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A Method of Multi-attribute Decision Making Based On Basic Point and Weighting Coefficients Range

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Abstract

To solve multi-attribute decision making problem of limited schemes, multiple attribute indexes is generally synthesized to a single evaluation index. So it is necessary to determine the weighting coefficient of each attribute index. In this paper we propose a method of multi-attribute decision making based on basic point and weighting coefficients range. Weighting coefficient of each index may be calculated with the method in this paper, provided weighting range of each index, basic point and its comprehensive evaluation value are given. The method not only involves the subjective estimating of the people, but also avoids the comparison and evaluation between various attributes. If comprehensive evaluation value of basic point is difficult to determine, one can give a probing value, modify the value gradually until satisfying consequence is obtained.

Keywords: multi-attribute decision making; basic point; weighting coefficient

1. Foreword

To solve multi-attribute decision making problem of limited schemes[1-9], multiple attribute indexes are generally synthesized to a single evaluation index. So it is necessary to determine the weighting coefficient of each attribute index. There are many methods to determine the weights, which can be divided into two categories, the subjective method and the objective method. In many problems, weight of each index depends on people's subjective evaluation. But this subjective evaluation is often vague and unclear. Generally, it is difficult to give the exact weight of each index. But it is easy to give weighting range of each index. In addition, in solving specific problems, a scheme can be found, which is of reasonable comprehensive evaluation. The scheme can be used as a reference scheme, and is also a basic point[10]. If there is no reference scheme available, one can select or create a scheme as a basic point, and give it a suitable comprehensive evaluation value by experts. Therefore, the basic point and the weighting range become the constraint conditions which weighting calculation must meet. Based on the above considerations, we propose a method of multi-attribute decision making based on basic point and weighting range in this paper.

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2. Model and Method

Assume there are n schemes to be evaluated, there are m attribute indexes of each scheme. x_{ij} is the *ith* index of scheme j ($i=1,2,...,m$; $j=1,2,...,n$), thus all indexes of all schemes compose a matrix $(x_{ij})_{m\times n}$.

Suppose scheme j^* is basic point, and its comprehensive evaluation value is E_{j^*} given by experts, E_{j^*} is known.

Set the weight of the *ith* index is w_i （$i=1,2,...,m$）, $\sum_{i=1}^{m} w_i = 1$, w_i is unknown. Suppose $w_i \ge 0$, and $a_i \le w_i \le b_i$, a_i and b_i are known, and $0 \le a_i \le 1$, $0 \le b_i \le 1$.

In order to compare conveniently, x_{ij} must be normalized by the following formula (1) or (2).

(1) if larger the value of x_{ij} is, larger the comprehensive evaluation value of the scheme is, then

$$r_{ij} = \begin{cases} (x_{ij} - x_{i\min})/(x_{i\max} - x_{i\min}) & if \quad x_{i\max} \ne x_{i\min} \\ 1 & if \quad x_{i\max} = x_{i\min} \end{cases} \tag{1}$$

(2) if smaller the value of x_{ij} is, larger the comprehensive evaluation value of the scheme is, then

$$r_{ij} = \begin{cases} (x_{i\max} - x_{ij})/(x_{i\max} - x_{i\min}) & if \quad x_{i\max} \ne x_{i\min} \\ 1 & if \quad x_{i\max} = x_{i\min} \end{cases} \tag{2}$$

Where $x_{i\max} = \max\{x_{ij} \mid j=1,2,...,n\}$, $x_{i\min} = \min\{x_{ij} \mid j=1,2,...,n\}$, r_{ij} is the optimal membership degree of the *ith* index of scheme j ($i=1,2,...,m$; $j=1,2,...,n$), $(r_{1j}, r_{2j},...,r_{mj})^{\mathrm{T}}$ is the relative membership vector of scheme j.

$$\mathbf{R} = (r_{ij})_{m\times n}$$

Thus, the relative membership matrix $(r_{ij})_{m\times n}$ composed of m indexes of n schemes is obtained.

$$E_j = \sum_{i=1}^{m} w_i r_{ij} \tag{3}$$

E_j is the comprehensive evaluation value of scheme j ($j=1,2,...,n$).

And, r_{ij^*} is the optimal membership degree of the *ith* index of basic point scheme j^*, so $\sum_{i=1}^{m} w_i r_{ij^*} = E_{j^*}$ must be satisfied.

Therefore, $(1,1,...,1)^{\mathrm{T}}$ is the relative optimal scheme, $(0,0,...,0)^{\mathrm{T}}$ is the relative worst scheme. Obviously, scheme j is more close to $(1,1,...,1)^{\mathrm{T}}$, its comprehensive evaluation value is larger; scheme j is more close to $(0,0,...,0)^{\mathrm{T}}$, its comprehensive evaluation value is smaller.

Because each scheme is of good quality, but also of bad quality, can not be asked to be optimal enough. Let

$$\varepsilon_j(\mathbf{W}) = \sqrt{\sum_{i=1}^{m} w_i^2 (1 - r_{ij})^2 + \sum_{i=1}^{m} w_i^2 (r_{ij} - 0)^2}$$

$\varepsilon_j(\mathbf{W})$ is weighted distance between the membership degree vector $(r_{1j}, r_{2j},...,r_{mj})^{\mathrm{T}}$ of scheme j and the relative optimal scheme $(1,1,...,1)^{\mathrm{T}}$, and between $(r_{1j}, r_{2j},...,r_{mj})^{\mathrm{T}}$ and the relative worst scheme $(0,0,...,0)^{\mathrm{T}}$. Because $\varepsilon_j(\mathbf{W})$ is a kind of distance, $\varepsilon_j(\mathbf{W})$ must be minimum enough.

In order to calculate conveniently, we use

$$\delta_j(\mathbf{W}) = \sum_{i=1}^{m} w_i^2 (1 - r_{ij})^2 + \sum_{i=1}^{m} w_i^2 (r_{ij} - 0)^2$$

to measure the distance instead of $\varepsilon_j(\mathbf{W})$. Obviously the distance $\delta_j(\mathbf{W})$ should be asked to be minimum, thus a multi-objective programming model is obtained as follow.

$$\min \quad [\delta_1(\mathbf{W}), \delta_2(\mathbf{W}),...,\delta_n(\mathbf{W})]^T$$