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Research Article

The Cooperation Partner Selection of Private Sector under Public-Private-Partnership Projects: An Improved Approach under Group Decision-Making Based on FRS, SAW, and Integrated Objective/Subjective Attributes

Jiawu Gan,[1] Yingying Zhang,[2] Yanan Hu,[2] and Sen Liu [2]

[1] *International Business School, Yunnan University of Finance and Economics, Kunming 650221, China*
[2] *School of Logistics, Yunnan University of Finance and Economics, Kunming 650221, China*

Correspondence should be addressed to Sen Liu; liusencool@163.com

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With the intensification of market competition, the choice of partners in the private sector plays a vital role in the success or failure of the government's public sector in the bidding process. Based on FRS (factor risk scoring system), SAW (simple additive weighted), and the integrated subjective or objective fuzzy group decision-making methods, the private sector partner selection is carried out under the PPP (public-private partnership) model in this paper. First of all, a decision committee is established to select attributes and identify potential partners. Secondly, we determine the important decision of the consistency of the manufacturer, introduce linguistic variables, calculate and collect the fuzzy weighted personal attributes, evaluate the importance of the attributes, and get the comprehensive fuzzy evaluation. Thirdly, we establish fuzzy value matrix based on fuzzy evaluation and get the total fuzzy vector by multiplying respective weighted vectors and fuzzy evaluation matrix, then calculate the defuzzification value of each total score, and choose the alternative with the maximum score. Finally, an example is given to demonstrate the rationality of the algorithm.

1. Introduction

With the increasing demand for infrastructure, the investment of financial funds alone is far from enough to satisfy people's demand for infrastructure. Insufficient investment has become a major bottleneck restricting China's infrastructure construction. PPP (Public-Private-Partnership) model has been favored by all levels of government in China, because it can alleviate the financial pressure, improve the efficiency of public goods supply, and realize the risk sharing between the public and the private [1]. China attaches great importance to the research on the application of PPP model in the field of infrastructure, but ignores the field of private partner selection [2, 3]. However, private partner selection is responsible for the project design, construction, and operation management of the early project construction, which undoubtedly determines the realization of the final goal of the project [4]. Therefore, this paper will establish a scientific and reasonable evaluation system for partner selection in PPP mode, which provides reference for selecting private partners in infrastructure projects

From the above analysis, we can see that, under the Public-Private-Partnership Projects, the selection of cooperation partner problem is essentially a multiattribute group decision problem (MAGDM). Lourenzutti proposed a generalized TOPSIS method for group decision-making with heterogeneous information in a dynamic environment. Wang et al. combined the SAW, TOPSIS, and GRA methods [5]. Chen et al. introduced an approach to partner selection with grey target model to minimize the vertical projection distance [2]. Liu et al. proposed a method based on the proposed IFAHA operator and the proposed IFWAHA operator [6].

However, as shown above, there are some limitations on the selection of private sector partners under the MAGDM public and private partnership projects: (1) the existing studies do not take into account the degree of importance of the objective attribute and subjective attribute in the decision-making problem [5, 7]; (2) the traditional methods usually rely on objective data or subjective judgment, and few studies make more accurate judgments in combination with objective data and subjective judgment [8–10].

Therefore, in order to fill the research gap, a new MAGDM method has been proposed, which has integrated objective/subjective attributes to solve the cooperation partner selection of private sector under Public-Private-Partnership projects. The methods proposed mainly include the following steps: first, we collect decision opinions, establish decision matrices, and normalize them; second, by introducing linguistic variables and integrating objective/subjective attributes, the decision opinions provided by each DM are aggregated into the comprehensive evaluation values. Finally, refer to the comprehensive evaluation values and identify which cooperation partner is suitable for the Public-Private-Partnership projects.

The rest of this paper is structured as follows. Section 2 proposes the evaluation criteria for private enterprise partner selection under Public-Private-Partnership Projects. Section 3 introduces the general procedure of the proposed method and decision analysis. Section 4 demonstrates a numerical example, and Section 5 presents the conclusions.

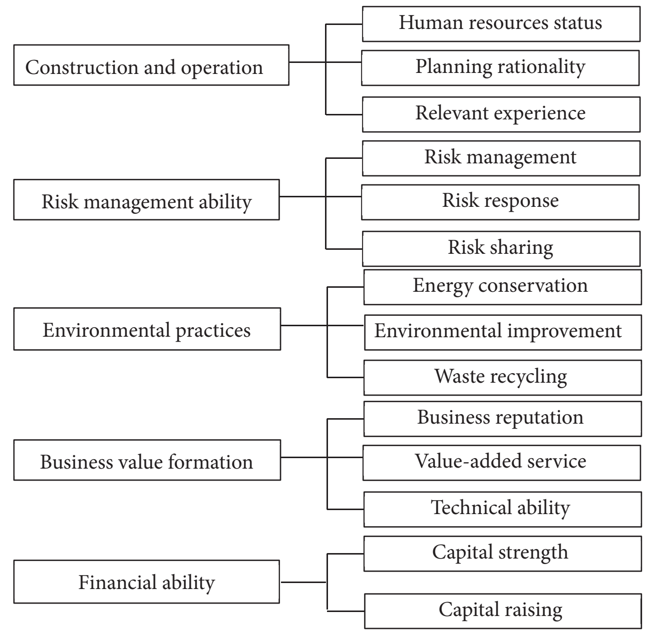

Figure 1: The evaluation criteria of private sector under PPP projects.

2. The Evaluation Criteria of Private Sector under Public-Private -Partnership Projects

From the perspective of the PPP project operation process and the role of the private sector partners, this paper divides the partner selection evaluation into five parts: construction and operations, risk management ability, environmental practices, business value formation, and finance [4, 11]. Specifically, the five evaluation criteria are construction and operation ability, risk management ability, environmental practices, business value formation, and financial ability, which are shown in Figure 1.

In general, the evaluation criteria of private sector under PPP projects can be classified into the below several categories:

(i) **Construction and Operation Ability**. The PPP project is obviously different from the traditional construction model in the talent echelon and organizational structure. Therefore, the whole process of construction is not the superposition of the process of design and construction. The construction and operation ability is more focused on the whole process control of the whole life cycle of the PPP project [1]. Hence, we classify construction and operation ability into human resources status, planning rationality and relevant experience. By these criteria, we can select the most suitable partners of PPP projects in construction and operation ability.

(ii) **Risk Management Ability**. PPP project financing structure is complex and the investment is huge; the construction and operation of the project will be a variety of unknown factors at any time. These show that the reasonable risk sharing is one of the key factors of the success of the PPP project [4]. Therefore, private partners must effectively identify risk factors and respond to risk management measures in a timely and reasonable manner [2, 12]. Among them, risk management system, risk response measures, and risk sharing plan are important indicators to measure the risk management level of private partners.

(iii) **Environmental Practices.** Environmental protection has become the consensus of all countries in the world, especially in China. Many studies also considered that environmental issues should be fully taken into account in the implementation of PPP projects [13–15]. The environmental practices involve many aspects, such as industrial pollution and domestic pollution [16]. We deem that environmental practices should be given enough thought in the cooperation partner selection of PPP projects, because otherwise the environmental issues will not be in control. The secondary indicators of environmental practices can be classified into energy conservation, environmental improvement, and waste recycling, which can reflect well the PPP partner's practical attitude and action toward environmental issues.

(iv) **Business Value Formation.** PPP, as an important part of a financing mode, usually is used to relieve infrastructure funding pressure and raise the funds rate for local governments in China [15]. PPP is a long-term collaboration between the public and private sectors for joint construction of town and country infrastructure projects, or offering public goods and service [17, 18]. In the PPP projects, we think the public and private sectors are to cooperate

Table 1: Linguistic variables and fuzzy numbers for weights.

Linguistic variables	fuzzy number
Very low (VL)	(0, 0, 0, 3)
Low (L)	(0, 3, 3, 5)
Middle (M)	(2, 5, 5, 8)
High (H)	(5, 7, 7, 10)
Very high (VH)	(7, 10, 10, 10)

∗Note: from [21].

to complete not only infrastructure construction, but also the formation of business value. Hence, we propose the secondary indicators of business value formation as business reputation, value-added service, and technical ability, which can effectively reflect the shared value of partners in PPP projects.

(v) **Financial Ability**. It is an important index to judge the strength of private partners. If the ability of the use and management of funds is weak, the rational planning and financing of funds cannot be carried out, so the funding gap will appear, which will affect the construction of the project [19, 20]. The financial ability of the partner can be divided into capital strength and capital raising. Capital strength is a core indicator to measure the private partner's financing ability. A good partner's financing ability is mainly reflected in the guarantee of stable funds, the timely and rational use of funds, and the schedule of fund utilization according to the progress of projects. Hence, we propose the secondary indicators of financial ability as capital strength and capital raising, which can guarantee the ability of investors in the economic convenience to carry out investment projects

3. Preliminary

3.1. Fuzzy Set Theory. Since linguistic variables cannot be directly handled by mathematical methods, in order to solve this problem, each linguistic variable is related to the fuzzy number representing the meaning of each common linguistic term. In FST, transform values are applied to convert linguistic terms into fuzzy numbers [22]. Determining the number of transformation values is usually intuitive: however, too few transformations reduce the resolution, while too many transformations make the system too complicated and unrealistic. In the current study, 1-5 is used as an important weight, and 1-9 is used for ranking behavior [22–24].

The fuzziness of partner selection problem, the individual attributes of the candidate, and the importance weight of ratings to various subjective criteria are used as linguistic variables in this study [8]. Table 1 lists the weights of individual attributes, and Table 2 gives the evaluation of the program and various subjective criteria as linguistic variable values. Trapezoidal fuzzy number is easy to use and convenient to explain. For example, the weight of a very important specific attribute can be measured with trapezoidal fuzzy numbers represented by (7, 10, 10, 10). The linguistic variables and

Table 2: Language variables and fuzzy numbers for ratings.

Linguistic variables	fuzzy number
Very poor (VP)	(0, 0, 0, 20)
Between very poor and poor (B VP& P)	(0, 0, 20, 40)
Poor (P)	(0, 20, 20, 40)
Between poor and feasible (B P& F)	(0, 20, 50, 70)
Feasible (F)	(30, 50, 50, 70)
Between feasible and good (B F& G)	(30, 50, 80, 100)
Good (G)	(60, 80, 80, 100)
Between good and very good (B G& VG)	(60, 80, 100, 100)
Very good (VG)	(80, 100, 100, 100)

∗Note: from [21].

fuzzy numbers for weights and ratings proposed by [21] are as shown in Tables 1 and 2.

3.2. FRS and SAW. This part describes a new fuzzy multiple attribute decision method (FMADM), which integrates the fuzzy set theory (FST), the traditional factor risk scoring system (FRS), and the simple additive weighted (SAW) method to locate the system. This program is suitable for individual and collective decisions. In the collective setting, the fuzzy evaluation of the decision-makers can be calculated in several ways. In these methods, there are five commonly used methods, including mean, median, maximum, minimum, and mixed operation. This paper uses the mean method to evaluate the importance of decision-makers; that is, the importance of decision-makers is the same (called homogeneous group). Under this condition, a new FSAWS method is proposed to solve the facility location problem for homogeneous groups in fuzzy environment.

In order to establish the decision matrices of decision-makers, decision-makers express their opinions (or performance appraisals) and investigate alternative alternatives of each attribute by questionnaire. These evaluations are usually fuzzy data forms. Fuzzy data can be a linguistic term or speech assessment. The purpose of this state is to convert the fuzzy data into trapezoid fuzzy data. The weights and attributes of the decision-makers of the same/heterogeneous group are aggregated based on the aggregation method. After normalization weight is calculated and the importance degree of decision-makers is evaluated, all performance evaluations are aggregated to each choice under each subjective attribute. The fuzzy weight of the individual attribute and the fuzzy total score of the decision-maker's individual selection of the same/heterogeneous group are blurred in the final state. Then, these alternatives are ranked according to the total score.

4. The Proposed Method

The proposed method has the following three steps. First, preparation stage: in this stage, we collect decision-making advice, establish decision matrices, and convert all verbal terms into trapezoidal fuzzy numbers. Second, aggregation stage: in this stage, we use aggregate FRS and SAW. Third, selection stage: in this stage, we construct fuzzy evaluation matrix and select the best option based on the total fuzzy

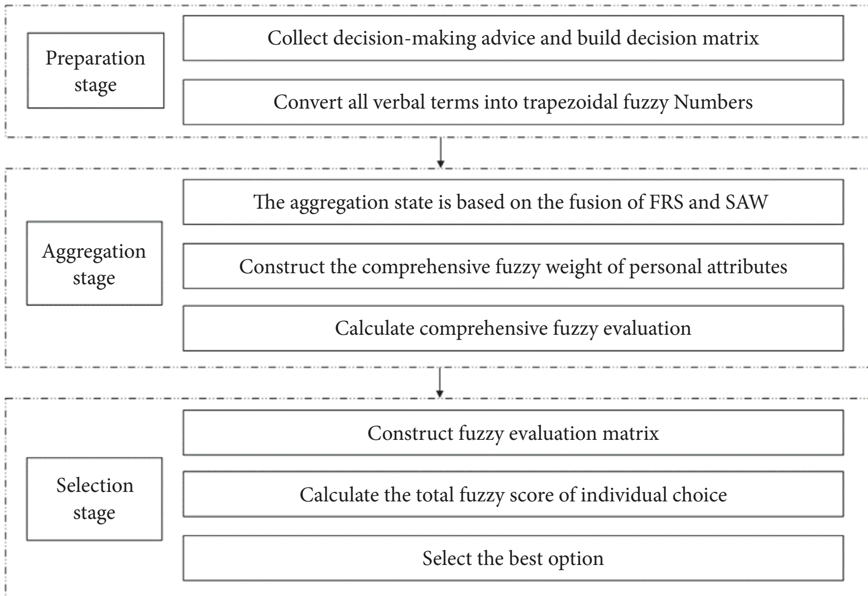

Figure 2: The conceptual framework of the proposed approach.

score of individual choice. Figure 2 illustrates the conceptual framework of the proposed method.

Step 1. We set up a committee of policy makers, selecting attributes and identifying potential private sector partners.

Step 2. We determine the degree of importance (or reliability) of the decision-maker. If the importance (or reliability) of the decision-maker is equal, then the decision within the group is considered to be homogeneous. Otherwise, the group is considered to be heterogeneous (nonhomogenous).

Suppose there are k decision committees (or experts) (D_t, $t = 1, 2, \ldots, k$) who are responsible for evaluating the M candidate address (A_i, $i = 1, 2, \ldots, m$) under the condition of each n attribute (C_j, $j = 1, 2, \ldots, n$) and attribute weight. The importance (or reliability) of a decision-maker is expressed as I_t, $t = 1, 2, \ldots, k$, where I_t belongs to $[0, 1]$ and $\sum_{t=1}^{k} I_t = 1$. If the importance (or reliability) and the weight of each decision-maker are taken into account, then the decision-maker fuzzy weight ω_t, $t = 1, 2, \ldots, k$, was assigned according to the importance of determining the final decision of the interview. Finally, the weight degree of I_t can be defined as follows:

$$I_t = \frac{d(\omega_t)}{\sum_{t=1}^{k} d(\omega_t)}, \quad t = 1, 2, \ldots, k, \tag{1}$$

Here, $d(\omega_t)$ gives the fuzzy weight of the fuzzy value by means of symbolic distance. If $I_1 = I_2 = \cdots I_k = 1/k$, the decision-maker group is called a homogeneous group; otherwise, the decision-maker group is called heterogeneous (heterogeneous) group.

Step 3. We introduce linguistic weighting variables (Table 2) for decision-makers, evaluate the importance of attributes, and calculate the fuzzy weights of individual attributes [25].

Let $W_{jt} = (a_{jt}, b_{jt}, c_{jt}, d_{jt})$ $j = 1, 2, \ldots, n$; $t = 1, 2, \ldots, k$ be the linguistic weight, and the decision-maker D_t gives the subjective attribute $c_1, c_2, \ldots, c_h$ and the objective attribute $c_{h+1}, c_{h+2}, \ldots, c_n$. The fuzzy attribute weight C_j of the aggregation of attribute $W_{jt} = (a_{jt}, b_{jt}, c_{jt}, d_{jt})$ $j = 1, 2, \ldots, n$ is evaluated by the k decision committee, whose definition can be listed as follows:

$$W_j = \left(I_1 \otimes W_{j1}\right) \oplus \left(I_2 \otimes W_{j2}\right) \oplus \cdots \oplus \left(I_k \otimes W_{jk}\right) \tag{2}$$

Herein,

$$\begin{aligned} a_j &= \sum_{t=1}^{k} I_t a_{jt}, \\ b_j &= \sum_{t=1}^{k} I_t b_{jt}, \\ c_j &= \sum_{t=1}^{k} I_t c_{jt}, \\ d_j &= \sum_{t=1}^{k} I_t d_{jt}, \end{aligned} \tag{3}$$

Step 4. Defuzzify fuzzy weight of individual attributes; calculate normalized weights and construct weighted vector. In order to solve the weight of fuzzy attributes, the symbolic distance is adopted. Fuzzy solution W_j is denoted as $d(W_j)$, so it can be expressed by the following formula:

$$d\left(W_j\right) = \frac{1}{4}\left(a_j + b_j + c_j + d_j\right), \quad j = 1, 2, \ldots, n \tag{4}$$

The normalized weight of the attribute C_j is denoted as W_j and is given by the following formula:

$$W_j = \frac{d\left(\omega_j\right)}{\sum_{j=1}^{n} d\left(\omega_j\right)}, \quad j = 1, 2, \ldots, n, \tag{5}$$

Here, $\sum_{j=1}^{n} W_j = 1$. The weight vector $W = [W_1, W_2, \cdots W_n]$ is thus formed.

Step 5. Use the language evaluation variables (Table 2) for fuzzy evaluation of subjective attribute evaluation and project decision of the individual, and then focus on fuzzy comprehensive evaluation. Let $X_{ijt} = (oijt, pijt, qijt, sjit)$, $i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, h$, $t = 1, 2, \ldots, k$ become the appropriateness evaluation of language, and the subjective attribute C_j given by decision-maker D_t is assigned to different location A_i. Let us further define the fuzzy evaluation of X_{ij} as the subjective attribute of the C_j candidate A_i set, which can be derived:

$$X_{ij} = \left(I_1 \otimes X_{ij1}\right) \oplus \left(I_2 \otimes X_{ij2}\right) \oplus \cdots \oplus \left(I_k \otimes X_{ijk}\right) \tag{6}$$

This formula can then be said and calculated:

$$X_{ij} = \left(o_{ij}, p_{ij}, q_{ij}, s_{ij}\right), \quad i = 1, 2, \ldots, m, \; j = 1, 2, \ldots, h, \tag{7}$$

Herein,

$$\begin{aligned} o_{ij} &= \sum_{t=1}^{k} I_t o_{ijt}, \\ p_{ij} &= \sum_{t=1}^{k} I_t p_{ijt}, \\ q_{ij} &= \sum_{t=1}^{k} I_t q_{ijt}, \\ s_{ij} &= \sum_{t=1}^{k} I_t s_{ijt}, \end{aligned} \tag{8}$$

Step 6. In the committee decision-maker, the fuzzy cost or benefit of the objective attributes is evaluated with various alternatives, and then the fuzzy valued attributes relative to the individual target scheme are calculated.

Objective attributes are determined in each unit and must be transformed into nondimensional indicators (or grades) to ensure linguistic compatibility with subjective attributes. Alternatives with the lowest cost (or maximum benefit) should have the highest rating.

Based on the above principle, let

$$r_{ij} = \left(a_{ij}, b_{ij}, c_{ij}, d_{ij}\right), \quad i = 1, 2, \ldots, m, \; j = q, q+1, \ldots, n, \; q = h+1; \tag{9}$$

It is the fuzzy related cost or benefit of C_j with the most subjective attribute of alternative address A_i. Equations (9) and (10) show the transformation objective attributes as follows:

$$x_{ij} = \left\{r_{ij} \div \max_i \left\{d_{ij}\right\}\right\} \otimes 100, \quad i = 1, 2, \ldots, m, \; j = q, q+1, \ldots, n, \tag{10}$$

Here, $\max_i\{d_{ij}\} > 0, X_{ij}$ represents the benefit of the transformed fuzzy evaluation r_{ij}, and x_{ij} can also be represented by the fuzzy number $x_{ij} = (o_{ij}, p_{ij}, q_{ij}, s_{ij})$, $i = 1, 2, \ldots, m$, $j = q, q+1, \ldots, n$, $q = h+1$. In addition, when r_{ij} becomes larger, x_{ij} becomes larger.

$$x_{ij} = \left\{\min_i \left\{a_{ij}\right\} \div r_{ij}\right\} \otimes 100, \quad i = 1, 2, \ldots, m, \; j = q, q+1, \ldots, n, \tag{11}$$

Among them, $\min_i\{a_{ij}\} > 0, x_{ij}$ means that the cost of fuzzy evaluation of transformation is also r_{ij}, x_{ij} can be expressed by fuzzy number $x_{ij} = (o_{ij}, p_{ij}, q_{ij}, s_{ij})$, $i = 1, 2, \ldots, m$, $j = q, q+1, \ldots, n$, $q = h+1$, and when r_{ij} becomes larger, x_{ij} becomes smaller.

Step 7. We establish a fuzzy valued matrix based on fuzzy evaluation.

The fuzzy evaluation matrix M can be expressed concisely as the following matrix format:

$$M = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ X_{m1} & X_{m2} & \cdots & X_{mn} \end{bmatrix} \tag{12}$$

Here, $x_{ij}, \forall i, j$ is the aggregate fuzzy evaluation of attribute A_i, $i = 1, 2, \ldots$, and m is related to attribute C_j.

Step 8. The fuzzy total score of individual alternatives is obtained by multiplying the fuzzy evaluation matrix with each weight vector. By fuzzy evaluation matrix M multiplied by the corresponding weight vector W, the total fuzzy subvector is obtained, exactly:

$$\begin{aligned} F = M \otimes W^T &= \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ X_{m1} & X_{m2} & \cdots & X_{mn} \end{bmatrix} \otimes \begin{bmatrix} W_1 \\ W_2 \\ \vdots \\ W_n \end{bmatrix} \\ &= \begin{bmatrix} x_{11} \otimes W_1 \oplus x_{12} \otimes W_2 \oplus \cdots \oplus x_{1n} \otimes W_n \\ x_{21} \otimes W_1 \oplus x_{22} \otimes W_2 \oplus \cdots \oplus x_{2n} \otimes W \\ \vdots \\ x_{m1} \otimes W_1 \oplus x_{m2} \otimes W_2 \oplus \cdots \oplus x_{mn} \otimes W \end{bmatrix} \\ &= \begin{bmatrix} f_1 \\ f_2 \\ \vdots \\ f_m \end{bmatrix} = \left[f_i\right]_{m+1} \end{aligned} \tag{13}$$

here, $f_i = \left(r_i, s_i, t_i, u_i\right)$, $i = 1, 2, \ldots, m$

Table 3: Importance weight of attributes.

Standard	Decision maker			
	D_1	D_2	D_3	D_4
C_1	M	VH	M	H
C_2	H	VH	VH	M
C_3	VH	H	H	VH
C_4	H	VH	H	M
C_5	VH	H	VH	VH

Table 4: Fuzzy weights and set fuzzy weights of attributes.

Attribute	Decision maker				AFW
	D_1	D_2	D_3	D_4	
C 1	(2, 5, 5, 8)	(7, 10, 10, 10)	(2, 5, 5, 8)	(5, 7, 7, 10)	(4, 6.75, 6.75, 9)
C 2	(5, 7, 7, 10)	(7, 10, 10, 10)	(7, 10, 10, 10)	(2, 5, 5, 8)	(5.25, 8, 8, 9.5)
C 3	(7, 10, 10, 10)	(5, 7, 7, 10)	(5, 7, 7, 10)	(7, 10, 10, 10)	(6, 8.5, 8.5, 10)
C 4	(5, 7, 7, 10)	(7, 10, 10, 10)	(7, 10, 10, 10)	(2, 5, 5, 8)	(5.25, 8, 8, 9.5)
C 5	(7, 10, 10, 10)	(5, 7, 7, 10)	(7, 10, 10, 10)	(7, 10, 10, 10)	(6.5, 9.25, 9.25, 10)

Step 9. We calculate the brittleness for each score, use the defuzzification method, and choose the alternative with the largest total score.

The ranking of the best positions is determined according to the distance of the fuzzy total score. The following fuzzy equation determines the individual position clear total score:

$$d\left(f_i\right) = \frac{1}{4}\left(r_i + s_i + t_i + u_i\right) \tag{14}$$

Here, the ambiguity value of the total fuzzy number of the address is given by the location of the symbol distance.

Then the ranking of the position can be defined as the fuzzy value of the total score of the individual choice.

5. Example Analysis

In this paper, a nuclear power plant project in Fujian, China (hereinafter referred to as X nuclear power plant), as an example, the tender announcement by the relevant government departments approved by the public release, and finally, A_1, A_2, and A_3 three combinations were selected as alternatives for further assessment.

Step 1. Committees with four decision-makers, D_1, D_2, D_3, and D_4, determine the best alternative. Subjective weights are as follows: (a) construction and operation capability (C_1); (b) risk management ability (C_2); (c) environmental practices (C_3); (d) business value formation (C_4). Objective weight: (e) financial capability (C_5); the importance weights of attributes are shown in Table 3.

Step 2. After meeting the committee with all policy makers, all the policy makers are convinced that the importance and reliability are equal ($I_1 = I_2 = I_3 = I_4$).

Step 3. We use linguistic weighting variables and their respective fuzzy numbers to evaluate the importance weight of each attribute. Based on the evaluation value, the fuzzy weight of personal attributes is calculated by equation. Fuzzy weights and set fuzzy weights of attributes are shown in Table 4.

The AFW stands for set fuzzy weights as shown in Table 5.

Step 4. The fuzzy value of the fuzzy weight is calculated by (4) and the normalized weight of the attribute is calculated by (5). These weights derive the value of the weight vector $W = [0.1699; 0.1971; 0.2115; 0.1971, 0.2244]$.

Step 5. We use linguistic level variables and their respective fuzzy numbers with respect to each subjective criterion (Table 2) to evaluate the fuzzy numbers of the four alternatives and then compute a comprehensive fuzzy score for each selection criterion by (6). The evaluation of decision-makers under subjective evaluation attributes and set evaluation are shown in Table 6.

Step 6. We evaluate the fuzzy financial with various alternatives and objective indicators and then use (11) to calculate the relative objective criteria to select the fuzzy rating, as shown in Table 7.

Step 7. We establish the fuzzy evaluation matrix with the aggregate rating, as shown in Table 8.

Step 8. We obtain the total fuzzy fraction of each position.

The total score in Table 9 shows that the descending order of the three alternatives is $A_3 > A_2 > A_1$. Therefore, the committee should recommend that alternative A_3 be selected as the appropriate partner in the four options.

6. Conclusions

This paper proposes an effective method to solve the problem of private sector partner selection in fuzzy homogeneous environment. Firstly, we select attributes and identify potential partners. Secondly, we get comprehensive fuzzy evaluation. Thirdly, calculate defuzzification value and choose an

Table 5: Fuzzy values of set fuzzy weights and normalized weights of attributes.

Method	Attribute				
	C_1	C_2	C_3	C_4	C_5
Calculating fuzzy values	6.6250	7.6875	8.2500	7.6875	8.7500
Normalized weight	0.1699	0.1971	0.2115	0.1971	0.2244

Table 6: Evaluation of decision makers under subjective evaluation attributes and set evaluation.

Attribute selection scheme		Evaluation of decision maker				Set evaluation
		D_1	D_2	D_3	D_4	
C_1	A 1	F	B. P & F	B. F& G	F	(22.5, 42.5, 57.5, 77.5)
	A 2	B. F & G	F	G	VG	(50, 70, 77.5, 92.5)
	A 3	B. P & F	G	B. P & F	B. F & G	(22.5, 42.5, 65, 85)
C_2	A 1	B. P & F	F	P	F	(15, 35, 42.5, 62.5)
	A 2	F	B. F & G	P	F	(22.5, 42.5, 50, 70)
	A 3	B. F & G	G	B. P & F	B. F & G	(30, 50, 72.5, 92.5)
C_3	A 1	G	G	G	B. F & G	(52.5, 72.5, 80, 100)
	A 2	B. F & G	P	B. F & G	VG	(35, 55, 70, 85)
	A 3	G	B. F & G	B. P & F	F	(30, 50, 65, 85)
C_4	A 1	G	P	G	B. P & F	(30, 50, 57.5, 77.5)
	A 2	B. F & G	P	G	G	(37.5, 57.5, 65, 85)
	A 3	G	B. F & G	VG	F	(50, 70, 77.5, 92.5)

Table 7: Evaluation of decision makers under objective evaluation attributes and set evaluation.

A_i	capital strength	capital raising	financial ability rating	fuzzy subjective
A_1	(18, 20, 30, 32)	(15, 15, 15, 15)	(33, 35, 45, 47)	(46.8, 48.9, 62.9, 66.7)
A_2	(14, 15, 15, 16)	(8, 10, 15, 16)	(22, 25, 30, 32)	(68.8, 73.3, 88, 100)
A_3	(12, 16, 16, 18)	(10, 10, 10, 10)	(22, 26, 26, 28)	(78.6, 84.6, 84.6, 100)

Table 8: Fuzzy evaluation matrix.

Ai	C_1	C_2	C_3	C_4	C_5
A_1	(22.5, 42.5, 57.5, 77.5)	(15, 35, 42.5, 62.5)	(52.5, 72.5, 80, 100)	(30, 50, 57.5, 77.5)	(46.8, 48.9, 62.9, 66.7)
A_2	(50, 70, 77.5, 92.5)	(22.5, 42.5, 50, 70)	(35, 55, 70, 85)	(37.5, 57.5, 65, 85)	(68.8, 73.3, 88, 100)
A_3	(22.5, 42.5, 65, 85)	(30, 50, 72.5, 92.5)	(30, 50, 65, 85)	(50, 70, 77.5, 92.5)	(78.6, 84.6, 84.6, 100)

Table 9: The scores obtained.

Attribute		
A_1	fuzzy number	(34.36, 50.28, 60.51, 76.87)
	Calculating fuzzy values	55.51
A 2	fuzzy number	(43.10, 59.68, 70.39, 86.68)
	Calculating fuzzy values	64.96
A 3	fuzzy number	(43.57, 60.43, 73.34, 91.32)
	Calculating fuzzy values	67.17

alternative plan. Finally, an example is given to demonstrate the rationality of the algorithm.

The method proposed in this paper has three main contributions and advantages. First, when considering the attributes of distribution center location, it is divided into subjective and objective attributes. The traditional FRS based on the combination of SAW and FST can be extended to the location selection of homogeneous/heterogeneous group decision domain in fuzzy environment. Second, the method proposed in this paper allows FMADM to accommodate linguistic terms represented by fuzzy numbers. This helps to create a decision-making process, which is more realistic than the existing system. Third, the method proposed in this paper uses simplified ranking of fuzzy numbers rather than complex programs, so the calculation speed is faster. This method provides a flexible method for decision-makers to choose any FMADM.

There is a great space for improvement in the selection of private sector partners. Researchers need to do further researches.

Data Availability

The data used to support the findings of this study are available within the paper.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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