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Ranking irregularities when evaluating alternatives by using some ELECTRE methods☆

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Abstract

The ELECTRE II and III methods enjoy a wide acceptance in solving multi-criteria decision-making (MCDM) problems. Research results in this paper reveal that there are some compelling reasons to doubt the correctness of the proposed rankings when the ELECTRE II and III methods are used. In a typical test we first used these methods to determine the best alternative for a given MCDM problem. Next, we randomly replaced a non-optimal alternative by a worse one and repeated the calculations without changing any of the other data. Our computational tests revealed that sometimes the ELECTRE II and III methods might change the indication of the best alternative. We treat such phenomena as rank reversals. Although such ranking irregularities are well known for the additive variants of the AHP method, it is the very first time that they are reported to occur when the ELECTRE methods are used. These two methods are also evaluated in terms of two other ranking tests and they failed them as well. Two real-life cases are described to demonstrate the occurrence of rank reversals with the ELECTRE II and III methods. Based on the three test criteria presented in this paper, some computational experiments on randomly generated decision problems were executed to test the performance of the ELECTRE II and III methods and an examination of some real-life case studies are also discussed. The results of these examinations show that the rates of the three types of ranking irregularities were rather significant in both the simulated decision problems and the real-life cases studied in this paper.

Keywords: Multi-criteria decision-making; Ranking irregularities; ELECTRE methods; The analytic hierarchy process (AHP); Multiplicative AHP

1. Introduction

Multi-criteria decision-making (MCDM) is one of the most widely used decision methodologies in the sciences, business, government and engineering worlds. MCDM methods can help to improve the quality of decisions by making the decision-making process more explicit, rational, and efficient. It is not a coincidence that a simple search (for instance, by using google.com) on the web under the key words “multi criteria decision making” returns more than one million hits. Some applications of MCDM in engineering include the use on flexible manufacturing systems [1], layout design [2], integrated manufacturing systems [3] and the evaluation of technology investment decisions [4].

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	Criteria			
	C_1	C_2	...	C_n
Alternatives	$(w_1$	w_2	...	$w_n)$
A_1	a_{11}	a_{12}	...	a_{1n}
A_2	a_{21}	a_{22}	...	a_{2n}
	.	.	.	
	.	.		.
	.	.		.
A_m	a_{m1}	a_{m2}	...	a_{mn}

Fig. 1. Structure of a typical decision matrix.

The typical MCDM problem is concerned with the task of ranking a finite number of decision alternatives, each of which is explicitly described in terms of different characteristics (also often called attributes, decision criteria, or objectives) which have to be taken into account simultaneously. Usually, the performance values a_{ij} and the criteria weights w_j are viewed as the entries of a *decision matrix* defined as in Fig. 1. The a_{ij} element of the decision matrix represents the performance value of the ith alternative in terms of the jth criterion. The w_j represents the weight of the jth criterion. Data for MCDM problems can be determined by direct observation (if they are easily quantifiable) or by indirect means if they are qualitative [49].

Another term that is also used frequently to mean the same type of decision models is multi-criteria decision analysis (MCDA). There is a subtle difference between these two terms. The term MCDM is often used to mean finding the best alternative in a continuous environment. However, in the setting of MCDA, the alternatives are not known a priori but they can be determined by calculating the values of a number of discrete and/or continuous variables. Usually, an MCDA method aims at one of the following four goals, or "problematics" [5,6].

Problematic 1: find the best alternative.

Problematic 2: group the alternatives into well-defined classes.

Problematic 3: rank the alternatives in order of total preference.

Problematic 4: describe how well each alternative meets all the criteria simultaneously.

Many interesting aspects of MCDA theory and practice are discussed in [7–13]. However, the terms MCDM and MCDA may also be used to denote the same class of models.

A prominent role in MCDM methods is played by the analytic hierarchy process (AHP) method which is based on pairwise comparisons as it was proposed by Saaty [14,15]. According to that method the decision maker compares two decision entities (pair of alternatives considered in terms of a single criterion or a pair of criteria) at a time and elicits his/her judgment with the help of a scale. Such a scale assigns numerical values to linguistic expressions and later these numerical values are analyzed mathematically and the a_{ij} values are determined.

Many methods have been proposed to analyze the data of a decision matrix and rank the alternatives. Often times different MCDM methods may yield different answers to exactly the same problem [11]. Some of the methods use additive formulas to compute the final priorities of the alternatives. Representatives of such methods are the weighted sum model (WSM) [16], and the AHP [14,15] and its variants (such as the revised or ideal mode AHP [17]). Some multiplicative versions of these methods have also been developed. Examples are the weighted product model (WPM) [18,19] and a later version of it; the multiplicative AHP [20,21]. In some earlier research it was found that the previous additive models might often exhibit cases of irregular ranking reversals under certain tests [11,22,23,17]. However, the previous multiplicative models are immune to most of these ranking irregularities.

Another family of MCDM models uses what is known as "outranking relations" to rank a set of alternatives. A prominent role in this group is played by the ELECTRE method and its derivatives. The ELECTRE approach was first introduced in [24]. It is a comprehensive evaluation approach in that it also tries to rank a number of alternatives each one of which is described in terms of a number of criteria. The main idea is the proper utilization of what is called "outranking relations". Soon after the introduction of the first version known as ELECTRE I [25], this approach has evolved into a number of other variants. Today the most widely used versions are known as ELECTRE II [26,27] and ELECTRE III [28]. Another variant of the ELECTRE approach is the TOPSIS method [29]. The TOPSIS method was also found to suffer of the ranking irregularities related to the AHP and its additive variants (according to some unpublished results by the authors).