52nd International Symposium on Operational Research

SYM-OP-IS 2025

BOOK OF ABSTRACTS

September 7 - 10, 2025
Palić, Serbia

SYM-OP-IS 2025

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SYM-OP-IS 2025
Palić, 7– 10 September 2025.

BOOK OF ABSTRACTS

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Prof. Dragan Pamučar Ph.D.
Prof. Milan Stanojević Ph.D.

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Proceedings of the 52nd Symposium on Operational Research – SYM-OP-IS 2025,
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PREFACE – Book of Abstracts

The Faculty of Organizational Sciences, University of Belgrade, in collaboration with partner institutions, proudly presents the *Book of Abstracts* of the 52nd Symposium on Operational Research – SYM-OP-IS 2025. Building on a long-standing tradition, SYM-OP-IS continues to serve as a meeting point for researchers, academics, practitioners, and students from Serbia and abroad who share a common interest in advancing the theory and practice of operational research.

This year, SYM-OP-IS attracted a notable number of contributions, reflecting the continued growth and strong engagement of the operational research community. In addition to the opportunity to publish full papers (either in International Conference Proceedings or in National Conference Proceedings), participants were also provided the option to contribute to the *Book of Abstracts*. This format enables the inclusion of ongoing research, preliminary findings, or work best communicated through discussion, thus broadening the thematic and methodological scope of the symposium.

This volume contains 23 abstracts, organized into 14 thematic sections. Although the contributions are presented in summarized form, the full scientific and practical value of the research has been conveyed through oral presentations, thematic sessions, and discussions held during the symposium. These exchanges have encouraged reflection on contemporary research challenges, highlighted the dynamic development of the field, and fostered collaboration across disciplines and professional environments.

Through its integrative program—consisting of plenary sessions, thematic sessions, and informal meetings—SYM-OP-IS continues to promote the exchange of ideas, deepen collaboration between theory and practice, and inspire new research directions that transcend disciplinary and national boundaries.

We express our sincere gratitude to all authors, reviewers, session chairs, and members of the organizing and program committees, whose efforts have contributed to the preparation of this volume. We also extend our appreciation to our partners and supporters for their continued commitment to strengthening the role of operational research in academic and professional contexts.

Special recognition goes to our sponsors — Egzakta Group, Coca-Cola Hellenic, Nescafé, and Zlatiborac — and to the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, whose generous support greatly contributed to the successful realization of SYM-OP-IS 2025.

We hope that the contributions presented in this *Book of Abstracts* will serve as a valuable record of the research shared during the symposium and as an inspiration for future studies, collaborations, and professional engagement in the field of operational research.

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Prof. Dragan Pamučar Ph.D.
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Belgrade, 2025

TABLE OF CONTENT

ARTIFICIAL INTELLIGENCE

CREDIT RISK ASSESSMENT IN BANKS: MACHINE LEARNING APPROACH

MILOŠ JORDANSKI[1], ŽELJKO JOVIĆ[2], MIROSLAV MARIĆ[3], MILOŠ LUTOVAC[4], VESNA MARIĆ[5]

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Abstract: *Credit risk assessment, monitoring, and effective loan processing are key to decision-making in banks. Advances in the field of Artificial Intelligence could help banks to improve their business decisions. In this work, we have collected publicly available data from the banking sector of the Republic of Serbia and build deep learning models on real data in order to predict loan default probability of new customers as well as the ones which have been regular in settlement of credit obligations in the previous year. The dataset consists of data from the financial statements of real economy companies as well as information on the status of companies in terms of regularity of settling their credit obligations. Results obtained in this paper show that machine learning approaches can successfully be used for credit risk assessment of companies. We have shown that using a deep learning model improves results compared to generalized linear model in terms of area of under the curve metric. In addition, our experiments have shown that using more data for training deep learning model improves performances of the model.*

Keywords: *Credit risk assessment, machine learning, generalized linear models, deep learning.*

AI SUPPORT FOR QUALITATIVE RESEARCH: VALIDATION OF DIGITAL TWINS THROUGH A CASE STUDY

ALEKSEJ MIGITKO[1], MINJA MARINOVIĆ[2], NIKOLA CVETKOVIĆ[3], UROŠ ŠOŠEVIĆ[4]

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Abstract: *This paper explores the application of artificial intelligence (AI) in the context of academic qualitative research, with the main goal of creating a tool that will serve as an auxiliary tool. Its purpose is to automate the process of collecting, analyzing, and synthesizing research insights. By using an AI system to generate so-called digital twins – entities that accurately represent the respondents' thought patterns – researchers are enabled to gain almost instant insight into the attitudes of the target group through natural language interaction. It is important to emphasize that the tool does not replace the researcher himself, but serves solely as a support in gaining insight, providing advice and suggesting directions for further research based on the data already processed. A preliminary evaluation, conducted on a pilot group of respondents, demonstrated a high level of match between the psychometric characteristics of individuals and their digital twins. The basis of this system is a structured set of analytical clusters that encompass different categories of thoughts and profiles, thus enabling thematically focused analysis and application by experts from different fields. The presented results clearly indicate the significant potential of integrating this approach into contemporary scientific practice, with a special emphasis on research projects that rely on an in-depth understanding of complex qualitative data.*

Keywords: Artificial intelligence, qualitative analysis, digital twins, scientific research.

MULTI-AGENT SYSTEM FOR MODELLING EVAPOTRANSPIRATION TIME SERIES

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Abstract: *The evapotranspiration has a significant role in understanding and forecasting climate. Since it depends on many factors, considering and including all these factors represent a challenging task for many researchers. This study introduces a model for predicting the evapotranspiration values for the next month. The model is based on a composition of four artificial neural networks. The networks differ in the input vectors, hidden layers and activation functions. Also they have different structure, while some are recurrent networks, the others are feed-forward. The design of these networks is governed by understanding the statistical properties of the data considered. Different features of the input layer demand different network design. We investigate the effects of each additional network in developing this system. The results are discussed on real data sets. The data sets contain monthly observations from January 1980 to December 2010 of temperature, vapor pressure, wind speed, humidity, sunshine hours and estimated evapotranspiration for the current month. The evapotranspiration values comprise the time series of monthly values that we want to model, aiming to forecast values for the one month ahead. We discuss how the model's efficiency improves by including each additional network into the system and compare the results in terms of the root mean square error, the mean absolute error and the correlation with the real data.*

Keywords: *Neural networks, evapotranspiration, time series.*

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E-BUSINESS

BUSINESS ANALYSIS OF META PLATFORM IN POST COVID-19 TIME

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Abstract: Meta is the largest social network globally in terms of the number of active users. It has built an ecosystem with all the characteristics of a modern monopoly. This paper aims to investigate and analyse the business results of the platform during the pandemic period and after the end of the COVID-19 pandemic. The research used data that the corporation publishes in the form of the Meta Annual Report, which serves investors for business on the stock exchange. The research includes the analysis of selected financial parameters, and the analysis of user trends to determine the stability of the network effect on the platform. In the analysis, a statistical trend regression model is used to determine the business result in the selected time period. The research results proved that the COVID-19 pandemic did not have a significant impact on the overall business results. The corporation entered the process of reorganization and expansion of business activities after the end of the pandemic, which had a positive effect on the financial result.

Keywords: digital transformation, Facebook, Meta, platform economy, social media.

DATA AUGMENTATION AND AI-BASED SENTIMENT ANALYSIS OF CUSTOMER REVIEWS IN E-COMMERCE

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Abstract: E-commerce offers many benefits to customers, including the possibility to easily find customer reviews on desired products. Customer sentiment plays a significant role in evaluating products distributed through digital platforms. This study presents a sentiment classification framework based on customer reviews collected from Amazon Handmade. A labeled dataset was constructed by categorizing each review into one of three sentiment classes: positive, negative, or neutral. Synthetic data, generated using the GPT-4 language model, were incorporated to enrich linguistic diversity and semantic variability. This augmentation strategy improved the model's ability to generalize across varied real-world expressions and writing styles, resulting in more accurate and robust sentiment classification. The average cosine similarity between original and synthetic reviews was 0.908, indicating high semantic consistency of the augmented data. Sentiment classification was performed using both rule-based and deep learning methods. Rule-based baselines, including VADER, TextBlob, and AFINN, showed limited performance, with accuracies around 60%. In contrast, a fine-tuned BERT model trained solely on real data achieved an accuracy of 83%, while the same model trained on the combined real and GPT-4-generated dataset reached 97% accuracy. These results demonstrate that augmenting real reviews with GPT-generated data significantly enhances the reliability and accuracy of sentiment predictions.

Keywords: E-commerce, sentiment analysis, Amazon Handmade, BERT, GPT-4, NLP, data augmentation.

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ФОН
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ECONOMIC MODELS AND ECONOMETRICS

IDENTIFICATION OF INFLATION ATTENTION REGIME IN SERBIA

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Abstract: *Inflation is one of the main macroeconomic issues that individuals and policymakers observe. However, not all levels of inflation trigger the same interest of public. Naturally, there are two substantially different regimes, i.e. low inflation attention, and high inflation attention regime. These regimes are identified in Serbia based on the available monthly data from 2011M1 to 2025M5. Data are extracted from Google searches of word "inflation" in Serbian and normalized to the month with the most Google searches of that word. Based on available data, we used the following common statistical methodology used in literature to make the distinction between the regimes. Months with the high attention regime are those when Google searches for inflation in that month exceeds the 75th percentile. Otherwise, low inflation attention regime emerges. One of the crucial insights is that negative supply side shocks are significant drivers of inflation attention. Identification of these regimes has high importance for monetary policymaking, due to the strong interdependence with inflation expectations and ultimately with the Consumer Price Index (CPI) measured inflation rate. Anchoring inflation expectations is conditio sine qua non of inflation stabilization, and success on that partially depend on inflation (in)attention.*

Keywords: *Inflation attention, inflation rate, inflation expectations, monetary policy, Serbia.*

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ENVIRONMENTAL MANAGEMENT AND NATURAL RESOURCE MANAGEMENT

CLIMATE CHANGE AND ENVIRONMENTAL PERFORMANCE IN WESTERN BALKANS

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Abstract: *The Western Balkan countries are endangered by the climate change effects, and in these economies, climate activism of any kind began later than in the rest of Europe. Moreover, the environmental performance of the Western Balkan region is below the EU average. This paper aims to analyze climate change mitigation in Western Balkan economies. For this purpose, the Environmental Performance Index (EPI) and the ranking for 2024 were used. In this paper, data were obtained through a secondary literature review, including relevant publications, articles, and documents related to the countries of the Western Balkans. The methods used in the paper are analytical and comparative. The results indicate that Albania is the highest-ranked Western Balkan country according to the value of climate change mitigation measured by the EPI index. North Macedonia follows Albania. Then comes Bosnia and Herzegovina, followed by Serbia and Montenegro, respectively. The concluding remarks include recommendations that all Western Balkan economies must enhance their institutions, policies, and capacities because poor governance frequently makes it difficult to enact climate change policies and adapt to the EU environmental acquis. Thus, costlier adaptation measures will result from a lack of systematic planning in response to the climate change effects.*

Keywords: Climate change mitigation, Environmental performance index, Rank, Western Balkans.

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LITERATURE

Andre, P., Boneva, T., Chopra, F. & Falk, A. (2024). Globally representative evidence on the actual and perceived support for climate action. Nat. Clim. Chang. 14, 253–259. https://doi.org/10.1038/s41558-024-01925-3. Retrieved from https://www.nature.com/articles/s41558-024-01925-3

Andrejević Panić, A., Cvetanović, S., Milićević, S., & Mulić, D. (2024). Environmental performance of countries and the policy of greening the economy. Ecologica, 31(115), 249-257. https://doi.org/10.18485/ecologica.2024.31.115.1

Belis C. A., Djatkov D., Lettieri T., Jones A., Wojda P., Banja M., Muntean M., Paunović, M., Niegowska M., Marinov D., Poznanović G., Pozzoli L., Dobricic S., Zdruli P., & Vandyck T. (2022). Status of environment and climate in the Western Balkans, EUR 31077 EN, Publications Office of the European Union, Luxemburg, doi:10.2760/294516.

Block, S., Emerson, J. W., Esty, D. C., de Sherbinin, A., Wendling, Z. A., et al. (2024). 2024 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

Cierco Gomes, T. M. R. (2019). The European Union accession and climate change policies in the Western Balkan countries. Climate Change and Global Development: Market, Global Players and Empirical Evidence, 153-173. https://doi.org/10.1007/978-3-030-02662-2_8

Dosti, B., Doci, S., & Kule, D. (2024). Western Balkans' Environmental Performance toward EU Integration and Sustainable Development: A Comparative Analysis. Economic and Social Development: Book of

Proceedings, 113th International Scientific Conference on Economic and Social Development – Prague, 27-28 June, 2024, 47-56.

Green Agenda (2020). Regional Cooperation Council, https://www.rcc.int/greenagenda

Knez, S., Štrbac, S., & Podbregar, I. (2022). Climate change in the Western Balkans and EU Green Deal: status, mitigation and challenges. Energy, Sustainability and Society, 12(1), 1-14. https://doi.org/10.1186/s13705-021-00328-y

Mitić, P., Hanić, A., Kojić, M., & Schlüter, S. (2023). Environment and Economy interactions in the Western Balkans: Current situation and prospects. In: Tufek-Memišević, T., Arslanagić-Kalajdžić, M., Ademović, N. (eds). Interdisciplinary Advances in Sustainable Development. ICSD 2022. Lecture Notes in Networks and Systems, vol 529. Springer, Cham. (pp. 3–21). https://doi.org/10.1007/978-3-031-17767-5_1

Mitić, P., Kojić, M., Minović, J., Stevanović, S., & Radulescu, M. (2024). An EKC-based modelling of CO2 emissions, economic growth, electricity consumption and trade openness in Serbia. Environmental Science and Pollution Research, 31(4), 5807-5825. https://doi.org/10.1007/s11356-023-31617-y

Piksiades, D. (2020). Progress in fulfilling the requirements of the Paris Agreement on Climate Change in the Western Balkans. Conference proceedings Post-Socialist transformation of the City, November 12 & 13, 2019, University of Novi Sad, Faculty of Philosophy, Department of Sociology, 167-185.

Samborska, V. (2024) - "How much have temperatures risen in countries across the world?" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/temperature-anomaly'

Savić, S., Trbić, G., Milošević, D., & Popov, T. (2023). Climate Change and Urban Climate in the Western Balkans. In: Trbić G., Popov T., & Mirjanić D. (eds.) Natural Resources Management in a Changing Climate. Academy of Sciences and Arts of the Republic of Srpska, Banja Luka, Monograph LIV: 1–39.

Stojkovski, L., & Bazerkoska, J. B. (2024). Climate Change as a Security Issue in the Western Balkans. Contemporary Macedonian Defense/Sovremena Makedonska Odbrana, 24(46), 11-22.

Vlasceanu et al. (2024). Addressing climate change with behavioral science: A global intervention tournament in 63 countries. – processed by Our World in Data, Retrieved from https://www.science.org/doi/10.1126/sciadv.adj5778

Vulevic, A., Castanho, R. A., Gómez, J. M. N., Lausada, S., Loures, L., Cabezas, J., & Fernández-Pozo, L. (2021). Cross-border cooperation and adaptation to climate change in western Balkans Danube area. In Governing Territorial Development in the Western Balkans: Challenges and Prospects of Regional Cooperation (pp. 289-308). Cham: Springer International Publishing.

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FINANCE AND BANKING

USE OF STATISTICAL AND ECONOMETRIC MODELS IN CREDIT RISK ANALYSIS

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Abstract: *Risk control of banks has social significance. Disruptions in the banking sector have a negative impact on the entire economy. What's more, they cause significant social upheavals (let's remember the "pyramid banks" in our country from the beginning of the 90s). The question is both from the point of view of economic development and from the aspect of profitability of the bank itself, how high can bank placements be and how much risk can be taken in order not to jeopardize the security of the bank's obligations. Banking risks are credit, market, currency, solvency risk and operational risk. The paper deals with the oldest of financial risks - credit risk. If there is something that unites the renaissance banker sitting at the bench with money - "banco" and the risk analyst in the high-rise of Wall Street, then it is credit risk. The oldest, but still the most important risk. Today, thanks to modern computer technology, the archiving of databases, the movement of parameter values in the past, it is possible to predict the risks taken. Credit risk is observed at the level of an individual credit line - standalone risk, or in concentration - portfolio credit risk. In order to establish the relationship between the risk of the total exposure and the capital of the bank, which is the last line of defense of solvency, by the G7 countries, the Basel standards were promoted. Credit risk parameters are the basic tools for risk monitoring. The default rate, and the loss due to default, are derived based on*

Keywords: *Statistical models, econometric models, credit risk, credit score, default liability, lender.*

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GAME THEORY

ANALYSIS OF BUSINESS STRATEGIES OF INTERNATIONAL CARD SCHEMES IN THE NATIONAL MARKET USING GAME THEORY

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Abstract: In the modern world, companies cannot effectively operate or survive in the market without utilizing cashless payment systems. The most common form of non-cash payment is through payment cards. In this paper, we analyze business strategies and strategic moves applied by international card schemes on the national market of payment cards, in order to eliminate competition. National card schemes are present only in the market of the countries where they were created, while international card schemes operate worldwide. There are notable differences in their equity capital, annual revenue, and consequently, their budgets for research and development. Additionally, many national card schemes are motivated not only by profit but also by societal interests, which further reduces their negotiating potential. The national market of card payments can be viewed as a zero-sum game because the gain of one card scheme represents the loss of another; that is, the others in that market. The question arises as to what strategies card schemes use to improve their market share. This paper presents several strategies employed by international card schemes to maintain a dominant market position, and several games are modeled to analyze such market situations.

Keywords: International card schemes, national card schemes, payment cards, game theory, strategies.

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HEURISTICS

SOLVING THE MULTIDIMENSIONAL KNAPSACK PROBLEM USING A GENETIC ALGORITHM

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Abstract: *The Multidimensional Knapsack Problem (MdKP) is a generalization of the classic knapsack problem, aiming to maximize profit under capacity constraints for each dimension $d \in N$. A linear integer mathematical formulation of the problem is presented and utilized within the exact solver CPLEX 22.1.1 to obtain optimal solutions. To find high-quality solutions for larger instances, a heuristic based on the concept of the Genetic Algorithm (GA) was implemented. Parts of the proposed GA were parallelized to enhance the algorithm's performance. For testing purposes, existing instances from the well-known OR-Library were used, along with newly generated small, medium, and large problem instances. The proposed genetic algorithm was run on all considered instances, and the obtained results were analyzed and compared with the optimal or best-known solutions. Experimental results show that the solutions obtained by the genetic algorithm match all optimal solutions found by CPLEX 22.1.1 for small instances. For medium-sized instances, the GA reaches most of the optimal solutions or yields near-optimal ones. For large instances that CPLEX 22.1.1 was unable to solve, the proposed GA provides solutions within a short execution time.*

Keywords: *Multidimensional knapsack problem, mathematical programming, heuristic, genetic algorithm.*

METAHEURISTIC APPROACH TO SOLVE A VARIANT OF GENERALIZED REGENERATOR LOCATION PROBLEM IN OPTICAL NETWORKS

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Abstract: *The generalized regenerator location problem (GRLP) deals with the optimal placement of regenerators in optical network in order to preserve signal quality between the end-user pairs with minimal number of installed regenerators. This study considers a variant of GRLP that involves weights of end-user pairs reflecting their importance or priorities in an optical network and the costs of installing regenerators for each location. The considered GRLP variant addresses two objectives: to maximize the sum of weights of connected end-user pairs and to minimize the total costs of installing regenerators. As the optical network involves large number of nodes, metaheuristic approach is used to solve the problem under consideration. Several S-metaheuristic and P-metaheuristic concepts are modified in accordance to the problem's characteristics. The proposed metaheuristic methods are tested on the modified GRLP data sets from the literature and the obtained results are compared in terms of solution quality in respect to several metrics.*

Keywords: *Generalized location problem, S-metaheuristic, P-metaheuristic, multi-objective optimization.*

A COMPARATIVE STUDY OF INTENSIFICATION TECHNIQUES IN HYBRID ACO FOR THE FAR FROM MOST STRING PROBLEM

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Abstract: *The Far From Most String Problem (FFMSP) is a hard combinatorial optimization problem encountered in sequence analysis, where the goal is to identify a string that is dissimilar to most strings in a given set. It has significant applications in bioinformatics, including mutation detection, pathogen strain differentiation, and in broader domains such as outlier detection, coding theory, and information security— where selecting sequences that maximize dissimilarity is essential. Solving the FFMSP efficiently requires advanced metaheuristic methods, as exact algorithms become impractical for real-world instance sizes. In this work, we conduct a systematic study on enhancing hybrid Ant Colony Optimization (ACO) algorithms for the FFMSP by focusing on the intensification components. Specifically, we investigate and compare multiple implementations of the path relinking strategy, comparing random and greedy approaches for guiding solution recombination. In addition, we explore the impact of different local search implementations, analyzing both best-improvement and first-improvement neighborhood search variants. Comprehensive experiments on synthetic benchmark instances demonstrate how the choice of path relinking and local search configuration influences the solution quality and computational efficiency of the hybrid ACO framework.*

Keywords: *Mathematical optimization, ant colony optimization, FFSMP, local search, path relinking.*

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INFORMATION SYSTEMS AND TECHNOLOGY

A THEORETICALLY SOUND PROCEDURE FOR ELICITING THE PARAMETERS OF A VARIANT OF ELECTRE-TRI

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Abstract: *The additive multiattribute value function model is the main and historically the first model proposed for representing the preference of a decision maker (DM) on a set of alternatives described by multiple attributes (or criteria). From the outset, the exact conditions under which the preferences of the DM can be represented in this model were established. Having at our disposal an exact axiomatic description of a model enables us to design rigorous methods for eliciting the model's parameters. In the case of the additive value function model, such parameters are the marginal value functions and the tradeoffs. Among the rigorous methods for eliciting them is the construction of standard sequences. Even though rigorous methods are often not applicable as such in practical decision situations, they do provide useful guidelines when it is required to depart from them without betraying the essence of the model. Apart from the well-established multiattribute value function theory, a large number of methods were proposed to rank, chose from or sort into ordered categories alternatives evaluated with respect to several criteria. However, much less attention (to say the least) was devoted to give them firm theoretical foundations, which leaves these methods unprotected against suspicions of arbitrariness. Outranking methods such as ELECTRE or PROMETHEE are early examples of such alternative methods, all based on pairwise comparisons. Some efforts were recently made for establishing axiomatic foundations for the outranking relation of the ELECTRE methods. However, a characterization of rankings obtained by means of ELECTRE methods has not been achieved to date. Fortunately, the case is different for ELECTRE-Tri, a method proposed for sorting alternatives into predefined ordered categories. In contrast with ranking methods, which reflect a relative evaluation of the alternatives, sorting methods aim at absolute evaluation. Bouyssou and Marchant (B&M) gave an axiomatic characterization of a variant of ELECTRE-Tri, used with the pessimistic (or pseudo-conjunctive) assignment rule. They named the characterized sorting model Non-Compensatory Sorting (NCS) model. B&M axioms allow us to clearly understand the parameters of the model, namely, the limit profile(s) and the set of sufficient coalitions of criteria. It is hence possible to design rigorous elicitation methods in which the decision maker is asked to assign well-chosen alternatives into a category. The purpose of this work is to present some questioning algorithms in the case of sorting in two ordered categories. The difficult part is the elicitation of the set of sufficient coalitions of criteria. We present an algorithm based on a depth first search exploration of the set of criteria coalitions. This algorithm is not optimal in terms of the number of questions (neither in the worst case nor on average) but it is flexible. Its performance is compared to that of an algorithm that is optimal in the worst case and to what is known about questioning strategies that are optimal on average.*

Keywords: *Multicriteria decision aiding, multicriteria sorting, non-compensatory sorting model, ELECTRE-Tri, parameters elicitation.*

MANAGEMENT

ARTIFICIAL INTELLIGENCE USAGE IN HIGHER EDUCATION: BENEFITS AND CONCERNS

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Abstract: *The need for artificial intelligence (AI) in higher education (HE) has rapidly increased recently alongside the simultaneous raising of new AI tools. Researchers indicate numerous benefits and risks of AI usage in HE for both teachers and students. Therefore, the paper aims to explore the benefits and concerns related to the use of AI in higher education, specifically focusing on its impact on students' learning. The research will be conducted among university students, with a sample drawn from the Republic of Serbia. Descriptive statistical analysis, along with ANOVA or t-tests, will be used to analyze the data collected. The results of the empirical research are expected to reveal both the positive and negative effects of AI usage on students' learning experiences, offering insights into how AI can enhance educational processes and where challenges may arise. The study will be limited to a specific region and sample size, so the results may not accurately reflect what would be found in other educational settings. It is recommended that educators and administrators carefully consider the integration of AI tools into their curricula, ensuring that they complement traditional learning methods while addressing any concerns regarding equity, accessibility, and the potential impact on students' performance.*

Keywords: *Artificial Intelligence (AI), higher education, learning experience.*

THE IMPACT OF THE GIG ECONOMY ON THE HOSPITALITY SECTOR

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Abstract: *The hospitality industry is facing significant challenges such as seasonal peaks, sudden demand surges, and last-minute staff shortages, which have become major recruitment pain points. As a response to these challenges, the gig economy, based on short-term engagements and flexible forms of work, is increasingly shaping the labor market. The aim of this paper is to analyze the impact of gig economy in job mediation. Findings from previous research reveal the ambivalent impact of the gig economy. On the one hand, it enables rapid recruitment, lower hiring costs, and adaptability to seasonal demand. However, the main drawbacks for employers, include reduced quality control, weak employee loyalty, and challenges in maintaining sustainable human resource strategies. As for gig workers, although this model allows additional income and autonomy in the short term, it often leads to limited professional development and lack of benefits in the long term. In order to minimize the risks associated with these platforms, new frameworks must be introduced to safeguard all participants in the process. Therefore, gig economy may be considered a useful complementary mechanism for addressing short-term staffing needs, but not a sustainable long-term solution to employment challenges in the hospitality sector.*

Keywords: *Gig economy, hospitality, human resources, digital platforms.*

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MATHEMATICAL PROGRAMMING

MARKET FOR INFORMATION IN ASYMMETRIC INFORMATION ENVIRONMENTS: INSIDER - OUTSIDER DYNAMICS

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Abstract: *Information asymmetry remains a key driver of inefficiencies in financial markets, where insiders often exploit privileged signals at the expense of outsiders and noise traders. To study this imbalance, we propose a model in which insider information is correlated to varying degrees with the information available to outsiders, allowing us to investigate how correlation alters market quality and profit distribution. The analysis relies not only on theoretical modeling but also on advanced optimization techniques and numerical algorithms designed to compute equilibrium strategies. Through iterative procedures and computational simulations, we determine profit-maximizing equilibria for insiders, outsiders, and noise traders. This approach captures non-linear effects and strategic adjustments that cannot be observed through closed-form analysis alone. Our findings show that higher positive correlation improves liquidity, increases efficiency, and raises the profitability of outsiders and noise traders while reducing insider rents. Negative correlation, in contrast, generates unstable trading dynamics and irregular equilibrium outcomes. These results underscore the importance of algorithmic and numerical optimization methods in capturing the true dynamics of asymmetric markets and provide guidance for future regulatory policies on disclosure and transparency.*

Keywords: *Asymmetric information, insider trading, computational methods, financial market dynamics, correlated signals.*

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MULTICRITERIA ANALYSIS AND OPTIMIZATION

A NEW APPROACH TO DECISION-MAKING IN CRISIS SITUATIONS

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Abstract: *The problem of making a decision to choose an adequate warehouse in conditions of lack of time, then of goods in the required assortment and quantities at the target destinations, as well as the conditions in which the aforementioned takes place, can be strategic for any organization. There are many criteria that are crucial for choosing the warehouse itself, and they are often opposed to each other. The intensities of the criteria's influence on decision-making are also different. The emphasis in this paper is on defining a multitude of criteria and their causal effects on the decision-making process. This paper offers a proposal for the application of a new multi-criteria decision-making (MCDM) model of a unit of the Serbian Armed Forces in the selection of an adequate warehouse for filling with adequate goods the centers for the reception of infected persons that were urgently formed during the Covid-19 crisis. For the above, well-known tools to help decision makers were used; in this case the combined method of AHP and DEMATEL.*

Keywords: *Criteria, warehouse, MCDM, AHP and DEMATEL.*

SIMULATION AND STOCHASTIC MODELS

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MARKOV CHAIN MODEL FOR SPREADING RUMORS

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Abstract: *Mathematical models of the spread of rumors are a well established research subject, especially for their similarity with modelling the spread of infectious diseases. In particular, the problem of spreading of rumors in the finite group of people can be analyzed by means of discrete - time Markov chain, where a unit of time corresponds to the interval between two consecutive interactions between the individuals in the group. We slightly generalize the existing models by introducing the possibility of multiple sources of rumor (individuals who initially know the same rumor). The technique used for obtaining the distributional properties of waiting time until the rumor is spread in the group is based on computing the fundamental matrix of the corresponding Markov chain, which is suitable tool for dealing with several combinatorial scenarios in discrete time.*

Keywords: *Rumor spreading, discrete-time Markov chains, waiting time.*

SOFT COMPUTING

TRENDS IN THE APPLICATION OF SOFT ROBOTIC GLOVE IN THE REHABILITATION OF STROKE PATIENTS IN THE REPUBLIC OF SERBIA

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Abstract: *A soft robotic glove (smart glove) in modern medicine, in the field of rehabilitation, is a revolutionary device that can successfully restore the function of the hand and fingers during the rehabilitation process. The device is widely used in the world, while in Serbia, it is not widely used. The aim of the work was to show patients with hand-to-finger dysfunction the possibility of alleviating their problems by using a smart glove. Approaching the possibility of wearing a glove was done through the education of randomly selected patients. The education consisted of showing tutorials from the Internet with the necessary clarifications. After the education, the patients expressed their opinion through an interview, which can be generalized in the statement that the information was very useful to them and that they understood that they could benefit from the glove in the form of an improvement in their health condition. Patient education played a significant role in patients' willingness to accept the possibility of using a soft robotic glove.*

Keywords: *Patient education, soft computing, soft robotic glove, rehabilitation, stroke.*

COMPARISON OF METAHEURISTIC ALGORITHMS IN PORTFOLIO OPTIMIZATION: EVIDENCE ON HEDGE FUND RETURNS

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Abstract: *This study extends prior research on Artificial Bee Colony (ABC) portfolio optimization by conducting a comparative assessment of several metaheuristic techniques applied to the hedge fund portfolio optimization problem. Following a survey of existing research, we implement five distinct nature-inspired algorithms: two rooted in swarm intelligence (Artificial Bee Colony and Particle Swarm Optimization) and three based on evolutionary principles (Genetic Algorithm, Differential Evolution, and Harmony Search). The asset universe consists of ten indices representing diverse hedge fund strategies, with the optimization objective being the minimization of Conditional Value-at-Risk (CVaR). The efficacy of the resulting portfolios was evaluated against standard industry proxy indices. The empirical validation was conducted over a three-year period, incorporating an annual rebalancing protocol. Our analysis reveals that metaheuristic-optimized portfolios can achieve highly competitive risk-return profiles. Notably, the portfolio constructed via the ABC algorithm delivered performance comparable to a diversified fund-of-funds benchmark, while demonstrating a considerable performance advantage over an equal-weighted hedge fund index. These findings affirm the practical utility of metaheuristic frameworks for sophisticated asset allocation, offering a robust methodology for constructing portfolios with managed downside risk in the alternative investment domain, characterized by non-normal return distributions.*

Keywords: *Metaheuristic algorithms, portfolio optimization, hedge funds, swarm intelligence, evolutionary algorithms.*
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TRAFFIC, TRANSPORT AND COMMUNICATIONS

EVALUATING EQUITY OF URBAN AIR MOBILITY ENVIRONMENTAL IMPACTS: INSIGHTS FROM THE MUSE PROJECT

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Abstract: This paper presents research results developed within the SESAR MUSE (Measuring U-Space Social and Environmental Impact) project. The goal of MUSE is to develop performance indicators, methods, and tools for the comprehensive assessment of Urban Air Mobility (UAM) impacts on the population in European cities. As part of this effort, the MUSE U-space Environmental and Social Performance Framework was created, comprising 41 indicators across 8 focus areas (noise, visual pollution, privacy concerns, access and equity, economic aspects, emissions, public safety, and wildlife). The framework allows high-resolution impact assessment across spatial, temporal, demographic, socioeconomic and behavioural dimensions. This paper focuses on the "Access and Equity" performance indicators. A novel simulation toolset developed in MUSE was applied to a parcel delivery case study in Madrid. To evaluate equity, we use deviation-based metrics: the relative deviation of each grid cell (zone) exposure from the mean, and the average inequity, calculated as the mean of absolute deviation for all affected zones. The obtained results reveal how drone-based noise and visual pollution exposures differ across zones, making them essential for detecting spatial inequalities. These findings support the development of mitigation strategies and U-space policies, contributing to improved performance monitoring and stronger public acceptance of UAM.

Keywords: Urban Air Mobility, social acceptance, unmanned aircraft, drone, performance indicators, access and equity.

ACKNOWLEDGMENT

CHOOSING THE RIGHT VERTIPORT LAYOUT: CAPACITY AND COST COMPARISON

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Abstract: Vertiports, as ground infrastructure, represent one of the key enablers of the Urban Air Mobility (UAM) concept implementation. Even though vertiport location and vertiport capacity are identified as two aspects that can substantially impact UAM service performance, there is a notable lack of comprehensive studies in this field. In this paper, we estimate the capacity and area of the different vertiport layouts relying on published vertiport design criteria and operational concepts assumed based on relevant literature. We calculate the vertiport infrastructure cost by considering the area, the number of electric chargers, and whether the vertiport is located at ground level or on a rooftop. Our analysis includes multi-function, linear, pier, and satellite layouts, featuring one or two Final Approach and Take-Off areas (FATOs) and two to ten gates. By examining the trade-off between infrastructure cost and capacity, we offer insights to guide future decision-makers in selecting appropriate vertiport layouts based on available space and location.

Keywords: Urban Air Mobility, vertiport, layout, capacity, infrastructure cost, informed decision-making.

ACKNOWLEDGMENT

INTEGRATING FRAM AND BAYESIAN NETWORKS FOR RISK ASSESSMENT IN AIR TRAFFIC CONTROL

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Abstract: *The Air Traffic Control (ATC) system is about to change significantly in the coming years due to increased traffic demand and the introduction of advanced automation tools and emerging technologies. In this context, using efficient methods for risk assessment is crucial to enable proactive safety management and ensure the continued maintenance of an adequate level of safety. These methods should address increased system complexity, dynamic interactions, and uncertainty in future operations. Conventional approaches may not be able to cover the potential new behaviors and interdependencies characteristic of socio-technical systems such as ATC. This research introduces a hybrid methodological framework that combines the Functional Resonance Analysis Method (FRAM) and Bayesian Belief Networks (BBN) in the risk assessment of a future ATC system. The main idea of this research is to assess the safety of the future ATC system from a strategic perspective with particular emphasis on the increasing role of automation in the work of Air Traffic Controllers (ATCos) and its impact on the overall functioning of the ATC system. To understand different interactions between various system's elements, the first part of the research includes the analysis using the FRAM method as a new alternative to traditional safety assessment. The second part of the research applies the BBN method for quantitative assessment and evaluation of variability obtained from FRAM analysis. FRAM is a qualitative method that identifies system functions and interactions between them, while BBN is a probabilistic graphical model that represents uncertain relationships between variables. A combination of those two approaches can contribute to a more comprehensive analysis of the safety of a complex system using both qualitative and quantitative data. FRAM provides cause and effect relationships and the possible performance variability, while BBN quantifies these relationships, enabling probabilistic analysis and supporting data-driven safety assessment. They provide both functional understanding and numerical evidence to define potential safety improvements.*

Keywords: *Risk assesment, Functional Resonance Analysis method, Bayesian networks, air traffic control.*