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ORIGINAL ARTICLE

A three phase supplier selection method based on fuzzy preference degree

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Abstract As competition is growing high on this globalized world, the companies are imposing more and more importance on the process of supplier selection. After the foundation of fuzzy logic, the problem of supplier selection has been treated from the viewpoint of uncertainty. The present work reviews and classifies different approaches towards this problem. A new fuzzy preference degree between two triangular fuzzy numbers is introduced and a new approach is prescribed to solve the problem using this preference degree. The weights of the Decision Makers are considered and a methodology is proposed to determine the weights. Moreover, a unique process of classifying the suppliers in different groups is proposed. The methodologies are exemplified by a suitable case study.

1. Introduction

Supplier selection problem is one of the most significant one in Supply Chain Management (SCM). In today's extremely competitive corporate environment, it sounds airy to produce high quality and low cost products without a satisfactory supplier or a group of satisfactory suppliers. It is quite substantial that the better selection of suppliers reduces the purchasing cost and increases the competitive attitude of the companies. So the objective of the evaluation process of the supplier selection problems is to maximize the overall value to the purchaser and build proper relationship between buyers and suppliers. In literature several methods (Chen, 2000; Kheljani et al., 2010; Kumar et al., 2004; Li et al., 2007; Liu and Liu, 2010; Muralidharan et al., 2002; Shyur and Shih, 2006; Sreekumar, 2009; Vaezi et al., 2011; Wang, 2005) have been proposed to solve the problem through different kinds of methodology. Some of them are Weighting Method, Statistical Method, (Analytic Hierarchy Process) AHP, Data Envelopment Analysis (DEA), Technique for Ordered Preference by Similarity to Ideal Solution (TOPSIS) etc. In 2007, Li et al. proposed a grey based TOPSIS method to rank the suppliers by aggregating the DMs' opinion on the suppliers and attributes. The authors used grey possibility degree to compare each supplier with the ideal supplier. The methodology was followed in some other research articles too (Jadidi et al., 2008; Mukherjee and Kar, 2012). Muralidharan et al. (2002) employed a novel

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model based on aggregation technique for combining DMs' preferences into one consensus ranking. A brief of the existing literature will be discussed in Section 3.

The application and evaluation of the weights of the DMs is also a very crucial part of this type of decision making procedure. In literature, it is quite noticeable that there are only few techniques which involve the weights of the DMs in the methodology. But this assumption may affect the process of decision making, as a finite number of human beings' perception on a certain matter should not be considered as equally likely. In this paper a new technique is proposed for the said problem.

Our motive for the concerned problem certainly arises due to the following drawbacks of the existing literature.

1. Weights of the DMs have not been studied in most of the methods.
2. The suppliers have not been classified even after the completion of the ranking procedure, in any logical way.

Moreover the fuzzy preference degree (introduced in this paper) needs to be tested on a well known decision making platform and supplier selection is certainly a better choice for that.

The proposed methodology is a three phase algorithm. The first phase evaluates the weights of the DMs following a novel procedure. The second phase executes the ordering of the suppliers. And the final phase classifies the suppliers in different groups. While performing the second phase, each supplier is compared to the Positive Ideal Supplier (PIS) and Negative Ideal Supplier (NIS) by the fuzzy preference degree between two Triangular Fuzzy Numbers (TFN).

The paper is structured as follows. Section 2 discusses preliminary ideas and concepts, relevant to the topic. In Section 3, a brief review of the existing literature on supplier selection problem is described along with a moderate classification. Five significant supplier selection methods are picked out of them and we demonstrate their working algorithms. In Section 4, fuzzy preference degree is proposed along with its properties. Section 5 exhibits the projected methodology and in Section 6, a case study is provided to depict the effectiveness of the method. A comparative analysis is also provided, later in this section.

2. Preliminaries

The concept of fuzzy logic and fuzzy mathematics was introduced by Zadeh (1965) in 1965, when the two-valued logic completes its era. Initially it was given in prescribed form for engineering purposes and it got some time to accept this new methodology from different intellectuals. For a long time a lot of western scientists has been apathetic to use fuzzy logic because of its threatening to the integrity of older scientific thoughts. But once it got the stage, it performed fabulously. From mathematical aspects to engineering systems, it spreaded all over and the betterments of all types of systems were certainly there. After all, the society chose Fuzzy Logic as a better choice. In Japan, the first sub-way system was built by the use of fuzzy logic controllers in 1987. Since then almost every intelligent machine works with fuzzy logic based technology inside them.

In this section some preliminary concept on fuzzy and grey systems is overviewed.

Let X is a collection of objects called the universe of discourse. A fuzzy set denoted by $\widetilde{A}$ on X is the set of ordered pairs $\widetilde{A} = \{(x, \mu_{\widetilde{A}}(x)) : x \in X\}$ where $\mu_{\widetilde{A}}(x)$ is the grade of membership of x in $\widetilde{A}$ and the function $\mu_{\widetilde{A}}(x) : \mathrm{X} \rightarrow [0,1]$ is called the membership function.

2.1. Fuzzy numbers and TFNs

Definition 2.1.1. Let a be a given crisp number on the real line R. If there lies some uncertainty while defining a then we can represent a along with its uncertainty by an ordinary fuzzy number $\widetilde{A}$. To represent $\widetilde{A}$ mathematically and graphically a membership function $\mu_{\widetilde{A}}(x)$ is used which must satisfy the following conditions:

1. $\mu_{\widetilde{A}}(x)$ is upper semi continuous.
2. In a certain interval $[a, b]$ on R, $\mu_{\widetilde{A}}(x)$ is non zero, and otherwise it is zero.
3. There exists an interval $[c,d] \subset [a,b]$ such that
   (i) $\mu_{\widetilde{A}}(x)$ is increasing in $[a, c]$
   (ii) $\mu_{\widetilde{A}}(x)$ is decreasing in $[d, b]$, and
   (iii) $\mu_{\widetilde{A}}(x) = 1$ in $[c, d]$.

Now a TFN $\widetilde{A}$ satisfies all the above conditions and it is represented by $\widetilde{A} = (a,b,c)$.

Let us consider two TFNs $\widetilde{X} = (x_1, x_2, x_3)$, $\widetilde{Y} = (y_1, y_2, y_3)$ and a crisp number c. Then the basic arithmetic operations are as follows:

$\widetilde{X} \oplus \widetilde{Y} = (x_1 + y_1, x_2 + y_2, x_3 + y_3)$,
$\widetilde{X} \sim \widetilde{Y} = (x_1 - y_1, x_2 - y_2, x_3 - y_3)$,
$\widetilde{X} \otimes \widetilde{Y} \approx (x_1y_1, x_2y_2, x_3y_3)$ [Multiplication results an approximate fuzzy number]
and $\widetilde{X} \otimes c = (cx_1, cx_2, cx_3)$.

Definition 2.1.2. The distance between the TFNs $\widetilde{X} = (x_1, x_2, x_3)$ and $\widetilde{Y} = (y_1, y_2, y_3)$ is defined by Chen (2000) as:

$$d(\widetilde{X}, \widetilde{Y}) = \sqrt{\frac{1}{3}\left[(x_1 - y_1)^2 + (x_2 - y_2)^2 + (x_3 - y_3)^2\right]} \tag{2.1}$$

2.2. Grey system and interval grey numbers

Grey system theory (Deng, 1989) was proposed by Deng on the basis of grey sets. The systems that lack in information are pertained as Grey Systems. In the perspective of any type of numbers, Grey numbers represent the information between completely known and completely unknown situations, i.e., Grey System is the bridge connecting White System and Black System. We now take a look on some definitions of Grey theory.

Let X is the universal set of considerations. Then a Grey set G of X is defined by its two mappings $\bar{\mu}_G(x)$ and $\underline{\mu}_G(x)$:

$\bar{\mu}_G(x) : X \rightarrow [0,1]$ and $\underline{\mu}_G(x) : X \rightarrow [0,1]$ such that $\bar{\mu}_G(x) \geqslant \underline{\mu}_G(x), x \in X$. The Grey set G becomes a fuzzy set when the upper and lower membership functions in G are equal to each other, i.e., when $\bar{\mu}_G(x) = \underline{\mu}_G(x)$. When the lower and upper limits of any information can be estimated by real numbers, we certainly are able to express it by an IGN $\otimes G = [\underline{G}, \bar{G}] = \{\theta \in \otimes G : \underline{G} \leqslant \theta \leqslant \bar{G}\}$ where θ is an information and $\underline{G}, \overline{G}$ are respectively the lower and upper limits of the information's existence.