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Relative effectiveness analysis under fuzziness

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Abstract

Effectiveness is an important criterion of performance evaluation that requires the extent to which the goals are achieved. Finding a value for this criterion becomes difficult, when it is considered in the context of fuzzy goals. However, we often require it numerically in a scale to monitor the performance level in a meaningful way. But, there exists no such structured methodology in the literature to compute effectiveness value in a fuzzy environment. This paper defines a fuzzy effectiveness measurement model in a multi-criteria framework to assess this value in the range of 0 to 1. A fuzzy goal programming approach is used to determine the effective point, which also acts as the benchmark for the proposed relative effectiveness analysis. Finally, this approach is demonstrated for its applicability, taking an example of performance evaluation of candidates in a semester examination. The result is then compared with the existing procedure of cumulative- grade- point average.

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*Keywords:*Effective point; multi-objective decision-making; fuzzy goal programming; performance evaluation; relative effectiveness; priority.

1. Introduction

In Management literature, effectiveness is considered as one of the important criteria of performance evaluation. Broadly, it is defined as the degree to which all the performance criteria achieve their targets[1,2,3]. Hence, it depends on the achievement of goals and has been explained as a measure of the distance between observed outputs and a set of desired goals[4]. This implies that higher the effectiveness, lessis the distance of achievement from the target. In this context, Golany and Tamir[4]extended DEA[5] to evaluate effectiveness while classifying the criteria as outputs and inputs. They viewed effectiveness of a decision making unit (DMU) in terms of threshold limits of the corresponding output vector and considered a DMU to be effective, only if, the outputs are greater than or equal to these limits. But,

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the question arises as to how to define these goals or threshold limits. In goal programming[6], goals are sometimes set as un-attainable targets and so, efforts are made to minimize the deviation of achievements from these goals. In that case, explaining the degree of effectiveness as the measure of the distance between achievements and their corresponding goals becomes meaningless. Though, there is no difficulty in assuming an un-attainable target as a goal, but there is also a need to define an achievable target as an effective goal, so that the degree of effectiveness can be computed. In this context, the interactive multi-objective linear programming (MOLP) procedure of Golany[2]as an extension of DEA, to obtain an effective point among the alternative efficient points is quite meaningful. For this, he reduced the multi-objective effectiveness problem to a LP, and maximized the objective function as the sum of output variables with respect to the envelopment constraints. For the effectiveness analysis, he determined the output targets for given inputs with respect to the effective point. However, in his model, he did not ensure a common minimum achievement level for all the goals to be qualified for effectiveness measurement. At the same time, the literature has also been completely silent regarding fuzziness of the goals.

The purpose of this paper is to propose a fuzzy effectiveness measurement model (FEMM) to assess a set of DMUs having imprecise targets. In this model, the fuzziness of the goals is explained as the level of satisfaction of the criteria as per the decision–maker in the interval [0, 1] A suitable membership function can represent this relationship, which may be linear, piecewise linear or even non-linear. Hence, achieving the maximum overall satisfaction in all the criteria simultaneously becomes the key issue in determining a non-dominated effective point as the frame of reference. Thus, this point becomes the benchmark for effectiveness measurement of all the DMUs under consideration, and is the principle behind relative effective analysis (REA), as discussed in this paper. The major contribution in this paper is that, the value of effectiveness is explained in the range 0 to 1, where the effective point is set at a value 1. Closer the DMU to the effective point, higher is the effectiveness and hence, higher is the effectiveness value. The details of REA is presented in the subsequent sections,

In the following section 2, a benchmarking model, as a first step in REA, is described in a fuzzy goal programming form[7]. Interval priorities[8, 9]are used to model the membership function of the fuzzy goals in terms of piece-wise linear functions. A two-phase methodology is employed for generating the effective point on the basis of empirical data on the criteria. Section 3utilizes this point to represent the FEMM as a set of fuzzy goals. Based on the achievement values of the DMUs and the effective goal, triangular marginal value functions are used to normalize the effectiveness criteria in the range of[-1, 1]. The model is then extended to a multi-attribute ranking procedure to assess the relative effectiveness of the DMUs in the range of 0 to 1. Section 4provides the application of the whole procedure for the effectiveness evaluation of performance of students in a semester examination and compares the result with their individual cumulative-grade-point-averages. The last section 5 discusses some concluding remarks of the work.

2. Benchmarking model

Let there be m DMUs whose effectiveness are to be compared along n effectiveness criteria. In order to obtain the effective point, let us consider the following fuzzy goal programming formulation of FEMM as:

Find E. To satisfy $E_j = \sum_{i=1}^{m} e_i x_{ij}$ % E_j ; j = 1, 2, 3…n_1; (1)

$E_k = \sum_{i=1}^{m} e_i x_{ik}$ ^ E_k ; k = 1, 2, 3…n_2

Subject to

$$\sum_{i=1}^{m} e_i = 1 \text{ ; and} \qquad .(2)$$

$e_i \geq 0$: i =, 2… m; and $n_1 + n_2 = n$