correlation is measured by the Pearson correlation coefficient. We eliminate one criterion from our model and then we calculate a new ranking of the model. A small correlation between ranking results shows the importance of the criterion. From the result, we can see that a strongly correlated criterion with another criterion can have a major influence on the resulting ranking.

Keywords: benefit of the doubt,correlation,criteria

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Statistical Analysis of Determinants of Military Recruitment

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Abstract. The conclusions of the NATO Summit in Wales in 2014 and the subsequent change in the security situation entail a requirement for an increase in the number of members of the Czech Army, which competes for human resources in the labour market. This paper focuses on the problem of identifying and analysing the determinants of military recruitment affected by the development of the country's economic environment, measured through economic growth, labour market equilibrium, or wages. Statistical methods including the stepwise regression were used to select variables influencing the military recruitment. The results of parametric and nonparametric regression analyses confirm a positive effect of the wages, and a negative effect of the labour market equilibrium. Moreover, the economic growth has no statistically significant effect on military recruitment.

Keywords: military recruitment, determinants, regression, correlation

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A Generalized Approach to Measure Sensitivity in Linear Programming

Milan Hladík [1]

Abstract. The traditional sensitivity analysis in linear programming is a well-known and established technique to measure the effects of variations of one selected coefficient on the optimal value and the optimal solution. Usually, the analysis is based on the invariancy of the computed optimal basis. However, one-coefficient variations are very simple cases and do not reflect the overall complexity of the practical situations. That is why there were developed several extensions of this classical approach. For instance, the tolerance approach to sensitivity analysis was introduced to handle independent and simultaneous variations of selected coefficients. Therefore, it provides the decision maker with a convenient technique to model more complex variations of the data.

In our presentation, we go yet further and consider variation of possibly all input data with respect to a given matrix norm. In particular, we address the problem of determining the maximum variation of the data in the norm such that the computed optimal basis remains optimal. We present not only general results valid for an arbitrary norm, but we also analyse particular matrix norms, including for example the spectral and the maximum norm. Eventually, we inspect computational complexity and distinguish for which norms the problem is efficiently computable and for which it is intractable. For the computationally more demanding cases, we propose polynomially computable lower and upper bounds.

Keywords: linear programming, sensitivity analysis, tolerance analysis, matrix norm, NP-hardness

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Designing an Efficient Transportation System under a Constrained Budget and Cost Uncertainty

Robert Hlavatý[1], Helena Brožová[2]

Abstract. We revisit a particular case of the traditional transportation problem of Hitchcock and Koopmans with multiple objective functions. We assume that the maintenance costs of each supplier influence the capacities on the suppliers' side. Further, we assume that the maintenance costs are subject to uncertainty and can vary within a predefined range. We seek to design an optimal transportation system with respect to all objectives while arranging the capacities of the suppliers considering a given budget and uncertainty in the maintenance costs. We propose an algorithm based on the De Novo optimization concept, which yields an efficient constellation of the suppliers' capacities under the constrained budget. To capture the uncertainty within the budget, we employ the concept of gamma-robust optimization. We illustrate the algorithm on a simple artificial case. It turns out that the proposed approach allows for efficient budget use and offers robust solutions that face the financial uncertainty of the decision-maker.

Keywords: De Novo Optimization, Multi-objective Linear Programming, Robustness, Transportation problem, Uncertainty

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Introducing the gasmodel Package for Score-Driven Models

Vladimír Holý[1]

Abstract. In recent years, score-driven models have emerged as a valuable methodology for time series modeling, particularly in econometrics and quantitative finance. These models allow for any underlying probability distribution with dynamics driven by the conditional score for any time-varying parameters. To facilitate the estimation, forecasting, and simulation of score-driven models, I have developed a new R package called "gasmodel". This package offers a range of score-driven models, including volatility, duration, count, and ranking models. In this talk, I introduce the package and discuss some of its applications.

Keywords: R package, score-driven models, generalized autoregressive score models, dynamic conditional score models

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A User Recommendation System Based on Graph Neural Network and Contextual Behavior

Jiří Homan[1], Ladislav Beránek[2], Radim Remeš[3]

Abstract. Today, recommendation systems are an integral part of e-commerce services on the Internet. In connection with their development, neural networks have become the most used approach to recommender systems. In our post, we will demonstrate the use of graph neural networks to create a recommender system. E-commerce systems can be modeled using a bipartite interaction graph. There are two essential parts to this chart, users and items. In our model, context is added to them and integrated into the mentioned parts of the bipartite graph using the theory of hypothetical functions. Different elements of a bipartite graph can interact using edges. Therefore, modeling the interaction of elements can be transformed into modeling the interaction of nodes on the corresponding graph. We implemented a recommender system model in Python and used relevant libraries, which we tested on standard datasets. These experiments showed the good ability of our model for recommendations. We used the root mean square error (RMSE) and mean absolute error (MAE) indicators.

Keywords: E-commerce, Recommender Systems, Graph Neural Networks, Belief Function Theory

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Numerical Valuation of Investment Opportunities under Two-Factor Uncertainty

Jiří Hozman[1], Tomáš Tichý[2]

Abstract. Real options approach applies to a wide range of investment opportunities in order to help investors achieve better risk management and more robust financial outcomes. In this paper we focus on a decision-making framework that incorporates two sources of uncertainty in evaluating strategic investments, namely unit output commodity price and unit cost. Incorporating both factors provides a more realistic and accurate approach to evaluating embedded flexibilities, especially in highly uncertain environments. Using contingent claim analysis, the values of investment opportunities can be identified as solutions to the relevant two-factor Black-Scholes equations, adjusted to match the specific features of real options. As explicit formulae for this kind of PDE problem are only available in certain scenarios (as for conventional financial options), one must rely on numerical techniques in general. Inspired by the methodology from numerical valuation of one-factor real options, we employ and extend the discontinuous Galerkin approach to the two-factor option case exercisable at a fixed time (i.e., European-style option). Finally, the proposed numerical scheme is applied to a simple conceptual expansion decision problem for illustration purposes.

Keywords: real option pricing, project value, option value, two-factor Black-Scholes equation, discontinuous Galerkin method

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Optimal Location for Bike-Sharing Stations

Dušan Hrabec[1], Karel Šohaj [2], Vlastimír Nevrlý[3], Kateřina Víchová[4]

Abstract. Bike-sharing systems (BSSs) arise worldwide as a sustainable and attractive travel alternative, especially in city logistics. In many cities, there are already existing bike-sharing networks of stations where customers can borrow and leave these bikes. In the Czech Republic, several companies are providing BSS services; however, various conditions, such as costs, payments, and contracts (with cities, customers, owners of stations, etc.), differ across cities and providers. One of the aims of this work is to review the current state of BSS in EU countries and Czech towns. A mixed-integer linear mathematical model is then developed to optimize either existing or completely new locations of bike-sharing stations. The model, among others, reflects walking distance as a parameter that are customers willing to walk to the nearest bike-sharing station and assigns a weight parameter to each (customer) node in the network reflecting the importance of the node (to distinguish, e.g., among hospital, train station, shopping center, restaurant or an apartment and family house, etc.). The model is applied in a case study of a selected Czech town willing to provide needed data in cooperation with a company operating the BSS. After consulting the preliminary results with the provider, a sensitivity analysis of some selected parameters is investigated. Finally, we discuss future research directions that interest all the involved members (towns, providers, customers) with similar targets.

Keywords: location problem, bike-sharing systems, location-allocation, transportation, demand models, accessibility, built environment

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Cost Optimization Model for Synchronous Storage and Dispatch in Production Warehouse

Andrea Hrníčková [1], Karel Ječmen [2], Dušan Teichmann [3], Denisa Mocková [4]

Abstract. There are various types of warehouses in the logistics chain, one of them are production warehouses. These are warehouses, which storage capacity is used to complete product processes before shipping to the customer or to homogenize the qualitative parameters of the material before processing. This process is called refinement. Typical examples of products that go through the refining process can be found in the food and chemical industry, especially fermentation processes in brewing and distilling, or stabilizing chemical processes in cosmetology. These products usually require transportation to the production warehouse immediately after production, where take place storage with a refining process while observing specific, predefined conditions (for example, a certain temperature or humidity in the warehouse). In these conditions, the products must spend the minimum required time, and in most cases the stay in the warehouse must not exceed the maximum defined time, otherwise the final product could deteriorate. These mentioned factors affect not only the quality of the product, but also the financial complexity of the entire process. This paper deals with the application of the linear programming method for the purpose of optimizing the total costs of production, synchronous warehousing process with the refining process and dispatching finished products to customer using a heterogeneous vehicle fleet.

Keywords: costs optimization, linear mathematical programming, production warehouse

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Regime Switching Behaviour of Selected European Stock Market Returns

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Abstract. This paper deals with the regime switching behaviour of the selected European stock market returns measured by the DAX index, CAC40 index and STOXX600 index based on the Markov switching (MSW) framework. The paper utilizes the daily data from January, 2018 to January, 2023 and thus enables to capture the behaviour of stock markets during the tranquil as well as turbulent periods. The univariate MSW models were estimated supposing two regimes corresponding to bull and bear market phases characterized by higher returns with lower volatility and lower returns with higher volatility, respectively. The results confirmed the time-varying behaviour of stock returns and corresponding volatility for all analysed returns identifying the turbulent periods corresponding to the global economic slowdown in 2018, as well as to the Covid-19 outbreak in 2020 and to the outbreak of the war in Ukraine in 2022.

Keywords: Markov switching model, regimes, stock market returns

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Measuring and Analyzing the Technical Efficiency of Hockey Players

Lucie Chytilová[1], Jana Hančlová[2]

Abstract. Ice hockey is a trendy sport all over the world. Analysing the efficiency of hockey players is a valuable tool that helps sports managers with player selection, team composition and team performance evaluation. The literature offers only a limited number of scientific studies assessing the efficiency of hockey players or clubs. This research aims to help hockey clubs, managers, and coaches evaluate the efficiency of their players using data envelopment analysis and regression analysis. This research evaluates the technical performance of hockey players using DEA models, ranks the best players, tries to reveal the primary sources of player inefficiency, and uses regression to analyse the change of trend in hockey to evaluate better the future development of the efficiency of hockey players. The models are empirically applied to NHL players over several seasons to see the efficiency gains. The evaluation used in this paper attempts to incorporate greater objectivity into decision-making. It may be an essential step in developing a systematic methodology for evaluating hockey players in the future. However, the results of this first analysis are only visible in the realm of DEA and the possibility of assessing the effectiveness of hockey players. Further developments in regression have yet to identify specific areas of training opportunities.

Keywords: DEA, efficiency, hockey, method of least squares, regression

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Application of the Two-Stage DEA Model in SMEs Business

Lucie Chytilová[1], Hana Šverková[2]

Abstract. This study aims to investigate the efficiency of SMEs. First, we introduce a new two-stage DEA model for evaluating firm performance with multi-year variables to measure efficiency based on accounting data in model development. It is primarily concerned with the stable operation of enterprises. The process is divided into two sub-processes: efficiency of human capital (first stage) and efficiency of business (second stage). The outputs of the first stage are the inputs for the second stage. These variables are identified as stocks, investments and economic results of 2020. The external inputs (inputs of the first stage) are also variables from 2020, but the final outputs (outputs of the second stage) are from 2021, which can describe the natural processes in SMEs. The results divide businesses into efficient and inefficient (both overall and in individual phases). Based on these results, the relationships between human capital, business skills and performance are examined. The plan provides recommendations for better functioning and business support in the SME sector.

Keywords: DEA, two-stage, small and medium business

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Best-Worse Method: Comparison with Traditional Approaches

Josef Jablonský[1]

Abstract. Deriving weights of the set of criteria or deriving the priorities of the alternatives with respect to a criterion is an important task in solving multiple criteria decision making problems. Analytic Hierarchy/Network Process (AHP/ANP) is based on a construction of pair-wise comparison matrices (PCM) that contain the expression of preferences of decision makers (DMs). Prioritization methods derive priorities (weights of the criteria, priorities of the alternatives) from the PCM. The most common and popular methods are the eigenvector method, logarithmic least square method and least square method. One of the newer approaches how to derive priorities based on DMs preferences is the Best Worse Method (BWM). The aim of this study is to compare traditional approaches of deriving priorities and the BWM. A special attention is devoted to consistency issues of all considered methods. The illustrative example demonstrates the results of the study.

Keywords: Best-Worse Method, Analytic Hierarchy Process, pairwise comparisons, optimization

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Optimizing the Fleet of Transport Ambulances

Ľudmila Jánošíková[1], Peter Jankovič[2]

Abstract. The paper addresses the problem of designing an optimal fleet of transport ambulances. The analysis was ordered by Merea, a.s., which is the second biggest provider of medical transport services in Slovakia. The goal is to propose the number and the locations of the vehicles that could perform planned transports of patients among healthcare facilities. The vehicles are supposed to serve the patients distributed across the whole country. Today, planned transports are accomplished by emergency ambulances. The fully equipped emergency ambulances are necessary in critical cases when the patients need specialised medical care, but they are too expensive for the patients who are not in life-threatening conditions. If a doctor's assistance is not needed during the transport, then the transport can be done using a less equipped, and thus cheaper vehicle. The problem was formulated as a capacitated locations problem and solved using a general integer programming solver. The demand for the model was derived from historical data on planned transports including years 2019 to 2022. Since the mathematical programming model simplifies the reality a lot, we used a detailed computer simulation model to verify whether all required transports could be done with the calculated number and deployment of vehicles. We have found that at minimum 17 vehicles is needed to meet the demand but experiments with a higher number of vehicles were performed as well.

Keywords: ambulance fleet, discrete location, agent-based simulation

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Using Game Theory to Address Climate Change

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Abstract. The economic and financial consequences of climate change are currently a highly discussed topic. It is a global and complex issue, the clarification of which is of interest to many scientists from various disciplines. In our present paper, we focus on a methodology based on game theory, since we consider this scientific discipline as a less elaborated concept. Game theory seems to us to be a suitable tool for finding solutions, as its concept is based on decision making in an interactive world, seeking the optimal decision for a player that depends on the decision of another player. Our goal will be to formulate a game similar to the "Prisoner's Dilemma". The game will be formulated for Slovakia and the question will be asked whether Slovakia is more motivated to not engage or to engage in mitigation activities given the expected quantified gains.

Keywords: game theory, prisoner's dilemma, climate change

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Queueing Model for Reducing of Waiting Time at Airports

Martin Jasek [1], Ivana Olivkova [2]

Abstract. Reducing the time of the transport process is today a modern trend in all sectors of transport, including air transport. The aim of the work is to focus on the ground side of the air transport process, namely the possibility of reducing the transport time by reducing the waiting time at the airport. In addition to the duration of passenger check-in, we will also focus on calculating the costs incurred in this process. Probably the best method of mathematical modeling of this process is mass service models. The aim of this work is to design a system that would be functional for a various number of incoming passengers, where, depending on the number of passengers registered for the flight, a different number of lines would be used, as needed, so that the processing system would be suitable from both an economic and time (waiting) point of view.

Keywords: air transport, passenger check-in, queueing theory, mathematical modeling, economics, time efficiency

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Optimizing the Selection of a Portfolio of Transport Infrastructure Investment Projects Including Elements of Uncertainty Modeled Using Fuzzy Logic

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Abstract. Along with the development of the society, emphasis is placed on the modernization and development of quality transport infrastructure. Investing in infrastructure is implemented using investment projects, which are financed in the vast majority from public sources. The amount of the available budget is usually lower than the amount of funds needed to implement all the projects being prepared, and therefore it is necessary to select a portfolio of investment projects for implementation. During the selection process, indicators representing the quantified societal benefits resulting from the implementation of projects, as well as their financial demands and the available budget, are assessed. However, the selection is carried out in the initial phase of the preparation of investment projects, and due to the preparation period of several years, the implementation takes place in a few years. The development of the economic situation has been very turbulent and fluctuating in recent years, while the situation at the time of project implementation often does not correspond to the expected market development in the initial phase of project preparation. As a result, the amount of financial indicators and the estimated available budget at the time of implementation are significantly different than what was assumed during the selection. This can have a negative effect on the output of the optimization of the selection of the project portfolio from the point of view of fulfilling the overall societal benefit. The aim of the article is to present an approach to optimizing the selection of a portfolio of transport infrastructure investment projects for implementation, including elements of uncertainty in the area of the available budget and the estimated amount of funds needed to implement individual investment projects. Uncertainty is modeled using fuzzy logic, and the goal of optimization is to maximize the cumulative value of social benefits represented by monitored indicators.

Keywords: linear programming, fuzzy, transport infrastructure, optimization

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Threshold Values for Calculating the Efficiency of a Transport Company's Investment

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Abstract. The aim of the contribution is to determine the threshold values of the parameters of the evaluation of the efficiency of the investment project of a transport company using the methods of net present value and internal rate of return. The simulation of the railway transport project will be set for seasonal and year-round operation of the railway in the alternatives of a noninflationary discount rate, a discount rate corresponding to an increased rate of inflation and subsequently under the conditions of the current high rate of inflation. The effect of any subsidy from public funds on the threshold values of the project's effectiveness will also be considered.

Keywords: Threshold value, investment projects, transport company, rate of inflation

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Estimation of the General Measure of Stochastic Non-Dominance

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Abstract. This paper deals with the general measure of stochastic non-dominance, which was developed to understand the situations when stochastic dominance rules are broken. It can be derived analytically for some distributions. However, in the case of other distributions, such as the log-normal and gamma, it is useful to be able to estimate it. We do so by a numerical study, in which we approximate these distributions by discrete distributions with equiprobable atoms. This paper describes how the numerical study is designed, and presents the estimated measures of stochastic non-dominance between selected distributions.

Keywords: stochastic dominance, measure of stochastic non-dominance, approximation

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Bilevel Models in Portfolio Selection Problems

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Abstract. This paper deals with bilevel optimization problem in which we want to minimize transaction costs which are proportional and we want to have our portfolio mean-risk efficient. As a measure of risk we consider Conditional Value-at-Risk. The bilevel optimization problem is presented, reformulations of the problem according to the probability distribution are described as well. The goal of the paper is to present reduction of bilevel optimization problem to a single level optimization problem and to show equivalence between these two types of reduction.

Keywords: bilevel optimization, portfolio optimization, Conditional Value-at-Risk

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Ambiguity in Stochastic Optimization Problems with Nonlinear Dependence on a Probability Measure via Wasserstein Metric

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Abstract. Many economic and financial applications lead to deterministic optimization problems depending on a probability measure. It happens very often (in applications) that these problems have to be solved on the data base. Point estimates of an optimal value and estimates of an optimal solutions set can be obtained by this approach. A consistency, a rate of convergence and normal properties, of these estimates, have been discussed (many times) not only under assumptions of independent data corresponding to the distributions with light tails, but also for weak dependent data and the distributions with heavy tails. However, it is also possible to estimate (on the data base) a confidence intervals and bounds for the optimal value and the optimal solutions. To analyze this approach we focus on a special case of static problems depending nonlinearly on the probability measure. Stability results based on the Wasserstein metric and the Valander approach will be employed for the above mentioned analysis.

Keywords: Stochastic optimization problems, static problems, empirical measure, point estimates, interval estimates, nonlinear dependence

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Heterogeneous Effects of Financial Uncertainty: Evidence from Global Financial Crisis

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Abstract. We measure financial uncertainty employing textual analysis of newspaper articles in the period from 1985 to 2017. We show boosted effects of financial uncertainty shocks on the economic activity after the financial crisis. However, we identify lower negative effects of financial uncertainty on the interest rates after the crisis period. In addition, we provide analysis of financial uncertainty effects on several finan- cial indicators and confirm negative effects of financial uncertainty on house prices after the financial crisis and positive effects on several spreads before the crisis periods.

Keywords: financial market, uncertainty, news media, global financial crisis

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Filtering Methods for Output Gap Estimation and the Empirical Taylor Curve: A Comparative Study

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Abstract. The empirical Taylor curve relationship between the variances of inflation and the output gap has been studied and utilized in macroeconomic policy analysis. However, the majority of existing research relies heavily on the Hodrick-Prescott filter to estimate the output gap, which may in some cases lead to biased results. This study critically examines the sensitivity of the empirical Taylor curve related to the choice of filtration technique for output gap estimation. Three alternative filtering methods are used in this analysis to highlight potential discrepancies in the resulting relationship: The Hodrick-Prescott filter, the Christiano-Fitzgerald filter and Beveridge-Nelson decomposition. These findings indicate that the choice of filtration technique significantly influences the estimated Taylor curve relationship. Consequently, this affects the evaluation of monetary policy in certain periods, calling for a more cautious approach when choosing the appropriate filtering methods for output gap estimation.

Keywords: monetary policy, output gap, Taylor curve

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Sportka - "Better" Strategies Based on Analyses of Specific Number Combinations?

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Abstract. Lotteries are still very popular in our country despite (or perhaps because of) the unfavourable economic situation. That is why many people are still trying to find a way how to get better results in lotteries. In this paper, we will focus on the Sportka lottery. More precisely, we will discuss a model proposed by Tautermann. His model is based on statistics of different types of combinations and uses long-term historical data, and the author believes that his model ensures better results than a random bet.

Keywords: Lottery, theoretical distribution

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Facility Layout Problem with Heterogeneous Material Handling System Constraints

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Abstract. Manufacturing system design and production planning are among the most influential aspects of minimizing production expenses. Efficient arrangement of workshops and path planning influences the total cost of the material handling system and can reduce production lead time.

The focus of this article is to reflect the area demand of not only workshop space but also of the material handling system. That includes space which is occupied by logistic areas next to workshop entrances and space occupied by logistics aisles.

The model of this system includes the limitation of total facility space where unequal rectangular workshops have to be placed in the open field arrangement. Facility and workshops with defined access points are connected by a material handling system with an unequal size of the exits, entrances, and aisles widths. Aisled widths are based on real-world constraints, including current Czech laws and dimension demands of manipulation tools.

A constructive algorithm with dispatching rules is designed to create a facility layout. The algorithm is tested on designed problem instance. The objective is to optimize multiple criteria such as material handling costs, accessibility maintenance costs, the shape of the utilized area etc.

Keywords: Facility Layout Problem, Open Field Layout, heterogeneous aisles, material handling system

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Estimation Procedure for Complex Model with Spatial and Temporal Features

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Abstract. The relations between macroeconomic variables distributed over time and space could be very complex. Therefore, when performing empirical analysis, it is important to take into account as many assumed features of the examined variables as possible. This article introduces dynamic panel regression model that account for numerous features that one could expect within modelled relationships and provides estimation procedure to obtain consistent estimation of corresponding parameters. This complex model allows for modeling spatial and temporal dynamics, as well as spatially heterogeneous responses while using endogenous regressors in one framework.

Keywords: linear panel model, spatial and temporal dynamics, spatial heterogeneity, random response parameters, endogenous regressors

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Decision Making in Finance via Stochastic Dominance

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Abstract. Stochastic dominance is a statistical tool developed for comparing the random variables among each other. In financial applications, these random variables represents random returns of the considered assets or portfolios. The paper focuses on portfolio selection problems with stochastic dominance constraints for various orders of stochastic dominance relations. Firstly, the tractable necessary and sufficient conditions for particular probability distributions are discussed. Secondly, these conditions are employed in the portfolio selection problems. Finally, the extensions for the case of endogenous randomness are presented. The theoretical results are accompanied by numerical examples.

Keywords: portfolio selection,stochastic dominance,endogenous randomness

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Determining the Optimal Location of the Logistics Center in the Presence of Limiting Conditions

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Abstract. The problem of the optimal location of a logistics center that is supposed to supply, for example, shops is often solved in logistics. Optimum location is important for saving transport costs. The problem is, however, in the existence of limiting conditions that generate areas where a logistics center cannot be built.

This article describes a mathematical model that is able to solve this problem and interpret the results graphically. The sum of transportation costs is an objective function, the mathematical model calculates the coordinates of the logistics center so that the value of the objective function is minimal. The existence of restricted areas creates restrictive conditions that are part of this model. Restricted areas can be defined using various mathematical shapes (circle, ellipse, rectangle, etc.). From a mathematical point of view, this situation is a deployment problem, but modified by restricted areas. And to solve the problem defined in this way, limiting conditions in the form of implication were used. If the x-coordinate of the logistics center lies in a restricted area, the value of the y-coordinate must be such that the logistics center is located outside the restricted area. For example when the restricted area has an ellipse shape the constraint condition for the y coordinate must work with the equation of the ellipse. Of course, this problem does not arise only when building a logistics center, but in every situation where it is necessary to determine the correct position of a central point that is inserted into a set of points. And there are links between the points and the central point. Finding the optimal location to place: a new machine in a factory, a waste dump, a grain silo, etc.

Keywords: mathematical model, limiting conditions, modified deployment problem

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Development of the Efficiency of the Czech Automotive Industry

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Abstract. The automotive industry is an integral part of every European economy. In the Czech Republic, this sector is one of the most important industrial sectors. This article deals with an evaluation of production efficiency of the Czech automotive industry with regard to the size of the enterprises. For the purpose of evaluating efficiency, this article used the method of data envelopment analysis. Calculations are based on accounting data of individual enterprises with available data for the period between 2010 and 2019. Radial input-oriented BCC models are constructed separately for individual years. Efficiency is derived based on the amount of capital and the cost of employees in contrast to total amount of sales and the profit and loss statement in individual years. In addition, the Malmquist index was used to calculate changes in efficiency over time. The results of our analysis show that differentiating efficiency results with respect to the size of the enterprise makes sense, as especially small enterprises differ considerably in their results.

Keywords: Czech Republic, data envelopment analysis, efficiency, automotive industry

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Analysis of the Demand for Local Food in the Czech Republic by Applying the Theory of Planned Behavior

Petra Králová [1], Jana Krajčová [2]

Abstract. This paper aims to explore the motivations to buy locally farmed food. We used the tools from the Theory of Planned Behavior to identify the inherent factors that drive consumer choices. We focused on Gen Z, as this can provide important insights on a specific and important customer segment. The motivations for buying locally farmed food vary, in general and across generations. Some believe that locally farmed food is healthier because it contains fewer chemicals, others stress that it is closely linked to the natural environment and its biochemical composition. Some consumers are socially responsible and they want to support their community and the local farmers or reduce their carbon footprint. For younger generations, buying behavior is also part of the lifestyle, their personality and uniqueness. We conducted a survey of 232 Generation Z young adults above the age of 17, to inquire about their motivations and preferences to buy locally farmed food. Our questionnaire and the general methodology based on theory of planned behavior extended with the variable "uniqueness-seeking lifestyle" follows the approach of Ham [18], but focuses on locally farmed food and the Czech market in particular. We conducted the exploratory factor analysis, in order to identify which responses correlate the most with respondents' latent motivations to buy locally farmed food. Preliminary findings confirm intuitive expectations and help us link responses to individual questions to latent constructs of behavioral beliefs, attitudes, subjective norms, perceived behavioral control, uniqueness seeking lifestyle and commitment. Understanding the motivations for buying locally farmed food can help us design more successful marketing strategies which will not only help to support local farmers but also the local environment and the overall sustainability.

Keywords: locally farmed food, theory of planned behavior, Gen Z

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Econometric Aspects of Elasticity of Substitution

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Abstract. This paper reviews the current knowledge on the concept of elasticity of substitution in economic analysis and explores its econometric applications. The elasticity of substitution is a vital tool in microeconomics for determining the substitutability of products. Unlike cross-price elasticities, which require adjustments for endogeneity, the elasticity of substitution can be analyzed directly using market optimum data. Additionally, the elasticity of substitution provides information on the degree of substitutability. However, the use of elasticity of substitution is not without limitations, such as the occurrence of perfect substitutes in data or nonlinear pricing. This paper offers solutions for these issues and outlines the key assumptions necessary for correct usage of the estimator for elasticity of substitution.

Keywords: Elasticity of substitution, Estimator, Market optimum data, Nonlinear pricing

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Towards an Alternative Generalization of CES Function

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Abstract. This paper explores ways to improve the usefulness of the Constant Elasticity of Substitution (CES) function in microeconomics. Although the concept of elasticity of substitution is a valuable tool for identifying substitutes and complements, the limitations of standard CES function, such as attributing the same elasticity of substitution to each pair of goods, have hindered its effectiveness. To address this issue, this article reviews previous research on the generalization of CES function. It examines the Nested CES function, representing the best possible generalization of CES function, and its implications for analyzing relationships between distinct product pairs. Subsequently, the paper proposes a newfunction, the Almost Constant Elasticity of Substitution (ACES) function, as another potential instrument for such analysis, and demonstrates its possible impact on the analysis of cross-price elasticity.

Keywords: CES function, Elasticity of substitution, Generalization, Nested CES function, Cross-price elasticity

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Energy Consumption and Economic Growth in the Czech Republic and Slovakia

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Abstract. Energy consumption and economic growth are interconnected, and the relationship between them is complex and dependent on various factors. Key aspects of this relationship include: energy consumption as a driver of economic growth; technological progress and efficiency; structural changes in the economy; policies and regulations. This article examines the long-term relationship between energy consumption and real GDP for the Czech Republic and Slovakia from 2005 to 2022. Many studies have explored the linkages between energy consumption, economic growth, and energy efficiency. The aim of this contribution is to contribute to this topic by analyzing the Granger causality between the indicators. This paper focuses on the predictive power (Granger causality) rather than estimating the true causal relationship of the VAR/VECM model. The results for both countries indicate that energy consumption Granger-causes GDP. This means that energy-saving policies may slow down the pace of GDP growth. These findings are based on the analysis of Eurostat data from 2005 to 2022 for the Czech Republic and Slovakia, using the statistical software EViews 11 for calculations.

Keywords: ADF test, energy, GDP, Granger causality, VEC model

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Efficiency Analysis of Building Material Producers in the Czech Republic

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Abstract. The construction industry is one of the key sectors of the Czech economy and is often considered as an important indicator of economic development. It is a sector that is very sensitive to the economic cycle, but usually reacts with a delay to significant fluctuations in the cycle. Demand for construction work and building materials is influenced by the situation on the labour market and the development of household disposable incomes or interest rates for housing finance, as well as by the price of building land. The supply of construction materials is mainly influenced by the production capacity of firms, the prices of construction materials and works, or expected market regulations. The situation in the building materials market has not received much attention in the available literature. Therefore, in this paper, we focus on the largest producers of building materials in the Czech Republic and the development of the efficiency of these firms in the year 2018 based on 2 data sources and using DEA models. The aim is to analyse the efficiency of companies in the given year and to examine whether large and established companies performed better than small and medium-sized companies. At the same time, the aim is to see if we obtain similar results using different economic data from 2 different sources. DEA models with 3 inputs 1 output, resp. 1 input and 3 outputs, used on 2 sets of data showed that large companies are more efficient than small and medium companies in this sector.

Keywords: construction industry, building materials production, DEA models

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Self-learning Metaheuristics for Pareto Front Approximation

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Abstract. This paper reports recent research and development in the field of specific location problems, in which two contradictory objectives need to be minimized. Considering two conflicting criteria in the mathematical model leads to the necessity of constructing a special subset of feasible solutions called a Pareto front. Each pair of its elements must hold the non-dominance property. Since obtaining the complete Pareto front proved to be computationally difficult, the experts' attention has been paid to the development of various approximate approaches including metaheuristics and hyperheuristics. The content of this paper focuses on a family of self-learning metaheuristics based on minimization of an area determined by a set of non-dominated solutions for approximation of the Pareto front of bi-criteria location problems.

Keywords: Discrete location problems, conflicting criteria, Pareto front approximation methods, metaheuristics

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Socioeconomic Determinants of Electric Vehicle Adoption in Czechia

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Abstract. In an effort to reduce transportation-related CO_2 emissions to levels below those of 1990, the European Union and the Czech Republic are prioritizing the transition from internal combustion engines to battery-operated and hybrid propulsion vehicles. This study examines Czech vehicle registration data in the retail sector from 2019 to 2022, utilizing a stepwise linear regression approach to develop a model that explains the rate of electric vehicle adoption based on 37 socioeconomic predictors across 206 Czech administrative regions. The resulting model identifies five significant predictors, demonstrates a robust goodness of fit, and effectively mitigates the spatial autocorrelation initially observed in the data.

Keywords: Battery electric vehicles, Hybrid vehicles, Technology adoption and diffusion, Czechia

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Distributionally Robust Fixed Interval Scheduling with Heterogeneous Machines under Uncertain Finishing Times

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Abstract. We deal with operational fixed interval scheduling problems where start times are given and the actual finishing times can be influenced by random delays. We further consider heterogeneous case, i.e., multiple job and machine types. And we assume that the multivariate distribution of delays follows an Archimedean copula. We consider the highest worst-case probability that the schedule remains feasible, where given proportion of marginal distributions of delays are stressed. This problem has a reformulation containing a commonly used risk measure. We implement a decomposition algorithm and compare it with MIP solver.

Keywords: Stochastic optimization, Fixed interval scheduling, Heterogeneous machines, Risk measures

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Analysis of Commercial Property Prices on the Czech Market

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Abstract. The development of the commercial real estate market plays an important role in the financial stability of the country, especially through the level of credit of companies operating in this area. This article analyses the price development of the Commercial Real Estate Capital Value Index (CRECVI) in the Czech market along with selected economic macro aggregates. Specifically, the market for production and storage facilities was analysed.

Within the framework of the cointegration analysis, an ADL model is constructed to describe how prices of the production and storage facilities react to changes in selected macroeconomic indicators. From the ADL model, an error correction model is then obtained by recalculation, which separately describes the short-run and long-run relationships between the time series. The results of the analysis show that the prices of warehouse properties are mainly influenced by the evolution of gross domestic product, unemployment and the level of inflation and interest rates.

Keywords: cointegration analysis, CRECVI index, ADL model, commercial real estate, EC model

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System Dynamics Modelling Scenarios for Economic-ecological System of the Aral Sea

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Abstract. The paper is dedicated to the implementation of System Dynamics modelling in the domain of the Shrinking Aral Sea's catastrophe. The problem of irrational Water Management in the agricultural sector and its adverse impact on the environment in the Republic of Uzbekistan is modelled by means of System Dynamics techniques. In the framework of stated problem, the Stock and Flow diagram is constructed in order to outline the causality between demographical structure, overwhelming water usage in agroeconomic activities and its influences on environmental subsystems such as immersive diminishment of the Aral Sea's water volume as well as degradation of its water quality from the standpoint of its salinity.

In the paper the model construction is defined, subsequently, model and its parameters are validated. Furthermore, the paper includes the baseline as well as what-if scenarios of the key variables, namely, the volume of water flowing to the Aral Sea, the volume of the Aral Sea and its salinity.

Keywords: Aral Sea, Computer simulation, System Dynamics, Water Management, scenarios

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Income Effects of a Liberal Migration Policy

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Abstract. This study investigates the income effects of a relaxed migration policy, which increases quotas for skilled and unskilled workers by 5%. Using data from the Global Trade Analysis Project database 10 and an experimental design modified from Walmsley et al. (2007), we examine the impact of migration on 21 regions, including labor importing and exporting countries, with a focus on Slovakia and Germany.

Our analysis considers the real income changes for residents, native migrants, and new migrants. We also conduct a welfare analysis to assess the effects on allocative efficiency, endowments, technology, commodity terms-of-trade, investment-savings terms-of-trade, changes in preferences, and the effects of remittances. Our findings suggest that the real income of residents in labor importing countries will increase due to both skilled and unskilled labor migration, while the impact on residents in labor exporting countries is ambiguous. We observe a regressive impact on native migrants in most regions of exporting countries, as well as in importing countries, except for unskilled migrants in Canada and Japan, and both unskilled and skilled migrants in the United States.

Overall, this study highlights the income effects of a liberal migration policy and provides insights into its implications for different groups in both importing and exporting countries.

Keywords: migration, income, skilled and unskilled labor, native migrants, residents

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Strong Robustness of Convex and Concave Monge Matrices in Max-min Algebra

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Abstract. Strong robustness of both convex and concave Monge matrices over max-min algebra is studied. Strong robustness of a matrix is connected with the greatest solution of the eigenproblem, i.e. the greatest eigenvector corresponding to the matrix. In this paper important properties of threshold digraphs of convex and concave Monge matrices in regard to matrix strong robustness are pointed out. Equivalent conditions for period equal to one of a strongly connected threshold digraph for a convex Monge matrix are presented. The period of a strongly connected threshold digraph for a concave Monge matrix is shown to be equal one. Moreover, the strong connectivity can be verified effectively by checking the existence of cycles of every pair of consecutive nodes. Necessary and sufficient conditions for convex Monge matrix and concave Monge matrix to be strongly robust were proved. Using obtained results effective algorithms for checking strong robustness in both cases are described.

Keywords: max-min algebra, convex Monge matrix, concave Monge matrix, strong robustness

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On the von Neumann Regularity of Max-min Matrices

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Abstract. The 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, 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. Many practical situations can be described using max-min matrix equations. Several properties of matrices in max-min algebra have been studied. One of them is von Neumann regularity, which means that there is a matrix X such that $A \otimes X \otimes A = A$.

Keywords: max-min algebra, interval matrix, von Neumann regularity, von Neumann X-regularity

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Effect of Factor Numbers in the Approximation of Returns on Portfolio Performance

David Neděla[1]

Abstract. Many strategies for setting the number of factors even simple or advanced have been implemented in a returns approximation process. Thus, in this contribution, the objective of this contribution is to analyse the effect of two simple strategies for determining an appropriate number of factors obtained from the principal component analysis (PCA) on the performance of the portfolio. Moreover, we also analyse the impact of the application of several dependency matrices to PCA. To approximate the return series, this study employs a nonparametric regression model based on conditional expectations and kernel estimator. The effect on the constructed portfolio is shown employing a portfolio model that maximizes the Sharpe ratio. Furthermore, different time periods of US stock market data are considered.

Keywords: multifactor analysis, nonparametric regression, performance measuring, principal component analysis

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Parameter Optimization of Trend Detection Algorithm Presented on Selected Stock Prices

Jakub Neugebauer[1]

Abstract. Trend analysis and prediction of stock prices have always been key parts of investment strategy decision-making. Many methods to support this analysis have been purposed from basic ones like technical analysis to more complex ones like machine learning methods, which have been lately on the rise in many econometric fields including time series prediction. The method of time series trend analysis used in this paper is based on community detection of a network created from sets of statistics describing trends at a certain time. The goal of this paper is to set up parameters of the already proposed trend detection algorithm in order to maximize the precision of trend detection. The function to maximize used in this paper is a total return from investments if a stock has always been bought at the uptrend beginning and sold (shorted) at the start of the downtrend. The behavior of the trend detection algorithm under its different parameters is shown on real data of selected stocks from S&P 500. Further inspection of algorithm predictive ability is shown on these data as well. The outcome of this paper is a method that finds optimal parameters of the trend detection algorithm and even further improves its precision.

Keywords: stock price prediction, trend detection, parameter optimization

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Models of Military Expenditures

Jakub Odehnal[1], Lenka Brizgalová[2], Jiří Neubauer[3], Lucie Svobodová[4]

Abstract. The aim of the article is to present the possible use of the Autoregressive Distributed Lag model to identify military expenditures determinants and to verify the model's ability to make short-term predictions of military expenditures of selected Baltic countries. In order to analyse economic environment as determinant of military expenditures, the following variables were used: budget balance as percentage of gross domestic product, foreign debt as percentage of gross domestic product, inflation, the state of the economy measured by gross domestic product. The results do not reveal uniformity of economic determinants among the Baltic countries, but confirm the positive effect of gross domestic product on military expenditure in case of Latvia and Estonia. The positive effect between military spending and inflation is confirmed for Lithuania. In case of Lithuania, Latvia and Estonia, the expected positive link is found between military expenditures and the levels of fiscal deficit or external debt. Generally, we can conclude that the economic environment is one of the main factors influencing military expenditures; however, at present, military expenditures are mainly driven by the change in perception of security threats in Europe.

Keywords: ARDL model, Economic Determinants, Military Expenditures

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Investment Portfolio Selection from Shares of Environmental Companies

Juraj Pekár[1], Ivan Brezina[2], Marian Reiff[3]

Abstract. The paper presents the possible use of the portfolio selection optimization model based on the CVaR risk measure when investing in environmental companies. The most important factors in investing are taking risk and return rates into account. Currently, investing in environmental funds is a popular tool. When creating a portfolio, it is possible to make an investment by choosing an investment strategy provided by a financial institution, but it is also possible to create own portfolio. In the contribution, we point out the possible use of the portfolio selection model based on the CVaR risk rate when creating own composition of assets. In the paper, we consider investing in the largest environmental companies selected by Value. Today analytics company.

Keywords: return, CVaR, environmental investment

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Application of CCR and SBM Models in Measuring the Efficiency of IT Clusters in the Czech Republic and Slovakia

Natalie Pelloneová[1], Vladimíra Hovorková Valentová[2]

Abstract. This paper analyses the technical efficiency of members of two cluster organizations operating in the Czech Republic and Slovakia. There are many methods of measuring the efficiency of companies. This paper focuses on the Charnes, Cooper, Rhodes, and Slack Based Measure models, comparing the efficiency analysis results calculated by the two aforementioned methods. The presented research examines four research samples consisting of member companies in the IT Cluster and Košice IT Valley in 2013 and 2020. Both clusters were created as a result of a cluster initiative and brought together companies from the ITC sector. The firms that form the core of the above-mentioned clusters are active in sectors with the following statistical classifications: NACE 620100, 620200, and 620900. This paper compares the results obtained using both methods.

Keywords: IT sector, cluster organization, data envelopment analysis, CCR model, Slack Based Measure

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Strong Generalized Eigenvector of Fuzzy EA-Interval Matrices

Ján Plavka[1]

Abstract. GGeneralized eigenproblems in a fuzzy algebra (for given matrices A, B find a vector x and a constant c such that Ax=cBx, where the standard pair of operations, plus and times, have been replaced by the operations maximum and minimum) play important role in practical problems related to scheduling optimization, modeling of fuzzy discrete event dynamic systems and fuzzy analysis. Steady state of synchronization discrete event dynamic system can be characterized by a solution of a generalized eigenproblem. In practice, the entries of matrices and vectors are considered as inexact data (intervals). An interval vector intX is said to be a strong eigenvector of square interval matrices intA, intB if Ax=cBx holds for each x in intX, A in intA, B in intB and for some constant c. We suppose that an interval matrix intA can be split into two subsets according to forall exists quantification of its interval entries (EA-interval matrix). The properties of strong generalized eigenvector of EA-interval matrices are studied and characterizations of equivalent conditions are presented. As a consequence of the obtained results, efficient algorithm for checking obtained equivalent conditions is introduced.

Keywords: matrix, interval, eigenvector

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A Bargaining Theory Application in a Coordinated Closed Loop Supply Chain

Petr Pokorny[1]

Abstract. In this paper we present a Closed Loop Supply Chain (CLSC) model where a retailer sells products manufactured by a manufacturer. The products can be returned like returnable packaging (either disposable or reusable) used in the beverage industry. Both CLSCs can choose to work together through a revenue-sharing contract to improve their profits. The contract, once signed, sets limits on the revenue share within which the members can negotiate. It is assumed that the market with returns is growing, which provides a further scope for bargaining. We show that the share of revenue that the retailer can retain is smaller when both members want to cooperate, when the manufacturer is the leader, but the retailer is able to negotiate slightly better terms for its share of surplus profit as the returns market grows.

Keywords: Closed-Loop Supply Chain, Bargaining Theory, Game Theory, Nash Equilibrium, Revenue Sharing

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Testing Structural Breaks in Large Dynamic Model

Zuzana Prášková[1]

Abstract. A linear dynamic panel data model with cross-sectional dependence is considered. A procedure to detect changes in coefficients of lagged variables is proposed and asymptotic distribution of the test statistic is studied in case that both the number of panels and number of observations are infinitely large. Bootstrap variants of the test statistic are considered that take into account both the temporal and the cross-sectional dependences and the asymptotic and bootstrap critical values are compared.

Keywords: panel data,changes detection,bootstrap

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Computational Eperiments with a Special Case of Quadratic Maximization over an Interval Box

Miroslav Rada [1]

Abstract. We deal with the following special case of box-constrained maximization of convex quadratic function: We consider classical linear regression. We are given a (crisp) matrix of observations of regressors, however, observations of regressands are uncertain and we are given only an interval for each observation. Our goal, considering Ordinary Least Squares (OLS) estimates, is to find the maximal Residual Sum of Squares (RSS) over the interval-valued regressand.

RSS is a convex function of the regressand and its maximization over the interval box of regressands is known to be an NP-hard problem. The NP-hardness holds true even for the special case of "one-dimensional regression" where the regression is fitted by a constant only. In this case, the problem can actually be interpreted as "maximize sample variance over an interval valued dataset". This special case of the worst-case variance is widely studied in literature. Several algorithms exploiting the special structure of the underlying quadratic form were proposed.

In this talk, we take one of them and show how it can be generalized such that it is able to handle maximization of RSS in a regression with an arbitrary number of parameters. Then, we compare its computational performance with state-of-the-art solvers. Finally, we demonstate the behaviour of the algorithm on random input data – it turns out that it is likely that there is a probabilistic setup under which the algorithm works in polynomial time on average, similarly as it was recently proved for the one-dimensional case.

Keywords: quadratic programming, robust optimization, arrangements of hyperplanes

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Calculating Desirable Properties In MCDM

Jaroslav Ramík[1]

Abstract. Pairwise comparisons matrices (PCMs) are inevitable tools in some important multiple criteria decision making methods, e.g. AHP, TOPSIS, PROMETHEE and others. In this paper we investigate some important properties of PCMs which influence the generated priority vectors for final ranking the given alternatives. The novelty of our approach is that the priority vector is calculated as the solution of an optimization problem where an error objective function is minimized subject to constraints given by the desirable properties. The properties of the optimal solution are discussed and some illustrating examples are presented.

Keywords: multi-criteria decision making (MCDM), pairwise comparison matrix, consistency, coherence, priority vector

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Unveiling the Myth: Investigating the Existence of Hot Hands in Gaming

Jan Rejthar[1]

Abstract. This paper addresses persistent issues in the literature surrounding the Hot Hand phenomenon, which has attracted research attention in sports, betting, and investing for decades. The study utilizes data from players of KovaaK's aim trainer as a unique approach to overcome limitations faced by the existing literature. Rigorous Monte Carlo permutation tests are conducted on the data, controlling for family-wise error rate (FWER) and setting a false discovery rate (FDR), to investigate the existence of the Hot Hand. Surprisingly, the results indicate no evidence to support the notion of a Hot Hand in the KovaaK's data. The study concludes that gamers' hands do not possess the mythical Hot Hand ability.

Keywords: Hot Hand, permutation tests, gaming, KovaaK's

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The Impact of the COVID-19 Pandemic in the Brewing Industry with Regard to Profitability, Cost and Production Efficiency

Jana Sekničková[1], Martina Kuncová[2]

Abstract. A large number of economic subjects in the Czech Republic are firms operating in the manufacturing industry. Most of these firms transform inputs such as labour, capital and raw materials into outputs such as products. Most of these firms then evaluate the efficiency of their operations in their annual report. The efficiency analysis of a firm or its branches is usually carried out using ratio indicators. However, modern approaches allow the use of more sophisticated tools for analysis, such as data envelopment analysis (DEA) models, which allow firms to be evaluated more comprehensively and to include a greater variety of inputs and outputs without having to explicitly specify the relationships between them.. Brewing companies have been evaluating their efficiency in the same way for many years. However, the COVID-19 pandemic has had a significant impact on the foodservice sector as a whole, significantly affecting not only firms' profits but also consumption and, consequently, beer production. A lot of companies have been forced out of business by the pandemic. This paper focuses on the evaluation of firms in the brewing sector with respect to profit, cost and production efficiency and examines the impact of the COVID-19 pandemic in the Czech Republic on the whole brewing sector in order to analyze the main sources of inefficiency. The results of the DEA models used showed that of the 124 breweries studied, only 2 were efficient in all 3 perspectives (profit, cost and production efficiency) and furthermore the hypothesis that profit efficient firms are also production and cost efficient was not confirmed in the sector.

Keywords: DEA model, brewing industry, profitability, production efficiency

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Nowcasting Unemployment Using Mixed Data Sampling and Google Trends Data

Tereza Singerová[1], Lukáš Frýd[2]

Abstract. Forecasting macroeconomic variables commonly encounters the problem that data describing the current state are available with a significant, sometimes annual, lag. One possible solution is to use data from Google Trends for nowcasting the current values of macroeconomic variables. However, Google Trends data is available at a different, usually higher, frequency than macroeconomic data. To avoid losing potentially useful information in the formof aggregating these data, MIDAS regression can be used to link data with different frequencies. Using the Czech Republic's unemployment as an example, we show the higher predictive power of the combination of Google Trends and MIDAS regression compared to the traditionally used ARIMA and ARIMAX models.

Keywords: Google Trends, MIDAS, Nowcasting, Unemployment

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Average Reward Optimality in Semi-Markov Decision Processes with Costly Interventions

Karel Sladký[1]

Abstract. In this note we consider semi-Markov reward decision processes evolving on finite state spaces. We focus attention on average reward models, i.e. we establish explicit formulas for the growth rate of the total expected reward. In contrast to the standard models we assume that the decision maker can also change the running process by some (costly) intervention. Recall that the result for optimality criteria for the classical Markov decision chains in discrete- and continuous-time setting turn out to be a very specific case of the considered model. The aim is to formulate optimality conditions for semi-Markov models with intervention and present algorithmic procedures for finding optimal solutions.

Keywords: controlled semi-Markov reward processes, long run optimality, intervention of the decision maker

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Priority Single-Server Queuing System with Optional Second Server Activated upon Request – Simulation Study

Rostislav Stryk[1], Abate Getaw Sewagegn[2], Petr Jaluvka[3], Michal Dorda[4]

Abstract. Queueing systems with priorities can often be met in practice - e.g. in healthcare or transport. These systems are specific in that there are at least two classes of customers, while priorities are defined for individual classes of customers, according to which customers are served - the priority can be non-preemptive (higher priority customers do not interrupt the service of a lower priority customer) or preemptive-resume (higher priority customers interrupt the service of a lower priority customer). In this paper, we focus on a queueing system with three classes of customers, where the first class has the highest priority and the last third class has the lowest priority. By default, individual customers entering the system are served by single server. However, if a situation arises where the queue length of non-priority customers exceeds a certain defined threshold, it is possible to activate a second parallel server, which helps with serving the lower priority customers. The article describes the simulation model of this queueing system and, based on the experiments carried out, recommendations for the activation of the second server are defined.

Keywords: priority queue, optional server, simulation, colored Petri nets, air traffic control

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Estimation of the Elasticity of Input Substitution in European Regions

Karol Szomolányi[1], Martin Lukáčik[2], Adriana Lukáčiková[3]

Abstract. The paper estimates the elasticity of input substitution in different European regions. European regional data is used for estimation. The chosen procedure focuses on estimating the econometric specification of labor demand. A frequency filter filters the time series in the econometric specification to adjust the relationship from other systematic economic processes. The short-term estimate is obtained by differentiating the variables of specification. The elasticity of substitution is estimated at the regional level as well as at the aggregate level. The research paper also estimates the aggregate elasticity of substitution according to regional growth rate and regional development level measured by real PPP GDP per person. The estimated elasticity of substitution varies in different countries, but in most cases, it is less than one, contrary to the Cobb-Douglas production function form. In aggregate, the estimate of the elasticity of substitution is about 0.6. A region's economic growth and development level have no impact on the estimated value of the elasticity of substitution. This result suggests that the European regions had a similar steady state during the studied period.

Keywords: elasticity of substitution, European regions, frequency filter, labor demand

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Performance Comparison of Industry Clusters: Canonical Correlation Analysis vs Data Envelopment Analysis

Eva Štichhauerová[1], Miroslav Žižka[2]

Abstract. The paper evaluates the performance of companies in two industries - automotive and textile in 2019 and 2020 concerning their membership in a cluster organisation. The surveyed firms in both sectors were divided into three groups. The first group included member companies of the cluster organisation. Their performance is expected to be higher than the other two groups due to their direct involvement in cluster activities. The second group includes companies operating in the cluster's region. In this case, it can be assumed that these firms could benefit from the positive externalities of the existing cluster organisation. Their performance could thus be better than that of the third group of companies operating in other regions already too far from the cluster. Two alternative methods, Data Envelopment Window Analysis and Canonical Correlation Analysis, were used to assess the performance of the companies. Both tools can handle more inputs and outputs, but they work differently. This paper compares the results obtained using both methods and discusses their advantages and disadvantages.

Keywords: Canonical correlation analysis, Data envelopment analysis, Window analysis, technical efficiency, cluster organisation

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Relationship between ESG Disclosure and Financial Ratios

Kristina Šutiene [1], Daniele Bielskyte [2], Lina Dagiliene [3], Raminta Vaitiekuniene [4]

Abstract. Nowadays more and more attention is paid to not only the financial indicators of companies, but also to voluntarily provided information on corporate social responsibility, which can be generally measured by environmental, social and governance (ESG) disclosure indicators. However, not all companies are still inclined to invest in ESG activities or their disclosure, as they believe that this does not bring the benefit, but, on the contrary, can have a negative impact on their financial indicators. This debate, what is the relationship between ESG disclosure and financial performance, is also noticeable in the scientific literature, and there is still no consensus. More specifically, the studies distinguish between three views on the relationship, i.e. a positive connection, a negative connection, or there is no connection between ESG disclosure and financial indicators. This study particularly investigates ESG disclosure and financial performance relationship in the domain of food and beverage industry of Europe's biggest companies. This sector has been chosen because it is one of the largest sectors and is closely linked to ESG problems in the world. By means of statistical analysis and artificial intelligence methods, we investigate the relationship between ESG disclosure and financial ratios, with the aim to determine which financial ratios have the greatest impact on ESG scores. The obtained results showed that it can be a stimulus for companies to invest in ESG activities, since ESG indicators do not have a negative impact on financial indicators and can even have a positive impact. This project has received funding from the Research Council of Lithuania (LMTLT),agreement No S-PD-22-23.

Keywords: ESG,financial ratios,artificial intelligence,manufacturing companies

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Czech Republic in the Euro Area: A Two-Country DSGE Model

Patrik Šváb[1]

Abstract. This paper examines the interaction of the Czech economy (CR) and its Euro Area (EA) counterpart and the potential impacts of the monetary union entry on the Czech economy. For that purpose, I derive and calibrate a two-country DSGE model, as a merge of two basic open-economy New Keynesian models with price rigidities, supposing that the CR as a small economy is dependent on the EA, but not vice-versa. The model provides a basic tool for an impulse-response analysis with various types of shocks, originating in both economies, including the EA-CR spillovers. In the second model setup, with a potential adoption of the common currency, the results of the analysis show that without an independent monetary policy, domestic inflation would become significantly more volatile, whereas the variation in the output gap does not change. Considering a conventional intertemporal loss function, the adoption of the euro would be welfare-decreasing according to the model.

Keywords: Czech Republic, Euro Area, Two-Country DSGE

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Underwriting and Investment Efficiency in the Czech Life Insurance Sector: A Two-stage DEA Window Analysis Approach

Petra Tisová[1], Martin Flegl[2]

Abstract. Regarding the long insurance contracts´ duration, the investment activities mean the most important source of the revenues of the life insurers. However, the insurers must invest with respect to the Prudent Person Principle, which means investing only in instruments whose risks are clear, respect the duration of the insurance policies and are in the best interest of beneficiaries and/or policyholders. Therefore, having a confidence in the insurer(s) seems essential, especially due to the act of the delaying of the insurance payment in the case of the covered loss from the premium settlement. Considering the relatively small Czech business market, the insurers oriented on the life insurance are supposed to prove their investment effectiveness to operate on the market in the future. So, a two-stage Window Analysis Data Envelopment Analysis model was constructed to investigate the underwriting and investment efficiency of 23 Insurers. For this purpose, data from the Czech Insurance Association were used covering a period from 2012 to 2021.

Keywords: Czech Republic, Data Envelopment Analysis, Investment efficiency, Life insurance, Underwriting efficiency

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Impact of Political Structural Breaks on the Volatility of Latin America Exchange Rates

Petra Tomanová[1], Marcial Lagos[2]

Abstract. Major political events, such as corruption scandals, presidential impeachment proceedings, and general elections, might be associated with points of structural breaks in the volatility of exchange rates. First, to identify those break points in the exchange rates of Latin America, we use the iterated cumulative sums of squares (ICSS) algorithm. Second, to address the asymmetrical nature of volatility, we use the EGARCH(1,1) model to determine if incorporating these break points results in a decrease in volatility persistence.

Keywords: exchange rate, structural break, volatility

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Sustainable Partner Selection and Order Allocation: An Application in Turkish Textile Industry

Tuğçe Dabanli Kurt [1], Derya Eren Akyol [2]

Abstract. In order to guarantee the sustainability of the supply chain, the collaboration of all elements is crucial. Therefore, the partner selection problem including sustainable elements has found an important place in sustainable supply chain management. Until now, companies have only considered price and quality factors in their raw material procurement or subcontracting decisions. Now, all three pillars of sustainability, which are in conflict with each other, need to be included. In this study, we discuss an integrated multi-objective partner selection and order allocation problem that aims to optimize the conflicting economic, environmental and social objectives. In order to illuminate the model under consideration, a real-life application in the textile industry in Turkey is presented. The study contributes to the examination of the situation of sustainability practices in the Turkish textile industry and the relations with sub-contractors. The proposed model is solved with different multi-objective problem solving methods and the results are compared.

Keywords: sustainability, partner selection, order allocation, supply chain management, textile industry

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Does Performance of the Largest European Corporates Concur with Green Deal Targets?

Raminta Vaitiekuniene [1], Kristina Šutiene [2]

Abstract. Corporates are playing a very important role in climate neutrality. Therefore, the purpose of the research is to evaluate the performance of the largest European corporates, revealing how corporates contribute or do not contribute to the implementation of the Green Deal. Systematization of scientific literature, selection of input and output variables based on the results of scientific literature, analysis of statistical relationships as the main research methods are applied to achieve the purpose. The results of the article show that the largest European corporates, selected from the most significant European stock index Euro Stoxx 50, do not equally contribute to the implementation of the Green Deal. The companies' environmental, social, and governance indicator (ESG), which reflects the level of the company's green deal, ranges on average between 35.90 and 65.05 points. The highest score was achieved in Euro stoxx 50 utilities sector companies (65.05 points), and the lowest score in real estate and communication services sector companies (accordingly, 35.90 points and 41.36 points). Part of the analyzed corporates from the consumer discretionary, financials, industrials, information technology and real estate sectors could contribute more to the improvement of sustainable environment and social responsibility, as these corporates demonstrate better financial performance. On the other hand, corporates from the consumer staples and materials sectors that are already actively contributing to the implementation of the green deal do not necessarily have accumulated greater financial resources. The relationship between return on assets and companies' ESG indicator is positive in the communication services, industrials, information technology and real estate sectors. This project has received funding from the Research Council of Lithuania (LMTLT), agreement No S-PD-22-23.

Keywords: green deal,ESG ratio,financial performance,Euro Stoxx 50 Index

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General Bounds for Functionals of the Lifetime, Compatible with Life Tables

Mark Van Lokeren[1]

Abstract. In life insurance, life tables are used to estimate the survival distribution of individuals. The tables only provide survival probabilities at integer values, and information about the distribution of deaths between two consecutive integer values is not available.

Many actuarial quantities are functionals of the lifetime, and computing them requires full information of the lifetime. Examples of such functionals are the complete expectation of life, or the net premium for benefits payable at the moment of death.

A possible solution to this problem is the introduction of fractional age assumptions. However, it turns out that these computations depend strongly on the assumptions, which makes it rather difficult to generalise the results.

We propose a new method to compute upper and lower bounds of functionals of the lifetime, which are compatible with the information from life tables. As the method does not rely on any other assumptions, the obtained bounds are the most general one can obtain based upon the available information. Moreover, the bounds are sharp, and the method also yields an example of a lifetime that achieves them.

Our method is based on techniques from optimal control. To the best of our knowledge, it is the first time that such techniques are applied in the context of life insurance.

Keywords: life table,functional of the lifetime,bounds,optimal control

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Portfolio Cash Flow on Peer-to-Peer (P2P) Lending Platform: The Quantile Regression Approach

Petra Vašaničová[1], Marta Miškufová[2]

Abstract. Peer-to-peer (P2P) lending is a financial technology that has emerged in recent years as an alternative to traditional lending methods. Bondora is a European P2P lending platform that offers investors the opportunity to invest in consumer loans originated in Estonia, Finland, and Spain. This paper analyzes the cash flow statement of Bondora. The aim of this paper is to find out the relationship between paid principal and paid interest of Bondora platform using quantile regression on monthly data from April 2009 to April 2023. Quantile regression is a valuable statistical technique that offers advantages over traditional linear regression because it can determine whether individual percentiles of a dependent variable are more affected by independent variables than other percentiles of a dependent variable, which is then reflected in the change in regression coefficients. This study examines the performance of Bondora's loan portfolio and discusses the future of Bondora and its potential for growth and expansion. Results show that over time the influence of the paid principal on the paid interest increases. This study offers valuable insights to investors for evaluating the profitability of their investments and enables them to make informed decisions about future investments on the P2P lending platform.

Keywords: ANP, DSS preferences evaluation, strategic management decisions, sensitivity analysis, BE, cognitive bias

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Clustering Methods Usable in Loss Reserving in Non-Life Insurance and Their Comparison

Petr Vejmělka[1]

Abstract. Insurance companies perform loss reserving as an important part of their activities. Reserving corresponds to the estimation of an insurer's liability from future claims payments. We can find many approaches to estimating the pertinent reserves in the literature. In this article, we consider a method using state-space modeling that transforms run-off triangles, a widely considered scheme of claims, into time series with missing observations. Usually, there is more information about claims available, such as the type of claim, on the basis of which it would be possible to split these claims to several groups according to their similarity. With this approach, we would achieve greater homogeneity within the given groups, and due to this, we could also expect more accurate estimates.

The aim of this paper is to compare clustering methods applicable as part of the reserving that are available in the form of different packages implemented within the R software. This paper includes an application of unsupervised classification to claims portfolios, which were created with the use of a generator designed based on a real portfolio. Thanks to this generator, future expenses for incurred claims are also known, and it is therefore, possible to compare how accurate the reserve estimates are.

Keywords: reserve, clustering, state-space model, time-series, non-life insurance

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The Influence of Influencers: Assessing the Impact of Influencer Marketing on Brand Awareness

Lukáš Veverka[1]

Abstract. This article investigates the impact of influencer marketing on webpage visits, which can serve as a proxy for brand awareness. Using a dynamic time series methodology, the study evaluates the effect of influencer programs on organic webpage visits by estimating both the long-run propensity and impact propensity. The study employs Fourier transformation to estimate seasonality throughout the year and finite distributed lag to assess the immediate impact of influencers. It also looks for patterns within the month, such as the payday effect. The empirical data used for this research was obtained from Google Analytics for a Fast Moving Consumer Goods (FMCG) company that sells clothes. The findings suggest an initial increase in webpage visits, but statistical significance cannot be established.

Keywords: Fourier transformation, Dynamic time series, Data-driven marketing

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Estimating Stochastic Volatility Models - a Comparison of Bayesian MCMC and Machine Learning Approaches

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Abstract. Estimation of stochastic volatility model parameters from historical return data poses a difficult computational problem that cannot be handled easily with classical maximum likelihood methods due to presence of the latent stochastic volatility. A significant progress has been achieved applying the Bayesian Markov Chain Monte Carlo (MCMC) or Particle Filter approaches. However, the methods are computationally intensive and their convergence to true parameter values is often difficult to analyze. In our previous research we have proposed an alternative machine learning approach where a neural network is trained using an artificially generated large training data set where, conditional on a model, different combinations of parameters and return time series are sampled. The goal of our research is to compare the two estimation approaches in case of the Heston (or log-variance) model and show that the machine learning approach provides a competitive, flexible and efficient estimation method compared to the classical Bayesian MCMC method.

Keywords: stochastic volatility,MCMC,machine learning,model estimation

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Optimizing Time/Cost Trade-Off Problem with Net Present Value Maximization: The Exact Solution Procedures

Majid Yazdani [1], Tarik Aouam [2]

Abstract. This work introduces an innovative approach to address the Discrete Time/Cost Trade-Off Problem in project scheduling optimization, with a specific emphasis on maximizing net present value. The primary objective of this study is to optimize the net present value of cash flows by strategically selecting execution modes for activities. Our proposed mathematical model presents a comprehensive solution methodology for this complex problem.

To effectively handle the inherent computational complexity, we leverage the benders decomposition technique, which offers an exact solution approach. Furthermore, we incorporate a pre-processing step to streamline the project network and introduce some innovative feasibility cuts into our solution methodology, thereby enhancing its computational efficiency.

To assess the efficacy of our approach, we conduct extensive computational experiments encompassing a wide range of scenarios and parameter variations, drawing from relevant literature. Through meticulous analysis and comprehensive experimentation, we demonstrate that our solution procedures consistently yield optimal or near-optimal solutions for realistic project scheduling sizes. Remarkably, our approach surpasses both a state-of-the-art nonlinear commercial solver and an existing heuristic algorithm in terms of solution quality and computational resource utilization.

Keywords: project scheduling, exact solution procedures,time/cost trade-off problem,Benders decomposition

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The Exact Solution of Vehicle Routing Problem by Mixed Integer Linear Programming in Matlab

Jaromír Zahrádka[1]

Abstract. This contribution comes up with a specific solution of the vehicle routing problem. The driver has to deliver the goods from the central warehouse to n customers as efficiently as possible. Each customer has ordered goods that fill a certain number of containers. Each customer point of delivery is given by GPS coordinates. The objective of the solution is to select the number of vehicles and their routes between customers in such a way that the total travel time, including the time for unloading the goods, is as short as possible. Each delivery point is visited only once by one of the vehicles. All used vehicles have a pre-limited capacity of containers. All vehicles return to the central warehouse. In this contribution, the algorithm of the exact solution of the vehicle routing problem was created, which can be used in general for any number n of customers. The algorithm is implemented in Matlab code.

Keywords: Matlab code, mixed integer linear programming, optimization, point of delivery, vehicle routing problem

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Two-Stage or One-Stage DEA Model?

Petra Zýková[1]

Abstract. The paper deals with the efficiency analysis solved by data envelopment models (DEA). DEA models are a general tool for efficiency and performance evaluation of a set of homogenous decision-making units (DMUs). DEA models divide the set of units into two subsets – efficient and inefficient units. Usually, DEA models analyse DMUs in one period. This paper deals with a dynamic DEA model. The dynamic DEA models contain a vector of time weights. The DEA models could have one or more stages. This paper compares the two-stage dynamic DEA models with the basic one-stage dynamic DEA model. The compared models contain an increasing vector of time weights.

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