A SDV-MOORA Technique for Solving Multi-Criteria Decision Making Problems with No Preference

Mohamed F. El-Santawy[1,*] and A. N. Ahmed[2]

[1]Department of Operation Research, Institute of Statistical Studies and Research (ISSR), Cairo University, Egypt
*Corresponding author: lost_zola@yahoo.com
[2]Department of Mathematical Statistics, Institute of Statistical Studies and Research (ISSR), Cairo University, Egypt

Abstract: The Standard Deviation (SDV) is a well known measure of dispersion, which suits the problem of allocating weights in MCDM. In this paper we try to address this problem by employing the Standard Deviation to allocate weights, then combining the proposed method to a well-known technique called Multi-Objective Optimization on the basis of Ratio Analysis (MOORA). The new approach so-called SDV-MOORA can be used when no preference among the criteria considered. Also, it is validated and illustrated by ranking the alternatives of a given numerical example.

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1. Introduction

The merit of MCDM techniques is that they consider both qualitative parameters as well as the quantitative ones, MCDM includes many solution techniques such as Simple Additive Weighting (SAW), Weighting Product (WP) [5], and Analytic Hierarchy Process (AHP) [7]. The problem of allocating the weights of criteria when no preference is an open research area. Many scholars tried to tackle this problem by various techniques like Information Entropy Weight method, the weighted average operator (OWA), and other several methods [4].

The objective of the present paper is to enhance evaluation and selection methodology of the Multi-Objective Optimization on the basis of Ratio Analysis (MOORA) method. This paper attempts to explore the applicability of MOORA by employing the Standard Deviation to allocate weights, in order to solve different MCDM problems when no preference exist. The new method so-called SDV-MOORA is applied for ranking alternatives in numerical example given.

The rest of this paper is organized as follows: Section 2 is made for the MOORA approach, the proposed Standard Deviation method is illustrated in section 3, in section 4 a numerical example is given for validation, and finally section 5 is made for conclusion.

2. MOORA

A MCDM problem can be concisely expressed in a matrix format, in which columns indicate criteria (attributes) considered in a given problem; and in which rows list the competing alternatives. Specifically, a MCDM problem with m alternatives ($A_1, A_2, \ldots, A_m$) that are evaluated by n criteria ($C_1, C_2, \ldots, C_n$) can be viewed as a geometric system with m points in n-dimensional space. An element x_{ij} of the matrix indicates the performance rating of the i^{th} alternative A_i, with respect to the j^{th} criterion C_j, as shown in Eq. (1):

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccccc} C_1 & C_2 & C_3 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} \end{array} \tag{1}$$

Brauers first introduced the MOORA method in order to solve various complex and conflicting decision making problems [3]. The MOORA method starts with a decision matrix as shown by Eq. (1). The procedure of MOORA for ranking alternatives can be described as following:

Step 1: Compute the normalized decision matrix by vector method as shown in Eq. (2)

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}, \quad i = 1,\ldots,m;\ j = 1,\ldots,n. \tag{2}$$

Step 2: Calculate the composite score as illustrated in Eq. (3)

$$z_i = \sum_{j=1}^{b} x_{ij}^{*} - \sum_{j=b+1}^{n} x_{ij}^{*}, \quad i = 1,\ldots,m. \tag{3}$$

where $\sum_{j=1}^{b} x_{ij}^{*}$ and $\sum_{j=b+1}^{n} x_{ij}^{*}$ are for the benefit and non-benefit (cost) criteria, respectively. If there are some attributes more important than the others, the composite score becomes.

$$z_i = \sum_{j=1}^{b} w_j x_{ij}^* - \sum_{j=b+1}^{n} w_j x_{ij}^*, \; i = 1,...,m. \tag{4}$$

where W_j is the weight of j^{th} criterion.

Step 3: Rank the alternative in descending order.

Recently, MOORA has been widely applied for dealing with MCDM problems of various fields, such as economy control [2], contractor selection [1], and inner climate evaluation [6].

3. Standard Deviation for allocating weights

In this paper, the well known standard deviation (*SDV*) is applied to allocate the weights of different criteria. The weight of the criterion reflects its importance in MCDM. Range standardization was done to transform different scales and units among various criteria into common measurable units in order to compare their weights.

$$x'_{ij} = \frac{x_{ij} - \min\limits_{1 \le j \le n} x_{ij}}{\max\limits_{1 \le j \le n} x_{ij} - \min\limits_{1 \le j \le n} x_{ij}} \tag{5}$$

$D'=(x')_{mxn}$ is the matrix after range standardization; max x_{ij}, min x_{ij} are the maximum and the minimum values of the criterion (j) respectively, all values in D' are $(0 \le x'_{ij} \le 1)$. So, according to the normalized matrix $D' = (x')_{mxn}$ the standard deviation is calculated for every criterion independently as shown in Eq. (6):

$$SDV_j = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(x'_{ij} - \bar{x}'_j)^2} \tag{6}$$

where $\bar{x}'_j$ is the mean of the values of the j^{th} criterion after normalization and $j = 1,2,\ldots,n$.

After calculating (*SDV*) for all criteria, the weight (W_j) of the criterion (j) can be defined as:

$$W_j = \frac{SDV_j}{\sum_{j=1}^{n} SDV_j} \tag{7}$$

where $j = 1,2,\ldots,n$.

4. Numerical Example

In this section, an example of four alternatives to be ranked through comparing five criteria is presented to explain the method proposed. In the provided example, no pretence exists among criteria, the absence of weights allocated to criteria is tackled by applying the Standard Deviation to assign weights to criteria. As shown in Table 1, the four alternatives, their performance ratings with respect to all criteria, and the utility types of all criteria are presented.

Table 1. Decision matrix

	C_1	C_2	C_3	C_4	C_5
Utility type	Max	Max	Max	Min	Min
Alternative 1	50	10	12	40	16
Alternative 2	45	20	20	43	28
Alternative 3	30	25	11	29	20
Alternative 4	42	12	18	20	34

In the above example, there is no preference among the criteria, no weights specified for them subjective by the decision maker, so the Standard Deviation method will be applied in this problem. Table 2 illustrates the range standardization done to decision matrix as in Eq.(5).

Table 2. Range standardized decision matrix

	C_1	C_2	C_3	C_4	C_5
Alternative 1	1	0	0.111	0.87	0
Alternative 2	0.75	0.667	1	1	0.6667
Alternative 3	0	1	0	0.39	0.2222
Alternative 4	0.6	0.133	0.778	0	1

Table 3 shows the values of the Standard Deviation (SDV_j), and the weight assigned to each criterion (W_j) as shown in Eqs. (6 and 7). The weights' assignment process is very sensitive which will be reflected on the final ranking of the alternatives.

Table 3. Weights assigned to criteria

	SDV_j	W_j
C_1	0.4250	0.1856
C_2	0.4663	0.2036
C_3	0.4917	0.2148
C_4	0.4588	0.2004
C_5	0.4479	0.1956

By applying the procedure of MOORA, the normalized decision matrix found in Table 2 is used. In Table 4, the benefit, cost, and composite scores are listed for all alternatives. The second alternative should be selected because it has the maximum composite score.

Table 4. Ranking lists and scores

	Benefit criteria	Cost criteria	Composite score	Rank
Alternative1	0.1526	0.1261	0.0265	4
Alternative2	0.3815	0.2517	0.1298	**1**
Alternative3	0.1684	0.0923	0.0761	2
Alternative4	0.2341	0.1600	0.0741	3

5. Conclusion

In this paper, the standard deviation describes the dispersion of the values of criteria, giving the more dispersed values criteria more importance and much weights. The MOORA method is combined to the proposed method to constitute a new approach called SDV-MOORA in order to rank the alternatives when no preference found (i.e. no weights are provided for criteria).

***Corresponding Author:**
Mohamed Fathi El-Santawy
E-mail: lost_zola@yahoo.com

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