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A supplier selection model with fuzzy risk analysis using the balanced solution technique with a soft set

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A R T I C L E I N F O

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A B S T R A C T

In this paper, a supplier selection model was developed for a retailer. Suppliers have different influence factors that have a risk of profit loss or less profit as well as a loss of goodwill to a retailer. Thus, a retailer must choose a supplier that can provide better profit and better goodwill. Different suppliers have different business policies. Here, different risk factors and their corresponding severity in profit loss and goodwill loss are considered as a fuzzy number. Next, the total risk in profit loss and goodwill loss is formulated. To select a supplier with the minimum risk, a balanced solution of the soft set theory was applied to a numerical example.

1. Introduction

Purchasing is an essential business function because of profit management. The most important purchasing decisions involve selection of an appropriate source of supply, which is the most important component of purchasing. If a correct decision is made in a particular instant, then the needs of a retailer should be met perfectly. The objective of supplier assessment is to determine the extent to which a particular supplier will be able to meet her/his delivery obligation, both now and in the future. The choice of a particular supplier is a very difficult. Different suppliers have different business characteristics. Each characteristic has some risk. Considering all of the risk factors, a retailer must choose a appropriate supplier such that his/her loss of profit will be at a minimum. Risk analysis using fuzzy set theory is a very powerful method. The fuzzy set was first introduced by Zadeh [17]. Subsequently, the use of the fuzzy set has been applied to a large area of mathematics. Zadeh [18] also introduced the concept of the linguistic variable and its application to approximate reasoning. Dubois and Prade [5] presented examples of the theory and application of fuzzy set theory. Fuzzy risk analysis problems have been studied different areas. Various methods exist to perform fuzzy risk analysis in different areas. The ranking method of a fuzzy number is an important technique to perform risk analysis. Chen et al. [3] introduced Fuzzy risk analysis based on ranking generalized fuzzy numbers with different left heights and right heights. Chen and Wang [2] presented the ranking of fuzzy number using α cuts, the belief feature and the signal/noise ratio for analysing the risk of a manufacturing system. Chen and Sanguansat [4] introduced a new fuzzy ranking of a generalized fuzzy number for risk analysis. Patra and Mondal [12] presented a new ranking method of generalized trapezoidal fuzzy numbers and applied it to evaluate the risk of diabetes problems. In addition, there are some similarity measure methods available to perform risk analysis. Wei and Chen [13] presented a new similarity measure of generalized trapezoidal fuzzy numbers to perform fuzzy risk analysis using linguistic term values. In 2010 Xu et al. [16], also introduced a new similarity measure using the COG point of two linguistic valued trapezoidal fuzzy numbers and a new arithmetic operator of linguistic valued trapezoidal fuzzy numbers. Wu et al. [14,15] performed risk analysis of corrosion failures of equipment in refining and petrochemical plants using the fuzzy set theory. Markowski et al. [10] used fuzzy logic in an explosion risk assessment. Wu et al. [14,15] performed supply chain outsourcing risk analysis using an integrated stochastic fuzzy optimization approach. Chan and Kumar [1] presented a global supplier development model considering risk factors using the fuzzy extended Analytical Hierarchy Process based approach. Here, the soft set theory was introduced for the selection

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of a supplier. The soft set theory is a useful tool for the decision making problem. Molodtsov [11] first introduced the soft set theory as a completely generic mathematical tool for modelling uncertainty. Maji et al. further studied the soft set [7,9] and fuzzy soft set [6,8]. Mitra Basu et al. [19] presented a balanced solution based on the fuzzy soft set in a decision making problem of medical science.

In this paper, a new model was established to select a retail supplier to achieve the minimum risk of the retailer. Each of the suppliers has different characteristics and business tactics. Each of the characteristics may have some risk to a retailer in the business. Thus, each characteristic is considered to be an influence factor of business risk to a retailer. All of the influence factors have a collective effect that can be generalized as profit loss and goodwill loss. Thus, these two types of risks were considered here, and supplier selection was performed according to the balanced solution procedure using the soft set theory.

The rest of the paper is organized as follows. In Section 2, some preliminary ideas of the fuzzy set, soft set and balanced solution procedure are discussed. In Section 3, the model formulation and methodology of finding the risk of a system is introduced. In Section 4, a numerical example is given, and in Section 5, conclusions are presented.

2. Preliminaries

2.1. General fuzzy number (GFN)

It is known that for any fuzzy number $\tilde{A}$, there are four numbers $a_1, a_2, a_3, a_4 \in$ R and two functions $\phi(x), \psi(x) : R \rightarrow [0, 1]$, where $\phi(x)$ is nondecreasing and $\psi(x)$ is nonincreasing, such that we can describe a membership function $\mu_{\tilde{A}}(x)$ in the following manner:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & \text{for } x < a_1 \\ \phi(x) & \text{for } a_1 \le x < a_2 \\ 1 & \text{for } a_2 \le x \le a_3 \\ \psi(x) & \text{for } a_3 < x \le a_4 \\ 0 & \text{for } a_4 < x < \infty \end{cases} \quad (1)$$

Functions $\phi(x)$ and $\psi(x)$ are called the left side and right side of the fuzzy number $\tilde{A}$, respectively. In this paper, we denote the general fuzzy number as $[a_1, a_2, a_3, a_4]$ (Fig. 1).

2.2. Soft sets

Let U be an initial universe set and E be a set of parameters. Let $P(U)$ denote the power set of U. Let $A \subset E$. A pair (F, A) is called a soft set over U, where F is a mapping given by $F : A \rightarrow P(U)$. In other words, a soft set over U is a parameterized family of subsets of the universe U.

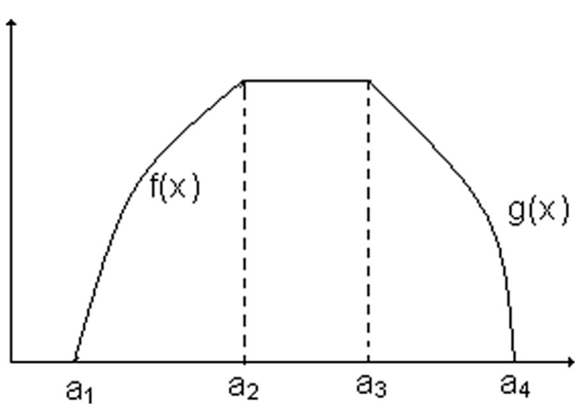

Fig. 1. Membership function of a GFN.

2.3. Fuzzy soft sets

Let U be an initial universe set and E be a set of parameters (which are fuzzy words or sentences). Let $P(U)$ denotes the power set of U. Let $A \subset E$. A pair (F, A) is called a soft set over U, where F is a mapping given by $F : A \rightarrow P(U)$.

2.4. Level soft set of a fuzzy soft set

Let $\Omega = (F, A)$ be a fuzzy soft set over a finite universe U, where $A \subseteq E$ and E is the parameter set. Let $\lambda : A \rightarrow [0, 1]$ be a membership function defined on A; thus, the fuzzy set in A, i.e., A_λ, is called a threshold fuzzy set. The level soft set of the fuzzy soft set Ω with respect to the fuzzy set A_λ is a crisp soft set $L(\Omega; \lambda) = (F_\lambda, A)$ defined by $F_\lambda(a) = L(F(a); \lambda(a)) = \{x \in U; F(a)(x) \ge \lambda(a), \forall a \in A\}$.

2.5. Balanced algorithm to find a balanced solution of a fuzzy soft set-based decision making problem

In many decision making problems, one object is selected from a list of objects on the basis of parameters chosen by a decision maker. In such problems, when choice parameters are equally weighted and the decision maker prefers to choose an object that maintains an equal balance between the membership values of all of the choice parameters, the following algorithm is very useful to obtain the synchronized solution of these decision making problems.

Step-1: Find a normal parameter reduction Q of the choice parameter set P. If it exists, then construct the tabular representation of (F, Q). Otherwise, construct the tabular representation of the FSS (F, P) with the choice values of each object.

Step-2: Compute the potentiality (p_{fs}) of the FSS as follows:

$$p_{fs} = \sum_{i=1}^{m} \sum_{j=1}^{n} \mu_{ij}$$

where μ_{ij} is the membership value of the i-th object with respect to the j-th parameter, m is the number of objects and n is the number of parameters.

Step-3: Determine the Mean Potentiality (m_p) of the fuzzy soft set up to ρ significant figures (where ρ is the maximum number of significant figures among all of the membership values of the objects concerned with the problem):

$$m_p = \frac{p_{fs}}{m \times n}$$

Step-4: Form a m_p-level soft set of the FSS and represent this in tabular form, and then, compute the choice value c_i for each object O_i $\forall i$.

Step-5: If c_k is maximum and unique among $c_1, c_2, \ldots, c_m$ (where m is the number of objects (rows)), then the optimal choice object is O_k and the process is stopped. If c_k is not unique, then go to Step-6.

Step-6: Determine the non-negative difference between the largest and smallest membership value in each column and exhibit it as α_i, $i = 1, 2, \ldots, n$, where n is the number of choice parameters.

Step-7: The same procedure is followed for each row (object); denote the difference values as β_j; $j = 1, 2, \ldots, m$.

Step-8: Take the average (α) of the α_i's up to ρ significant figures and name it ν.

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