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Decision-maker's preferences modeling in the stochastic goal programming

Belaïd Aouni [a,*], Foued Ben Abdelaziz [b], Jean-Marc Martel [c]

[a] *Decision Aid Research Group, School of Commerce and Administration, Laurentian University, Sudbury, ON, Canada P3E 2C2*

[b] *Institut Supérieur de Gestion, Le Bardo 2000, Tunis, Tunisie and College of Business and Management, University of Sharjah, P.O. Box 27272, Sharjah, UAE*

[c] *Faculté des Sciences de l'Administration, Université Laval, Québec, QC, Canada G1K 7P4*

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Abstract

Generally we assume that the decision-maker is able to delimit with precision and without difficulty, the values of the goals associated with the objectives of a decision-making situation. However, such values may be probabilistic in nature. In such situation, the decision-maker does not know with certainty the values of the goals related to the different objectives. To deal within such decision-making situations, the literature proposes several techniques, based on the stochastic goal programming (SGP) model. These approaches do not take into account explicitly the decision-maker's preferences. In the present paper, we exploit the concept of the satisfaction functions to explicitly integrate the decision-maker's preferences in the SGP model.

Keywords: Stochastic goal programming; Decision-maker's preferences; Satisfaction functions; Imperfect information

1. Introduction

The goal programming (GP) model is one of the well-known multi-objective mathematical programming (MOP) models. This model allows to take into account simultaneously several objectives in a problem for choosing the most satisfactory solution within a set of feasible solutions. More precisely, the GP designed to find a solution that minimizes the deviations between the achievement level of the objectives and the goals set for them. In the case where the goal is surpassed, the deviation will be positive and in the case of the under achievement of the goal, the deviation will be negative. First developed by Charnes et al. (1955) and Charnes and Cooper (1961) then applied by Lee (1973) and Lee and Clayton (1972), the GP model gained a great deal of popularity and its use has spread in diversified fields such as: management of the water basins, management of solid waste, accounting and financial aspect of

* Corresponding author. Tel.: +1-705-6751151; fax: +1-705-6754880.
E-mail address: baouni@laurentian.ca (B. Aouni).

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stock management, marketing, quality control, human resources, production, transportation and site selection, space studies, telecommunications, agriculture, forestry and aviation (Aouni and Kettani, 2001). Additional details on the GP applications are available in Romero (1991).

The GP model is both a MOP model and a special case of the distance function model. In fact, the GP model minimizes $\sum_i (\delta_i^+ + \delta_i^-)$, subject to the constraints $f_i(\underline{x}) - \delta_i^+ + \delta_i^- = g_i$ ($\forall i \in I$, where I objectives are considered), $\underline{x} \in X \subset R^n$; δ_i^+ and $\delta_i^- \geqslant 0$; where g_i represent the level of aspiration (the goal) associated with the objective $f_i(\underline{x})$, and X designates the set of the feasible solutions. The variables δ_i^+ and δ_i^- indicate the positive and negative deviations (respectively) of the achievement level $f_i(\underline{x})$ from aspirated level.

The goal g_i can be probabilistic where the decision-maker does not know its value with certainty. It is worth to note that the examination of the literature shows the near absence of the decision-maker in the various formulations of the stochastic GP model (SGP). In other words, the existing SGP literature does not explicitly integrate the decision-maker's preferences into the model.

In this paper, we first examine the existing literature regarding the SGP model. Then, we develop a GP model in a probabilistic environment where the structure of the decision-maker's preferences is explicitly considered by utilizing the concept of satisfaction functions introduced by Martel and Aouni (1990). These functions comprise discrimination thresholds as it is the case of outranking methods (Roy and Bouyssou, 1993).

2. The GP model in an uncertain environment

The first formulation of the stochastic GP model goes back to the late 1960s with Contini's works (1968). He considers the goals as uncertain variables with a normal distribution. Under an equivalent form of the linear regression model, Contini's (1968) model maximizes the probability that the consequence of the decision will belong to a certain region encompassing the uncertain goal. Thus, this model tries to generate a solution that is close to the uncertain goals. In their works, Stancu-Minasian (1984) and Stancu-Minasian and Giurgiutiu (1985) present a synthesis of methodologies used in multiple objectives programming in a stochastic context. The different approaches proposed utilize the solution to a deterministic equivalent program.

Several other techniques have been proposed to solve the SGP model. The most popular technique is the Chance Constrained Programming (CCP) developed by Charnes and Cooper (1952, 1959, 1963). The stochastic linear problem can be formulated as follows:

Program 1

$$\text{Max} \quad f(\underline{x}) \tag{1.1}$$

$$\text{s.t.} \quad \sum_{j=1}^{n} a_{ij}x_j \leqslant \tilde{b}_i, \tag{1.2}$$

$$\underline{x} \geqslant 0,$$

where $\underline{x}$ denotes an n-dimensional random vector of the decision variables; a_{ij} denote an $m \times n$ matrix A of deterministic technology coefficients; $\tilde{b}_i$ denote an m-dimensional vector $\underline{b}$ (stochastic) resource limitations.

The CCP model is a deterministic equivalent formulation of Program 1 (Charnes and Cooper, 1963). This technique allows the uncertainty related to several parameters of the problem such as the constraints coefficients, the objectives coefficients and the goals values. The main idea behind the CCP technique it to allow the decision-maker to generate the most satisfactory solutions by making compromises between the various achievement degree of the objectives and the risk associated with these objectives. In fact, the CCP attempts to maximize the expected value of the objectives while assuring a certain probability of realization of the different constraints. Depending on the treatment of the constraints, there are two distinct approaches for the CCP, namely the unconditional CCP and the joint CCP.

2.1. The unconditional CCP

The unconditional CCP considers the probability to realize each one of the constraints independently from the others. Program 1 can be rewritten as follows: