

PLENARY LECTURES

Overcoming the Barriers: Getting Operational Research Used in Healthcare*Sally Brailsford*

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Abstract: This talk addresses a key, controversial issue in the health OR literature, namely the apparent failure of OR modelling to become embedded and widely implemented as practical management tools within healthcare organizations. There is a massive academic literature in this field, but the vast majority of published papers are either purely theoretical or report individual one-off success stories. The evidence suggests that simulation has failed to become part of the regular “management toolkit” in the healthcare sector, in contrast with its success in manufacturing and service industries, and the military and defence sectors. The reasons for this remain unclear. The research presented here is a case study to evaluate the adoption (or otherwise) of one particular simulation modelling tool, Scenario Generator, which was developed by the SIMUL8 Corporation in a collaborative partnership with the UK’s National Health Service Institute for Innovation and Improvement. In this talk we present a brief summary of barriers and facilitators to the successful use of the Scenario Generator software itself, but the main aim is to focus more broadly on factors influencing the successful adoption of OR models in general within healthcare organisations. The insights gained in this case study are relevant to improving the uptake of OR modelling in general within public sector organisations anywhere in the world.

Solving Data Analysis Problems with (Global) Optimization Tools*Emilio Carrizosa*

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Abstract: Many Statistical Data Analysis tasks lead in one way or another to Global Optimization problems, which may include continuous and integer variables, and may have a very large number of variables, making exact Global Optimization impossible. Different problems recently addressed by our research group will be analyzed. These include problems in Supervised and Unsupervised Classification, and Principal Component Analysis as well. The problems will be described, formulated, and results obtained when solving them will be discussed.

Multi-Objective Variable Neighborhood Search*Abraham Duarte*

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Abstract: Solutions to real-life optimization problems usually have to be evaluated considering multiple conflicting objectives. These problems have been mainly solved with evolutionary algorithms. In this talk we will explore the adaptation of the Variable Neighborhood Search metaheuristic (VNS) to solve multi-objective combinatorial optimization problems. In particular, we describe how to design the shake procedure, improvement method and acceptance criterion within the variable neighborhood search schema, when two or more objectives are considered. Using the previous ideas we propose an adaptation of RVNS, VND and GVNS for solving multi-objective optimization problems. We validate these proposals by considering a challenging bi-objective problem, which includes two well-known NP-hard problems (i.e., the anti-bandwidth maximization and the cutwidth minimization problems). We report empirical tests over 20 instances and we show that the proposed heuristics outperform reference methods in the multi-objective community (NSGA-II and SPEA2).

Oligopolistic Location and Capacity Allocation with Competing Customers*Athanasia Karakitsiou¹, Athanasios Migdalas²*¹ Department of Business Administration, Technological Educational Institute of Serres, Serres, karakitsiou@teiser.gr² Department of Mathematical and Physical Sciences, Faculty of Engineering, Aristotle University of Thessaloniki, Thessalonica, samig@gen.auth.gr

Abstract: We consider modeling competitive location and capacity allocation situations in which customers incur the transportation costs and, moreover, they may compete for the offered level of services. The cases of fixed, elastic and stochastic demands are considered. We present bilevel and multilevel programming models which are interpreted and analyzed in game theoretic terms. The issues of optimality conditions and computational complexity are also discussed. Tailored population based metaheuristic algorithms are developed and preliminary computational results are given.

Keywords: Oligopoly, facility location, capacity allocation, bilevel programming, multilevel programming, Nash equilibrium, team games, Stackelberg strategy, optimality conditions, population-based metaheuristics.

Are All Failures in Delivering Projects ‘On Time Within Budget’ Really Inevitable?*Zohar Laslo*

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Abstract: The improvement in the organization of project control is a major challenge facing project organizations today. Control systems consist of inspection routine, present views and implementation of coordination when deviation from the planned trajectory is discovered. The disability of control systems to reduce failures in delivering projects ‘on time within budget’ derives mainly from the defective practice of choosing simple solutions for complex problems which are invariably wrong. Inspection timetable on the basis of time or cost intervals disables the display of realistic present views since in contrary to production and process systems where the output can be continuously measured, the outputs during the course of the project’s advancement are mostly immeasurable. By utilizing the deterministic ‘critical path model’ for assessing the project completion time the project manager is grossly misled into thinking that the chance of ‘on time within budget’ delivery is very good when in reality it is very poor. Moreover, coordination aimed at the reestablishment of the project targets is inferior when uncertainties are not taken into consideration. Control routines with rational timetabling of the inspection points, present views based on Monte Carlo simulations and coordination that takes into consideration the impact of the execution mode on time and cost uncertainties that derive from different sources may enable the attainment of project deliveries ‘on time’ and as much as possible ‘within budget’ when prevalent control routines cannot.

Keywords: Project management, uncertainty, project control, corrective actions, execution modes, time-cost tradeoffs, Monte Carlo simulation.

Supercomputing for Bigdata: Dataflow vs. Controlflow (The Programming Paradigm and the Ongoing Research)*Veljko Milutinović*

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Abstract: DataFlow computers, compared to ControlFlow computers, offer speedups of 20 to 200, and power reductions of about 20. However, the programming paradigm is different. This talk explains the paradigm, using Maxeler as an example (Maxeler is 20% owned by JPMorgan), and sheds light on the ongoing research in the field.

Some Successful Applications of Variable Neighborhood Search

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Abstract: Variable Neighborhood Search (VNS) is a simple and effective metaheuristic for solving combinatorial and global optimization problems. It is based upon systematic changes of neighbourhoods both in a descent phase, to find a local minimum, and in perturbation phase, to escape from their valleys. VNS have been successfully applied to many problems with real applications. We survey some of the most relevant successful applications of VNS appeared in the literature.

Assessment of the consequences of a given accident (its effects on human life, traffic efficiency, property and environment) are also accomplished through a similar approach. By integrating these assessments into the simulation model, the risks generated by each vessel, as it moves along the Strait, are calculated in regard to the natural and man-made conditions surrounding it (such as, vessel characteristics, pilot/tugboat deployment, proximity of other vessels, current & visibility conditions, location in the Strait etc.). A series of scenarios (regarding vessel arrival rates/scheduling policies, pilot captain deployment, local traffic density, current & visibility conditions, etc.) are experimented with, leading to some interesting observations and policy indications. Results obtained will be presented and discussed.

Keywords: Risk analysis, simulation, logistics.

A Simulation Based Risk Analysis Study of the Maritime Traffic in the Istanbul Strait

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Abstract: Development and results of a simulation based risk analysis study for the Istanbul Strait will be presented. In this study, first, a simulation model for the transit traffic in the Strait (which considers traffic regulations, vessel profiles, pilotage/tugboat services, meteorological and geographical conditions) is developed. Regarding risk assessment, two sets of factors are sought for during the execution of each transit: the probability and potential consequences of an accident, at various points along the Strait during that transit. Then, as a simulation run proceeds, the risks generated by each transit vessel, at different regions of the Strait, are assessed by multiplying and aggregating these two sets of factors.

Since, vessel and environmental conditions associated with each transit are generated in the simulation, the conditional probability of an accident, under a given setting of various accident causing factors is sought for. However, historic accident data is insufficient for a proper statistical consideration of all possible settings of these factors; so, in parallel to many other risk assessment studies, subjective expert opinion is relied upon in estimating these conditional accident probabilities. Expert opinion on accident probabilities is extracted through questionnaires focusing on pairwise, uni-dimensional comparisons of factor settings (while keeping the remaining factors at pre-determined fixed levels).

Worst-case Analysis under Severe Uncertainty

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Abstract: A close examination of the state of the art in areas such as decision under severe uncertainty and robust optimization reveals that, for all the advances over the past fifty years, the seemingly simplistic, some might say naive, „worst-case“ approach to uncertainty continues to dominate the scene. In this presentation I examine this stalwart of non-probabilistic modeling of uncertainty and I explain some of the subtle (mostly modeling) issues associated with its use and misuse in such areas as climate change, economics, ecology, homeland security, finance, risk analysis, and so on. I also take the liberty of speculating on why, despite its obvious (and not so obvious) weaknesses, it will probably remain the preeminent approach to severe uncertainty in the area of robust decision-making, thus continuing to challenge the modeling (and rhetorical) skills of scholars, analysts, and decision-makers.

Keywords: Robust optimization, constraints satisfaction, responsible decision-making, severe uncertainty, non-probabilistic uncertainty, worst-case analysis, local robustness, global robustness, Black Swans, unknown unknowns.

Sustainable decisions using a multicriteria approach

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CONTRIBUTERS

■ B1 BANKING & FINANCIAL DECISION MAKING

Licensing Mechanisms under Returns to Scale

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Abstract: Patents provide inventors with diffusion control of their inventions during a period of time. Thus, a patent acts as incentive for innovation. The licensing policies are categorized in up front fee, per unit royalty and ad valorem royalty. In this paper we study the licensing of a cost reducing innovation by an internal patentee. The analysis considers a Cournot duopoly characterized by non-constant returns to scale. The patentee chooses strategically whether to charge a per-unit or an ad-valorem royalty to the other firm in the industry. Our results indicate that an internal innovator may generate different incentives for his licensing contract depending on the cost reduction imposed by the use of the new technology.

Keywords: Patent, licensing royalty, Ad-valorem, Cournot duopoly, game theory.

Integrating FAHP and FCOPRAS for Evaluating Financial Performance

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Abstract: Financial performance evaluation is very important in a highly competitive environment for companies, so an accurate and appropriate performance evaluation is critical. Financial performance indicators must be carefully identified in the evaluation process because they reflect the competitiveness of a company. Generally, accounting measures are used for performance evaluation. However, these measures are not sufficient for performance evaluation solely in the modern industry time. So, value based measures have recently been introduced to express the company value. In this study, a hybrid approach is proposed for financial performance evaluation of automotive parts manufacturer companies traded on Tehran stock exchange (TSE). For this purpose, a hierarchical financial performance evaluation model is structured based on the accounting measures and value based measures. In this approach fuzzy analytic hierarchy process (FAHP) was applied to determine the weight of the criteria and then the companies are ranked by using fuzzy complex proportional assessment (FCOPRAS) that presented basis on crisp COPRAS by this study.

Keywords: Financial performance, fuzzy analytic hierarchy process (FAHP), fuzzy complex proportional assessment (FCOPRAS).

Ranking of Banks Using Logical Aggregation

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Abstract: Banks have an effective role in the economical, social and political development of every country. Thus, it is of essential importance to evaluate bank performance. The ranking of banks according to their performance is important for creditors, investors and stakeholders since it determines bank's capabilities to compete in the sector. The aim of this paper is to rank the largest banks in Serbia using logical aggregation (LA) based on interpolative Boolean algebra (IBA). LA has the ability to aggregate mutually dependant factors properly as well as to model logical connection among them. To evaluate overall performance in more objective and transparent manner, instead of a single criterion, both financial and non-financial

factors are taken into consideration. Our multi-criteria model enrich the insight into the bank performance and provides better ranking and post-ranking analysis.

Keywords: Bank performance, ranking, interpolative Boolean algebra, logical aggregation.

Structure and Performances of the Sectors in Serbian Economic Development

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Abstract: Economic growth and development can be based on different sectors. Depending on the available resources, each country tries to invest in the sectors that will push forward its economic activity. The paper analyses Serbian economy, i.e. its structure and performance of industry sectors. Optimization model has been used to show the sectors (activities) to invest in for achieving better economic performances. The results show that the sectors important for achieving economic progress are information and communication, professional, scientific and technical activities, financial and insurance activities, and transportation and storage.

Keywords: Economic development, industry sectors, Serbia, optimization.

■ B2 COMBINATORIAL OPTIMIZATION & INTEGER PROGRAMMING

To Schedule a Two Stage Flowshop Problem with n Jobs and m Machines

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Abstract: In this paper we propose a two-stage flowshop scheduling problem with two independent machines in the first stage to process two different products but each product must go through $(m-2)$ common machines for the remaining processes. The problem arises in manufacturing environment such as power transmission tower industry in which profiles with different sizes first go through different types of machines and then through a series of common machines for other processes. The objective of this problem is to minimize makespan. The special case of the problem, i.e., two-stage flowshop with one common machine, is known to be NP-HARD. Hence it is unlikely to find an optimum solution for the problem. Therefore two heuristics were proposed for solving the problem. The first is a heuristic which solves small size problem rather quickly, and the other is an algorithm developed by using Tabu Search methodology. The performance of the proposed algorithms were compared with the algorithm known as NEH. The computational experiments showed that the algorithm by using Tabu Search.

Keywords: Scheduling, multistage flowshop, tabu search.

One Application of the Sedimentation Algorithm for Solving Max-Sat Problem

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Abstract: Work presents one application of the Sedimentation Algorithm – general algorithm for solving combinatorial optimisation problems, proposed by author – for solving Maximum Satisfiability problem (MAX-SAT). It proves ability of the

Sedimentation Algorithm to be applied in the field of Boolean satisfiability problems, especially for the MAX-2SAT and MAX-3SAT cases. Computational results of the work contains comparison between the Sedimentation Algorithm and the best specific solvers for the MAX-2SAT and MAX-3SAT problems.

Keywords: Sedimentation Algorithm, Boolean satisfiability, MAX-SAT, MAX-2SAT, MAX-3SAT, solver, combinatorial optimisation.

A Hybrid Evolutionary Algorithm for Solving the Two-Stage Capacitated Facility Location Problem

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Abstract: The goal of the Two-Stage Capacitated Facility Location Problem (TSCFLP) is to choose locations for opening depots and plants, each with associated installation cost and capacity limit, and to design distribution plan to a given set of customers, such that total distribution and installation costs are minimized. We propose a hybrid metaheuristic method (HEA), which represents a combination of an evolutionary algorithm and two local-search heuristics for solving the TSCFLP. The proposed algorithm uses the CPLEX 12.1 solver incorporated in the HEA frame for efficient calculation of the fitness function. The described HEA approach is tested on modified data set from the literature and on a newly generated set of the TSCFLP instances with up to 2000 users, 200 potential locations for establishing depots and 50 potential sites for opening plants. The results of computational experiments show that the proposed HEA method quickly reaches all known optimal solutions, and also provides solutions on large-scale instances that could not be solved to optimality. Regarding the quality of HEA's solutions and short running times, we may conclude that the proposed HEA represents a promising metaheuristic method for solving the TSCFLP and other similar facility location problems.

Keywords: Two-level facility location, evolutionary algorithm, local search, combinatorial optimization.

Using T-Joins to Approximate Solutions for Min Graphic K-Path TSP

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Abstract: We consider a generalized Path Traveling Salesman Problem where the distances are defined by a 2-edge-connected graph metric and a constant number of salesmen have to cover all the destinations by traveling along paths of minimum total length. We show that for this problem there is a polynomial algorithm with asymptotic approximation ratio of $3/2$.

Keywords: Combinatorial optimization, polynomial approximation, T-joins, graphic TSP, depots.

The Freedom Degree Optimization Hypercylindric Function

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Abstract: We present the results of theoretical research of the generalized Hypercylindric function (HY) by generalizing two

known functions related to the sphere hypersurface and hypervolume and the recurrent relation between them. By introducing two-dimensional degrees of freedom k and n (and the third, radius r), we develop the derivative functions for all three arguments, and the possibilities of their use. The symbolical evolution, numerical experiment and graphical presentation of functions are realized using the Mathcad Professional and Mathematica softwares.

Keywords: Optimization, geometric hypercylindric function, special functions.

Symmetry Properties of Resolving Sets in Hypercubes

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Abstract: In this paper we consider some special characteristics of distances between vertices in the n -dimensional hypercube graph Q_n and, as a consequence, the corresponding symmetry properties of its resolving sets. It is illustrated how these properties can be implemented within a simple greedy heuristic in order to find efficiently an upper bound of the so called metric dimension $\beta(Q_n)$ of Q_n , i.e. the minimal cardinality of a resolving set in Q_n .

This heuristic was applied to generate upper bounds of $\beta(Q_n)$ for n up to 22, which are for $n \geq 18$ better than the existing ones.

Keywords: Graph theory, metric dimension, hypercubes.

■ B3

CONSTRUCTION PROJECT MANAGEMENT

A Conceptual Grey Analysis Method for Construction Projects Scheduling

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Abstract: Concerning engineers, project management is a crucial field of research and development. Projects of high uncertainty and scale are characterized by risk, primarily related to their completion time. Thus, safe duration estimations, throughout the planning of project management schedules is a key objective for project managers. However, traditional linear approaches fail to include and sufficiently serve the dynamic nature of activities' duration. On this ground, attention should be paid on designing and implementing methodologies that approximate the duration of the activities during the phase of planning and scheduling too. Grey analysis mathematical modeling seems to gain ground, since it gradually becomes a well-adapted and up-to-date technique for numerous scientific sectors. This paper examines the contribution of the logic behind the aforementioned analysis, aiming to predict possible future divergences of task durations in construction projects. Based on time observations of critical instances, a conceptual method is developed, for making duration estimations and communicating deviations from the original schedule, in a way that approximations will fit reality better. The whole procedure endeavors to investigate the decrease of uncertainty, regarding project completion time and reduce, up to a scale, a possible inaccurate estimation of a project manager. The utmost effort is about exploiting gained experience and eliminating the "hedghog syndrome". This is attainable by designing a reliable, easily updated

and readable information system. An enlightening example is to be found in the last section.

Keywords: Grey analysis, information system, project management, technical constructions, uncertainty.

One Approach in Business Plan Scenario Development in Case Study – Railway Transport of Montenegro

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Abstract: After the first steps in railway system reforming process, a railway operator starts operating and making its own plans on an independent basis, with regards on the business achievements. Middle and long-term business planning in railway companies makes very complicated process which contains a number of interest groups, levels of decision making, with a certain amount of risk. One of the most important topics of a business plan is to choose a proper development scenario. The paper deals with the practical problem – solving development scenario selection for railway passenger transport operator, using Fuzzy Analytic Hierarchy Process approach.

Keywords: Business plan, Railway operator, Fuzzy-AHP approach.

■ B4 DATA ENVELOPMENT ANALYSIS & PERFORMANCE MEASUREMENT

Application of the Cooper-Framework for Evaluation of the Efficiency of Bank Branches

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Abstract: In this paper is presented the possibility of applying the COOPER-framework to evaluate the relative efficiency of the bank branches of one bank. The six phases of the framework, which are interrelated, are being followed in the empirical study, and their sub-phases are adjusted. The application of the framework is described in the paper, and also the benefits arising from its use are being indicated.

Keywords: COOPER-framework, DEA window analysis, banking, efficiency.

Cross-Efficiency Evaluation under the Principle of Rank Priority of DMUs

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Abstract: Cross-efficiency evaluation has been suggested as an alternative method of efficiency evaluation and ranking in data envelopment analysis (DEA) based on peer evaluation logic. A factor that possibly reduces the usefulness of the cross-efficiency evaluation is that cross-efficiency scores may not be unique due to the presence of alternative optima. As a result, it is recommended that secondary goals should be introduced in cross-efficiency evaluation. This paper seeks to improve the secondary goal proposed by Wu et al. [Expert Systems with Applications, 36, 4826-4829, 2009] by introducing two models that could be used as secondary goals to choose suitable weights in cross efficiency evaluation. Proposed methods consider the performance ranking of DMUs by optimizing the rank of each DMU under evaluation. An advantage of the proposed methods is that the obtained weights can reflect the relative strengths of the DMU

which is under consideration. Numerical examples are provided to illustrate the approaches.

Keywords: Data envelopment analysis (DEA), cross efficiency, secondary goal, ranking.

Determining the Relative Efficiencies of Manufacturing Companies in Istanbul Stock Exchange by Using Data Envelopment Analysis

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Abstract: Manufacturing industry has an important impact on the economic growth of Turkey. The developments in this sector directly affect economy. Manufacturing industry comprises various sub sectors which demand different inputs form other sectors. Because of these reasons, the trends in manufacturing industry can be leading indicators for the future of economy. In this paper, relative financial efficiencies of 155 companies that are quoted to Istanbul Stock Exchange in 2011 have been evaluated by using data envelopment analysis. Data envelopment analysis is a linear programming based method which is frequently used in both public and private sectors in order to evaluate the relative financial efficiencies of companies. Also the financial situations (basic efficiency) and the ranking of all companies (super efficiency) are determined in this research. In data envelopment analysis, fixed yield assumption according to the scale has been considered. EMS 1.3 (Efficiency Measurement System 1.3) package programme is used for data analysis. Totally 6 inputs and 4 outputs variables are used by considering 2011 data for data envelopment analysis.

Keywords: Data envelopment analysis, efficiency measurement, manufacturing industry.

Corporate Performance Evaluation by a Combined Approach of Balanced Scorecard (BSC) and Fuzzy Multi-Criteria Decision Making (FMCDM)

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Abstract: Assessment and performance improvement is considered by many corporate and organization managers. By increasing the strategic management and quality management programs in organizations, the need for a comprehensive plan for performance management methodology is more evident than ever. One of the most widely used models in the context is balanced scorecard model that balances all aspects of the organization concerned. In this study, taking into account the strengths of the BSC model, the combination of BSC and fuzzy multi-criteria decision making techniques was used for performance evaluation. This study aimed to evaluate performance of DAMDOSHAN corporate, after initial review of the four BSC model and designing the questionnaire and collecting data, importance degree of the main dimension of BSC model was calculated by FANP and corporate performance was prioritization and compared by FTOPSIS. The findings show that the main "customer" with importance degree (0.303) was the most importance of the main criterion and "financial" (0.276), "internal processes" (0.215) and "learning and growth" (0.204), respectively were other dimensions of performance evaluation in dairy companies. The best performance dimensions in DAMDOSHAN, respectively were "customer" and "financial" and the worst were "Internal Processes" and "Learning and Growth". Compared to three other companies in the area in terms of overall performance, DAMDOSHAN has second priority after KALEH.

Keywords: Performance evaluation, balance scorecard, fuzzy multi criteria decision making.

Measuring and Analysis of the Key Performance Indicators in an Industrial Enterprise Applying Information System

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Abstract: The paper presents the results of measuring and analyzing of the key performance indicators (KPI's) in a complex industrial company, applying the model of the specially developed client application for managing of the performance in the industrial company. The aim of this study was to demonstrate that the general approach and principles of organization and management of an industrial enterprise - based on the integration of its functions are universally valid and that it is possible to establish a standardized system of criteria - parameters (performances) of the process, which in required and sufficient measure reflect the effectiveness of the overall success of the industrial enterprise. Research results, also, indicate that applying of the particular model for the measurement of KPI's in the industrial company, supported by company's information system, completely legitimating stated needs, that company information system, beside its basic role related to automation of the business process, to be extended on the elements that can provide process of analysis.

Keywords: Process quality industrial company, key performance indicators (KPI's), control, IT.

Efficiency Measurement of NBA Players using Data Envelopment Analysis

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Abstract: One of the most complex calculations in every business is efficiency assessment. As sports are one of the biggest industries, efficiency analysis is crucial for decision making. In order to evaluate NBA player efficiency, which is based on multiple inputs and outputs data envelopment analysis is used. In this paper 26 NBA player were evaluated. This analysis provides efficiency and rank of each player, not only obtained by DEA, but with NBA efficiency evaluation methods. Furthermore, NBA efficiency evaluation methods are compared with DEA.

Keywords: Data envelopment analysis, efficiency analysis, basketball players.

Process Management and Six Sigma Methodology the Platform for Increasing the Efficiency of Processes

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Abstract: Business Process Management hasn't methods for removing steps in processes which are identified in analysis as inefficient or ineffective. Tools and techniques from Six Sigma are borrowed for those tasks. Six Sigma methodology is focused on defining, measuring, analyzing, improving, and controlling business processes. Process Management tools, and the problem solving methodology of Six Sigma, have come together to increase the efficiency, effectiveness, and ongoing control of a process to levels of performance. This paper will attempt to provide answers and defining tasks:

- How Six Sigma-based process improvement initiatives can be used on processes across the enterprise, not just manufacturing processes.
- How Six Sigma and BPM combined offer one of the most powerful process improvement solutions possible.

- Defining steps delineated below to integrate BPM and Six Sigma.
- Defining the tasks for managers in Serbia in the future.

Keywords: Business process management, six sigma, process improvement.

Assessing Efficiency of the Tax Administration by DEA and Regression Analysis

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Abstract: In this paper, we analyse the performance of the tax administration using data envelopment analysis (DEA) and regression analysis in thirteen European countries. In the first phase, DEA input-oriented model with the three input and two output parameters has been used for the efficiency evaluation. The influence of selected independent variables on grey economy, which represents an approximation of tax evasion and efficiency of tax administration, was conducted by regression analysis in the second phase. The main goal is to investigate influence of the relative efficiency and number of employees in tax administration as well as country employment rate on grey economy level.

Keywords: Tax administration, data envelopment analysis, regression analysis.

An AMPL Optimization Software Library for Data Envelopment Analysis

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Abstract: This work presents a new optimization software library, which includes a number of Data Envelopment Analysis (DEA) models. All the DEA models have been implemented in the AMPL algebraic modeling language for mathematical programming and solved using either Gurobi Optimizer v5.5 or MINOS v5.51 (for those models having general nonlinear objectives). In order to verify the correctness of the results, real world datasets have been examined and solved using the well-known commercial DEA Solver Pro v8.0c by SAITECH, Inc. We also present a literature review of both commercial and non-commercial DEA software packages and discuss about the benefits and drawbacks of our proposed DEA model library.

Keywords: Optimization software, AMPL, data envelopment analysis.

Incorporating User Preferences in DEA with Ordinal Regression

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Abstract: Value-based DEA is a recent development that resorts to value assessment protocols from multiple criteria decision analysis (MCDA) to transform the original input/output data to a value scale, thus driving the efficiency assessments in line with individual preferences. In this paper, we present a piece-wise linear programming approach to value-based DEA by employing a data transformation-variable alteration technique and assurance region constraints. We propose a hybrid approach to incorporate the decision maker's value functions in the context of DEA through ordinal regression.

Keywords: Data Envelopment Analysis (DEA), value-based DEA, ordinal regression.

The Use of DEA for Determining the Adequacy of Operation of Business Decision-Making Units in Health Care

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Abstract: The authors of the article deal with the quantitative analysis of results of the development of health care services. The aim of the article is to determine the key conditions for measuring the results of health system functioning and evaluation of its adequacy. The research question focuses on the method of measuring the operational efficiency of Slovenian hospitals. The introduction defines efficiency within the concept of adequacy and its dimensions of efficiency, accessibility and quality. The empirical part of the article presents the use of the DEA method for determining the adequacy of operation of hospitals on the basis of data on Slovenian hospitals. It is apparent that the model for the evaluation of adequacy of operation of hospitals is suitable within limitations. The interpretation of results is hampered by inadequately structured data and non-transparent prices of hospital services. Therefore, the results of the research indicate the direction in which the database should be developed to ensure greater comparability in a rather heterogeneous population of hospitals. Furthermore, the authors point out that new indicators, reflecting the condition of the dimensions of adequacy, should be included in the model for the purposes of the evaluation of adequacy. On the basis of the results of the research, the question of implementing suitable methods of planning and controlling the adequacy of the functioning of health care into practice arises.

Keywords: DEA method, linear programming, health care, efficiency, adequacy

■ B5 DATA MINING ANALYTICS FOR BUSINESS INTELLIGENCE

The R Language in Business Intelligence

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Abstract: Business intelligence is currently very topical in the world and represents a continuation of the information decision support system with which it is closely related. The beginning of development is closely linked to automation of business process in the company. Different transaction systems have proved to be very high quality generators of large amounts of data that made the 'explosion' of data. So, the creation of a huge database needed to be simple or easier to access. A growing awareness of the usefulness of information has contributed to the development of the new discipline called Business Intelligence (BI). The development of technology, computers and the Internet has significantly contributed to easier organization of data, which would also become more useful if turned into information and knowledge. Knowledge can refer to the users of products and/or services, or the market in which the company operates. From the perspective of the enterprise, the business intelligence system places the primary emphasis on the users of products and services. Data mining combines concepts, tools and algorithms of machine learning and statistics to analyze very large data sets, so as to gain insight, understanding and effective knowledge, and it is applied for this purpose in many organizations. In the recent years, the market of data mining tools has become more and more flooded, with more than fifty commercial tools. R is statistical software, and an object-oriented high-level programming language used for data analysis, which includes a large number of statistical procedures such as t-test, chi-square test, standard linear models, instrumental variables estimation, local regression polynomials, etc. The R language has built-in functions for the nearest neighbor method allowing the automatic classification, the

association rules showing the connection probability between two or more events, decision tree models, numerous methods of single and multiple regression, and many others, which makes it a very high-quality tool in data mining techniques.

Keywords: R language, business intelligence.

Applicability of Linguistic Summaries

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Abstract: Linguistic summaries are able to reveal relational knowledge about the data providing a human consistent summarization of large databases by fuzzy SQL-like query language. The validity of a linguistic summary depends on membership functions of summarizers and quantifiers. The paper examines their creation and usage in different part of data management: estimation of missing values, support decision making and data dissemination. Linguistic summaries provide information to users keeping data which are either confidential or not free of charge hidden. Also linguistic summaries do not burden decision makers with large tables of numbers but offer them relational knowledge extracted from a databases.

Keywords: Linguistic quantifiers, linguistic summarizer, data mining, database.

Evaluating Autoencoder Neural-Networks as a Dimension Reduction Tool for Topic Prediction

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Abstract: Topic prediction is an important task in the area of text-mining, aiming to discover a way to predict complex topics within textual documents. Since the models of documents are usually expressed in a very high-dimensional space, dimensions being possible words, it is important to first reduce the dimensionality of this space. Existing algorithm mostly rely on a standard method for dimensionality reduction, namely the Principle component analysis. This study explores the use of autoencoder neural networks as an alternative for this task, and presents some experimental evidence of the performance, also compared to the PCA.

Keywords: Autoencoder, Neural-networks, Dimensionality reduction, Topic prediction, Machine learning.

A Novel Approach to Hierarchical Clustering Based on Logical Measure of Dissimilarity

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Abstract: This paper proposes an approach to hierarchical clustering based on a logical measure of dissimilarity. The proposed approach is a one step further toward including logic theory in the process of clustering. The proposed logical measure is interpolative-type generalization of the exclusive disjunction relation. In order to use it as a measure of dissimilarity we prove reflexivity, symmetry and triangle inequality. Further we incorporate it in a standard form clustering algorithm. The proposed approach is tested on the exemplary study of cluster-analysis of the European countries by their macroeconomic performances. The results are compared with the same clustering algorithm based on Euclidean distance function as a measure of dissimilarity. Comparative analysis of the results shows great differences indicating that "more closer" does not necessarily mean "more similar".

Keywords: cluster analysis, hierarchical clustering, proximity relation, dissimilarity relation, interpolative relation, interpolative Boolean algebra.

■ B6 DECISION SUPPORT SYSTEMS

ETO ERP Software Evaluation using Multi Criteria MACBETH Model

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Abstract: This study deals with how to evaluate appropriate Engineering-to-Order Enterprise Resource Planning (ETO ERP) software of the common drawbacks associated with ETO manufacturing approach. ETO ERP supports the requirement of companies that manufacture products based on unique engineering designs. ETO products require special processes for estimates, purchasing materials, engineering changes, cost allocation and etc. to manage process. Many domestic ETO companies are not strong enough and many have closed their business under big order loss because of lack management skills. Thus, ETO ERP software evaluation requires critic assessment and is one of the multi criteria decision making problems in strategic manufacturing. To solve this problem, this study utilized the Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) model to quantify the attractiveness and repulsiveness of possible alternative ERPs. This model defines quantitative performance expression and aggregation from qualitative pairwise comparisons of situations issued from the decision-maker. The model illustrated the best alternative ETO ERP software, considering five main criteria which were manufacturing management, inventory management, purchasing management, quality management, and product technology.

Keywords: ERP, ETO, MACBETH, MCDM.

Web DSS for Bio-Energy Projects Evaluation: The Poland Case

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Abstract: In order to comply with the goals set in the EU Directive 2009/28/EC Poland will have to reach the 15% electric energy share from renewable energy sources (RES) in 2020. Around 90% of this share is going to come from solid biomass co-fired with coal and lignite in the main-network power stations. It has been calculated that the 15% biomass share in RES-E will require a total cultivation area of perennial energy crops of about 1 million ha [Zaliwski et al., unpublished results] while the current area of perennial plantations equals about 10,000 ha. Bio-energy issues constitute spatially dependent problems by definition due to the state-of-the-art technology and the bulky nature of biomass. Moreover, biomass profitability is linked to the structure and perspectives of the arable cropping systems since these are able to supply considerable quantities in the short and medium term required to fulfil the ambitious targets aimed at by policy makers. Therefore, appropriate tools are necessary to enable a comprehensive analysis and support decisions of policy makers, industry, researchers and farmers.

A Web Spatial DSS has been developed in order to facilitate the planning of the introduction of straw biomass for energy in the case of Poland. The DSS has the conventional, model-driven architecture, comprising four components (subsystems): a language layer, a presentation layer, a database and a problem-processing engine. The language and presentation layers are integrated into one interface capable of handling both spatial and non-spatial data. In this paper, the structure of the web spatial DSS is initially presented followed by an extended presentation of the underlying decision support model. Finally preliminary results from the Poland case study are presented.

Keywords: Web based Spatial DSS, Energy crops, Poland.

Spatial Multi-Criteria Decision Analysis for Industrial Site Selection: The State of the Art

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Abstract: Site selection is one of the basic vital decisions in the start-up process, expansion or relocation of businesses of all kinds. Starting from the meeting criteria defined in the business strategy, location selection process begins as recognition of existing or projected need to meet new or growing market. Recognition of the need to initiate a series of activities directed for looking geographical area and specific location. Conquer new territories for business starts collecting geopolitical data, where location is a part of it. The selection of an industrial site involves a complex array of critical factors involving economic, social, technical, environmental, political issues, etc. It is obvious that many factors must be involved in the decision-making process, which makes the problem challenging choice in the selection of appropriate tools to enable concentration data, information and knowledge. New trends in information technologies put Geo-information technology in the center of events in industrial locations science. Like any technology that is trendy Geographic Information Systems have exaggerated the benefits and latent defects, but in choosing the industrial location allowing multi-criteria decision making based on space and time, in this time of technology are indispensable. Geographic Information Systems are used in conjunction with other systems and methods such as expert systems (ES), systems for decision making (DSS) and the method for multi-criteria decision making (MCDM). This paper presents the state of the art in Spatial multi-criteria decision analysis for industrial site selection.

Keywords: Industrial site selection, Geographic Information Systems (GIS), Multi-criteria decision making (MCDM), Decision Support Systems (DSS).

An Example of Secure Android Application in SOA-Based Mobile Government System

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Abstract: In this paper, we consider an overview of a possible secure model for m-government system. The proposed model is based on secure mobile application and SOA-Based central platform. The model additionally consists of external entities, such as: PKI, XKMS, Authentication Server, UDDI and Time Stamping server. The proposed model could be used in different local and/or cross-border m-government scenarios. As a possible example of described secure mobile application we considered a secure Android based Web services application for which some experimental results are given.

Keywords: Android based mobile phone application, m-government, Web Service, SOAP protocol, XML-Security, WS-Security, XKMS protocol, SAML, timestamp.

Towards a Web Based Decision Support System for Choosing Higher Education Studies

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Abstract: The vocational orientation of youngsters that are about to enter, study at, or have recently graduated from higher education (HE)

institutions, as well as linking between HE and labour market are two research areas that have not been investigated extensively in Balkan countries. Among the tools used in vocational orientation are the job (or occupational) profiles that provide standardized and digitized descriptions of different professions. This article focuses on the analysis and design of a web based decision support system (a digital guide) aiming to assist its users in getting thoroughly informed about and eventually in choosing HE studies in Greece, in relation to their vocational prospects. Apart from reviewing related previous research work and relevant web based systems, main elements of the system's analysis and design, extensions that could lead to even more powerful systems and conclusions about the advantages, limitations and practical application of the digital guide are presented.

Keywords: Computer assisted studies guide, vocational orientation, higher education, specialty of studies, decision support system, System analysis and design.

A Decision Support System for Parallel Machine Scheduling Using Simulated Annealing

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Abstract: Parallel machine scheduling is a particular type scheduling problem that occurs where there is more than one machine performing the same task in the same environment. Scheduling in parallel machine environment is important from both the practical and theoretical points of view. In this study, a Decision Support System (DSS) is designed for parallel machine scheduling problem with sequence dependent setup times and due dates. The scheduling model of the decision support system uses simulated annealing meta-heuristics. In the solution process, each schedule is established for several different objectives such as the minimization of makespan, total tardiness, maximum tardiness, number of tardy jobs. Thus the proposed DSS gives alternative schedules to decision makers and makes possible to choose appropriate one by demonstrating tradeoffs between alternative solutions for shop-floor.

Keywords: Decision support system, parallel machine scheduling, sequence dependent setup times, simulated annealing.

■ B7 E-COMMERCE IN OPERATIONS MANAGEMENT

Introducing M-Health Education Applications in the Health System of Serbia

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Abstract: Mobile health (m-Health) is a rapidly growing field providing the potential to enhance numerous issues such as: patient education, prevention of diseases, enhancement of diagnostically procedures, improvement of proposed medical treatments, lower health care costs and increases access to health care services. m-Health Education is the name given to an emerging new set of applications of mobile devices to the training, testing, support and supervision of health care workers, as well as to the provision of health information to individuals. The paper describes research into the application using m-HealthEd in Serbia. The study included 200 patients on anticoagulant therapy and lasted for one year. Patients entered the measured values of INR in blood in m-HealthEd application. m-HealthEd application help healthcare workers to conduct diagnoses and decide on appropriate treatments, or medical assistance for individuals. The applications have an educational

aspect and the main aim is directly improving the delivery of healthcare services. The survey results indicate that 59% of patients used m-HealthEd application throughout the research. The percentage is very high, especially considering the aspect of the patients' age (median is 61 years of age).

Keywords: Healthcare, m-Health, m-Health Education.

■ B8 GAME THEORY

A Survey of Game-Theoretic Approaches in P2P Networks

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Abstract: Game theory constitutes a mathematical method for rational decision making in competitive and conflicting situations under specified rules, and thus is closely associated with decision theory. The applicability and usefulness of game theory have already been proved in the research area of network optimization. Applications of strategic games arise in the design of communication networks, wireless sensor networks, P2P networks and others. P2P networks consist of autonomous nodes that not only collaborate for sharing and consuming resources but also act independently and governed by selfish motives. Thus, game theoretic solutions lend themselves well for problems arising in P2P networks. The proposed work surveys the recent developments on game-theoretic approaches in P2P networks. We provide a classification of approaches dealing with problems in various areas of P2P systems, such as peer incentives, trust, formation of overlay networks, routing and others.

Keywords: Network Optimization, Game Theory, P2P networks.

Nash Equilibrium for Stochastic Differential Games with Incomplete State Information

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Abstract: In this article, we consider N-person stochastic differential non-zero sum games with incomplete state information of a diffusion process. It is assumed that every player in the game has the accurate information only for some components of a state vector. The problem is solved, first in the form of feedback on the known components of the state, available to the appropriate player and then in the form of feedback on the known components of the state and the state probability density. The Fokker-Planck-Kolmogorov equation transforms the initial problem into deterministic non-zero sum games with distributed parameters. The Krotov extension principle is used to state sufficient conditions for the Nash equilibrium solution.

Keywords: Stochastic differential games non zero sum, feedback control, incomplete information on state vector, partially observed control, Nash equilibrium control, Fokker-Planck-Kolmogorov equation.

■ B9 HEURISTICS, METAHEURISTICS & NATURE INSPIRED OPTIMIZATION ALGORITHMS

Diagnosis of Cardiovascular Diseases Using Neural Networks

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Abstract: A parallel committee machines technique for neural network systems with back propagation together with a majority voting scheme is presented in this paper. Previous research with

regards to predict the presence of cardiovascular diseases has shown accuracy rates up to 72.9% but it comes with a cost of reduced prediction accuracy of the minority class. The designed neural network system in this article presents a significant increase of robustness and it is shown that by majority voting of the parallel networks, recognition rates reach to > 90 in the V.A. Medical Center, Long Beach and Cleveland Clinic Foundation data set.

Keywords: Machine learning, parallel neural networks, boosting by filtering, cardiovascular diseases.

An Artificial Bee Colony algorithm for Multicast Routing Problems

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Abstract: Recently, a number of swarm intelligence algorithms based on the behaviour of the bees has been presented. These algorithms are divided, mainly, in two categories according to their behaviour in the nature, the foraging behaviour and the mating behaviour. The most important approach that is inspired by the foraging behaviour of the bees is the Artificial Bee Colony (ABC) Algorithm. Artificial Bee Colony (ABC) optimization algorithm is a population-based swarm intelligence algorithm that was originally proposed by Karaboga and Basturk and it simulates the foraging behaviour that a swarm of bees perform. In this algorithm, there are three groups of bees, the employed bees (bees that determine the food source (possible solutions) from a prespecified set of food sources and share this information (waggle dance) with the other bees in the hive), the onlookers bees (bees that based on the information that they take from the employed bees they search for a better food source in the neighborhood of the memorized food sources) and the scout bees (employed bees that their food source has been abandoned and they search for a new food source randomly). In this paper, a hybridized algorithm for the solution of the multicast routing problem is presented. Routing has always been of immense importance in communication networks due to its impact on the network performance and the significance of scalable and adaptive routing has sky-rocked during the last decade as a consequence of the ever increasing demand for Internet and mobile communications. A routing algorithm selects one or more paths over which devices communicate with each other. The selection of these paths is based on the status of the network and optimization criteria aiming at maximizing network performance by pursuing e.g. optimization of resource utilization, or/and minimization of congestion (packet delay), or/and minimization of packet loss, etc. Due to these facts, routing problems are combinatorial optimization problems which differ with respect to type, i.e., a routing may be of unicast, multicast or anycast type depending on the number of communicating devices, with respect to the network topology which may be of fixed infrastructure or of ad-hoc wireless infrastructure. The results of the algorithm are compared with the results of a number of versions of Particle Swarm Optimization algorithm.

Keywords: Artificial Bee Colony, Particle Swarm Optimization, Variable Neighborhood Search, Multi-cast Routing Problem.

VNS for Correcting Infeasible GPD Estimation Methods

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Abstract: Generalized Pareto distribution (GPD), as a stochastic model for excesses over high thresholds, has numerous applications in hydrology, ecology, finance, and other fields. Successful application in any of these fields requires efficient method for estimating parameters of the distribution. The best known and the simplest GPD estimation methods are method of moments and

method of probability-weighted moments, which are often used as first steps in more complicated estimation procedures. However, both methods in large number of cases produce infeasible, therefore inapplicable, parameter estimates. The goal of this paper is to give practical recommendations on how to fix the infeasibility of these methods and obtain estimates with desired properties (minimum bias/error or maximum likelihood) at the same time. This is done by introducing more general estimates, depending on additional parameters, and using a variant of Variable Neighborhood Search to minimize the corresponding objective functions.

Keywords: Generalized Pareto distribution, method of moments, method of probability-weighted moments, variable neighborhood search, global optimization.

Comparison of Different Variable Neighborhood Search Strategies for Solving the Bipartite Unconstrained 0-1 Quadratic Programming Problem

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Abstract: This work presents new heuristic algorithms based on the Variable Neighborhood Search methodology for solving the Bipartite unconstrained 0-1 Quadratic programming Problem (BQP). Given a bipartite graph $G = (I;J)$, the problem consists of selecting a subgraph $G_0 = (I_0;J_0)$ which maximizes the cost of the nodes in the sets I_0 and J_0 plus the costs of the edges between them. BQP has applications in approximating matrices by a rank-one binary matrix and calculating cut-norm of matrices. It can also be used to solve other well-known optimization problems like Maximum Weight Biclique, Bipartite Maximum Weight Cut, Maximum Weight Induced Subgraph, etc. We propose an experimental comparison illustrating that our proposal is competitive with the state-of-the-art algorithms.

Keywords: Variable Neighborhood Search, Bipartite unconstrained 0-1 Quadratic programming Problem, Metaheuristics.

A General Neighborhood Search for Traveling Salesman Problem with Draft Limits

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Abstract: Traveling Salesman Problem with Draft Limits (TSPDL) is a new variant of the well-known Traveling Salesman Problem (TSP), proposed recently in the context of maritime transportation. TSPDL consists of visiting and delivering goods for a set of ports using a ship located initially at a depot. Since each port has a delivery demand known in advance the ship starts tour with a load equal to the total demand, visits each port exactly once and comes back to the depot performing the lowest cost tour. However, to each port is assigned a draft limit, which represent the maximal allowed load on the ship upon entering some port. We propose two General Variable Neighborhood Search for solving Traveling Salesman Problem with Draft Limits. The proposed methods are tested on a set of benchmark instances from the literature and computational results shows that they are very efficient in solving this problem.

Keywords: Traveling salesman problem, draft limits, variable neighborhood search, maritime transportation.

Continuous DE-VNS for Solving Very Large Optimization Problems

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Abstract: DE-VNS is a self-adaptive heuristic that combines two well known metaheuristic approaches: Differential Evolution (DE)

and Variable Neighbourhood Search (VNS). This algorithm utilizes the concept of VNS to estimate the crossover parameter of DE. DE-VNS prove to be very good for low and large scale multimodal problems, and decent for unimodal problems. Bearing in mind that curse of dimensionality is one of the fundamental flaws of many heuristics, in this paper we aim to prove robustness DE-VNS heuristic. In order to demonstrate that, we use common test functions with up to 10,000 variables. We also compare DE-VNS with other heuristics from the perspective of the computational efforts and success rate. Since there is not much heuristics that deals with extremely large problems, especially with more than 5,000 variables, our paper may be considered as the benchmark for future comparisons.

Keywords: Global optimization, very large scale problems, variable neighbourhood search, differential evolution.

Solving the Clique Partitioning Problem as a Maximally Diverse Grouping Problem

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Abstract: The clique partitioning problem (CPP) can be described as follows. Given a complete graph $G=(V,E)$, we wish to find a partition of the node set into nonempty, disjoint subsets V_1, \dots, V_k , such that the sum of edge weights over the k induced subgraphs G_1, \dots, G_k , is maximized. Let d_{ij} denote the weight (or distance) of edge (i, j) , for all pairs (i, j) . The number of subgraphs k is determined by the optimization. For the problem to be nontrivial some of these edge weights must have negative values. Otherwise, an optimal solution is given by the original graph G and $k=1$.

A mathematical formulation of the problem is given by (Oosten et al., Networks (2001)):

$$\begin{aligned} \max \quad & \sum_{(i,j) \in E} w_{ij} x_{ij} \\ \text{s.t} \quad & \\ & x_{ij} + x_{ir} - x_{jr} \leq 1, \text{ for all distinct } i, j, r \\ & x_{ij} \in \{0,1\}, \text{ for all } (i, j) \in E \end{aligned} \tag{CPP}$$

If $x_{ij}=1$, then edge (i, j) is in the clique partition; otherwise it is not. The constraint set ensures that all edges in the complete subgraph $G_t, t=1, \dots, k$, are included in the solution.

We now investigate the relation between the CPP and the maximally diverse grouping problem (MDGP). Let $y_{ig}=1$, if node i belongs to group g , and 0 otherwise. Suppose the cardinality of V is n ; $|V|=n$. We reformulate CPP as the following equivalent quadratic binary integer program:

$$\begin{aligned} \max \quad & \sum_{g=1}^n \sum_{i=1}^{n-1} \sum_{j>i}^{n-1} d_{ij} x_{ig} x_{jg} \\ \text{s.t.} \quad & \\ & \sum_{g=1}^n x_{ig} = 1, \quad i=1, \dots, n \\ & x_{ig} \in \{0,1\}, \quad i=1, \dots, n, \quad g=1, \dots, n \end{aligned} \tag{MDGP1}$$

This formulation is equivalent to the general MDGP where the groups can be any size, including empty! An advantage to MDGP1 is the reduced number of constraints, from $O(n^3)$ to n . Another advantage is that any method used for MDGP may be applied (perhaps after some small modifications) to solve CPP.

Multi-Step Hybrid Approach to Variable Neighborhood Search for Global Continuous Optimization

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Abstract: This paper proposes a multi-step hybrid approach to variable neighborhood search (VNS) for global continuous optimization. The proposed method combines several global and local search methods with the VNS algorithm in order to create powerful multi-step hybrid. There are numerous papers showing that hybrid optimization methods produce better results than single methods. The aim of this paper is to find out if the multi-step hybrid approach is better than widely used hybrid methods, or more precisely, to show that there is a better approach than simply combining a local search method with the global one. Various optimization methods are combined within different multi-layered structures, mixing global and local, exact and heuristic search methods. Obtained combinations are tested against standard global optimization problems. The proposed multi-step hybrid approach shows better overall results than standard VNS and other commonly used hybrid methods. Small dimension problems, which are easily solvable by common local and global optimization methods alone, may induce overhead when applying the proposed approach. Similarly, solution finding for convex problems, which are easily solvable by gradient methods, would be hindered as well. Luckily, in the practical sense of execution time and resource usage, for small problems this overhead is insignificant. Further research will be oriented toward finding a preferred order of optimization algorithms in the proposed multi-step hybrid approach. Researchers from the fields of variable neighborhood search and hybridization would be mostly concerned with these results, but also anyone in practical need for solving large optimization problems.

Keywords: Continuous global optimization, variable neighborhood search, multi-step optimization, hybrid optimization.

Grouping Patients after Surgery by Minimum Sum of Squares Clustering Method

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Abstract: In this paper we first collect data after surgery of 825 patients in hospital in Serbia, taking into account 36 their attributes. Among 825 patients, 32 of them had the occurrence of dehiscence laparotomy. We analyze the risk of taking surgery based on clustering patient in groups, taking into account the presence of infection, diabetic and neoplastic disease. The minimum sum-of-squares model is used and tested by k-means and VNS-means algorithms. Some interesting conclusions are derived.

Keywords: Minimum sum-of-squares clustering, Surgery, Dehiscence laparotomy, k-means, VNS

Combining Mixed Integer Linear Optimization and VNS Approaches for Solving the Aircraft Collision Avoidance Problem by Performing Horizontal Maneuvers

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Abstract: A combination of Mixed Integer Linear Optimization and metaheuristic Variable Neighborhood Search approach is

presented in this work to deal with the aircraft conflict detection and resolution problem. Given a set of aircraft in a given air sector, the aim of the problem consists of providing a new configuration for each aircraft such that every conflict situation is avoided. A conflict situation is such an event in which two or more aircraft violate the safety distances that they have to keep during their flights. A mixed integer nonlinear optimization model is presented as well as the methodology to solve the problem by dividing the mathematical model in two by considering velocity changes on the one hand and turn changes on the other hand. Due to the problem features, a quick answer is required but given the difficulty of the mathematical model in the case of turn changes, a Variable Neighborhood Search approach has been applied to solve the problem in a very small computing time.

Keywords: Air traffic management, conflict detection and resolution, variable neighborhood search, mixed integer nonlinear optimization.

An Adaptive ES with a Ranking Based Constraint Handling Strategy

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Abstract: To solve a constrained optimization problem, equality constraints can be used to eliminate a problem variable. If this is not feasible, the relations imposed implicitly by the constraints can still be exploited. Most conventional constraint handling methods in Evolutionary Algorithms (EAs) do not consider the correlations between problem variables imposed by the constraints. This paper relies on the idea that a proper search operator, which captures mentioned implicit correlations, can improve performance of evolutionary constrained optimization algorithms. With this in mind, an Evolution Strategy (ES) along with a simplified Covariance Matrix Adaptation (CMA) based mutation operator and a ranking based constraint handling method. The proposed algorithm is tested on 13 benchmark problems. The outperformance of the algorithm is significant when compared with conventional ES-based methods.

Keywords: Constrained Optimization, Evolution Strategies, Covariance Matrix Adaptation.

Bee Colony Optimization Algorithm for the Minimum Cost Berth Allocation Problem

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Abstract: A new algorithm based on Bee Colony Optimization (BCO) applied as a meta-heuristic technique in order to solve Minimum Cost Berth Allocation Problem with fixed handling times of vessels is presented. The goal is to minimize the total costs of waiting and handling, as well as earliness or tardiness of completion, for all ships. In the computational experiments, the results of BCO are compared with the Mixed Integer Programming (MIP) heuristics as well as with the CPLEX commercial solver.

Keywords: Meta-heuristics, scheduling, handling cost.

Parameter Calibration in the Bee Colony Optimization Algorithm

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Abstract: We present a case study in which we examine in detail the behavior of the Bee Colony Optimization (BCO) metaheuristic when applied to the p-center problem. On a number of benchmark problems, we perform a fine-tuning of several parameters of the BCO algorithm, yielding insights into the behavior of the algorithm,

its robustness and efficiency, and reach six new best-known solutions.

Keywords: Meta-heuristics, nature-inspired algorithms, combinatorial optimization, location analysis, p-center problem.

The Effects of Using a Self-Learning Shake Procedure in the Variable Neighborhood Search

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Abstract: In this paper, we propose a Self-Learning Shake procedure (SLS) that is incorporated in the basic Variable Neighborhood Search method (VNS). The SLS procedure leads the VNS to a neighborhood of the current best solution, by using the experience from previous iterations when solving a considered problem instance. The VNS method with the proposed SLS procedure was tested and compared with the standard VNS for solving the well-known Multiple-Level Uncapacitated Facility Location Problem (MLUFLP). The obtained results show that the implemented SLP procedure provides significant reduction of CPU time, when compared to the standard shaking procedure in the VNS method.

Keywords: Variable neighborhood search, self-learning shake, metaheuristics, multi-level uncapacitated facility location problem.

Computing Graph Separators with Variable Neighborhood Search

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Abstract: Given an undirected and connected graph $G = (V, E)$ and a bounded positive integer b , the Vertex Separator (VS) problem consists of finding the set of vertices C , whose removal divides G into two separated components A, B , where $\max\{|A|, |B|\} \leq b$. This NP-hard optimization problem appears in a wide range of applications. For instance, in telecommunication networks, a separator determines the capacity and brittleness of the network. In the field of graph algorithms, the computation of balanced small-sized separators is very useful, especially for divide-and-conquer algorithms. In bioinformatics and computational biology, separators are required in grid graphs providing a simplified representation of proteins. This paper presents a new heuristic algorithm based on the Variable Neighborhood Search (VNS) methodology for computing vertex separators. We compare our procedure with the state-of-the-art methods (two branch-and-bound procedures recently published). Computational results show that our procedure obtains the optimum solution in all of the small and medium instances, and obtains high-quality results in large instances. Although the branch-and-bound methods assess the optimality of the solution found, they need large computing time. On the other hand, our procedure obtains almost all optima in a small fraction of that time (without assessing the optimality of the solution found).

Keywords: Combinatorial optimization, metaheuristics, VNS, graph separators.

A New Integer Linear Formulation for a Memory Allocation Problem

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Abstract: This paper introduces a new integer linear formulation (ILP formulation) for addressing memory allocation problem. The

first formulation was given in [6]. Formulated model was solved and compared with formerly existed model by using IMB ILOG CPLEX optimizer. Numerical experiments have been tested on real instances and instances expanded for our specific problem for both models. We show that our model perform faster than model proposed in [6] on major number of instances.

Keywords: Electronic design, ILP, memory allocation, VNS.

A Cooperative Neighborhood Variable Neighborhood Search for the Vehicle Routing Problem with Times Windows under Availability Constraints

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Abstract: Disruption Management is an emerging field, where operational research techniques are used to deal with delays in many environments. Yu Gang defines the concept of Disruption Management as «in the beginning of an economic cycle an optimal or quasi optimal plan is obtained by the use of some optimization models. When an original planning is executed, disruptions, which are caused by several internal or external factors, may occur from time to time. As a result, the original planning cannot remain optimal or even Feasible. For this reason, we need to prepare a new revised plan reflecting the constraints and objectives of the evolved environment while minimizing the negative impact of disruption». In this work we present a rescheduling model based on Variable Neighborhood Search metaheuristic for the vehicles routing problem with time windows when one or more vehicles require preventive maintenance activities after the supply of a set of customers.

Keywords: vehicle routing problem, variable neighborhood search, disruption management, VRPTW.

Delivery Shop Scheduling Problem

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Abstract: In this article we propose a new type of scheduling problem - the delivery shop scheduling problem (DSS). It is derived from the two-stage assembly problem, a well-known NP complete problem. The goal is to minimize the total time spent to finish the first stage assembly process in order to deliver the product with minimal delay. To solve this task, we used a Variable Neighborhood Search (VNS) based heuristic both on generated data sets and data sets available in literature.

Keywords: Scheduling, delivery shop, heuristics, variable neighborhood search.

Problem of Exploration of Online Social Networks with Interaction between Resource Nodes

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Abstract: In this study, an efficient exploration of an online social network is considered. Given the set of users that possibly have common property or share the same interest, the goal is to minimize the amount of time searching for defined characteristics, while both connection parameters between user and control nodes and interaction between control devices is taken under consideration. A mathematical model is developed and solved by an iterated simulated annealing method (ISA), which uses a short-term memory of undesirable moves from previous iterations while

exploring the search space. When the memory storage becomes full, an iterated local search to jump to a randomly chosen solution in a distant area of the search space is applied. Two data sets with up to 2 500 users in a considered social network are generated. For small-size data sets with up to 100 nodes optimal solutions in a very short CPU time are obtained. Small average values of the average gap and standard deviation on medium-size and large-scale data set show stability of the ISA, while the small average computational time shows algorithm's efficiency.

Keywords: Online social network, simulated annealing, iterated local search, short-term memory.

A Metaheuristic Approach to the Dominating Tree Problem

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Abstract: This paper considers a recently introduced NP-hard problem on graphs so called the dominating tree problem (DTP). In order to solve this problem a variable neighborhood search (VNS) based heuristic is developed. Feasible solutions are obtained using the set of vertex permutations which enables implementation of a standard neighborhoods structure and an appropriate local search procedure. Experimental results include two classes of randomly generated test instances. Optimality of VNS solutions on smaller size instances has been verified by CPLEX.

Keywords: Dominating tree problem, graphs, variable neighborhood search, optimization.

Particle Filter – Improving Resampling Using a Metaheuristic

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Abstract: In the paper, we present a modification of the particle filter that uses a reduced Gaussian variable neighborhood search algorithm in resampling phase. The variable neighborhood search is implemented in resampling step in order to mitigate degeneracy phenomenon. It is done by iteratively moving particles from its current positions to the parts of the state space where the posterior distribution is higher. Simulation results are presented to demonstrate performance of newly developed algorithm over other standard filters.

Keywords: Optimization methods, particle filters, recursive estimation, variable neighborhood search.

A Metaheuristic Approach to Solving a Multiproduct EOQ-Based Inventory Problem with Storage Space Constraints

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Abstract: In this paper a static time-continuous multiproduct EOQ-based inventory problem with storage space constraints is modelled as a combinatorial optimization problem on the corresponding dynamic discrete time system control process. For solving this model a metaheuristic technique based on variable neighbourhood search principle is developed, and its efficiency is preliminary investigated within several numerical experiments.

Keywords: Multiproduct EOQ inventory problem, discrete time system control, variable neighbourhood search.

■ B10 LINEAR & NONLINEAR PROGRAMMING

Scalar Correction Method for Solving Large Scale Unconstrained Minimization Problems

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Abstract: We introduce a gradient descent algorithm for solving large scale unconstrained nonlinear optimization problems. The computation of the initial trial steplength is based on the usage of both the quasi-Newton property and the Hessian inverse approximation by an appropriate scalar matrix. The nonmonotone line search technique for the steplength calculation is applied later. The computational and storage complexity of the new method is equal to the computational and storage complexity of the Barzilai and Borwein method. On the other hand, the reported numerical results indicate improvements in favor of the new method with respect to the well known global Barzilai and Borwein method.

Keywords: Nonlinear programming, nonmonotone line search, BB method, quasi-Newton methods, gradient descent methods.

Binary Logistic Regression in Case Study Researches

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Abstract: Main aim of this paper is to present and justify the use of (binary) logistic regression in researches which are based on case study methodological approach. Paper is based on the assumption that the so-called quantitative and qualitative methods can be interwoven. In case studies, commonly considered as a qualitative research approach, the quantitative data processing has increased during the last decade (Kent, 2010; Bryne, 2010), while the regression data processing techniques became much more respected in so called qualitative researching (de Meur and Gottcheiner, 2009). In the first part of the paper the data processing with (binary) logistic regression and case study researching are described. Description exposes junctions and crossing points of the both approaches. Second part is concentrated on the application of both methods. As an example the methodology and results of the Slovene evaluation research on investments in skills&competencies needed for youth employment are presented.

Keywords: multivariant and binary regression, quantitative and qualitative data processing, case study, evaluative research.

Computational Comparison of Pivoting Rules for the Revised Simplex Algorithm

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Abstract: The simplex algorithm is the most widely-used method for solving linear programming problems. Pricing is the operation of the selection of an improving non-basic variable in order to enter the basis in each iteration of the algorithm. Pricing is one of the most time-consuming steps in simplex type algorithms and it is essential to reduce the time taken to perform this step. In this paper, we perform a computational comparison in which the pricing operation is computed with eight different pivoting rules: (i) Bland's rule, (ii) Dantzig's rule, (iii) Greatest Increment Method, (iv) Least Recently Considered Method, (v) Partial Pricing Rule, (vi) Queue Rule, (vii) Stack Rule, and (viii) Steepest Edge Rule; and incorporate them with the revised simplex algorithm. All pivoting rules have been implemented in MATLAB and the test set used in the computational study is the Netlib (Optimal, Kennington, and Infeasible) set of linear problems.

Keywords: Linear programming, revised simplex method, pricing, pivoting rules, MATLAB.

Hybridized Methodology of Nonlinear Goal Programming Problem Solving

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Abstract: This work concerns the development of novel type of a feasible direction algorithm for nonlinear goal programming optimization. The new algorithm is based upon enhancements of the search direction determination and the line search steps. The optimization of an econometric modeled economic policy can be typically defined as non-linear goal-programming problem. The non-linearity of the optimization problem here is placed in constraint of gross domestic product set up as subject and presented here by Cobb–Douglas function. To such models, a new methodology, named HNGP (Hybridized Non-Linear Goal Programming), was developed.

Keywords: Non-linear goal programming, Cobb-Douglas's function, Euler's homogeneous function theorem, feasible direction method.

■ B11 LOCATIONAL ANALYSIS

Simple Plant Location Model in Agriculture Aviation in Serbia

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Abstract: Agriculture is a significant strategic factor in Republic of Serbia and implementation of best or at least appropriate technologies in agricultural production could create possibility to get higher returns of good quality products. This way of production would create a lower product price and Serbia could reduce food import and, at the same time increase food export. One of the most productive way for nutrition and protection of agricultural crops on large fields is usage of agriculture aviation. Use of aircrafts in the technology of growing these crops would give better results in terms of yield and quality and also it will be necessary to use aircrafts due to underground water. The subject of this paper is application of simple plant location model in one company in Serbia to determine number of agricultural airfields which will be used for farming of the land and allocation of fields to specific airfields.

Keywords: Simple plant location model, agriculture aviation, allocation.

■ B12 LOGISTICS & SUPPLY CHAIN MANAGEMENT

Sales Forecasting Practices in Albanian Companies

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Abstract: Although, forecasting is a widely researched area and a common practice in business life, this is the first attempt to report and discuss the sales forecasting practices in Albanian companies. The purposes of this research were to investigate the sales forecasting practices under different working conditions and to identify the most prevalent forecasting areas where improvements are required for enhancing the overall forecasting performance. The research showed that Albanian companies heavily rely on subjective methods, developed based on an independent approach,

without cross-functional integration, and mainly for short-term time horizons. Forecasting software and hardware are not used in sales forecasting and no training is provided towards improving practitioners forecasting skills.

Keywords: Sales forecasting, subjective methods, Albanian companies.

Just In Time Implementation in Greece: Some Empirical Evidence

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Abstract: Purpose: This study aims to find out whether the system Just in Time (JIT) is used by businesses operating in Greece. It is designed to distinguish the benefits of implementing JIT and identify the problems that companies usually encounter during use.

Design/methodology/approach: The data analyzed in this paper were collected by a structured questionnaire which was sent to several industries electronically.

Findings: The findings showed that most of the companies surveyed have either only some of the conditions for the successful implementation of a JIT system or there is a significant trend towards this direction. The responded companies overview this system as a way to reduce inventory and improve quality.

Originality / value: This study contributes to a very limited number of empirical studies on JIT implementation that exist in general and in Greece specifically.

Keywords: Just-In-Time, survey, Greece.

The Evaluation of Quality Objectives in Food Production Processes

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Abstract: There is no defined methodological approach which would evaluate and rank the quality objectives of processes in food supply chain (FSC) in uncertain environments which is one of the basic problems in improving and managing the processes. The quality objectives of primary production process are defined by knowledge and experience of management team. The fuzzy rating of the relative importance of each pair of the identified quality objectives and uncertain quality objective values are described by linguistic expressions which are modelled by triangular fuzzy numbers. The weight vector of criteria is calculated by the extent analysis method on fuzzy Analytic Hierarchical Process (AHP). The rank of quality objectives is calculated at the time period. The rank of quality objectives corresponds to the rank of triangular fuzzy numbers which describe weighted values of quality objectives. The proposed model is illustrated by an example.

Keywords: Quality objectives, food supply chain, fuzzy sets, fuzzy AHP.

An Approach for Determining Corporate Strategy Based Supplier Selection Criteria

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Abstract: This paper presents a model that determines the most crucial criteria, which have a strong relationship with corporate strategies for supplier selection. It proposes the use of the Delphi technique integrated with fuzzy cognitive maps.

Keywords: Supplier Selection, Delphi Technique, Fuzzy Cognitive Mapping

EOQ Approaches for Stochastic Inventory Systems

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Abstract: In this paper the most commonly used inventory control policies i.e. the order quantity/reorder point, (r, Q) , the periodic review replenishment interval order up-to, (R, T) , the periodic review replenishment batch ordering (r, nQ, T) , and the (s, S, T) are revisited. Through a unified presentation of their average cost, this paper reviews the comparisons (in cost terms) between the above mentioned policies and EOQ type approximations.

Keywords: EOQ, heuristics, continuous review, periodic review, stochastic demand.

A First Study of Particle Swarm Optimization on the Dynamic Lot Sizing Problem with Product Returns

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Abstract: We study the behavior of a popular metaheuristic optimization algorithm, namely Particle Swarm Optimization (PSO), on the single-item dynamic lot sizing problem with returns and remanufacturing. The most suitable variants of the algorithm are identified and applied after the necessary modifications. The performance of the algorithm is assessed on an extensive test suite employed in previous studies. Its performance is compared with that of the adapted Silver-Meal algorithm as well as with its recently enhanced versions. The results suggest that PSO is very competitive and can be considered as a promising alternative for solving the considered problems.

Keywords: Lot sizing, inventory, remanufacturing, particle swarm optimization

An Approach to Production Planning for Supply Chain Performance Improvements

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Abstract: This paper presents some of the results obtained by studying Petri nets' capability for modelling and analysis of production planning system in correlation with supply chain key performance indicators. A simulation model using a timed, hierarchical Coloured Petri Net (CPN) and software package CPN Tools was developed. The goal was to apply this simulation model, for determination of production triggering decision in relation with stock cover level and customer service level requirements, based on forecasted demand, production capacities and defined lot sizes.

Keywords: Production planning, customer service level, stock cover, Petri nets.

Using Rough Set Theory for Supply Chain Management Process in Business

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Abstract: In today's competitive and global environment, supply chain management and its applications have become very important for all organizations. Organizations can improve their competitive force by selecting proper business partners for their supply chain process. Supply chain comprises a worldwide network of suppliers, factories, warehouses, distribution centers and retailers through which raw materials are acquired, transformed and delivered to the end user. Various methods have been applied to supply chain management in order to reduce costs and delivery period and also gain competitive advantage. Methods such as neural networks, analytic hierarchy, fuzzy programming and rough set theory have been applied to supply chain management. Rough set theory was developed by Pawlak in the beginning of 1980s. It is a new mathematical tool to deal with intelligent data analysis and data mining. Rough set can reduce decision complexity and improve the efficiency of decision. By that way applying rough set can be seen as feasible and scientific for supply chain management. In this paper, the factors affecting the choice of suppliers are considered and then rough set theory has been applied to these data in order to determine the suitable supplier for an organization.

Keywords: Rough set theory, supply chain, rule extraction.

Reverse Inventory Routing Problem in Recyclables Collection

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Abstract: A key element of reverse logistics system is the collection or acquisition of used product discarded by last owners or consumers. This paper observes the problem of waste materials collection processes, which in essence comprises pick-up recyclables from collection points and transferring them to a recycling facility. Having in mind experience from forward supply chain management, and potentials of joint coordination of transportation and inventory decisions, this research propose modeling approach that simultaneously considers collection vehicles routing and recyclables inventories optimization in reverse logistic system. The problem studied in this paper can be described as multi period reverse inventory routing problem of collecting one type of recyclables with time windows and with objective to provide continuous supply of the recycling facility under minimal transport costs. To solve the problem we propose mixed integer linear programming model.

Keywords: Inventory Routing Problem, Recyclables collection, Mathematical programming.

Measuring Energy Efficiency of the Transport System In Serbia

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Abstract: Transport sector is one of the major energy consumers. Energy consumption in Serbia is growing every year. In situation of increasing global energy demands and rising energy costs, conserving energy becomes very important issue. Energy efficiency is one of the best and the most frequently used indicators of energy use. The main objective of this paper is estimating energy efficiency of transport modes in Serbia from 2001 to 2010. The data

envelopment analysis method is employed in this paper because it does not require the assumption of functional relationship between input and output variables, and also integrates different variables expressed in different units in a single measure of efficiency. Several hypotheses are tested in this paper. The Rail transport is more energy efficient than the road transport. Key factors that affect energy efficiency are also identified.

Keywords: Energy efficiency, Serbian transport system, data envelopment analysis.

Planning Logistics Network for Recyclables Collection

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Abstract: Rapid urbanization, increasing industrialization, rising incomes and a more sophisticated form of consumerism are leading to an increase in the amount and toxicity of waste all over the world. Whether it is reused, recycled, incinerated or put into landfill sites, the management of household and industrial waste comes at a financial and environmental cost. This paper presents modeling approach that can be used for designing one part of recycling logistics network through defining optimal locations of collection points, as well possible optimal scheduling of vehicles for collection of recyclables.

Keywords: Recycling, collection, location theory, scheduling.

Usability Measurement Framework for Mobile Touch Screen Devices in Transportation and Logistics

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Abstract: New modes of production are concomitant with new modes of distribution, which brings forward the realm of logistics. As enhanced productivity is the primary benefit of mobile technologies, alongside with the goal to help maximize productivity, improve safety, increase vehicle utilization and reduce cost, the necessity arises to evaluate their usability and acceptance. To evaluate users' subjective impressions about the system and their degrees of satisfaction the well-known questionnaire System Usability Scale (SUS) was employed in the study. Based on the SUS scores the results indicate that tablet is usable in field conditions. The results of the analysis can be adopted as a guideline for mobile application design user interface fine-tuning in the future versions.

Keywords: System usability scale, tablet computer, logistics.

Modeling a Two-Stage Supply Chain, With (S, s) Replenishment Policy and Exponential Lead Times: The VMI Approach

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Abstract: In this study, the system under consideration consists of two stages, a wholesaler and a retailer. The wholesaler follows a continuous review (s, S) policy and as a Vendor Manager of the whole supply chain network, he manages the Retailer's inventory level. We model this supply chain network as a continuous Markov process with discrete states. After the exploration of the transition matrices, we develop a computational algorithm in order to generate the performance measures for different values of the system's

characteristics. The major task is to compare the current VMI results, with the results we gained when we modeled the same supply chain network, where both wholesaler and retailer were following the (s, S) continuous review policy.

Keywords: Supply chain management, VMI, performance measures, Markov analysis.

■ B13 MARKETING & OPERATIONS MANAGEMENT

Evaluating Tourist Offer Attributes Using Conjoint Analysis

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Abstract: In the highly competitive business environment, the success of travel agencies deeply depends on their achieved levels of customer satisfaction. Accordingly, it is important to understand better the main drivers affecting the choice and later evaluation of a tourism destination by consumers. This paper introduces conjoint analysis as an appropriate tool for evaluating the preferences and expectations of customers. A survey was conducted and the results based on a sample of 514 respondents, members of the youth population are presented. Moreover, it has shown that the information obtained through Conjoint analysis can be used to develop both marketing and communication strategies.

Keywords: Preferences, tourism, conjoint analysis, marketing strategy.

Improving Performance Measures through Measuring Customer Satisfaction with Product's Attributes

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Abstract: Marketing research grew out of the needs and demands of the marketing system. Marketing system represents a conceptual model in which marketing mix and situational factors are seen as independent variables (input) and cause behavioral responses and performance measures (such as sales, market share, profit, return on investment, cash flow). Managers make decisions aiming to influence the performance measure in a predictable manner based on their information about marketing system. One of the non-monetary performance measure is customer satisfaction. In this paper we present the Kano model of customer satisfaction which classifies product attributes based on how they are perceived by customers and their effect on customer satisfaction. The Kano model can be of help when developing or improving a product or determining a market strategies.

Keywords: Marketing research, performance measure, Kano model, customer satisfaction.

Determining Consumer Preferences towards Environmental Packaging

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Abstract: Determining hidden consumer preferences is the key to success and a powerful weapon against the competition of every company, because it allows them to meet consumers' individual needs. Depending on consumers' requirements, each company will make an effort to meet their needs. This paper aims to provide a study of consumers' environmental purchasing decisions, as well as

an analysis of the importance of environmental packaging in the presence of other relevant attributes of a product. This paper provides an overview of applications of statistical technique, Conjoint analysis, in valuation of consumer preferences. Conjoint analysis determines the importance of each attribute based on consumers' preferences, by examining their tendencies towards certain attributes of a product. An empirical study is conducted. The preferences of respondents for particular characteristics of yoghurt are determined by Conjoint analysis. Companies can potentially reduce the cost of production and placement and increase sales of products on the market by discovering consumer preferences.

Keywords: Conjoint analysis, consumer preferences, purchasing decisions, environmental packaging, eco-label.

Assessment of Customer Satisfaction on the Macedonian Mobile Phone Market

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Abstract: The objective of this paper is to test a customer satisfaction index model on the Macedonian mobile phone market and to obtain information about the level of customer satisfaction on this market. The model used in this research is based on the previously developed European Customer Satisfaction Index model. The data were analyzed with the Partial Least Squares technique for Structural Equation Model estimation. According to the results, perceived value and perceived quality have the greatest impact on customer satisfaction. Loyalty is the ultimate variable in the model and is highly determined by customer satisfaction and less by company's image. The results indicate that Macedonian mobile phone users perceive certain unfairness regarding the price/quality ratio, i.e. they are not satisfied by the value the mobile phone industry provides them.

Keywords: Customer satisfaction, customer loyalty, mobile phones

■ B14 MATHEMATICAL MODELING & DECISION MAKING

On Computer Simulation of a System Using an Associated Model

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Abstract: To study a system often is associated with a mathematical model. The mathematical model is used to describe associated with the behavior of the system during a fixed period. In its evolution the system is influenced by random factors that are generated by computer. The simulation using the mathematical model associated with the system, you can make various experiments with computer, providing very useful information on the evolution and behavior of the system under consideration.

Analytical vs. Heuristics Approaches for Robustness Analysis in UTA Methods

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Abstract: The aim of this paper is to evaluate and compare an analytical approach with heuristics algorithms for robustness analysis in the UTA family methods. One of the basic steps in UTA type methods is the calculation of robustness measures through a post-optimality analysis process. During the post-optimality analysis different heuristics approaches are implemented for the estimation of the polyhedron of multiple/near optimal solutions of the LP models of UTA methods. These heuristics approaches are

supposed to work properly in comparison to most computationally expensive but more accurate analytic approaches, but this hypothesis has not been tested. In this paper all the edges of the polyhedron are explored by means of the Manas-Nedoma Hamiltonian search algorithm (labyrinth algorithm) and the results are compared with those produced by using heuristics algorithms.

Keywords: Robustness analysis, linear programming, multicriteria analysis.

Forecasting Electricity Demand Generation Applying a Grey Analysis Model

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Abstract: Energy policies are of significant importance in our rapidly changing world, being the dominant factor in world economy and growth. The hard competitive environment examines not only new energy resources but also methodologies to effectively manipulate energy generation and consumption. Researchers use models and tools, concerning the manipulation of information, to define the right approach to the major subject of electricity generation. In this paper, we use, at first, power generation of the Republic of Cyprus and Grey Analysis GM(1,1) to predict future generation demand. Then we use the demand forecasting of Cyprus Electricity Authority in order to validate our model, to correlate the sensitivity of given data and to compare the efficiency and accuracy of the proposed methodology.

Keywords: Demand forecasting, GM(1,1), grey analysis, power generation.

Estimation of Useful Energy for Solar Collectors Based on General Solar Irradiation Trends and Real Project Data

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Abstract: The aim of this paper is to establish mathematical models that will calculate the potential of solar radiation. The correlations of different solar energy parameters have been calculated. The empirical data used for the global solar radiation were extracted from the database of Joint Research Centre, Institute for Energy and Transport for the period 2001-2012. The typical meteorological year (TMY) has been formed on the basis of the data. The correlations were established between the following empirical data: insolation on a horizontal surface (Hh), insolation on a vertical surface (Hv), insolation on an optimum surface (Hopt) and useful energy (Qm). The useful energy was measured on the solar system designed by a small energetic company. The measurement was conducted in 2012. Results indicate that there is a strong correlation between measured insolation and useful energy, which allows precise estimations of useful energy for further projects.

Keywords: Mathematical model, global solar radiation, measured useful energy, correlation, estimation of useful energy.

What Gives Uniqueness to Input-Output Modeling?

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Abstract: The Input-Output modeling approach is based on the Romanian I-O Tables and the Wassily Leontief methodology (Nobel laureate in Economics, 1973). The conceptual and analytical

cadre of the I-O approach for a national macro model uses the behavioural analysis and support estimations equations for technical coefficients, macro indicators and other variables. The model databases use the 1989-2009 statistic data provided by the National Statistics Institute aggregated into seven sectors, in the interest of the current development of the Romanian economy. The paper deals with the needed operation to design and use, the synergies between econometric and accounting relationships, the integration of other I-O sub-models needed to address the economy as a whole model. The model describes the structure and the potential of the national economy, allow for achieving a solution that offers the best picture of the economy, enables strong and varied research modeling and forecasting capabilities and confirm the antiques advantages of the models based on I-O analysis.

Keywords: input-output, modeling, coefficients, forecast, national economy.

Joint Replenishment Policy for Two Substitutable Products with Demand Dependent of Their Inventory Levels

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Abstract: The optimal joint replenishment policy for a two product inventory system is studied. The products are substitutable, so in case of a stock-out for one of the products a known fraction of its demand can be satisfied by using the stock of the other product. In addition, the demand of each product is dependent of the inventory level of both of the products at a certain time. Numerical examples and a sensitivity analysis are also provided.

Keywords: Inventory, substitution, stock dependent demand, optimization.

Multi-Criteria Routing Algorithm Based on Interpolative Boolean Algebra

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Abstract: In order to improve the quality of service of distributed applications, we propose a multi-criteria algorithm based on interpolative Boolean algebra for routing in an overlay network. We use a mesh topology because it is easy to implement and also makes addressing of the cores quite simple during routing. In this paper, we consider two criteria: buffer usage, which is represented using the thermal field theory and the distance between peers, expressed as Euclidean distance. The proposed routing algorithm determines the optimal path using interpolative Boolean algebra, the decision at each node is made based on the ranking of available options considering multiple constraints. The simulation showed that the proposed approach provides better results than standard shortest path routing algorithm.

Keywords: Interpolative Boolean algebra, multi-criteria, routing, peer-to-peer.

Logic-Based Similarity Measures for Consensus

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Abstract: The measurement of similarity or dissimilarity between different objects is an important issue in data analysis, information retrieval, decision making, clustering, data mining etc. In this paper, similarity is perceived as a logical equivalence or bi-implication

between two objects. We introduce several logic-based similarity measures for computing consensus in group decision making. In order to measure a level of agreement among experts, we applied several similarity functions: min bi-implication, prod bi-implication and equivalence based on Interpolative Boolean Algebra (IBA). The aim of this paper is to make the comparison of the three logic-based similarity measures. Special attention is devoted to how these measures are appropriate to explain the notion of consensus within group decision making (GDM) problems. IBA equivalence proved to be the most suitable tool for estimating consensus as shown in the numerical example.

Keywords: Similarity measures, logical relations, fuzzy bi-implication, IBA equivalence, consensus.

Truth Functionality Is Consequence of Structural Functionality and Valid Only in Classical Two-Valued Case

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Abstract: The value of the complex Boolean function can be calculated directly on the basis of its components value. It is a principle known as the truth functionality. Properties of the Boolean algebra have indifferent values. The truth functional principle is taken as a valid principle in general case in the conventional generalization: multi-valued and/or real-valued realizations (fuzzy logic in the broad sense). This paper presents that truth functionality is not valued indifferent property of the Boolean algebra and it is valid only in two-valued realization, and thus it cannot be the basic of the value generalization. The value generalization (real-valued realizations) enables incomparably more descriptiveness than the two-valued classical Boolean algebra, so that the finite Boolean algebra is enough for any real application. Each finite Boolean algebra is atomic. Every Boolean function (the element of the analyzed finite Boolean algebra) can be presented uniquely as disjunction of the relevant atoms – disjunctive canonical form. Which atoms are and which are not included in the analyzed Boolean function is defined by its structure: 0-1 vector which dimension matches the number of atoms (in the case of n independent variables, the number of atoms is 2^n). Atom corresponds uniquely to each vector structure position and value 0 means that the adequate atom is not included in the analyzed function, and 1 means that it is included. The principle of the structural functionality is: the structure of the complex Boolean function is defined directly on the basis of its components structure. The truth functionality is a value image of the structural functionality only in the case of two-valued realization. Each insisting on the truth functionality, such as in the case of conventional multi-valued logic and fuzzy logic in general sense, is unjustified from the point of the Boolean consistency.

Keywords: Boolean algebra, atomic Boolean functions, disjunctive canonical form, Boolean function structure, structural functionality, truth functionality, generalized value realization of the Boolean functions

Decision Making with Consonant Belief Functions: Discrepancy Resulting with the Probability Transformation Method Used

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Abstract: Dempster-Shafer belief function theory can address a wider class of uncertainty than the standard probability theory does and this fact appeals the researchers in operations research society for potential application areas. For representation of statistical evidence, the class of consonant belief functions is used which is not closed under Dempster's rule of combination but is closed under Walley's rule of combination. In this research, it's shown that although the outcomes obtained using Dempster's and Walley's rule do result in the same probability distribution when plausibility transformation is

performed, they do result in different probability distributions when pignistic transformation is used which in turn may have a significant effect on decision making, on the choice of the decision alternative selected. The resulting discrepancy on the probability distributions is demonstrated via an example of missile type identification.

Keywords: Belief Functions, consonant belief functions, plausibility transformation, pignistic transformation.

■ B15 MATHEMATICAL PROGRAMMING

The Response of a Shear Beam as 1D Medium to Seismic Excitations Dependent on the Boundary Conditions

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Abstract: We study response of a shear beam to seismic excitations at its base. The research is conducted using computer simulation of the wave propagation on a numerical model. The wave equation is solved using the method of finite differences (FD) where the spatial and temporal derivatives are approximated with finite differences. We used formulation of the wave equation via the particle velocities, strains, and stresses. Integrating particle velocities in time, we obtained displacements at spatial points. The main goal in this research is to study phenomena occurring due to three different types of boundary conditions, Dirichlet, Neumann, and moving boundary when simple half-sine pulse propagates through 1D medium modeled as a shear beam.

Keywords: Wave propagation, particle velocity, stress, strain, boundary conditions, numerical simulation.

Parametric Computation of a Membership Function for the Solution of a Fuzzy Linear Fractional Optimization Problem

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Abstract: A linear fractional optimization problem with trapezoidal fuzzy numbers as coefficients in the objective function (FLFOP) is considered in this paper. Using the concept of fuzzy solution introduced by Dempe and Ruziyeva (2012) for the linear case, we propose a parametric method for computing the membership function of the solution of FLFOP. Our approach is based on the α -cuts of the fuzzy coefficients, Pareto optimal solutions of a bi-objective linear fractional optimization problem and parametric analysis of the solutions of linear fractional programs. Further, we derive sufficient conditions for a feasible solution to be α -maximal in FLFOPs with respect to the possibility and necessity fuzzy relations.

Keywords: Fuzzy optimization, trapezoidal fuzzy numbers, Bi-objective linear fractional programming, possibility fuzzy relation, necessity fuzzy relation.

Optimality and Duality for a Class of Continuous Fractional Programming Problems

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Abstract: In this paper we consider a class of continuous fractional programming problems with locally Lipschitz data. Convexity assumptions for continuous fractional programming problems are relaxed to those of generalized r -invexity assumptions. Optimality conditions are established under generalized r -invexity assumptions.

Subsequently two parameter-free dual models are formulated and several duality theorems concerning weak, strong and strict converse duality are proved in the framework of generalized r -invexity.

Keywords: Nonsmooth fractional programming, r -invexity, r -quasiinvexity, Mond-Weir duality, Wolfe duality.

Locating Undesirable Facilities with Variable Coverage Radius

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Abstract: Making decisions about spatial positions of undesirable facilities are crucial when it is necessary to minimize environmental risks. Such facilities should be located under conditions of minimal safety distance. For some dangerous goods, the minimal safety distance may be determined as a constant value which depends only on the dangerous goods' characteristics. Usually, the minimal safety distance depends on quantity and characteristics of particular dangerous goods, as well as other relevant characteristics. This paper considers the specific problem of determining dangerous goods locations in case when the minimal safety distance depends on quantity of dangerous goods stored and when different kinds of dangerous goods (with different characteristics) have to be stored in warehouses. Thus, in this paper a Mixed Integer Linear programming model is proposed for this kind of problem. Finally, a randomly generated numerical example has been used to verify the model. The computational results have been presented.

Keywords: Dangerous goods, safety distance, anti-covering, location.

Application of Fuzzy Inference Models on the Example of Zinc Ore Flotation Concentration

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Abstract: Fuzzy inference systems are becoming one of the most important analytical and modelling tools in modern process control. In this paper, a comparison of two most important fuzzy inference systems was presented in their application on a regular industrial process of zinc minerals flotation concentration. The training and the test data originate from the Rudnik Rudnik in the Republic of Serbia. The results of the preliminary case study shows that both Mamdani and Takagi-Sugeno inference systems can provide adequate results when applied for fuzzy modelling of an industrial flotation concentration process. However, more tuning is needed for the purpose of practical application or potential development and industrial-scale utilization of a fuzzy controller.

Keywords: Fuzzy inference model, zinc minerals flotation, Rudnik, Mamdani, Takagi-Sugeno.

■ B16 MILITARY OPERATIONAL RESEARCH

Fuzzy Logic as a Support Process in Decision Making with Engagement Group for Making Additional Obstacle

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Abstract: In the paper is described the stage in the decision making process during selecting directions of actions Group for making additional obstacle. The decision making process is followed by

higher or lower level of indefiniteness of criteria needed for making relevant decisions. Since the fuzzy logic is very suitable to express indefiniteness and uncertainty, in the paper is described the decision making process using fuzzy approach.

Keywords: Decision making process, fuzzy logic, group for making additional obstacle.

Capability Based Defence Development Planning - Optimal Option Selection for Capability Development

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Abstract: This article presents a model which is an attempt of objectification of the defence development options ranking. Model is compiled on the basis of Capability Based Planning process, which determinates required defence capability and options for capability development according to possible scenarios of security threats. Model considers essential parameters from scenarios, required capabilities and options cost, for capability development options ranking for purpose of optimal option selection. For determination of parameters and their values, useful tool is expert assessment. The presented model allows presentation of the development options rank and priorities to the decision makers in terms of decision support, so it influences the choice of the defence development options. On the other hand, subjective expert evaluation of used parameters could negatively influence objectification of this model. This model could be helpful tool for defence planners in way of development options ranking and determination of defence development priorities.

Keywords: Defence, development planning, capability, capability based planning.

Capabilities Modeling of NLOS-Missiles in Modular Unit of Guard Forces Battle Team

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Abstract: Considerations in this paper deals with designing and modelling, of optimal force packages for the guard forces tactical units, based on expected use of new NLOS weapon technologies, and theirs tactical requirements of tasks in missions of aimed defence roles. Company battle teams (CBT), are offered as flexible designed tactical receivers and integrators of modular formation elements equipped with NLOS weapon. Modular element with the special performances required for the guard forces, in composition of their combat unit, coming from the advantages of new NLOS-weapons which enables remote fire support capability by direct detecting, engaging and attacking of random and discovered targets, from different directions at the respectable tactical distances. In this paper fire power capabilities of modular units are tested in simulations by improved engaging tactics, accorded with NLOS performances. New deterministic combat model, composed of the ambush ripple tactics at the very beginning, (guerrilla warfare), and direct fire in the further layers attacks is employed. This represents effects of sudden attack on the grouped point targets disposed on the water and ground surfaces at the very beginning and continual prepared battle in the further attacks layers. Modelling provides dimensional verification of modular formation elements, regarding the number of forces, crews, and targets engagement possibilities and their linking communication requirements for integrative battle functions in CBT modular composition.

Keywords: Tactics, modular battle company, guard forces, NLOS missiles, Lanchester deterministic equations, technology.

The Use of Matrix Contradictions in Solving Technical Problems

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Abstract: In this time, modern technical device characterized: complexity, variety and limited service life. Each product have service life cycle from entering on market to it out of date. If you want to have longer service life device, we need to make some inventive activities. Making this activities means that in specifying point of time, we have to make some activities on product in aim its improvement. For improvement product in this time is more and more uses scientific methods on based on scientific basis with modern techniques and tools. One of the contemporary methods which has been applied in improving the technical facilities is: Theory of solving inventive tasks - TRIZ. As the basic tools which are used in the application of this methodology with order to solve specific technical problems used is inventive principles and contradiction matrix. In this paper is an attempt to approach the process using inventive principles and the contradiction matrix in solving technical problems for the, which gives a specific example.

Keywords: Technical contradiction, inventive principles, matrix of contradictions.

■ B17 MULTIPLE CRITERIA DECISION ANALYSIS & MULTI-OBJECTIVE OPTIMIZATION

Weights, Consistency and Uncertainty in Group AHP

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Abstract: This paper tackles the analytic hierarchy process (AHP), a well-known approach for handling multi-criteria decision making problems. AHP enables combining empirical data and subjective judgments, and also intangible and immeasurable criteria. It is based on pairwise comparisons of criteria and alternatives which are hierarchically structured. When several decision makers are involved, group AHP (Saaty & Peniwati 2008) replaces AHP which deals with only one decision maker. In group AHP, the main problems are: how to aggregate the individual comparison matrices into a group comparison matrix, how to calculate weights from such a matrix, the question of consistency of the aggregated matrix, and the problem of aggregated interval comparison matrix, when considering the uncertainty of decision makers. Some new ideas for solving these problems are proposed: the proof about acceptable consistency of group matrix (Grošelj & Zadnik Stirn 2012), a group AHP method for calculating priority vector (Grošelj et al. 2011), and a method for aggregation of individual judgments into group interval judgment (Grošelj & Zadnik Stirn 2013).

Keywords: Multiple criteria decision making, group AHP, weights, consistency, interval comparison matrix.

MCDA Applied in Solving Specific Issue of Selection of Best Tolling System

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Abstract: Paper presents a MCDA method applied in specific problem of selection of best tolling system. Specific issue of selection of best tolling system is done on real example on motorway network of Republic of Srpska and it is funded by EU-WBIF. Analysis of characteristics of different tolling system applied in EU and summarization of characteristic in groups and subgroups is performed. Process of conducting the MCDA is done through creation of list of toll alternatives and list of criteria. List of

criteria sorted in groups and in subgroups and weightings are finalized on several workshops that gathered all stakeholders concerning this issue. Finally scoring of each criterion for each toll alternative is performed, and MCDA method is applied. Results are subjected to a full sensitivity analysis taking in to account range of weighting of each criterion from 0 to 100% and its influence on rankings order and stability of first place.

Keywords: Multiple criteria decision analysis, toll system, criteria, weighting, sensitivity analysis.

Portfolio Optimization Based on using Goal Programming

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Abstract: In recent years, portfolio optimization models that consider more criteria than the standard objectives of the Markowitz model have become popular. But, one criticism over the proposed approaches in this theory is that they fail to embody all the investor's objectives, through the various stages of the decision process. In other words, to solve such multi-criteria models in the multi-attribute utility theory approach, a utility function should be constructed based on the decision maker's preferences. Then, by solving an optimization problem we can find a solution that maximizes that utility function. But the key assumption in portfolio optimization is that this utility function is unknown.

The aim of this paper is to present an approach for an investor to find a portfolio that maximizes his/her unknown utility function. To this end, by generating input/output weights as the investor's underlying value structure about objective functions for estimation of unknown utility function we help the investor further converge toward a highly preferred solution of the multi-criteria model. The validity of the proposed approach is tested through an illustrative application in Iran Stock Exchange.

Keywords: Portfolio optimization, utility function, goal programming.

Evaluating Indicators of Organizational Agility by Fuzzy Multi Criteria Decision Making: (Iran Power Development Organization)

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Abstract: The changing is characteristics of organizations and institutions in the field of competition. Beginning of the twenty-first century organizations have experienced changes to their surroundings. This change leads organizations to the new challenges, the lack of attention to their survival and success of the organization threatens the increasingly. Organizations to respond to the challenges of the modern approach to business agility developed. Purpose of this research is evaluating key indicators of Iran Power Development Organization agility, therefore after initial analysis of four main variables include of "leveraging impact of people and information", "cooperate to enhance competitiveness", "enriching customer", "mastering change and uncertainty" and designing questionnaire, collecting data and using the fuzzy multi-criteria decision making technique, data were analyzed. The findings shows that "cooperate to enhance competitiveness" with the importance degree (0.301) is the most importance of the main criterion for selecting the more agile organizational unit. While in Iran Power Development Organization it has third priority; The main criteria "leveraging impact of people and information" with the importance degree (0.277), "mastering change and uncertainty" with the importance degree (0.238), "enriching customer" with the importance degree (0.184), were three next most important criterion in the selection of organizational units are more agile.

Keywords: Organizational agility, fuzzy logic, fuzzy multi-criteria decision making.

Ranking the Selected Firms in the Steel Industry in North of Iran Considering the Sustaining Manufacturing using by FVIKOR Technique

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Abstract: Abstract: In recent years, companies are faced with increasing pressures to Thinking about Environmental and social impacts of its industrial operations. Attention to the Environmental effects has become to a Concept beyond of Economic benefits and Thinking about Industrial Processes. Minimizing of environmental Harmful effects of industrial operation is Fundamental goal in industrial modern organizations. Focusing and thinking in sustainable Manufacturing Models is considered as appropriate respond to achieving this goal. In this paper, after the investigates and thinks critically the existing Models on Literature, we use a comprehensive model for evaluation of sustainable manufacturing. Finally, using by FANP and FVIKOR techniques, we rank the Firms in the Steel Industry in north of Iran Considering the Sustainable Manufacturing.

Keywords: Sustainable manufacturing, FVIKOR, FANP, steel industry, Iran.

Students' Preferences towards English Medium Instruction: A Conjoint Analysis

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Abstract: Continuous quality improvement and modernization of the educational process are some of the most important factors for the success of educational institutions. To determine students' preferences towards using English to teach content courses (English Medium Instruction – EMI), conjoint analysis is proposed in this paper. Conjoint analysis is a research technique for measuring customers' preferences, and a method for simulating how customers might react to changes in current products or to new products introduced into an existing market. Students' preferences towards EMI will be determined using an illustrative example. More precisely, we will identify students' preferences towards EMI, in order to perform market segmentation and to determine the optimal structure of their offer. Fulfillment of student needs will result in a more efficient teaching and in maximization of the students' achievement. Happy and successful students present the best way to attract potential students and to provide a stable competitive position of college in today's market.

Keywords: Conjoint analysis, students' preferences, English Medium Instruction, segmentation, simulation.

The Application of Quantitative Analysis in Financial Leasing Sector in Serbia

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Abstract: The paper presents the results of a relative efficiency evaluation, performed on the data collected from 17 lessors, which operate in Serbia. Collected data covers the reference period of three consecutive years – 2009, 2010 and 2011. The relative efficiency of each lessor is evaluated by Data Envelopment Analysis (DEA) and Distance Based Analysis (DBA). The companies are ranked based on the obtained index of efficiency that is calculated using these two methods. In addition, DEA provides information of inputs need to be reduced for some inefficient lessors to become efficient, while DBA provides an overview of the most influential inputs in determining the efficiency, and given that

each company can establish the optimal control in order to increase efficiency.

Keywords: Efficiency, Data envelopment analysis (DEA), Distance Based Analysis (DBA), leasing companies.

Measuring Attractiveness of Secondary Education Programs: Evidence from Pisa Survey

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Abstract: In this paper we measure the attractiveness of educational profiles in Serbia using two methodological approaches. We compose composite index of attractiveness and also we use multi-criteria outranking approach. We apply author's modification of ELECTRE method – ELECTRE Multi-Level Outranking.

Keywords: Outranking, ELECTRE, PISA.

Solving the Web Service Selection Problem Using Multi-Objective Linear Fractional Programming

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Abstract: The Service Oriented Approach (SOA) is based on the idea that distributed applications can be flexibly composed by integrating independently developed component services. When choosing actual services to be included in the composition their non-functional (Quality of Service – QoS) properties must also be taken into account due to the fact that a large number of available services offer similar functionality. On the other hand certain constraints regarding the required performances (i.e. the required QoS levels) may also be given. Therefore, web service selection presents a multi-objective multiple constraint problem and in this paper we model it as a discrete multi-objective linear fractional programming problem (MOLFPP). In order to solve this problem we adapt a previously published technique for generating strongly efficient solutions to a MOLFPP to the discrete case. We present a complete methodology for solving the web service selection problem and report the experimental results obtained by testing it on 50 instances generated by varying the input parameters.

Keywords: Web service selection, SOA, QoS, multi objective programming, linear fractional programming.

MADM and Time Series

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Abstract: In this paper we will create and solve a MADM problem for transfer function time series models. We take into account that from a stochastic criterion of a MADM problem we have to build two cardinal criteria: the expectation, and the informational criterion (Shannon's entropy or Onicescu's informational energy). For the first one we consider the forecasted value, and for the second one we use the variance of errors, which is essential in computation of the value of second criterion.

Keywords: Transfer function time series models, MADM, linear regression, GDP per capita, employment rate.

Sufficient Efficiency Criteria in Multiobjective Fractional Programming with Generalized $(F, b, \varphi, \rho, \theta)$ -Univex n -set Functions

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Abstract: We consider some types of generalized convexity and discuss new global semiparametric sufficient efficiency conditions for a multiobjective fractional programming problem involving n -set functions.

Keywords: Multiobjective programming, n -set function, optimality condition, generalized convexity, fractional programming.

Multi Criteria Analysis Models in Defining Collection Strategies in Banking System

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Abstract: Nowadays, business conditions in banks are more complex and they require multi criteria approach to solving problems which allows compilation of a number of alternatives evaluated according to the predetermined criteria. The aim of this paper is to explain the importance of multi criteria decision making and, also to show possibilities of its use in resolving problems and making decisions in commercial banks. Information used in this study are based on data presented in academic journals and on usage of the softwares specialized for decision making support. This paper is intended for researchers and practitioners who deal with the principles of decision making and practitioners who make decisions in commercial banks.

Keywords: Multi criteria analysis, commercial banks, AHP, ELECTRE.

Multitribute Approach to Restructuring of the Regional Exploitation of the Technical Rock

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Abstract: A multivariable approach in problem solving is displayed in the example of systems restructuring of the technical rock open pits in the region of Velenje, Republic of Slovenia. While ranking five open pits, with fourteen criteria conditions, the models PROMETHEE, ELECTRE, AHP and VIKOR models were used. Because the model ranks are differentiated, the final comparison of the open pits was done through weighting. The conclusion emphasizes that there is no general scientific accord as to which models or methods are more suitable as tools for the analysis of this type of problems and reaching of management decisions.

Keywords: Multivariability, restructuring, regional planning, exploitation, technical rock.

■ B18 NETWORK OPTIMIZATION & TELECOMMUNICATIONS

The Frequency Assignment Problem: Bee Colony Optimization

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Abstract: The Frequency Assignment Problem (FAP) is the problem of assigning a frequency to each transmitter of a wireless network so that the measure of the quality of received signals is maximized. The FAP is a classical combinatorial optimization

problem. In this paper, the authors have considered fixed channel assignment scheme, where the forecasted demand is transformed to the requirement that a number of frequencies has to be assigned to each connection beforehand. The algorithm based on Bee Colony Optimization (BCO) for solving the problem is proposed. Computational results, obtained on a number of problem instances, testify the effectiveness of developed algorithm.

Keywords: Frequency allocation, wireless communication, bee colony optimization.

Wi-Fi Network Optimisation

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Abstract: Network optimisation is one of the most important aspects of effective management of information systems. Its purpose is to improve upon the existing network infrastructure using various methods. With the exponential growth of information technology comes the demand for greater network bandwidth and availability. This is especially evident when it comes to mobile devices that employ Wi-Fi networks. The most common issues with this type of network relate to reliability. Providing a case study of the current methods and practices, and presenting various recommendations for improvement, ensure a more efficient optimisation of Wi-Fi networks.

Keywords: Wi-Fi, network optimisation, telecommunications.

Applications of the Finite State Automata for Counting Subsets with Forbidden Differences

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Abstract: Denote by N_n the set of first n positive integers, i.e. $N_n = \{1, 2, \dots, n\}$. We will use the finite state automata to count the number of subsets (combinations) $B \subseteq N_n$ which do not contain two elements whose difference is equal to some elements of the finite set F . We will describe corresponding automaton and illustrate it through the examples.

Keywords: Combinations, finite state automata, exact enumeration, recurrences.

Maximum Flow over Time Network Interdiction

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Abstract: In this paper Maximum Flow Over Time Interdiction Problem (MFOTIP) is introduced and a mixedbinary linear programming solution method is proposed for this problem. Over time version of the renowned max-flow min-cut theorem plays a basic role in the proposed solution method. MFOTIP differs from deterministic network interdiction in the sense that MFOTIP takes into account the most important role of time in real world applications.

Keywords: Maximum flow over time, interdiction, mixed-binary linear programming.

■ B19 OPTIMIZATION SOFTWARE

Software Support for Optimization of Production Cycle Flow

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Abstract: This paper describes the software support for optimization of production flow of series in the production cycle.

Determining the duration of the production cycle is undoubtedly one of the most important elements of the production. Described application solution is designed for organization and analysis of production in this segment. For these reasons it can be expected that the described solution can be widely used in manufacturing organizations. This paper describes the most important elements of this analysis, and the application solution for its support. The software solution is characterized by a simple and practical applicability in a wide range of manufacturing organizations.

Keywords: Production cycle, production series, computer support.

SIM-PA: An Open Source-Based Simulation Language

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Abstract: In the paper, a new simulation language for discrete event simulation based on open source libraries and tools is presented. SIM-PA language has C-like block syntax and its conceptual framework is a modification of the process interaction world view. Paper gives insight into the language syntax and provides a benchmark example used for comparative analysis between SIM-PA and several simulation languages.

Keywords: Discrete-event simulation, process interaction, systems modeling, object-oriented programming.

■ B20 PARALLEL PROCESSING IN O.R. & GRID COMPUTING

Parallel and Distributed Software Assessment in Multi-Attribute Decision Making Paradigm

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Abstract: Multi-Attribute Decision Making (MADM) theory is a way to obtain good assessment for the parallel and distributed software. It provides tools to compute a synthetic characterization, named High Performance Computing (HPC) merit, which may be used in operations like software comparisons / rankings / optimizations. The paper presents the general assessment model with its associated assessment problems and a terse and telling case study. The assessment model is described and solved by the Internet mathematical service named OPTCHOICE (MADM modeling and optimal choice problem solving). It provides a multitude of normalization and solving methods generating diverse assessments, but always a global assessment is delivered.

Keywords: Software assessment, parallel and distributed computing, multiple attribute decision making, comparisons / rankings / optimizations through the agency of the high performance computing merits.

■ B21 PROJECT MANAGEMENT & SCHEDULING

The Foraging Search Algorithm for Resource Constrained Project Scheduling

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Abstract: The Resource-Constrained Project Scheduling (RCPS) Problem has been dealt with numerous methods for approximately

five decades. Since solving RCPS problems with exact methods is computationally expensive, metaheuristics are frequently used where an exploration-exploitation balance has been the main objective. This study introduces a novel metaheuristic method for solving RCPS problems. This new approach is compared with the Particle Swarm Optimization (PSO) algorithm using four instances. Moreover, the swap operator has been introduced for producing feasible schedules from particles and this new operator is used in both methods. Results indicate that the Foraging Search is a promising algorithm for solving RCPS problems.

Keywords: Project scheduling, particle swarm optimization, foraging search.

Common-Knowledge and Buyer-Supplier Chain Cooperation Management

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Abstract: Issues of moral hazard and adverse selection abound in each and every contract where one has a self interest and information that the other party does not possess. While this is a fertile research area, there is still need for more information on how you handle a party to a contract with more information than you. The moral hazard is very often the bottleneck in buyer-supplier cooperation, and the buyer and suppliers management is an epitome. This paper re-examines the issue in the buyers-suppliers cooperation with moral hazard by the framework of a principal-agent model under uncertainty. It highlights epistemic conditions for a possible resolution of the moral hazard between the buyer and the suppliers. For removing out such moral hazard in the buyer-supplier cooperation as above our recommendation is that the buyer and suppliers should commonly know their beliefs on the others' effort.

Keywords: Belief, common-knowledge, effort level, moral hazard, principal-agent model under uncertainty.

Are All Failures in Delivering Projects 'On Time Within Budget' Really Inevitable?

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Abstract: The improvement in the organization of project control is a major challenge facing project organizations today. Control systems consist of inspection routine, present views and implementation of coordination when deviation from the planned trajectory is discovered. The inability of control systems to reduce failures in delivering projects 'on time within budget' derives mainly from the defective practice of choosing simple solutions for complex problems which are invariably wrong. In contrast to production and process systems, where the output can be continuously measured, the outputs during the course of the project's advancement are mostly immeasurable; therefore, inspection timetable based on time or cost intervals does not necessarily represent realistic present views. By utilizing the deterministic critical path model for assessing the project completion time the project manager is grossly misled into thinking that the chance of delivery 'on time within budget' is very good when in reality it is very poor. Moreover, coordination aimed at the reestablishment of the project targets is inferior when uncertainties are not taken into consideration. Control routines with rational timetabling of the inspection points, present views based on Monte Carlo simulations, as well as coordination considering the impact of the execution mode on time and cost uncertainties may enable the attainment of project deliveries 'on time' and as much as possible 'within budget' when prevalent control routines cannot.

Keywords: Project management, uncertainty, control, time–cost tradeoffs, Monte Carlo simulations.

Selection of the Best Consultant for SAP ERP Project using Combined AHP-IBA Approach

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Abstract: This paper proposes a combined AHP-IBA model in selection of the best SAP consultant for an SAP ERP project. The goal of the SAP Project Manager is to choose the best consultant, who is able to implement standard SAP functionalities with quality and on time. To achieve this, Analytic Hierarchy Process (AHP) was used in this paper to determine the importance of criteria and with Interpolative Boolean algebra (IBA) logical interactions among criteria were modeled as well. The research suggests that the results are more accurate when an AHP method includes IBA. IBA is used to generate new attributes that establish interaction between the initial criteria.

Keywords: Interpolative Boolean algebra (IBA), Analytic Hierarchy Process (AHP), SAP ERP Consultant selection, project management.

■ B22 RISK ANALYSIS & MANAGEMENT

The Measuring of Stocks Illiquidity across Markets of the Balkan Peninsula

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Abstract: In this paper we measure the level of market illiquidity across national markets of the Balkan Peninsula including: Turkey, Greece, Bulgaria, Romania, Bosnia and Herzegovina (Sarajevo and Banja Luka), Croatia, Macedonia, Montenegro, Serbia, and Slovenia. We proxy illiquidity with the Zero Returns (ZR) measure. We found that the worst performer countries were Macedonia and Bulgaria according to risk-return relation. According to illiquidity measure we showed that Turkey had the most liquid market, while Serbia and Bosnia are the most illiquid. Additionally, our results suggest that the EU member countries are more liquid markets than the non-member countries.

Keywords: Illiquidity, Balkan, zero returns.

Conditional Extreme Value Theory Approach in Value-At-Risk Assessment

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Abstract: The recent financial crisis raised many questions concerning the adequacy of different risk measures and especially Value-at-Risk (VaR) methodologies. Although VaR belongs to extreme returns, current practice in VaR assessment relies heavily on modeling the whole distribution of returns. As an alternative, this study focuses on modeling tail behavior of returns and thus VaR, using Extreme Value Theory (EVT) methodology. This paper examines the performance of conditional EVT with the daily returns of Standard&Poors 500 Index from the period January 1998-April 2013 and BELEXline index from the period of September 2004-April 2013. This period is chosen since it covers major downturns in financial markets, thus being suitable for testing robustness of these models. Results proved that this model holds for all observed confidence levels

Keywords: Value-at-Risk, extreme value theory, volatility, fat-tails, heteroscedasticity.

From Local Robustness to Irresponsible Decision-Making

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Abstract: The differences between measures of LOCAL and GLOBAL robustness are, to all intents and purposes, clear as daylight. One would hardly expect, therefore, to find serious misconceptions of these measures in the literature on risk analysis and decision-making. And yet, as we show here, such misconceptions are at the center of a number of recent peer-reviewed articles, proposing the use of RADIUS OF STABILITY models to tackle a severe, non-probabilistic uncertainty. We call attention to the fact that such a proposition can lead to irresponsible decision-making. We also comment on the implications of misleading rhetorics about robustness for sound decision-making.

Keywords: Robustness, local, global, radius of stability, severe uncertainty

Qualification of Open Pit Mines Based on External Risks Assessment

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Abstract: Minerals industry is exposed to various risks which, in case of resulting in an unwanted occurrence, have major or minor unwanted consequences for both safety and reliability of the exploitation system and the business operations of a mining company. When defining the methods and procedures for the evaluation and management of risks in minerals industry, risks are generally qualified as external and internal. With the aim to have a more quality approach in risk assessment, it is necessary to classify external and internal risks from various aspects. This paper presents the qualification of external risks and a classification of open pit mines from the point of view of external risks assessment.

Keywords: Mining company, external risks, open pit mine.

The Economics of Moving to the Cloud

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Abstract: Cloud Computing as a concept that has revolutionized the business world. Clients have the ability to dynamically adjust available computing resources and pay for those resources accordingly. This paper is focused on the economics aspect of Cloud Computing and the cost effectiveness of its use. We propose using different metrics to estimate potential benefits of investments in the Cloud. Sharing the infrastructure, applications and hardware in an unknown environment leads to a lack of confidence in data integrity as well as applications delivered. Risk is at the heart of the decision making process when it comes to Cloud architecture and service delivery model. This paper points out the necessity of assessing perceived risk and including that uncertainty on business outcomes in financial assessments

Keywords: Cloud Computing, cloud model, IT investment, financial analysis, decision making metrics.

Bases of Modern Systems Concepts of (All-Embracing) Operations Management

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Abstract: Modern Systems Management Concepts (MSMC) which are established, verified, developed and confirmed in not only business (operations) systems, but also in other organizational

systems, are a good basis for further, more modern developments of practical-theoretical all-embracing management (research and management in a narrow sense) of all the systems of (global) economy. Based on (modern) Total Quality Management (TQM) through: (1) Modern Systems Management Theory (MSMT) and (2) Modern Systems Management Concepts (MSMC), for further development they use modern management methodology called the Tuzović's General Concept (TGC), or in application the Tuzović's General Continuum (TGC), using which it has been possible to develop a certain number of basic and expanded Systems Concept of Operations Management. In this paper, with its usage, systems analysis is given and systems synthesis of modern (operations) management concepts is also provided. Since the main concepts of management are: (i) competitiveness (the why), (ii) quality (the what) and efficiently flexibility (the how), it has been possible to conclude why modern organizations exist – to be prosperously competitive, which means that through their modern operations management, they provide real things (the what – quality /effective timeliness/) and in the right way (the how – profitably /efficiently flexibly/). Therefore, modern management ensures modern prosperity and competitiveness of an organization.

Keywords: Management, operations, concepts, Tuzović's General Concept (TGC).

Seismic Risk Assessment Using Mathematical Correlation and Regression

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Abstract: The actual design methods of structures under the influence of permanent, effective and climatic (wind, snow) loads, need an elastic behaviour of the structure and a static action of loads. The dynamic aspect of seismic action and inelastic behaviour of the structures affected by major earthquakes require specific design methods, governed by seismic design regulations. In Romania the field is covered by Seismic Design Code- part III – provision for seismic evaluation of Existing buildings, indicative P 100-3/2008. The article presents a calculation model of body A, building of Faculty of Land Reclamation and Environmental Engineering, Bucharest and also correlation and regression analysis of mathematical results to seismic evaluation of buildings, using MATHCAD PROFESSIONAL Software.

Keywords: Correlation function, regression function, seismic risk, seismic force.

Risk of Burnout Predictor Identification among Students at Faculty of Organizational Sciences

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Abstract: This paper presents the extension of previously conducted research in the field of student burnout – the syndrome of emotional exhaustion, depersonalization or cynicism and reduced personal accomplishment. The objective was to investigate the risk of burnout among students and to analyze the relationship between field of study and year of study with three dimensions of burnout using the Maslach Burnout Inventory – Student Survey. The results show that there is a significant difference between management and IT students, but only on subscale of efficacy. When it comes to year of study, 62.5% of students who are at their final year of study are at risk of burnout and special attention should be given to second year students which are at high risk of burnout.

Keywords: Risk of burnout, high risk of burnout, students, field of study, year of study, Maslach Burnout Inventory – Student Survey (MBI – SS).

Optimization of Human Resources Development Process by Applying Markov's Chain Dynamic Model

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Abstract: Process of globalization and contemporary management are based on assumption of global access to resources, similar business conditions and free competition. These questions are equally important for private and public sector. If public sector doesn't pay attention about costs, and allocated budget funds aren't used in rational way, these can lead to disruption of economic stability or decrease quality of services for the citizens. By applying Markov's chain method dynamic model is created and simulation of human resources development can be conducted. This enables more precise planning and more efficient implementation of training for public sector employees, which can result in considerable budget savings.

Keywords: Simulation, optimization, human resources management, Markov chain.

■ B23 STATISTICS & STOCHASTICS

On the Levy Processes and the Fractional Laplace Operator

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Abstract: We consider the heat equation with initial and boundary conditions, in which the Laplace operator is replaced by the fractional Laplace operator. We discuss its solution in terms of a Levy process, which is represented in terms of the subordinated Brownian motion.

Keywords: Brownian motion, heat equation, initial and boundary problem, levy process, subordinator, fractional Laplace operator.

A New Perspective on Evaluating S&T in ICT Oriented Societies: Statistical Approach

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Abstract: The aim of this paper is to present new ideas in evaluating indicators of countries welfare. As a remedy to the issue, World Bank's World Development Indicators 2012 define "The Information Society" and "Science and Technology" categories as important part of analysis. Accordingly, we will present composite indicator which synthesizes individual indicators from each category into one value. With this approach, we will be able to rank countries according to their ICT and S&T development level. Moreover, useful insights will be provided for the developing countries such as Serbia and path for enhancing their ranking will be elaborated.

Keywords: World development indicators, the I-distance method, the information society, science and technology, statistical methods.

Energy Spectra of Earthquake Strong Motion Records

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Abstract: Time-frequency representations are considered for the energetic characterization of the non-stationary earthquake motion records. These distributions map the one-dimensional time-domain

signals into bi-dimensional time-frequency domain functions. The evolutionary energy spectra describe the time-varying spectral content and the frequency dependence of effective duration of the earthquake motions. Different time-frequency distributions were considered in the analysis of non-stationary earthquake motion time-histories. The analyzed real seismic data includes translational components of motions on three orthogonal directions recorded in different site conditions during recent strong earthquakes.

Keywords: Time-frequency, earthquake motion records, time-varying spectra.

Impact of Different Body Segments on Precision of Gait Based Human Identification

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Abstract: Human gait as a biometric modality is vulnerable to occlusion. In many cases some section of human body is occluded during recording, either by some other body part or some other object. The purpose of this research was to determine whether occluded body parts can be left out from the recognition process. For this purpose we conducted a series of experiments using structured lighting for acquisition and method that accumulates gait sequence in to still image in order to perform CBIR techniques for recognition. Results retrieved indicated that recognition can be successful even with using only upper or lower extremities with slight drop of performances.

Keywords: Biometric, gait recognition, occlusion.

Time-Frequency Analysis of Romanian Earthquakes Records

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Abstract: In seismic engineering, the reliable earthquake characterization is fundamental in the analysis and synthesis of seismic ground motions. An important feature of such signals, which are nonstationary, is the change of their frequency content over time. Time or frequency descriptions alone do not provide an exhaustive information about these signals. The time domain description lacks the frequency information about the signals and the variability of earthquakes spectrum over time cannot be obtained from the classical Fourier analysis. The present study focuses on the spectral analysis of the Vrancea earthquakes, large magnitude seismic signals, affecting the entire territory of Romania using joint time-frequency distribution (TFD). These TFD's are based on signal decomposition, from Cohen's class or signal dependent. The obtained energy distributions are validated against some important constraints and numerically compared.

Keywords: Time-frequency analysis, energy distribution, signal dependent TFD's.

Lorenz Curve and Mysteries of Order Statistics

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Abstract: Divide at random segment of length 1 into n small segments. If we do not sort them, all of them are negatively correlated. After sorting them in ascending order, a curious phenomenon occurs: the smallest one is positively correlated with about 63% among the others, the greatest one only with a proportion $p(n)$ which tends to 0 as n tends to infinity. The empirical Lorenz curve attached to this family of small segments has a limit in probability. We conjecture that the limit does exist even almost surely and some other things, too. Those are mysteries of order statistics.

Empirical Likelihood Approximation to Neyman-Pearson Tests for Paired Data

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Abstract: In many case-control studies, it is common to utilize paired data when treatments are being evaluated. To operate with sets of paired observations, well-known classical procedures such as the Wilcoxon signed-rank test and the paired t-test are widely used in statistical practice. Recently proposed empirical likelihood (EL) concepts for creating distribution-free approximations of powerful parametric likelihood ratios cause to develop efficient alternatives to the classical tests for paired data. The EL methodology is commonly presented via nonparametric likelihoods of cumulative distribution functions, whereas most powerful parametric tests have structures that consist of density functions. In this paper, we present the density-based EL ratio test for the equality of the marginal distributions when sampling from a bivariate population. We show that in various shift alternative cases the presented test is superior to the classical procedures that may break completely or are frequently inferior to the density-based EL ratio test, when non-constant shifts in the two-sample problem are in effect or data distributions are skewed.

Keywords: Density-based empirical likelihood, paired data, paired t-test, two-sample location problem, Wilcoxon test.

Educational Development in Europe: Positions of Balkan Countries

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Abstract: Education is one of major human development indicators, and thus it is quite important to impose a way to measure educational development. This paper defines an educational development measurement based on a recently acknowledged statistical method, I-distance method, which combines a whole set of input parameters into one indicator suitable for comparative measurement and evaluation. Particularly, this paper evaluates educational development solely based on non-financial indicators. Special attention in this article is focused on the position and perspectives of Balkan countries, among the European educational development rankings. The Balkans are currently differently, but predominantly low ranked. They are still far away from meeting the EU development goals, and they have to improve all educational indicators in order to move up the ranking scale. Nonetheless, there are many fields with an open perspective to progress.

Keywords: Educational development, Europe, ranking countries, I distance, the Balkans.

Econometric Modelling of Unemployment in Serbia

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Abstract: The purpose of the paper is to econometrically exploit the characteristics of unemployment in Serbia upon the start of the 2008 economic crisis. The methodological framework is based on the cointegrated vector autoregressive model that consists of the following macroeconomic variables: unemployment rate, prices, nominal wages and nominal exchange rate. These variables are unitroot processes and their relationship is examined within the multivariate cointegrated time series set-up. Following the deductive modelling approach we reached the specification that explains unemployment rate by real wages. The results show the negative consequences of the economic crisis to the labour market, with an extremely high increase in the unemployment rate. Strong negative impact of real wages on unemployment rate is additionally

confirmed by its dynamic effects throughout the impulse response function.

Keywords: Cointegrated vector autoregressive model, impulse response function, real wages, unemployment rate.

Time Series Models

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Abstract: In this paper we will study the influence of qualitative variables on the unit root tests for stationarity. For the linear regressions involved the implied assumption is that they are not influenced by such qualitative variables. For this reason, after we have introduced such variables, we check first if we can remove some of them from the model. The considered qualitative variables are according the corresponding coefficient (the intercept, the coefficient of X_{t-1} and the coefficient of t), and on the different groups built tacking into account the characteristics of the time moments.

Keywords: Qualitative variables, Dickey-Fuller, ARIMA, GDP, homogeneity.

Using of Statistical Methods in the Making Decision Process – Case of Macedonian Companies

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Abstract: Good working and managing of a company depends on good decisions made by managers and employees. Decision-making process is going to be effective if statistical methods are applied. Using the statistical methods , available information and data, specific models and control cards can be made , which are going to be evaluated and tested, and this will help in decision- making process. Precisely this prompted us to conduct research in some Macedonian companies in order to determinate how often statistical methods are applied in decision making process. The research was conducted in companies from different industries and managers of different age, gender and education level. The sample is random and it is not representative. In Macedonia 40 companies were investigated.

Keywords: Statistical methods, application and use.

Scientific Research Publication Productivity in the Areas of Mathematics and Physics in South Eastern Europe

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Abstract: Paper presents the scientific publication productivity registered in Web of Science (WoS) databases in two fields of science: Mathematics and Physics, for authors from the countries of South East Europe (SEE). Using Revealed Publication Advantage (RPA) indicator calculated for SEE countries, policy makers could get insight to the scientific publication productivity in these two scientific fields in SEE countries compared to the world average. The scientific output in Mathematics and Physics from the SEE region represents majority of the overall scientific output in every particular country in this region. The scientific output in Mathematics and Physics from the SEE region is comparable with those of other research groups in the world. When analyzing Web of Science publications by field of research, Mathematics represents 2.1% of the total worldwide scientific production while Physics accounts for 8.8%, giving a total of 10.9% for Physics and Mathematics combined – over 1,547,187 publications in the period 2005-2010. In South East Europe, Mathematics is 3.5% of the total scientific production, while Physics is 9.6% - bringing the total for Physics and Mathematics to 13.1%.

Keywords: Scientific publication productivity, Web of Science, Revealed Publication Advantage (RPA) indicator, South East Europe (SEE), mathematics, physics.

Heavy Traffic Analysis of an M/G/1 Semi-Markov Queue

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Abstract: We present the analysis of a single-server semi-Markov queue under heavy-traffic assumptions. The inter-arrival times and the service times depend on a common Markov chain. The Laplace-Stieltjece Transform of the steady-state virtual waiting time is derived and used to obtain its limit distribution under heavy-traffic assumptions. The limit distribution of the virtual waiting time is exponential distribution.

Keywords: M/G/1 queue, Dependence between arrival and service times, Virtual waiting time, Heavy traffic limit distribution of virtual waiting time.