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EDITORIAL

Analysis of Simple Additive Weighting Method (SAW) as a Multi-Attribute Decision-Making Technique: A Step-by-Step Guide

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ABSTRACT

The simple additive weighting (SAW) method is one of the oldest and most widely used decision-making methods. It has a simple process that can be utilized in different subject areas such as engineering, environmental sciences, and energy. The main concepts of the SAW method are introduced in this paper and then a step-by-step guide to using SAW technique for decision-making and ranking purposes in multi-attribute cases is presented.

1. Introduction

The multi-attribute decision-making (MADM) methods are used for evaluating decision-making problems as selector models for choosing the best alternative [1]. These alternatives are evaluated by different attributes also considering the attributes' importance [2]. The SAW method also known as a weighted addition method is one of the simplest and the most widely-used decision-making methods. This method is the basis of most MADM methods such as the PROMETHEE and AHP methods. This method uses the concept of additive property for determining the ranks of the alternatives [3-5]. That is to say, the SAW as a classic version of the multi-attribute value method is "a value function is established based on a simple addition of scores that represent the goal achievement under each criterion, multiplied by the particular weights" [6].

The basis is to calculate the weighted sum of the performance ratings. This should be calculated for each alternative/object on all attributes/criteria. The decision-makers also should consider the weight of attributes in this process. Furthermore, a dimension-free rating for the attributes is obtained due to

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the normalization process in this method [7]. This method uses the idea of integrating the values of criteria and weights into a single value. The basis of the SAW method is only based on maximizing evaluation criteria, although the minimizing problems can be also converted into maximizing type by using specific formula (which will be discussed in the process steps) [5]. In this method, the minimizing and maximizing evaluation criteria/attributes are known as criteria of costs and benefits as well [8].

2. Application areas, merits, and demerits of the SAW

The SAW method possesses different application areas ranging from business to water management and financial studies [9]. Different studies are conducted based on utilizing the SAW method for ranking and selection purposes. This method can be also integrated with other MADM methods such as AHP, VIKOR, TOPSIS, and ELECTRE; some examples are as follows:

- Ranking the cloud render farm services
- Evaluating the quality of urban life;
- Risk assessment in public-private partnership projects;
- Selecting the most efficient devices;
- Studying available energy;
- Selecting sensors attached to the devices;
- Ranking the best resources at the local or lower level;
- Stock selection;
- Selecting Intercrop;
- Studying employee placement concept;
- etc. [10].

The main subject areas are shown in **Figure 1**. This figure is based on the "simple additive weighting" search term in the "ScienceDirect" database (conducted on 2022/06/2). The figure illustrates that according to the results this method is mostly used in the engineering, computer, environmental, and decision sciences subject areas.

As discussed, the SAW is one of the most widely-used MADM methods. This method has manifold advantages offered to the decision-makers, although the demerits are also negligible. The main positive and negative features are listed in this section in **Table 1**.

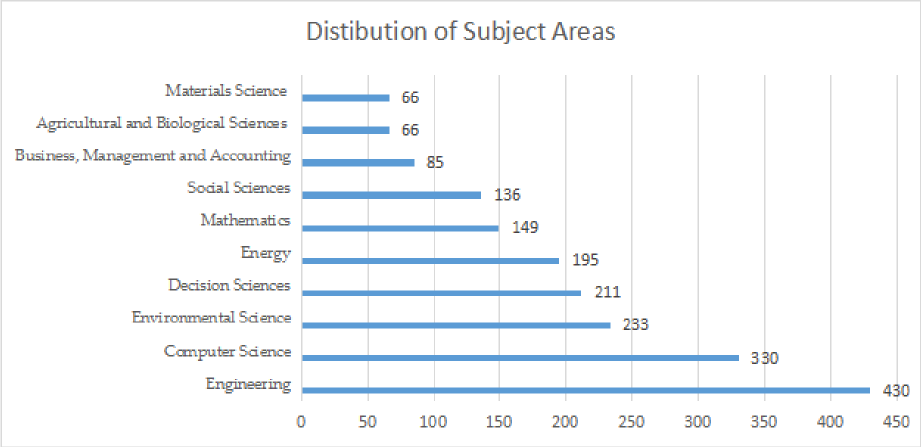

Figure 1. Distribution of subject areas used the SAW method.

Table 1. Merits and demerits of the SAW [5,8,9].

Advantages	Disadvantages
• The ability to compensate among criteria; • Being intuitive to decision-makers; • Simple calculation; • No need for complex programming; • Assisting to determine the differences between objects compared visually using the normalized values.	• Transferring minimizing criteria to maximizing (or using the formula discussed later) in the main concept; • Transferring negative values of r_{ij} to positive ones (discussed in the final section); • The obtained results are not always logical; • Must provide the attributes' weights and the decision matrix.

3. Process steps

The Simple Additive Weighting method is one of the most common multi-attribute decision-making (MADM) methods. Finding the weighted sum of the performance ratings for each alternative considering all attributes is the basic concept of the SAW method. For this, a normalized decision matrix must be prepared. This normalization process results in a scale that makes comparing with all alternative ratings possible [4]. The steps of the SAW method are presented in **Figure 2**.

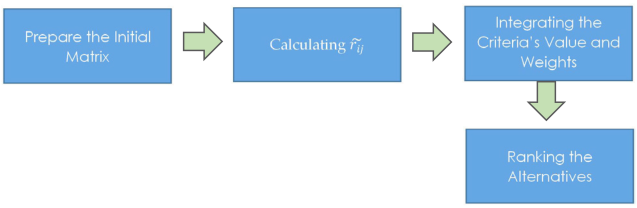

Figure 2. Steps of the SAW method.

Step 1. Prepare the Initial Matrix

This is an optional step that helps to conduct the following steps better. The initial matrix is prepared based on the values for *m* criteria and *m* alternatives/objects. There for, in this $m \times n$ matrix r_{ij} is the value of the *i* th criterion for *j* th object where:

- $i = 1,2, ..., m$;
- $j = 1,2, ..., n$.

Another point is to determine the weights of the criteria (w_i) to show their importance. These weights can be considered as numbers between zero and one (or by percentages) and considering $\sum_{i=1}^{n} w_i = 1$.

Step 2. Normalizing the Value of *i* th Criterion for the *j* th Alternative (Calculating $\widetilde{r_{ij}}$)

The $\widetilde{r_{ij}}$ is known as the normalized *i* th criterion's value for *j* th alternative/object. This value must be calculated in this step considering whether the problem is a cost or benefit type. The difference is that in the cost problems the object is minimizing, on the other hand maximizing is the object of a benefit problem. These differences reflect in the $\widetilde{r_{ij}}$ calculation as follows:

$$\widetilde{r_{ij}} = \frac{\min_j r_{ij}}{r_{ij}}; \text{ if } j \text{ is a cost attribute.} \quad (1)$$

$$\widetilde{r_{ij}} = \frac{r_{ij}}{\max_j r_{ij}}; \text{ if } j \text{ is a benefit/profit attribute.} \quad (2)$$

where r_{ij} is the value of the *i* th criterion for *j* th object. The $\min_j r_{ij}$ is the largest value of the *i* th criterion when all alternatives are compared, and in contrast, $\min_j r_{ij}$ is the smallest value for it. Therefore, $\widetilde{r_{ij}}$ is a normalized value for the *i* th criterion and *j* th alternative.

Step 3. Integrating the Values of the Criteria and Weights

The integration of the criteria and weights helps to gain a single magnitude that is the final performance value for each alternative. For this, the following equation can be used for the *j* th alternative/object:

$$S_j = \sum_{i=1}^{n} w_i \widetilde{r_{ij}} \quad (3)$$

Step 4. Ranking the Alternatives to Choose the Best One

In the final step, the best alternative is chosen based on the largest performance value of the S_j maximizing criterion, and the smallest for the minimizing criterion [5,11-13]. Numerical examples are provided in the literature [8].

Finally, there is another important consideration for the SAW method that is beneficial to be noted here:

The r_{ij} in this method should be positive. According to this requirement the negative values should be transferred to the positive ones ($\overline{r_{ij}}$) using different methods. For example, the following formula can be used:

$$\overline{r_{ij}} = r_{ij} + \left|\min_j r_{ij}\right| + 1 \quad (4)$$

Examples are provided in the literature [14].

4. Conclusions

The SAW method is one of the oldest and most common-used MADM methods. In this paper, the concept of SAW method, its advantages, disadvantages, and application areas were reviewed. Finally, the SAW process steps were explained in simple four steps. The process begins with identifying the alternative and criteria's values and then continues to gain the final performance values for the alternatives used to rank them.

Conflict of Interest

There is no conflict of interest.

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