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Supplier selection problem under Z-information

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Abstract

Supplier selection problem is a very important element of Supply Chain Management systems. The existing works are devoted to solving this problem under deterministic, stochastic, interval-based and fuzzy information. Unfortunately, up today no systematic research on supplier selection under partial reliability of information is proposed. In this paper we suggest new method for solving supplier selection problem under fuzzy and partially reliable information formalized by using Z-numbers. The method is based on determination of Z-number valued ideal and negative ideal solutions. A numerical example is provided to illustrate validity of the proposed approach to supplier selection problem.

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*Keywords:*supplier selection; multicriteria decision making; ideal solution; partial reliability; Z-number

1. Introduction

With globalizing economy, increasing competition, shortening transaction speed and developing communication and transportation technologies decision making problem in supplier selection is becoming more significant and at the same time more complex issue. The complexity of the matter is rooted in the very essence of the selection process, which involves various quantitative and qualitative criteria.

In an involved ecosystem of complicated market-places competitiveness of businesses becomes more and more dependent on the fast decision making regarding selection of right suppliers. Shortening product life cycles demand from industry champions attracts more attention to changing technologies, increasing standards and expanding

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augmented services. This overall puts more emphasis on the right methodology used in evaluating multiple criteria of a myriad of suppliers.

Multiple criteria involved in the process of decision-making are often uncertain and relative in their nature, as involve expert opinions[16,21], expectations and uncertainties[17,20] and risks. Nevertheless, the pace of current economic activity requires prompt and smart decisions under imperfect information[18,19].

Dickson for the first time provided a framework and laid the foundation of supplier selection problem approach, whereby he identified 23 different criteria for selection of suppliers[1]. Those included criteria such as, quality, delivery, performance history, warranties, price, technical capability, financial position, etc.

On other hand,in Ref. 2 they carried out a review of 74 articles in supplier selection and actually classified them into three categories: linear weighting methods, mathematical programming method and statistical approach.

Although some 50 years passed since foundation was laid for supplier selection problem this topic continues to represent an area of high interest and many scholars address this issue in their papers and research. As an example it is worth to note that www.webofknowledge.com of Thomson Reuters recital database alone returned 471 papers as search result for Fuzzy Approach to Supplier Selection problem since 2013 up to date.

As such the evaluation based on distance from average solution as a method of multi criteria decision making in the context of supplier selection problem is proposed[3]. Authors use a case study in order to demonstrate the suggested method and degree of its use. They also performed a sensitivity analysis by using simulated weights of criteria in order to understand the stability and validity of the results of the method discussed.

Interesting results were proposed on supplier selection problem under vague and incomplete data[4]. They suggested that modern methods used cannot guarantee optimality of the proposed solution as are based upon Analytical Network Process. In order to tackle this issue they suggested combining the above with Dampster-Shafer Evidence theory. In doing so the authors proved the accuracy of the combination by providing a specific numerical example.

Another interesting approach utilizing hesitant fuzzy sets for situations where sets of values are possible in the definition processes of membership of an element[5]. In their work they show how hesitant fuzzy linguistic term sets can determine the computational and linguistic detection based on fuzzy linguistic approach.

A useful method was suggested by Zhang and colleagues to deal at the same time with cardinal and ordinal information in selecting suppliers and making relative decisions[6]. In this method, assessment of alternative criteria and importance weights are both expressed by so-called hesitant fuzzy elements. The conclusion of the research suggests that although the suggested method does not require complicated computation it still yields pretty accurate decisions.

Taking into account that Multi Attribute Decision Making (MADM) as the most common of problems in the area of management, including supplier selection problem are characterized by inevitable uncertainty,a supplier selection in the context of Interval Valued Intuitionistic Fuzzy Sets (IVLFS) was prposed[7].They suggest a new definition and some calculation methods for IVLFS entropy and as such suggested and entropy based decision making in IVLFS and MADM problems. The explained theory is then articulated by showing its deployment in supplier selection problem.

Interval type-2-fuzzy values to explain decision makers' preferences in supplier selection problem was proposed in[8].They also introduced a new formula to compute the distance between two interval type-2 fuzzy sets. Then the performance of the proposed formula is compared to existing ones. Using this formula the authors suggest to use the hierarchy based clustering method to supplier selection problem. Overall results of the study show that not only the proposed formula and hierarchical clustering algorithm provide acceptable results but it also can be successfully used for interval type-2-fuzzy sets in order to obtain proximity of suppliers.

An interesting approach was also proposed to supplier selection problem characterized by fuzzy and partially reliable information[9]. The authors use Z-number-based formalization of sub-criteria and criteria evaluations and importance weights in a hierarchical decision problem. The proposed work is based on a wide analysis. However, the original Z-numbers are reduced to fuzzy numbers and then to crisp numbers that leads to sufficient loss of information that may affect validity of the results.

Unfortunately, up to day there is no a systematic work on supplier selection under Z-number-valued information. In this paper we suggest a new approach to hierarchical multicriteria decision making on supplier selection when information about criteria and sub-criteria evaluations and importance weights are described by Z-numbers. In this approach original Z-number valued information is not converted to fuzzy information. The best alternative (supplier) is considered as that which has the best balance of distances to ideal solution and negative ideal solution.

The method is based on arithmetic of Z-numbers and distance between Z-numbers. An example is provided to illustrate validity of the approach.

The paper is structured as follows. In Section 2 we provide some prerequisite material including definitions of a discrete Z-number, distance between Z-numbers, operations over Z-numbers etc. In Section 3 we formulate the problem of supplier selection under Z-number valued information. In Section 4 we describe the proposed method of solving the problem formulated in Section 3. In Section 5 we consider an example to illustrate application of the proposed approach. Section 6 is conclusion.

2. Preliminaries

Definition 1.Arithmetic operations over discrete random variables[10]**.**Let X_1 and X_2 be two independent discrete random variables with the corresponding outcome spaces $\mathrm{X}_1 = \{x_{11},...,x_{1i},...,x_{1n_1}\}$ and $\mathrm{X}_2 = \{x_{21},...,x_{2i},...,x_{2n_2}\}$ and the corresponding discrete probability distributions p_1 and p_2 . The probability distribution of $X_{12} = X_1 * X_2$, $* \in \{+,-,\cdot,/\}$, is the convolution $p_{12} = p_1 \circ p_2$ which is defined as follows:

$$p_{12}(x) = \sum_{x=x_1*x_2} p_1(x_1)p_2(x_2)\,,\ x \in \{x_1 * x_2 \,|x_1 \in \mathrm{X}_1, x_2 \in \mathrm{X}_2\}\,, x_1 \in \mathrm{X}_1, x_2 \in \mathrm{X}_2\,.$$

Definition 2. Probability measure of a discrete fuzzy number[11]**.** Let X be discrete random variable with pdf p. Let A be a discrete fuzzy number describing a possibilistic restriction on values of X . A probability measure of A , $P(A)$,is defined as

$$P(A) = \sum_{i=1}^{n} \mu_A(x_i)p(x_i) = \mu_A(x_1)p_j(x_1) + \mu_A(x_2)p_j(x_2) + ... + \mu_A(x_n)p_j(x_n)\,.$$

Definition 3. Discrete Z-number[12,13]**.**A discrete Z-number is an ordered pair $Z = (A, B)$ of discrete fuzzy numbers A and B . A plays a role of a fuzzy constraint on values that a random variable X may take. B is a discrete fuzzy number with a membership function $\mu_B : \{b_1,...,b_n\} \to [0,1],\ \{b_1,...,b_n\} \subset [0,1]$, playing a role of a fuzzy constraint on the probability measure of A , $P(A)$.

Definition 4.A distance between Z-number-valued vectors. The distance between Z-number valued vectors is $\mathrm{Z}_1 = (Z_{11}, Z_{12},..., Z_{1n})$ and $\mathrm{Z}_2 = (Z_{21}, Z_{22},..., Z_{2n})$ defined as

$$D\left(\mathrm{Z}_1, \mathrm{Z}_2\right) = \max_{i=1,...,n} d(Z_{1i}, Z_{2i})\,,$$

$$d(Z_{1i}, Z_{2i}) = \left(\frac{1}{n+1} \sum_{k=1}^{n} \left\{ \left| a^L_{1i\alpha_k} - a^L_{2i\alpha_k} \right| + \left| a^R_{1i\alpha_k} - a^R_{2i\alpha_k} \right| \right\} + \frac{1}{m+1} \sum_{k=1}^{m} \left\{ \left| b^L_{1i\alpha_k} - b^L_{2i\alpha_k} \right| + \left| b^R_{1i\alpha_k} - b^R_{2i\alpha_k} \right| \right\} \right),$$

where $a^L_{i\alpha} = \min A^\alpha_i, a^R_{i\alpha} = \max A^\alpha_i, b^L_{i\alpha} = \min B^\alpha_i, b^R_{i\alpha} = \max B^\alpha_i$.

Operations over Discrete Z-numbers[12,13]**.**Let Z_1 and Z_2 be discrete Z-numbers describing imperfect information about values of random variables X_1 and X_2 . The algorithm of computation of addition $Z_{12} = Z_1 * Z_2, * \in \{+,\cdot,\min,\max\}$ is as follows.

Step 1. Compute the result $A_{12} = A_1 * A_2$ of * operation of fuzzy numbers.

Step 2. Given fuzzy restrictions $\sum_{i=1}^{n_j} \mu_{A_j}(x_{ji})p_j(x_{ji})\ is\ B_j$, extract probability distributions $p_j, j = 1, 2$ by solvingthe following goal linear programming problem:

$$c_1v_1 + c_2v_2 + ... + c_nv_n \to b_j \qquad (1)$$

subjectto

$$\left.\begin{array}{l} v_1 + v_2 + ... + v_n = 1 \\ v_1, v_2, ..., v_n \geq 0 \end{array}\right\}. \tag{2}$$

where $c_k = \mu_{A_j}(x_{jk})$ and $v_k = p_j(x_{jk}),\ k = 1,..,n_j,\ k = 1,..,n_j$.

Thus, to probability distributions $p_j, j = 1,2$, we need to solve m simple problems (1)-(2). Let us mention that, in general, problem (1)-(2) does not have a unique solution. In order to guarantee existence of a unique solution, the compatibility conditions can be used[14].

Step 3. Given $p_j, k = 1,..,n_j$,construct the convolutions $p_{12} = p_1 \circ p_2$, as the result of operations over random variables $X = X_1 * X_2$ by using Definition 1:

$$p_{12s}(x) = \sum_{x_1 * x_2 = x} p_1(x_1) p_2(x_2), \forall x \in X_{12}; x_1 \in X_1, x_2 \in X_2 .$$

Step 4. Construct the fuzzy set of convolutions p_{12}, which is naturally induced by the fuzzy sets of probability distributions p_j , as

$$\mu_{p_{12}}(p_{12}) = \max_{p_{12} = p_1 \circ p_2} \min\{\mu_{p_1}(p_1), \mu_{p_2}(p_1)\} \tag{3}$$

subjectto

$$\mu_{p_j}(p_j) = \mu_{B_j}\left(\sum_{k=1}^{n_j} \mu_{A_j}(x_{jk}) p_j(x_{jk})\right),\ j = 1,2 \tag{4}$$

Step 5. As the fuzziness of information on p_{12s} described by Z_{12} induces fuzziness of the value of $P(A_{12}) = \sum_{k=1}^{n} \mu_{A_{12}}(x_{12k}) p_{12}(x_{12k})$,construct a discrete fuzzy number $Z_{12} = (A_{12}, B_{12})$:

$$\mu_{B_{12}}(b_{12}) = \max(\mu_{p_{12}}(p_{12})) \tag{5}$$

subject to

$$b_{12} = \sum_{k=1}^{n} \mu_{A_{12}}(x_{12k}) p_{12}(x_{12k}) \tag{6}$$

As a result, $Z_{12} = Z_1 * Z_2$ is obtained as $Z_{12} = (A_{12}, B_{12})$.

3. Statement of problem

Consider a problem of multiattribute decision making on supplier selection under Z-number valued information. Assume that $S = \{S_1, A_2, ..., A_n\}$ is a set of alternatives (suppliers) and $C = \{C_1, C_2, ..., C_m\}$ is a set of criteria. Each criterion $C_j, j = 1,...,m$ is characterized by associated sub-criteria $SC_{jk}, k = 1,...,m_j$. Moreover, any criterion C_j and sub-criterion SC_{jk} have Z-number valued importance weights W_j and W_{jk} .

Thus, the problem of supplier selection under Z-number valued information is characterized by decision matrices $D_{n \times m_j}, j = 1,...,m$ which describe suppliers evaluation with respect to the sub-criteria $SC_{jk}, k = 1,...,m_j$ .The decision matrix $D_{n \times m_j}, j = 1,...,m$ is as follows:

$$D_{n\times m_j}=\begin{array}{c} \begin{array}{cccc} SC_{j1} & SC_{j2} & \ldots & SC_{jm_j} \end{array} \\ \left[\begin{array}{lllll} S_1 & Z_{1j1}=\left(A_{1j1},B_{1j1}\right) & Z_{1j2}=\left(A_{1j2},B_{1j2}\right) & \ldots & Z_{1jm_j}=\left(A_{1jm_j},B_{1jm_j}\right) \\ S_2 & Z_{2j1}=\left(A_{2j1},B_{2j1}\right) & Z_{2j2}=\left(A_{2j2},B_{2j2}\right) & \ldots & Z_{2jm_j}=\left(A_{2jm_j},B_{2jm_j}\right) \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ S_n & Z_{nj1}=\left(A_{nj1},B_{nj1}\right) & Z_{nj2}=\left(A_{nj2},B_{nj2}\right) & \ldots & Z_{njm_j}=\left(A_{njm_j},B_{njm_j}\right) \end{array}\right] \end{array}$$

The considered problem of multiattribute choice is to determine the best supplier given the decision matrices $D_{n\times m_j},\ j=1,\ldots,m$:

Find $S^*\in \mathrm{S}$ such that $S^*\succ S_i,\ \forall S_i\in \mathrm{S}$,where $\succ$ is a preference relation.

4. Ideal point-based solution method

In this section we suggest an ideal point-based method for solving the problem considered in Section 3. The ideal point concept is a well-known concept in MADM. The procedures of determination of the best supplier by using ideal point-based method are as follows.

Step 1. Compute a Z-number valued criteria evaluations $Z_{ij}=\left(A_{ij},B_{ij}\right)$ as by using Z-number valued weighted arithmetic mean-based (ZWAM) aggregation of sub-criteria evaluations used in decision matrices $D_{n\times m_j}$ as follows.

$$Z_{ij}=W_{ij1}Z_{ij1}+W_{ij2}Z_{ij2}+\ldots+W_{ijm_j}Z_{ijm_j},$$

Where addition and multiplication of Z-numbers is implemented as it is shown in Section 2. The computed Z-number valued criteria evaluations $Z_{ij}=(A_{ij},B_{ij})$ form the decision matrix $D_{n\times m}$:

$$D_{n\times m}=\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \ldots & C_m \end{array} \\ \left[\begin{array}{lllll} S_1 & Z_{11}=\left(A_{11},B_{11}\right) & Z_{12}=\left(A_{12},B_{12}\right) & \ldots & Z_{1m}=\left(A_{1m},B_{1m}\right) \\ S_2 & Z_{21}=\left(A_{21},B_{21}\right) & Z_{22}=\left(A_{22},B_{22}\right) & \ldots & Z_{2m}=\left(A_{2m},B_{2m}\right) \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ S_n & Z_{n1}=\left(A_{n1},B_{n1}\right) & Z_{n2}=\left(A_{n2},B_{n2}\right) & \ldots & Z_{nm}=\left(A_{nm},B_{nm}\right) \end{array}\right] \end{array}$$

where a Z-number valued criteria evaluation $Z_{ij}=\left(A_{ij},B_{ij}\right), i=1,\ldots,n,\ j=1,\ldots,m$ is an aggregation of Z-number valued subcriteria evaluations $Z_{ij1}=\left(A_{ij1},B_{ij1}\right),\ Z_{ij2}=\left(A_{ij2},B_{ij2}\right),\ldots,Z_{ijm_j}=\left(A_{ijm_j},B_{ijm_j}\right)$.

Step 2. Proceed from the decision matrix $D_{n\times m}$ constructed at Step 1 to the weighted decision matrix $D^w_{n\times m}$ by multiplying Z-number valued criteria evaluations Z_{ij} by Z-number valued criteria evaluations W_{ij} :

$$D^w_{n\times m}=\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \ldots & C_m \end{array} \\ \left[\begin{array}{lllll} S_1 & V_{11}=W_{11}Z_{11} & V_{12}=W_{12}Z_{12} & \ldots & V_{1m}=W_{1m}Z_{1m} \\ S_2 & V_{21}=W_{21}Z_{21} & V_{22}=W_{22}Z_{22} & \ldots & V_{2m}=W_{2m}Z_{2m} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ S_n & V_{n1}=W_{n1}Z_{n1} & V_{n2}=W_{n2}Z_{n2} & \ldots & V_{nm}=W_{nm}Z_{nm} \end{array}\right] \end{array}.$$

Step 3. Given decision matrix $D_{n\times m}$, determine the ideal point $S^{id} = (Z_1^{id}, Z_2^{id}, ..., Z_m^{id})$ and the negative ideal point $S^{neg.id} = (Z_1^{neg.id}, Z_2^{neg.id}, ..., Z_m^{neg.id})$ as follows:

$Z_j^{id} = \max_{j=1,...,m} V_{ij}$, $Z_j^{neg.id} = \min_{j=1,...,m} V_{ij}$.

Max and min operations of Z-numbers are implemented in accordance to the approach shown in Section 2.

Step 4. For each alternative S_i compute distances $D\left(S_i, S^{id}\right)$ and $D\left(S_i, S^{neg.id}\right)$ to the ideal point S^{id} and the negative ideal point $S^{neg.id}$ respectively by using Definition 4.

Step 5. Compute the overall performance of each alternative as[15] $U(S_i) = \dfrac{1}{1+\left(\dfrac{D\left(S_i, S^{id}\right)}{D\left(S_i, S^{neg.id}\right)}\right)^2}$ and find the best alternative as follows:

Find $S^* \in \mathrm{S}$ such that $U(S^*) \geq U(S_i), \forall S_i \in \mathrm{S}$.

5. A numerical example

Consider a problem of selection of the best supplier among 3 alternatives $S_i, i = 1,...,3$. The considered problem is a two-level multi-criteria decision problem. The first level include five criteria $C_j, j = 1,...,5$: C_1, C_2, C_3, C_4, C_5, Each criterion has its own sub-criteria $SC_{jk}, k = 1,...,m_j$ .The following sub-criteria are used: Product price, SC_{11}, Freight cost, SC_{12},Tariff and custom duties, SC_{13}, Rejection rate of the product, SC_{21}, Increased lead time, SC_{22}, Quality assessment, SC_{23}, Remedy for quality problems, SC_{24},Delivery schedule, SC_{31}, Technological and R&D support, SC_{32}, Response to changes, SC_{33}, Ease of communication, SC_{34}, Financial status, SC_{41}, Customer base, SC_{42}, Performance history, SC_{43}, Production facility and capacity, SC_{44}, Geographical location, SC_{51}, Political stability, SC_{52}, Economy, SC_{53}, Terrorism, SC_{54}.

The Z-number-based sub-criteria evaluations of the alternatives are given in Table 1.

Table 1. The Z-number-based sub-criteria evaluations

Criteria, weights	Cost, C_1, W_1 =(L,S)			Quality, C_2, W_2 = (H,S)				Service performance, C_3, W_3 = (L,S)				Supplier's profile, C_4, W_4 = (VL,S)				Risk factor, C_5, W_5 = (VL,S)			
Sub-criteria, weights	SC_{11}, W_{11}=(VH,S)	SC_{12}, W_{12}=(M,S)	SC_{13}, W_{13}=(L,S)	SC_{21}, W_{21}=(H,S)	SC_{22}, W_{22}=(L,S)	SC_{23}, W_{23}=(M,S)	SC_{24}, W_{24}=(VL,S)	SC_{31}, W_{31}=(H,S)	SC_{32}, W_{32}=(VL,S)	SC_{33}, W_{33}=(L,S)	SC_{34}, W_{34}=(M,S)	SC_{41}, W_{41}=(H,S)	SC_{42}, W_{42}=(VL,S)	SC_{43}, W_{43}=(M,S)	SC_{44}, W_{44}=(L,S)	SC_{51}, W_{51}=(VL,S)	SC_{52}, W_{52}=(M,S)	SC_{53}, W_{53}=(L,S)	SC_{54}, W_{54}=(H,S)
Supplier 1	VH,CS	L,AS	L,CS	HA,VS	VH,VS	A,AS	VH,VS	LA,CS	A,AS	L, CS	L, VS	VL, VS	VL, AS	VH, CS	VH, S	VH, CS	VH, VS	VH, AS	L, NS
Supplier 2	AA, CS	A, CS	AA	VH, S	A, VS	L, S	H, CS	L, CS	VH, NS	A, AS	A, S	L, VS	HA, AS	AA, CS	L, NS	AA, CS	AA, VS	VL, CS	AA, NS
Supplier 3	L, CS	VH, AS	VH, CS	L, AS	L, S	VH, VS	L, VS	VH, VS	H, AS	H, VS	H, AS	VH, VS	VH, S	VL, CS	VL, AS	VL, CS	VL, VS	A, VS	VH, NS

The unified codebooks used for the Z-number-based sub-criteria evaluations, criteria and sub-criteria importance weights are given in Tables 2,3,4.

Table 2.The linguistic terms for A parts of Z-number-based sub-criteria evaluations

Linguistic value	Fuzzy value
Very Low (VL)	$\{1/0.03, 0/0.13\}$
Low	$\{0/0.03, 1/0.13, 0/0.25\}$
Low Average (LA)	$\{0/0.13, 1/0.25, 0/0.35\}$
Below Average (BA)	$\{0/0.25, 1/0.35, 0/0.5\}$
Average (A)	$\{0/0.35, 1/0.5, 0/0.65\}$
Above Average (AA)	$\{0/0.5, 1/0.65, 0/0.75\}$
High Average (HA)	$\{0/0.65, 1/0.75, 0/0.9\}$
High (H)	$\{0/0.75, 1/0.9, 0/1\}$
Very High (VH)	$\{0/0.9, 1/1, 1/1\}$

Table 3. The linguistic terms for A parts of Z-number-based criteria and sub-criteria weights

Linguistic value	Fuzzy value
Very Low (VL)	$\{0/0.01, 1/0.1, 0/0.19\}$
Low (L)	$\{0/0.18, 1/0.2, 0/0.22\}$
Moderate (M)	$\{0/0.27, 1/0.3, 0/0.33\}$
High (H)	$\{0/0.36, 1/0.4, 0/0.44\}$
Very high (VH)	$\{0/0.45, 1/0.5, 0/0.55\}$

Table 4. The linguistic terms for B parts of the used Z-numbers

Linguistic value	Fuzzy value
Not so sure (NS)	$\{0/0.5, 1/0.6, 0/0.7\}$
Almost sure (AS)	$\{0/0.6, 1/0.7, 0/0.8\}$
Sure (S)	$\{0/0.7, 1/0.8, 0/0.9\}$
Very sure (VS)	$\{0/0.8, 1/0.9, 0/1\}$
Completely sure (CS)	$\{0/0.9, 1/1, 1/1\}$

Let us solve the considered problem by using the ideal solution-based approach (Section 4). At step 1 we have computed the Z-number valued criteria evaluations for each supplier as the aggregated Z-number valued sub-criteria evaluations. The obtained $D_{n\times m}$ of Z-numbers with triangular fuzzy number-based parts is given in Table 5.

Table 5. The decision matrix $D_{n\times m}$

	C_1	C_2	C_3	C_4	C_5
S_1	((0.4, 0.57, 0.7), (0.9, 0.93, 0.96))	((0.5, 0.75, 0.99), (0.8, 0.92, 0.94))	((0.05, 0.22, 0.37), (0.8, 0.92, 0.94))	((0.4, 0.52, 0.63), (0.8, 0.92, 0.94))	((0.4, 0.65, 0.83), (0.7, 0.83, 0.88))
S_2	((0.38, 0.6, 0.77), (0.8, 0.9, 0.93))	((0.4, 0.6, 0.8), (0.86, 0.92, 0.94))	((0.17, 0.4, 0.63), (0.8, 0.89, 0.92))	((0.15, 0.35, 0.49), (0.76, 0.84, 0.88))	((0.53, 0.75, 0.97), (0.77, 0.85, 0.89))
S_3	((0.35, 0.57, 0.78), (0.86, 0.92, 0.94))	((0.2, 0.4, 0.53), (0.84, 0.91, 0.93))	((0.7, 0.94, 1.1), (0.79, 0.87, 0.9))	((0.35, 0.52, 0.65), (0.8, 0.87, 0.91))	((0.4, 0.5, 0.6), (0.82, 0.86, 0.9))

Second, we computed the weighted decision matrix $D^w_{3\times 3}$ (Step 2). Third, we determined the ideal point $S^{id} = (Z_1^{id}, Z_2^{id}, ..., Z_m^{id})$ and the negative ideal point $S^{neg.id} = (Z_1^{neg.id}, Z_2^{neg.id}, ..., Z_m^{neg.id})$ (Step 3). Fourth, we computed distances $D\left(S_i, S^{id}\right)$ and $D\left(S_i, S^{neg.id}\right)$ for each alternative $S_i, i = 1,...,3$ (Definition 4). For example, $D\left(S_i, S^{id}\right) = \max_{1,...,5} d\left(Z_{1j}, Z_j^{id}\right) = 0.375$. The other obtained values of $D\left(S_i, S^{id}\right)$ are $D\left(S_2, S^{id}\right) = 0.29$,

$D\left(S_3, S^{id}\right) = 0.3$. Analogously, we have obtained $D\left(S_i, S^{neg.id}\right)$: $D\left(S_1, S^{neg.id}\right) = 0.29$, $D\left(S_2, S^{neg.id}\right) = 0.2$, $D\left(S_3, S^{neg.id}\right) = 0.38$. Finally, we computed the overall performance $U(S_i), i = 1,...,3$ for each alternative:

$U(S_1) = 0.37, U(S_2) = 0.32, U(S_3) = 0.62$.

Thus, the best supplier is S_3.

6. Conclusion

In this paper we consider a multicriteria decision problem on supplier selection under partially reliable information. As more adequate formalization of partially reliable information on criteria and sub-criteria evaluations and importance weights, Z-numbers are used. The proposed solution method is based on arithmetic of Z-numbers and distance between Z-numbers and utilizes the concept of ideal solution. An example is provided to show validity of the proposed approach.

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