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EDITORIAL

Preface: Multiple criteria optimization and goal programming in science, engineering, and social sciences

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It is a real pleasure to announce the publication of this special volume of the *Annals of Operations Research*. It contains 22 interesting and original papers from researchers with expertise in Multiple Criteria Decision Making (MCDM), Goal Programming (GP), and applications to science, engineering, and social science. Multiple Criteria Decision Making (MCDM) or Multiple Criteria Decision Analysis (MCDA) is a discipline dealing with decision-making situations involving multiple and conflicting criteria, objectives, or attributes. There are several examples of MCDM problems in everyday life: in general considering multiple criteria explicitly leads to more informed and better decisions. MCDM models are usually characterized by an elevated level of complexity, and quite often it is necessary to use the decision maker's preferences to differentiate between possible solutions and determine the best compromise. Many important advances have been developed in this field since the start of the modern MCDM discipline in the early 60s, including new approaches, innovative methods, and sophisticated computational algorithms. The GP model is a branch of multi-criteria decision analysis and it is a well-known aggregating methodology for handling multiple, normally conflicting objective functions or measures. Each of these measures is provided with a goal or target value to be achieved, and unwanted deviations from this set of target values are then minimized in the objective function. The obtained solution through the GP model represents the best compromise that can be made by the decision maker. The GP model was introduced in the early 50s, and applications can be seen in several fields, such as accounting and the financial aspects of stock management, marketing, quality control, human resources, production, and operations management. The popularity and applications of GP have increased immensely due to the mathematical simplicity and modeling elegance. The main topics discussed and analyzed in this special volume are: Advances in MCDM, Multiple Objective Programming and Goal Programming, Stochastic MCDM, Stochastic GP, Fuzzy MCDM, Fuzzy GP, and applications to biology, economics, engineering, financial management, operations management, and social sciences.

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Three papers describe the state-of-the-art of MCDM and GP in different areas. "Multicriteria decision analysis with goal programming in engineering, management and social sciences: a state-of-the art review," by Cinzia Colapinto et al., presents a state of the art literature review on GP applications in three popular areas: engineering, management, and social sciences. "Goal programming model for management accounting and auditing: a new typology," by Belaid Aouni et al., provides an exhaustive literature review of the GP application within the field of accounting. The authors also propose a new typology which serves as a guideline for accountants to identify the most appropriate variant of GP to deal with a specific accounting related decision-making situation. Oluwaseun Sharomi and Tufail Malik review the available literature on mathematical models that use optimal control theory to deduce the optimal strategies aimed at curtailing the spread of an infectious disease in the paper "Optimal control in epidemiology." Mathematical modeling of infectious diseases has shown that combinations of isolation, quarantine, vaccine, and treatment are often necessary to eliminate most infectious diseases. However, if they are not administered at the right time and in the right amount, disease elimination will remain a difficult task. Optimal control theory has proven to be a successful tool in understanding ways to curtail the spread of infectious diseases by devising the optimal diseases intervention strategies. The method consists of minimizing the cost of infection or the cost of implementing the control, or both, leading to multiple criteria problems in a dynamic context.

In this special volume there are five papers that provide contributions to the theory of MCDM and GP. The paper "Nondifferentiable minimax programming problems with applications," by Thai Doan Chuong and Do Sang Kim, is devoted to the study of optimality conditions and duality in nondifferentiable minimax programming problems and applications. The authors use some advanced tools of variational analysis and generalized differentiation to establish new necessary conditions for optimal solutions of a minimax programming problem involving inequality and equality constraints. They also obtain sufficient conditions by means of L-invex-infine functions. They define a dual problem associated with the primal one, and explore weak, strong, and converse duality relations between them. Giovanni P. Crespi et al. deal with robust optimization in "Quasiconvexity of set-valued maps assures well-posedness of robust vector optimization." This is a fast growing methodology to study optimization problems with uncertain data. An uncertain vector optimization problem can be studied through its robust or optimistic counterpart. The authors formulate the counterparts as set optimization problems, as this appears to be more natural, especially when the uncertain problem is a nonlinear vector optimization problem. Nicolae Popovici applies MCDM concepts to equilibrium problems in "A decomposition approach to vector equilibrium problems." A vector equilibrium problem is generally defined by a bifunction that takes values in a partially ordered vector space. When this space is endowed with a componentwise ordering, the vector equilibrium problem can be decomposed into a family of equilibrium subproblems, each being governed by a bifunction obtained from the initial one by selecting some of its scalar components. The author shows that under appropriate convexity assumptions the set of all weak solutions of a vector equilibrium problem can be recovered as the union of the sets of proper solutions of its subproblems. In the paper "Multiple criteria hierarchy process for sorting problems based on ordinal regression with additive value functions," Salvatore Corrente et al. apply the Multiple Criteria Hierarchy Process (MCHP) framework to multiple criteria sorting problems and extend existing disaggregation and robust ordinal regression techniques that induce decision models from data. The new methodology allows the handling of preference information and the formulation of recommendations at the comprehensive level, as well as at all intermediate levels of the hierarchy of criteria. A case study on bank performance rating is used to illustrate the proposed methodology. Finally, the

aim of the paper "Fuzzy goal programming model for classification problems," by Soulef Smaoui and Belaid Aouni, is to propose a new approach, based on fuzzy goal programming, for classification problems where the cut-off value corresponding to the discriminant axe is considered as imprecise. The fuzziness was handled through different membership functions. The proposed model is illustrated through two and multi-groups classification problems.

Five papers deal with applications to financial economics and portfolio management. An extended portfolio selection model is discussed in the paper "An analytical derivation of the efficient surface in portfolio selection with three criteria," by Yue Qi et al. In standard mean/variance bicriteria portfolio selection, the efficient set is a frontier. There is a growing amount of discussion in the literature on the possibility to have additional criteria in portfolio selection. When one additional criterion is added, the efficient frontier becomes an efficient surface. In this contribution the authors provide an analytical derivation of the efficient surface when an additional linear criterion (on top of expected return and variance) is included. Among the results of the paper there is, as a higher dimensional counterpart to the 2-mutual-fund theorem of traditional portfolio selection, a 3-mutual-fund theorem in tri-criterion portfolio selection. Hatem Masri addresses the case of multiple stochastic goals for an objective function within the context of stochastic goal programming in "A multiple stochastic goal programming approach for the agent portfolio selection problem." The author also derives results from studying the agent portfolio selection problem. The proposed multiple stochastic goal programming approach allows investors to set different goals for the return objective function. A chance constrained approach is proposed to address the stochastic investors' minimum acceptable rates of return and a recourse approach to deal with investors' ideal rates of return. The author also reports the results of an empirical study from the Bahrain stock market. In the paper "Fuzzy chance-constrained goal programming model for multi-attribute financial portfolio selection," Laila Messaoudi et al. propose a fuzzy chance constrained goal programming model for solving a multi-attribute financial portfolio selection problem under two types of uncertainty, namely randomness and fuzziness. The chance-constrained goals are considered as random variables. The obtained solution represents the best choice that can be made by the financial decision maker when conflicting and incommensurable attributes such as the expected return, risk, and the earning price ratio are considered. The proposed model has been validated using data of the Tunisian stock exchange market during the period July 2003 to December 2007. Adil Baykasoglu et al. provide a new fuzzy Multiple-Attribute Decision Making (MADM) model for evaluating product pricing strategies in "A fuzzy multiple-attribute decision making model to evaluate new product pricing strategies." The problem is structured in a hierarchical setting, and possible interactions and interdependencies among hierarchically structured criteria are taken into consideration. Since new product pricing decisions entail decision makers' uncertain judgments concerning many interacting factors, Fuzzy Cognitive Maps (FCMs) are employed to analyze causal dependencies among attributes. Decision makers' linguistic assessments are transformed into ranking orders of the pricing strategies using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The proposed model has been implemented by a Turkish software company, and empirical studies have showed that it is efficient and easy to apply. Finally, the paper "A chance constrained recourse approach for the portfolio selection problem," by Meryem Masmoudi and Fouad Ben Abdelaziz, deals with the stochastic portfolio selection problem when the loss in the portfolio return is considered as a recourse cost. The authors suppose that the investor would penalize infeasible solutions for uncertain constraints with the most probable highest recourse cost rather than with the expected recourse cost as in the traditional recourse approach. This novel formulation which is mixed with a goal programming technique is used to solve a multi-objective stochastic

portfolio selection model. The model is illustrated by an empirical example using the weekly returns of the Standard & Poor's 100 securities between January 2001 and November 2011.

Three papers discuss applications of MCDM and GP to economics. In "A fuzzy goal programming model to analyze energy, environmental and sustainability goals of the United Arab Emirates," Raja Jayaraman et al. propose a Fuzzy Goal Programming (FGP) model that integrates optimal resource allocation to simultaneously satisfy prospective goals on economic development, energy consumption, workforce, and greenhouse gas (GHG) emission reduction applied to key economic sectors of the United Arab Emirates (UAE). Real-world problems often involve imprecise information, which makes fuzzy goal programming (FGP) models the most attractive choice. The model offers valuable insights to decision makers for strategic planning and investment allocations towards sustainable development. The authors demonstrate the validity and applicability of the model through a numerical example. Cinzia Colapinto et al. propose an application of MCDM to macroeconomics in "Sustainability and intertemporal equity: a multicriteria approach." In the literature, the need to consider sustainability and intertemporal equity issues leads one to consider different criteria (discounted utilitarianism, green golden rule, Chichilnisky criterion) in order to define social welfare. The authors compare and assess the outcomes associated with such alternative criteria in a simple macroeconomic model with natural resources and environmental concern (Chichilnisky et al. 1995), by relying on a multi-criteria approach. They show that among these three criteria, the green golden rule (discounted utilitarianism) yields the highest (lowest) welfare level, while the Chichilnisky criterion leads to an intermediate welfare level which turns out to be increasing in the weight attached to the asymptotic utility. These results suggest that completely neglecting finite-time utilities and focusing only on the asymptotic utility is not only more sensible from a sustainability point of view but also from a social welfare maximization standpoint. The paper "The conservative Kalai-Smorodinsky solution for multiple scenario bargaining," by Luisa Monroy et al., addresses two-person bargaining problems under uncertainty where several states of nature or future scenarios are considered. The authors propose a solution concept based on the distance to a utopia minimum outcome vector, which guarantees conservative levels of achievement for the agents. They also provide an axiomatic characterization for a significant class of these bargaining problems.

The remaining six papers present several applications of MCDM and GP to operations management. In the paper "Fuzzy approach to decision analysis with multiple criteria and uncertainty in health technology assessment," Michał Jakubczyk and Bogumił Kamiński propose an approach that allows one to introduce fuzziness into the decision making process in health technology assessment (HTA). Specifically, in the paper they (i) define a fuzzy preference relation between health technologies using an axiomatic approach; (ii) link it to the fuzzy willingness-to-pay and willingness-to-accept notions and show the survey results in Poland eliciting these; and (iii) incorporate uncertainty additionally to fuzziness and define two concepts to support decision making: fuzzy expected net benefit and fuzzy expected acceptability. Sebastian Rachuba and Brigitte Werners study a multi-criteria model for operating room schedules in "A fuzzy multi-criteria approach for robust operating room schedules." It is well known that operating room schedules are regularly influenced by uncertain demands such as unknown surgery durations or randomly arriving emergency patients. The performance of these schedules depends on the information available about these uncertainties when designing the schedules. The authors focus on an offline operational planning level that assigns patients to days and rooms without focusing on the intra-day sequence. They compute a robust compromise schedule focusing on stochastic surgery times and different objectives and simultaneously reserve time windows dedicated to randomly arriving emergency demand. In order to evaluate the schedule's quality, they perform an extensive

simulation study and demonstrate to what extent each robust schedule achieves the mentioned goals. The paper "Supply chain management through the stochastic goal programming model," by Alireza Azimian and Belaid Aouni, analyzes a generalized supply chain model. Supply chain design problems are often characterized by the presence of uncertainty related to the decision-making parameters. Stochastic goal programming is one of the classical aggregating procedures proposed to deal with stochastic multiple criteria decision making contexts. However, the classical formulation of the stochastic goal programming model does not integrate explicitly the manager's preferences. In this paper the authors utilize chance-constrained programming and the concept of satisfaction function to formulate strategic and tactical decisions within supply chain management subject to random demand, supply, and total cost. In the paper "Value analysis planning with goal programming," Marc Schniederjans et al. present a model to support planning decisions in the engineering methodology referred to as value analysis. A goal programming model incorporating elements of critical path method and concurrent engineering is proposed as a means to augment the planning of value analysis projects. The modeling approach builds and extends prior goal programming research by uniquely incorporating both timing and cost information to ease modeling complexity and reveal scheduling resource tradeoffs. In the paper "A recourse goal programming approach for airport bus routing problem," by Fouad Ben Abdelaziz et al. address the Airport Bus Routing Problem (ABRP) described as follows: A company owns several buses located at the airport to transport customers from many hotels and meeting points back to the airport according to their departure times. The ABRP can be viewed as a stochastic vehicle routing problem as the presence of customers at meeting points is random. The aim is to construct a minimum cost set of vehicle routes that satisfies all customers' timing requests and to minimize the customer's traveling time and the airport waiting time. The authors propose a multi-objective stochastic program (MSP) to model the ABRP and solve the MSP problem using a goal programming approach and a recourse approach. The paper "A three-dimensional bin-packing model: exact multicriteria solution and computational complexity," by Gregory S. Taylor et al., reexamines the three-dimensional or vector bin-packing problem in which the least number of bins is determined to accommodate p items to be packed. An exact analytical mixed-integer-programming formulation is offered to pack items by layers, while simultaneously considering the layer height. The linear computational complexity suggests that this analytical model can be solved efficiently irrespective of the number of items to be packed. A novel feature of the analytical model is that it yields Pareto optima, rather than a single optimum. This allows decision makers to choose among the nondominated solutions in consideration of other soft factors in bin packing.

The guest editor thanks all of the authors who submitted papers for consideration.