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A grey-based decision-making approach to the supplier selection problem

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Abstract

Supplier selection is a multiple-attribute decision-making (MADM) problem. Since the decision makers (DMs) such as preferences on alternatives or on the attributes of suppliers are often uncertain, supplier selection becomes more difficult. Grey theory is one of the methods used to study uncertainty, being superior in the mathematical analysis of systems with uncertain information. In this paper, we propose a new grey-based approach to deal with the supplier selection problem. The work procedure is as follows: firstly, the weights and ratings of attributes for all alternatives are described by linguistic variables that can be expressed in grey numbers. Secondly, using a grey possibility degree, the ranking order of all alternatives is determined. Finally, an example of a selection problem of supplier was used to illustrate the proposed approach.
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Keywords: Supplier selection; Multiple attribute decision making (MADM); Grey number; Grey possibility degree

1. Introduction

With the globalization of the economic market and the development of information technology, many companies consider that a well-designed and implemented supply chain management (SCM) system is an important tool for increasing competitive advantage [1]. The supplier selection problem become one of the most important components in SCM [2–4]. In the past, several methods have been proposed to solve the supplier selection problem, the main ones being the linear weighting methods (LW) [5,6], the analytic hierarchy process (AHP) [7,8], the analytic network process [9], total cost approaches [10,11] and mathematical programming (MP) techniques [12,13]. Although linear weighting is a very simple method, it depends heavily on human judgement and also weights the attributes equally, which rarely happens in practice. On the other hand, MP techniques cause a significant problem in considering qualitative factors. However, AHP cannot effectively take into account risk and uncertainty in estimating the supplier's performance because it presumes that the relative importance of attributes affecting supplier performance is known with certainty [14]. The drawback of MP is that it requires arbitrary aspiration levels and cannot accommodate subjective attributes [15]. Supplier selection is a multiple- attribute decision-making (MADM) problem. The decision

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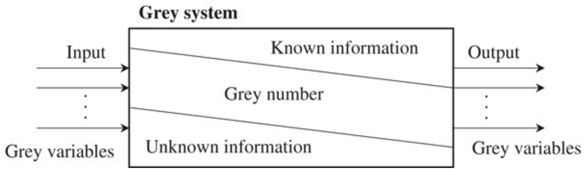

Fig. 1. The concept of a grey system.

makers (DMs) always express their preferences on alternatives or on the attributes of suppliers, which can be used to help rank the suppliers or select the most desirable one. The preference information on alternatives of supplier and on attributes belongs to the DMs' subjective judgements. In conventional MADM methods, the ratings and weights of the attributes are known precisely [16–18]. Generally, DMs' judgements are often uncertain and cannot be estimated by an exact numerical value. Thus, the problem of selecting suppliers has many uncertainties and becomes more difficult.

Grey theory [19] is one of the methods used to study uncertainty, being superior in the mathematical analysis of systems with uncertain information. In grey theory, according to the degree of information, if the system information is fully known, the system is called a white system; if the information is unknown, it is called a black system. A system with information known partialy is called a grey system. In recent years, a fuzzy-based approach has been proposed to deal with the supplier selection problem under uncertainty [20]. The advantage of grey theory over fuzzy theory [21, 22] is that grey theory considers the condition of the fuzziness; that is, grey theory can deal flexibly with the fuzziness situation [19]. In this paper, we propose a new grey-based approach to deal with the problem of selecting suppliers under an uncertain environment. The work procedure is briefly as follows: firstly, the weight and rating of attributes for all supplier alternatives are described by linguistic variables that can be expressed in grey number. Secondly, a degree of grey possibility is proposed to determine the ranking order of all alternatives of supplier. In the supplier selection process, the degree of uncertainty of the attributes has to be taken into account [23]. In many situations, the preference information on attributes is uncertain and inconsistent. In order to atone for the insufficiency of decision making, we present a grey possibility degree to select the ideal supplier based on grey numbers. It will be more suitable for the MADM system's more uncertain environment than other approaches. Finally, an example of supplier selection is used to illustrate the proposed approach.

This paper is organized as follows: Section 2 describes preliminaries which include grey theory and grey number comparison. Section 3 introduces the proposed grey-based approach. In Section 4 the proposed approach is applied to the supplier selection problem. Finally, conclusions are drawn in Section 5.

2. Preliminaries

2.1. Grey theory

Grey theory [19], which was proposed by Deng in 1982, is one of the new mathematical theories born out of the concept of the grey set. It is an effective method used to solve uncertainty problems with discrete data and incomplete information. The theory includes five major parts: grey prediction, grey relational analysis (GRA) [24, 25], grey decision, grey programming and grey control. Here, we give some basic definitions of the grey system, grey set and grey number in grey theory.

Definition 1. A grey system is defined as a system containing uncertain information presented by a grey number and grey variables. The concept of a grey system is shown in Fig. 1.

Definition 2. Let X be the universal set. Then a grey set G of X is defined by its two mappings $\overline{\mu}_G(x)$ and $\underline{\mu}_G(x)$.

$$\begin{cases} \overline{\mu}_G(x) : x \longrightarrow [0, 1] \\ \underline{\mu}_G(x) : x \longrightarrow [0, 1] \end{cases} \tag{1}$$

$\overline{\mu}_G(x) \geq \underline{\mu}_G(x)$, $x \in X$, $X = R$, $\overline{\mu}_G(x)$ and $\underline{\mu}_G(x)$ are the upper and lower membership functions in G respectively. When $\overline{\mu}_G(x) = \underline{\mu}_G(x)$, the grey set G becomes a fuzzy set. It shows that grey theory considers the condition of the fuzziness and can deal flexibly with the fuzziness situation.

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