The optimization model of whole process engineering consulting consortium members based on Z-number

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Abstract. At present, there are very few enterprises with whole-process engineering consulting capability and qualification. To carry out consulting work in a consortium is a necessary way to meet the actual situation of the industry and promote whole-process consulting quickly, and the selection of consortium members is the key issue. First of all, this paper summarizes the construction principle of the index system of consortium member selection, and describes the index system. Aiming at the consortium member selection model, on the basis of comprehensive consideration of 9 indicators, the evaluation value of Z-Numbers fuzzy numbers is obtained by using seven-point language terms, the index weight and expert weight are obtained by using the sequential method and entropy weight method, and the data are processed to get the alternative enterprise evaluation matrix. Fuzzy TOPSIS method suitable for Z-Numbers was introduced to solve the positive ideal solution closeness degree of each enterprise, so as to rank the alternative enterprises.

Keywords: whole-process consultation, member selection, Z-numbers, TOPSIS.

1. Introduction

The interest distribution of relevant stakeholders is an important part of the whole process of engineering consultation in the form of a consortium. The interest distribution of all parties in the consortium is crucial to the smooth implementation of the project. Reasonable interest distribution can improve the enthusiasm of all parties for cooperation. Dissatisfaction of any party may lead to the dissolution of the consortium or the reduction of service quality [1].

Xu et al. [2] established a three-stage evaluation model for the selection of members in the design team, and conducted preliminary analysis, fuzzy comprehensive evaluation, and dynamic adjustment of candidate members. Through case studies, it has been verified that this method has strong flexibility and is suitable for various evaluation situations. Fan et al. [3] established a dual objective 0-1 model based on comprehensive consideration of personal information and collaboration ability for the screening problem of R&D team members, and applied it to an example to solve it using genetic algorithm, verifying the feasibility of the model. Watanabe et al. [4] introduced visual analysis methods into the study of member selection. Based on the collected information, they systematically analyzed the basic indicators of candidate members and visualized the evaluation process and prediction results of candidate members. Kumar et al. [5] used the fuzzy analytic hierarchy process to calculate indicator weights, combined with the decision-making method of fuzzy multi-objective optimization, established an optimization model, and obtained the ranking of candidate members. Cheng et al. [6] established a partner selection model in the supplier selection problem, with the constraints of cost, quality, completion time, and service quality in lean systems, and the goal of reducing time consumption.

In summary, research on the selection of consortium members in supply chain, transportation, virtual enterprises, and other fields is extensive and in-depth. However, the acquisition of decision-making information lacks judgment on the reliability of information, and there is a possibility of information loss during the evaluation process. China's whole Process engineering consulting is still in its infancy. For small and medium-sized consulting enterprises to form a consortium, the lead enterprise should also establish a member selection model based on the internal characteristics and development status of the whole Process engineering consulting

2. The whole process of project consulting consortium member selection index system

The selection index of engineering consulting members in the whole process is screened and the index system is established. Member Member selection indicators are shown in Table 1. The meanings of specific indicators are as follows.

Table 1. Member selection evaluation index

Target	First-order index	Secondary index
Whole process project consulting consortium member selection evaluation index	Collaboration ability	Collaborative experience
		Ability to communicate
		Team-work ability
	Technical capacity	Enterprise qualification
		Quality of personal
		Relevant project experience
	Ability to organize and manage	Organization chart
		Incentive mechanism
		Enterprise culture

2.1. Index weight determination

The sequential method is a subjective weighting method. In the process of implementation, there is no need to construct judgment matrix and consistency test, and expert opinions can be fully expressed. There is no restriction on the number of indicators, and it has a good effect in determining the weight of indicators. The method firstly sorted the whole index, then compared the importance of adjacent indexes from weak to strong in pairs, and finally determined the weight of indexes by quantitative calculation by substituting the formula.

1) Deterministic order relation.

Suppose there are n indicators in the index system. Respectively expressed as $x_1, x_2 ... x_3$. Its weight is expressed as $w_1, w_2 ... w_3$. The importance of indicators is ranked by experts, and after ranking, it is represented by $x_1^* > x_2^* \cdots x_n^*$. The weight is expressed as $w_1^*, w_2^* \cdots w_n^*$.

2) Comparison of the importance of adjacent indicators.

Expert on adjacent indicators x_{j-1}^* and x_j^* Compared to the importance of the evaluation, Getting the importance assignment r_j,$r_j = w_{j-1}/w_j$ $(j = 2,3 \cdots, n)$, at the same time must satisfy $r_{j-1} > 1/r_j$, degree of importance. The assignments r_j are shown in Table 2.

Table 2. Importance assignment

r_j	Assignment specification
1.0	Indicator x_{j-1}^* is as important as indicator x_j^*
1.2	Indicator x_{j-1}^* is slightly more important than indicator
1.4	Indicator x_{j-1}^* is significantly more important than indicator x_j^*
1.6	Indicator x_{j-1}^* is more important than indicator x_j^*
1.8	Indicator x_{j-1}^* is extremely important than indicator x_j^*

3) Calculated weight.

According to Eq. (1), the weight of the least important index is obtained, and according to formula (2), the weight of other indicators is obtained successively [6]:

$$w_n^* = \frac{1}{1+\sum_{i=2}^{n}\prod_{i=k}^{n}}, \quad (j = n, n-1, \cdots 2), \tag{1}$$

$$w_{j-1}^* = r_j w_j^*, \quad (j = n, n-1, \cdots 2). \tag{2}$$

3. Whole process engineering consulting consortium member selection model

3.1. Modeling idea

The leading unit of the consortium selects the best partners for the whole process engineering consulting project, which is not only conducive to the smooth development of the project, but also conducive to the smooth implementation of the whole process engineering consulting model in the form of a joint body. Therefore, in view of the principle of selecting the best members, several experts were invited to evaluate and score the indicators of the alternative members based on Z-numbers method. The weight of each indicator was calculated by the sequential method. The weight of each expert was obtained by using the information reliability part of Z-numbers combined with the entropy weight method, and the data were summarized and substituted into fuzzy TOPSIS method. The positive and negative ideal distance of each member is calculated, and the member is ranked to determine the consortium cooperative enterprises

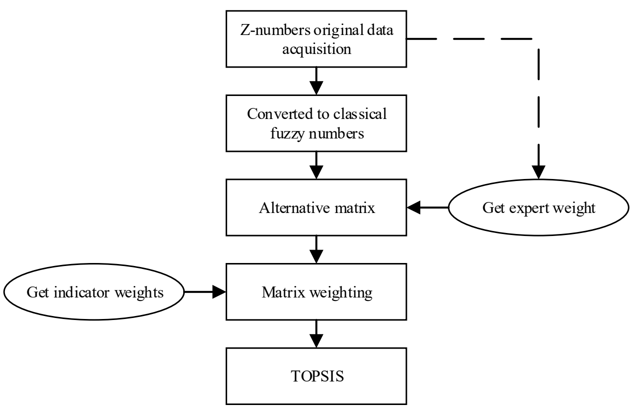

Fig. 1. Member selection flowchart

3.2. Z-numbers obtaining and processing data

3.2.1. The transformation of language variables

Language terms have fuzziness and uncertainty, which conform to the fuzzy limitation and reliability principle of Z-numbers. Studies show that language variables have the best effect between 6-10 partitions. If the score interval of language terms is too small, experts will not consider the relevant information of the evaluation object comprehensively, which will affect the accuracy of data. If the score interval of language terms is too large, experts should have high evaluation experience, evaluation efficiency, knowledge reserve and other conditions, and the amount of evaluation tasks of experts should be increased. Therefore, the 7-point conversion rule of language variables is adopted in this paper to convert the first part and the second part of Z-numbers into trapezoidal fuzzy numbers and triangular fuzzy numbers respectively. The conversion rules of language variables are shown in Table 3 and Table 4.

Table 3. Constraint language variables and trapezoidal fuzzy number conversion rules

Serial number	Constrains some language variables	Corresponding fuzzy number
1	VP	(0,0,0.1,0.2)
2	P	(0.1,0.2,0.2,0.3)
3	MP	(0.2,0.3,0.4,0.5)
4	M	(0.4,0.5,0.5,0.6)
5	MG	(0.5,0.6,0.7,0.8)
6	G	(0.7,0.8,0.8,0.9)
7	VG	(0.8,0.9,1,1)

Table 4. Conversion rules of reliability language variables and triangular fuzzy numbers

Serial number	Constrains some language variables	Corresponding fuzzy number
1	VL	(0,0,0.2)
2	L	(0.05,0.2,0.35)
3	ML	(0.2,0.35,0.5)
4	M	(0.35,0.5,0.65)
5	MH	(0.5,0.65,0.8)
6	H	(0.65,0.8,0.95)
7	VH	(0.8,1,1)

3.2.2. Z-Numbers are converted to classical fuzzy numbers

Kang proposed a method that can approximate Z-Numbers into classical fuzzy numbers under the premise of partial loss of information, which is conducive to improving decision efficiency and practical application. Its basic thinking path is as follows: First, let $Z = (A, B)$ be a Z-Number, Where A is the restrictive part, and the membership function is 1 $\{A = (x, \mu_A) | x \in [0,1]\}$, B is the reliability part. The membership function is expressed as $\{B = (x, \mu_B) | x \in [0,1]\}$; Part B of reliability judgment is transformed according to gravity center method. You get a clear number λ for a fuzzy number B, As shown in Eq. (3). For triangular fuzzy numbers the results of centroid calculation formula are shown in Eq. (4):

$$\lambda = \frac{\int xB(x)dx}{\int B(x)dx}, \tag{3}$$

$$\lambda = \frac{b_1 + b_2 + b_3}{3}. \tag{4}$$

Then, the barycenter value λ of reliability part B can be used as the weight of restriction part A. Then $Z = (A, B)$ can be converted into the classical trapezoidal fuzzy number Z'. As shown in Eq. (5). If the constraint part A is a trapezoidal fuzzy number, it can be expressed as Eq. (6):

$$Z' = \left\{(x, \mu_{A'}) \middle| \mu_{A'}(x) = \lambda \mu_A(x), x \in [0,1]\right\}, \tag{5}$$

$$Z' = \sqrt{\lambda} \times A = \left(\sqrt{\lambda} \times a_1, \sqrt{\lambda} \times a_2, \sqrt{\lambda} \times a_3, \sqrt{\lambda} \times a_4\right). \tag{6}$$

3.3. Expert weight calculation

The initial evaluation data contains the opinions of several experts, which need to be integrated to calculate the weight of each expert opinion. The reliability part of Z-Numbers represents the degree of experts' understanding of the information of evaluation objects. It can be used to calculate the weight of experts by combining the entropy weight method with the reliability part. When an expert has a full understanding of the information of evaluation objects, the accuracy of his evaluation will be higher, so the weight of the expert will be higher. The expert weight is calculated as shown in Eqs. (7), (8) and (9):

$$Z_{ij}^{x} = \frac{a + 4b + c}{6}, \tag{7}$$

$$\partial_x^Z = -\frac{1}{\sum_{i=1}^{m}\sum_{j=1}^{n} Z_{ij}^{x}} \ln\left(\sum_{i=1}^{m}\sum_{j=1}^{n} Z_{ij}^{x}\right), \tag{8}$$

$$\beta_x = \frac{\partial_x^Z}{\sum_{x=1}^{k} \partial_x^Z}, \tag{9}$$

where β_x represents the weight of the x TH expert, ∂_x^Z represents the reliability function of the x TH expert opinion, Z_{ij}^{x} represents the reliability value of the evaluation opinion of the x TH expert on the j TH index of the i TH evaluation object. That is, the reliability of Z-Numbers is partially clarified. There are a total of k experts, m evaluation objects and n evaluation indicators. Eqs. (10) and (11) were used to integrate the opinions of several evaluation experts into the evaluation matrix of alternative members:

$$\beta Z = (\beta a_1, \beta a_2, \beta a_3, \beta a_4), \tag{10}$$
$$H_{ij} = \beta_1 Z_{ij}^{1} + \beta_2 Z_{ij}^{2} + \cdots + \beta_k Z_{ij}^{k}. \tag{11}$$

3.4. TOPSIS determines the member ordering

1) The index weight obtained by the sequential method is weighted to the evaluation matrix of alternative members, as shown in Eq. (12), where α_j represents the weight of the jth index:

$$P = (\alpha_j H_{ij})_{m\times n}. \tag{12}$$

2) Determine the most ideal index A^+ and the least ideal index A^-:

$$A^+ = (P_1^+, P_2^+ \cdots P_n^+), \tag{13}$$
$$A^- = (P_1^-, P_2^- \cdots P_n^-), \tag{14}$$

When the j indicator is a benefit indicator, it is shown in Eq. (15). When the j indicator is a cost-type indicator, it is shown in Eq. (16):

$$P_j^+ = \left(\max_i p_{ij}, j \in J_1; \min_i p_{ij}, j \in J_2\right), \tag{15}$$
$$P_j^- = \left(\min_i p_{ij}, j \in J_1; \max_i p_{ij}, j \in J_2\right). \tag{16}$$

3) Solve the positive and negative ideal distance. The distance calculation of two trapezoidal fuzzy numbers is shown in Eqs. (17) and (18), and the distance calculation of two trapezoidal fuzzy numbers is shown in Eq. (19):

$$d_i^+ = \sum_{j=1}^{n} d(p_{ij}, p_j^+), \tag{17}$$
$$d_i^- = \sum_{j=1}^{n} d(p_{ij}, p_j^-), \tag{18}$$
$$d(a,b) = \sqrt{\frac{1}{6}\left[\sum_{i=1}^{4}(b_i - a_i)^2 + \sum_{i=1}^{3}(b_i - a_i)(b_{i+1} - a_{i+1})\right]}. \tag{19}$$

4) Solve the ideal point distance. Where, θ_i represents the degree of closeness between the i

TH evaluation object and the positive ideal solution:

$$\theta_i = d_i^- / (d_i^+ + d_i^-). \tag{20}$$

5) When sorting alternative units, the larger the θ_i value is, the better the evaluation object is and the more it meets the selection demand of the lead unit. The largest θ_i value belongs to the consortium partner.

4. Example

Currently, a design institute, as the lead enterprise, has formed a consortium to carry out the whole process of CBD construction engineering consulting project of a city business district. The design institute can provide design services and construction cost services. The project owner requires the whole process of engineering consulting services including supervision services. All submitted relevant information about their enterprises.

4.1. Determine index weight

The weight of each index is determined by the sequential method, as shown in Table 5.

Table 5. Weight of each indicator

First-order index	First-order index weight	Secondary index	Secondary index weight	Comprehensive weight
Collaboration ability	0.31	Collaborative experience	0.396	0.123
		Ability to communicate	0.275	0.085
		Team-work ability	0.33	0.102
Technical capacity	0.434	Enterprise qualification	0.245	0.106
		Quality of personal	0.412	0.179
		Relevant project experience	0.343	0.149
Ability to organize and manage	0.258	Organization chart	0.467	0.120
		Incentive mechanism	0.292	0.075
		Enterprise culture	0.243	0.063

4.2. Evaluation and scoring

4 industry experts are invited to evaluate A, B and C enterprises according to the 7-point scale terms, as shown in Table 6, 7 and 8.

4.3. Z-numbers transform

Z-Numbers are converted into classical fuzzy numbers, as shown in Table 9, Table 10 and Table 11.

4.4. Calculated expert weight

The reliability part of Z-numbers is clarified according to Eq. (7), the expert weight is calculated according to Eqs. (8) and (9), and the member selection evaluation matrix is obtained according to the index weight, as shown in Table 12.

4.5. TOPSIS calculates the rankings

Since indexes in this paper are benefit indexes, the values of positive and negative ideal solutions are treated as J_1. The positive and negative ideal distance of each unit in TOPSIS is shown in Table 13. The value of the alternative units is $\theta_1 = 0.850$, $\theta_2 = 0.154$, $\theta_3 = 0.625$.

Among them, Unit A has the highest evaluation value, that is, Unit A is the optimal partner.

The calculation results show that, after the evaluation of the indicators of the three supervision units A, B and C by four experts, the model-based calculation and analysis results show that unit A is the best and has obvious advantages. In reality, Unit A has advantages in technical ability and team cooperation ability, which is in line with the realistic results and verifies the applicability of the model.

Table 6. A Unit expert evaluation language value

		Expert 1	Expert 2	Expert 3	Expert 4
U_1	U_{11}	(MG,H)	(G,H)	(G,MH)	(MG,MH)
	U_{12}	(MG,MH)	(M,H)	(MG,M)	(MG,MH)
	U_{13}	(MG,VH)	(M,M)	(MG,M)	(MG,H)
U_2	U_{21}	(MG,ML)	(G,H)	(MG,H)	(VG,ML)
	U_{22}	(M,MH)	(MG,ML)	(MG,H)	(VG,H)
	U_{23}	(MG,M)	(G,MH)	(G,ML)	(M,M)
U_3	U_{31}	(MG,M)	(M,M)	(MG,MH)	(M,MH)
	U_{32}	(M,VH)	(MP,MH)	(MG,H)	(MP,MH)
	U_{33}	(MG,M)	(MP,H)	(MP,M)	(M,M)

Table 7. B Unit expert evaluation language value

		Expert 1	Expert 2	Expert 3	Expert 4
U_1	U_{11}	(M, H)	(M, M)	(P,MH)	(MP,MH)
	U_{12}	(P,MH)	(MP,MH)	(M,M)	(M,H)
	U_{13}	(M,H)	(M, MH)	(MP,ML)	(P,MH)
U_2	U_{21}	(MG,H)	(M, MH)	(MG,H)	(M,H)
	U_{22}	(MP,MH)	(M,ML)	(MP,H)	(M,M)
	U_{23}	(M,M)	(P,MH)	(MP,MH)	(P,MH)
U_3	U_{31}	(MG,H)	(M,MH)	(MG,H)	(MG,M)
	U_{32}	(MP,M)	(M,M)	(G,ML)	(M,ML)
	U_{33}	(G,H)	(MG,H)	(M,MH)	(MG,H)

Table 8. C Unit expert evaluation language value

		Expert 1	Expert 2	Expert 3	Expert 4
U_1	U_{11}	(MG,MH)	(MG,M)	(M,H)	(M,MH)
	U_{12}	(M,M)	(MG,VH)	(MG,M)	(MG,ML)
	U_{13}	(M,MH)	(MG,ML)	(MP,M)	(G,M)
U_2	U_{21}	(M,MH)	(MG,M)	(G,ML)	(MG,M)
	U_{22}	(MG,M)	(M,M)	(G,MH)	(M,MH)
	U_{23}	(M,H)	(MG,MH)	(M,ML)	(MG,MH)
U_3	U_{31}	(MG,MH)	(M,M)	(MG,H)	(MG,VH)
	U_{32}	(M,ML)	(MP,M)	(G,H)	(MG,MH)
	U_{33}	(M,M)	(MG,MH)	(MG,M)	(M,M)

Table 9. A unit classical fuzzy number

	Expert 1	Expert 2	Expert 3	Expert 4
U_{11}	0.447,0.537,0.626,0.716	0.626,0.716,0.716,0.805	0.564,0.645,0.645,0.726	0.403,0.484,0.564,0.645
U_{12}	0.403,0.484,0.564,0.645	0.358,0.447,0.447,0.537	0.354,0.424,0.495,0.566	0.403,0.484,0.564,0.645
U_{13}	0.483,0.58,0.676,0.773	0.283,0.354,0.354,0.424	0.354,0.424,0.495,0.566	0.447,0.537,0.626,0.716
U_{21}	0.296,0.355,0.414,0.473	0.626,0.716,0.716,0.805	0.447,0.537,0.626,0.716	0.473,0.532,0.592,0.592
U_{22}	0.322,0.403,0.403,0.484	0.296,0.355,0.414,0.473	0.447,0.537,0.626,0.716	0.716,0.805,0.894,0.894
U_{23}	0.354,0.424,0.495,0.566	0.564,0.645,0.645,0.726	0.414,0.473,0.473,0.532	0.283,0.354,0.354,0.424
U_{31}	0.354,0.424,0.495,0.566	0.283,0.354,0.354,0.424	0.414,0.473,0.473,0.532	0.322,0.403,0.403,0.484
U_{32}	0.386,0.483,0.483,0.58	0.161,0.242,0.322,0.403	0.447,0.537,0.626,0.716	0.161,0.242,0.322,0.403
U_{33}	0.354,0.424,0.495,0.566	0.179,0.268,0.358,0.447	0.141,0.212,0.283,0.354	0.283,0.354,0.354,0.424

Table 10. B unit classical fuzzy number

	Expert 1	Expert 2	Expert 3	Expert 4
U_{11}	0.358,0.447,0.447,0.537	0.283,0.354,0.354,0.424	0.081,0.161,0.161,0.242	0.161,0.242,0.322,0.403
U_{12}	0.081,0.161,0.161,0.242	0.161,0.242,0.322,0.403	0.283,0.354,0.354,0.424	0.358,0.447,0.447,0.537
U_{13}	0.358,0.447,0.447,0.537	0.322,0.403,0.403,0.484	0.118,0.177,0.237,0.296	0.081,0.161,0.161,0.242
U_{21}	0.447,0.537,0.626,0.716	0.322,0.403,0.403,0.484	0.447,0.537,0.626,0.716	0.358,0.447,0.447,0.537
U_{22}	0.161,0.242,0.322,0.403	0.237,0.296,0.296,0.355	0.179,0.268,0.358,0.447	0.283,0.354,0.354,0.424
U_{23}	0.283,0.354,0.354,0.424	0.081,0.161,0.161,0.242	0.161,0.242,0.322,0.403	0.081,0.161,0.161,0.242
U_{31}	0.447,0.537,0.626,0.716	0.322,0.403,0.403,0.484	0.447,0.537,0.626,0.716	0.354,0.424,0.495,0.566
U_{32}	0.141,0.212,0.283,0.354	0.283,0.354,0.354,0.424	0.414,0.473,0.473,0.532	0.237,0.296,0.296,0.355
U_{33}	0.626,0.716,0.716,0.805	0.447,0.537,0.626,0.716	0.322,0.403,0.403,0.484	0.447,0.537,0.626,0.716

Table 11. C unit classical fuzzy number

	Expert 1	Expert 2	Expert 3	Expert 4
U_{11}	0.403,0.484,0.564,0.645	0.354,0.424,0.495,0.566	0.358,0.447,0.447,0.537	0.322,0.403,0.403,0.484
U_{12}	0.283,0.354,0.354,0.424	0.483,0.58,0.676,0.773	0.354,0.424,0.495,0.566	0.296,0.355,0.414,0.473
U_{13}	0.322,0.403,0.403,0.484	0.296,0.355,0.414,0.473	0.141,0.212,0.283,0.354	0.495,0.566,0.566,0.636
U_{21}	0.322,0.403,0.403,0.484	0.354,0.424,0.495,0.566	0.414,0.473,0.473,0.532	0.354,0.424,0.495,0.566
U_{22}	0.354,0.424,0.495,0.566	0.283,0.354,0.354,0.424	0.564,0.645,0.645,0.726	0.322,0.403,0.403,0.484
U_{23}	0.358,0.447,0.447,0.537	0.403,0.484,0.564,0.645	0.237,0.296,0.296,0.355	0.403,0.484,0.564,0.645
U_{31}	0.403,0.484,0.564,0.645	0.283,0.354,0.354,0.424	0.447,0.537,0.626,0.716	0.483,0.58,0.676,0.773
U_{32}	0.237,0.296,0.296,0.355	0.141,0.212,0.283,0.354	0.626,0.716,0.716,0.805	0.403,0.484,0.564,0.645
U_{33}	0.283,0.354,0.354,0.424	0.403,0.484,0.564,0.645	0.354,0.424,0.495,0.566	0.283,0.354,0.354,0.424

Table 12. Alternative enterprise member selection evaluation matrix

	Company A	Company B	company C
U_{11}	0.0628, 0.0734, 0.0785, 0.0890	0.0270, 0.0369, 0.0393, 0.0492	0.0442, 0.0540, 0.0586, 0.0686
U_{12}	0.0322, 0.0391, 0.0439, 0.0508	0.0188, 0.0257, 0.0274, 0.0342	0.0302, 0.0365, 0.0413, 0.0476
U_{13}	0.0399, 0.0482, 0.0547, 0.0630	0.0223, 0.0302, 0.0317, 0.0397	0.0319, 0.0391, 0.0424, 0.0496
U_{21}	0.0490, 0.0569, 0.0624, 0.0687	0.0417, 0.0509, 0.0556, 0.0649	0.0383, 0.0457, 0.0495, 0.0570
U_{22}	0.0798, 0.0940, 0.1047, 0.1150	0.0385, 0.0520, 0.0595, 0.0729	0.0682, 0.0818, 0.0849, 0.0985
U_{23}	0.0603, 0.0707, 0.0733, 0.0838	0.0224, 0.0341, 0.0371, 0.0487	0.0522, 0.0637, 0.0697, 0.0812
U_{31}	0.0412, 0.0496, 0.0517, 0.0601	0.0471, 0.0570, 0.0644, 0.0744	0.0485, 0.0586, 0.0665, 0.0767
U_{32}	0.0216, 0.0282, 0.0329, 0.0394	0.0202, 0.0251, 0.0264, 0.0313	0.0264, 0.0321, 0.0349, 0.0406
U_{33}	0.0150, 0.0197, 0.0234, 0.0281	0.0289, 0.0344, 0.0373, 0.0428	0.0209, 0.0255, 0.0279, 0.0325

Table 13. Positive and negative ideal distances in fuzzy topsis

		Company A		Company B		Company C	
		$d(p_{1j},p_j^+)$	$d(p_{1j},p_j^-)$	$d(p_{2j},p_j^+)$	$d(p_{2j},p_j^-)$	$d(p_{3j},p_j^+)$	$d(p_{3j},p_j^-)$
T_1	T_{11}	0.0000	0.0409	0.0409	0.0000	0.0212	0.0197
	T_{12}	0.0000	0.0163	0.0163	0.0000	0.0028	0.0134
	T_{13}	0.0000	0.0223	0.0223	0.0000	0.0117	0.0106
T_2	T_{21}	0.0000	0.0126	0.0066	0.0063	0.0126	0.0000
	T_{22}	0.0000	0.0463	0.0463	0.0000	0.0166	0.0299
	T_{23}	0.0000	0.0394	0.0394	0.0000	0.0062	0.0337
T_3	T_{31}	0.0134	0.0000	0.0021	0.0114	0.0000	0.0134
	T_{32}	0.0035	0.0057	0.0085	0.0000	0.0000	0.0085
	T_{33}	0.0154	0.0000	0.0000	0.0154	0.0099	0.0056

5. Conclusions

To carry out consulting work in a consortium is a necessary way to effectively promote the whole process of engineering consulting. From three aspects of team cooperation, technical ability, organization and management, the whole process of project consulting consortium member selection evaluation index system including 9 indexes is put forward. Z-numbers combined with entropy weight method were used to obtain the weight of expert opinions, and

Z-Numbers fuzzy TOPSIS model was introduced to solve the ranking of alternative enterprises. The uncertainty and reliability of decision information were fully considered. Fuzzy TOPSIS was used to calculate the distance between fuzzy numbers, reducing the loss of information. It can reflect the reality well. The applicability of the model is verified by an example. The optimization model of the consortium members in the whole process of engineering consulting provides a feasible method to solve the problem of leading enterprises choosing partners.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions

Zecheng Liu: data curation, formal analysis, investigation, methodology, visualization, writing-original draft preparation. Jianyu Chu: conceptualization, funding acquisition, supervision, validation. Jinjian Du: project administration, software, writing-review and editing.

Conflict of interest

The authors declare that they have no conflict of interest.

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