Applied Mathematical Modelling 37 (2013) 112–126

Contents lists available at SciVerse ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

An avoiding information loss approach to group decision making

Zhongliang Yue

College of Science, Guangdong Ocean University, Zhanjiang 524088, China

ARTICLE INFO

Article history:
Received 4 November 2011
Received in revised form 22 January 2012
Accepted 3 February 2012
Available online 14 February 2012

Keywords:
Multiple attribute group decision making
Extended TOPSIS method
Positive ideal decision
Negative ideal decision
Supplier selection

ABSTRACT

Owing to the increasing complexity in various management, aggregating experts' knowledge and experiences to make an appropriate decision is an important research area. However, with aggregation of information in decision process, some information may be lost. The aim of this paper is to present a systematic methodology avoiding information loss for group decision making. An extended TOPSIS method is twice used to the current method, which is first used to determine the weights of decision makers, and second used to rank the preference order of alternatives. The proposed approach is straightforward and has no aggregation of information. A comparison of proposed method with other methods is also done. Finally, a numerical example for supplier selection is given to illustrate the application of the introduced method.

1. Introduction

Multiple attribute decision making approach is often used to solve various decision making and/or selection problems [1–6]. Due to the increasing complexity in decision process, aggregating group's knowledge and experiences to make appropriate decisions is a commonly used method. The multiple attribute group decision making (MAGDM) has been a crucial tool for evaluating and/or selection alternative [7–14].

The technique for order preference by similarity to ideal solution (TOPSIS) proposed by Hwang and Yoon [15] is one of the well-known methods for classical multiple attribute decision making. The underlying logic of TOPSIS is to define an ideal solution and negative ideal solution. The ideal solution is the solution that maximizes the benefit attributes and minimizes the cost attributes, whereas the negative ideal solution is the solution that maximizes the cost attributes and minimizes the benefit attributes. In short, the ideal solution consists of all best attribute values, whereas the negative ideal solution is composed of all worst attribute values. The optimal alternative is the one which has the shortest distance from the ideal solution and the farthest distance from the negative ideal solution [16–19]. It has been applied to a large number of cases in human resources management [20,21], advanced manufacturing [22,23], purchasing and outsourcing [24,25], selecting plant location [26], energy planning [27,28], supplier selection [29,30], e-sourcing [31], democratic appraisal [32], personnel selection [33,34], evaluation for air quality [35] and traffic police assessment [36].

With the deepening realization about TOPSIS technique, many extend TOPSIS techniques have been applied to group decision making environment [37–40,29,41–44]. However, as far as we know, most of works using TOPSIS technique to MAGDM exist aggregation(s) in decision process. According to the viewpoint proposed by Shih [45], these works about aggregation in group decision making can be classified as external or internal aggregation. As is known to all, the decision information may be lost in the aggregating process. How to avoid the aggregation(s) in decision process is an important research topic in MAGDM problems. In this paper, we present a systematic methodology based on an extended TOPSIS method for group decision. The proposed approach is straightforward and has no loss of information.

E-mail address: zhongliangyue@gmail.com

0307-904X/$ - see front matter © 2012 Elsevier Inc. All rights reserved.
doi:10.1016/j.apm.2012.02.008

The extended TOPSIS method developed in current paper is a technique used in dealing with MAGDM problems, which extends the ideal solutions expressed by vectors in traditional TOPSIS to ideal decisions expressed by matrices [46,47]. So, we can call it the group TOPSIS method. An extended TOPSIS method is twice used to the current systematic methodology, which is first used to determine the weight of decision maker (DM, or expert, or member of group), and second used to rank the preference order of alternatives. When we consider the weight of DM, we consider not only DM's own opinion/decision to close to other DMs, but also his/her influence as an expert in own area (attribute).

Rest of this paper is organized as follows. Section 2 gives a brief description of traditional TOPSIS method. Section 3 presents the detailed description of a systematic methodology avoiding information loss under group decision making environment, in which an extended TOPSIS method is used. Section 4 compares the developed method in this study with other methods. Section 5 demonstrates a numerical example. Finally Section 6 presents a conclusion of this paper.

2. Traditional TOPSIS method

In this section, we review the traditional TOPSIS method.

For convenience, throughout this paper, the decision process may be described by means of the following sets:

(1) three finite sets $M = \{1,2,\ldots,m\}$, $N = \{1,2,\ldots,n\}$ and $T = \{1,2,\ldots,t\}$, which are used in describing the sets of alternatives, attributes and DMs, respectively, and $i \in M$, $j \in N$, and $k \in T$;
(2) a set of m feasible alternatives called $A = \{A_1,A_2,\ldots,A_m\}(m \geqslant 2)$;
(3) a set of n attributes called $U = \{u_1,u_2,\ldots,u_n\}(n \geqslant 2)$;
(4) a set of t DMs called $D = \{d_1,d_2,\ldots,d_t\}(t \geqslant 2)$, which is used in next section.

For a multiple attributes decision making problem, suppose that each alternative $A_i (i \in M)$ is evaluated with respect to the n attributes $\{u_1,u_2,\ldots,u_n\}(n \geqslant 2)$, whose values constitute a decision matrix denoted by

$$X = (x_{ij})_{m\times n} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array}\begin{array}{c} \begin{array}{cccc} u_1 & u_2 & \cdots & u_n \end{array} \\ \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix} \end{array}. \tag{1}$$

The traditional TOPSIS method consists of the following steps [18,46,48]:

1. Calculate the weighted decision matrix.
   Suppose that $w = (w_1,w_2,\ldots,w_n)$ is the weight vector of the attributes, with $0 \leqslant w_j \leqslant 1$ and $\sum_{j=1}^{n} w_j = 1$, then we can construct the weighted decision matrix as

$$Y = (w_j x_{ij})_{m\times n} = (y_{ij})_{m\times n} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array}\begin{array}{c} \begin{array}{cccc} u_1 & u_2 & \cdots & u_n \end{array} \\ \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn}. \end{pmatrix} \end{array}. \tag{2}$$

2. Normalize the weighted decision matrix.
   In general, there are benefit attributes and cost attributes in the multiple attribute decision making problems. In order to measure all attributes in dimensionless units and facilitate inter-attribute comparisons, we introduce the following formulas [46] (4) and (5) to normalize each attribute value y_{ij} in decision matrix $Y = (y_{ij})_{m\times n}$ into a corresponding element r_{ij} in normalized decision matrix given by Eq. (3).

$$R = (r_{ij})_{m\times n} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array}\begin{array}{c} \begin{array}{cccc} u_1 & u_2 & \cdots & u_n \end{array} \\ \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn}, \end{pmatrix} \end{array}, \tag{3}$$

where

$$r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{m} (y_{ij})^2}}, \quad \text{for benefit attribute} \quad u_j,\ i \in M,\ j \in N, \tag{4}$$