A Partner Selection Method for Forming Innovation Alliance

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***Abstract*—Establishing innovation alliance has now become a very important and indispensable way for achieving the mission of research and development (R&D) of national mega projects in China. As an important component for constructing the collaborative partnership system, an appropriate approach of partner selection should be able to evaluate the performance of candidates objectively. Innovation alliance has members with different backgrounds, but the most suitable partner should be involved in the alliance by launcher before establishing alliance. For this reason, the aim of this paper is to take the different characteristics of organization as the influence factors into the account of weight setting, and propose a fuzzy analytic hierarchy approach (fuzzy AHP) to effectively evaluate candidates. According to the extension principle of fuzzy set theory, linguistic variables defined as fuzzy numbers are applied to pair-wise comparisons to avoid the vague situation, and this study proposes an approximate method for calculating the multiplication products of fuzzy number. This method can handle the vagueness and incompletion during the process of evaluation. A case study is also given to demonstrate the potential of the methodology.**

***Index Terms*—Innovation Alliance, National Mega Project, Partner Selection, Fuzzy AHP**

I. INTRODUCTION

With the development of hi-tech economies, a series of national mega projects has been launched by the Chinese government in recent years. For example, research and development (R&D) about aircraft engines has been listed as a national mega project in 2012. A hundred billion RMB is going to be invested in this project in order to conduct R&D over the next five years. National mega projects need huge investment, advanced technology, products innovation, and the acquisition of sufficient resources and fundamental research. The most important feature of these projects is innovation range from product to technique, and the success of them is also considered the symbol of innovation ability of China [1-2]. All kinds of organizations are eager to be involved in the R&D or manufacturing activities of these projects due to the high profits and bright perspectives. No organization, however, is able to fulfill the whole process of the project because of lack of resources and capabilities. Therefore, the importance of co-operation within different organizations has been emerging. Establishing a form of innovation alliance through different organizations, such as government sectors, enterprises, universities and academic institutions, may be an attainable way to acquire necessary resources and techniques for innovation. Agility and innovation are becoming increasingly important for creating value from products. Innovation alliance has currently become an important and indispensable form of co-operation between different organizations.

Although the concept about strategy alliance or virtual enterprise has been widely applied in the theoretical and practical field in the previous literature, some researchers [3-5] still found that incompatibility of partners is one of the most common reasons for failure, which means organizations in alliance cannot be satisfied with each other, or they were unable to achieve their assigned responsibility and finally resulted in collapse. Hence, selecting the appropriate partners must be carefully considered before such a partnerships system can be built.

It can be seen from previous literature that the research methods for partner selection have been studied from simple weighted scoring models to complex mathematical programming approaches [6]. Analytic hierarchy process (AHP) is one of the most common methods, introduced by Saaty [7], which is for solving unstructured problems. Although this method has been widely applied for evaluating the relative importance of a set of activities in a multi-criteria decision problem, it cannot handle the uncertainty and vagueness associated

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with mapping of one's decision to a number. Some researchers employed the fuzzy set theory to deal with the imprecision and vagueness, which from the subjective perception and the experience of humans in the decision-making process. These studies have extended the method of AHP to deal with the pair-wise comparison process using fuzzy utilities represented by fuzzy numbers. Chang [8] proposed an extent analysis approach for the synthetic extent values of the pair-wise comparison for handling fuzzy AHP. In the study of Bevilacqua, he proposed an approach of fuzzy quality function deployment to conduct supply partner selection. His approach addresses both internal and external variables to rank the potential partners, and transform the decision makers' verbal assessments to linguistic variables, which are more accurate than other non-fuzzy methods [9]. Yucel et al developed a weighted additive fuzzy programming approach for multi-criteria partner selection [10]. Fuzzy set theory allows the decision makers to incorporate unquantifiable information, incomplete information and non-obtainable information into decision model [11]. Their model has diminished the computational procedure, so it can deal with the rating of factors effectively.

However, the weighting process of criteria is affected by influence factor has not been considered in most prior research. In our case, the innovation alliance is a dynamic structure formation. Due to the particular merits, the partner in an innovation alliance might be a member in another alliance as well. It means that the biggest, richest or the most powerful organization may be not the most suitable partner for this alliance, so what type of organization they needed most for innovation has to be known before establishing alliance. Since the candidates needed for collaboration from different backgrounds, we address the characteristics of organization as influence factors for the weight setting of criteria because a general set of criteria cannot consider the priority of each organization. Additionally, the relative weights for each criterion with respect to each characteristic are calculated by the composite relative important weights.

The remainder of this paper is organized as follows. Section 2 describes the details of the proposed evaluation framework and the criteria. The process of weight setting and candidate evaluation is given in section 3. Section 4 illustrates an example with proposed method. In section 5, conclusions for this study are given.

II. Framework Of Evaluation

We structure the AHP model hierarchically based on the organization characteristics and criteria. The objective of partner selection is the first level of evaluation model, organization characteristics as influence factors in the second level, the criteria and sub-criteria are on the third and the forth level respectively.

A. Organization Characteristics

For achieving the mission of R&D, the launcher of alliance intends to build cooperative partnership with other organizations for relieving financial pressure, reducing R&D risk, shortening the research time, exchanging information, increasing the market share and so on [12-13]. Different patterns of innovation usually have different efforts and needs. When these partners are involved in R&D activities, launcher must decide whether and how to cooperate with other organizations. In practical situation, the organizations within national mega project usually are possibly constituted of governmental sector, enterprise, university and academic institution. All of them own their particular merits, which may play a special role during innovation process. Hence, the function of each partner in alliance also has to be known before establishing. Based on this, the types of organizations will be defined to strategy-based, capital-based, resource-based and learning-based in this study.

Strategy-based: To collaborate with the type of this organization like governmental organizations could obtain benefits of tax policy, the classified information or political privilege, which can accelerate the speed of innovation.

Capital-based: Capital investment has a positive impact on technological innovation, because more money invested in innovation activities can accelerate the speed of innovation. Alliance stands poised to benefit from the investments of cash-rich organization. These organizations can provide the financial support to develop the research quality of product, and also to share the cost of R&D.

Resource-based: Innovation is a complex process and requires many significant resources. The launcher of alliance could get these critical resources from other organizations. These resources include equipment, techniques, marketing channels, experts and other key resources for innovation.

Learning-based: The newest knowledge and technology is the key element for innovation. These organizations could also help launcher to solve the problem about human resources. Researchers in alliance can learn from the partners by conducting joint technology development.

B. Evaluation Criteria

As different organizations have different purposes and motivations for establishing innovation alliance, the identification of universal criteria weights for use in any situation will not be appropriate. The purpose of establishing innovation alliance in this paper is to make the breakthrough of new products or techniques, and finally to achieve the objective of the project. Innovation alliance needs to select partners that have common goals, burning desire, sophisticated skills, and complementary resources. Thus, every member should have the idea of sharing investment, management, risks and responsibility for profits and losses. Although meeting the requirement of innovation is the primary purpose of alliance, it can also bring huge profits and opportunities to the members in alliance. There is no doubt that it is a win-win situation.

The criteria for evaluating the performance of candidates have been discussed in the literature both theoretical and practical field. Geringer [14] was one the first man to conduct the study of partner selection criteria, he found even though there is no optional criteria for partner selection procedure, partners' culture, past experience, size, and structure were as important as the traditional criteria, such as financial assets, access to markets, and technical know-how. In the study of [15], it emphasized that complementary resources, symmetrical position and extension of social resources are necessary conditions for becoming a partner in an alliance.

Based on a detail literature survey, we employ the following four criteria for innovation partner selection mechanism, which are cooperative willingness, financial ability, complementary resources and technological ability. For each criterion, a cluster of sub-criteria for evaluating the suitability of candidate partners are also addressed.

The framework for partner selection is established as described in Figure.1.

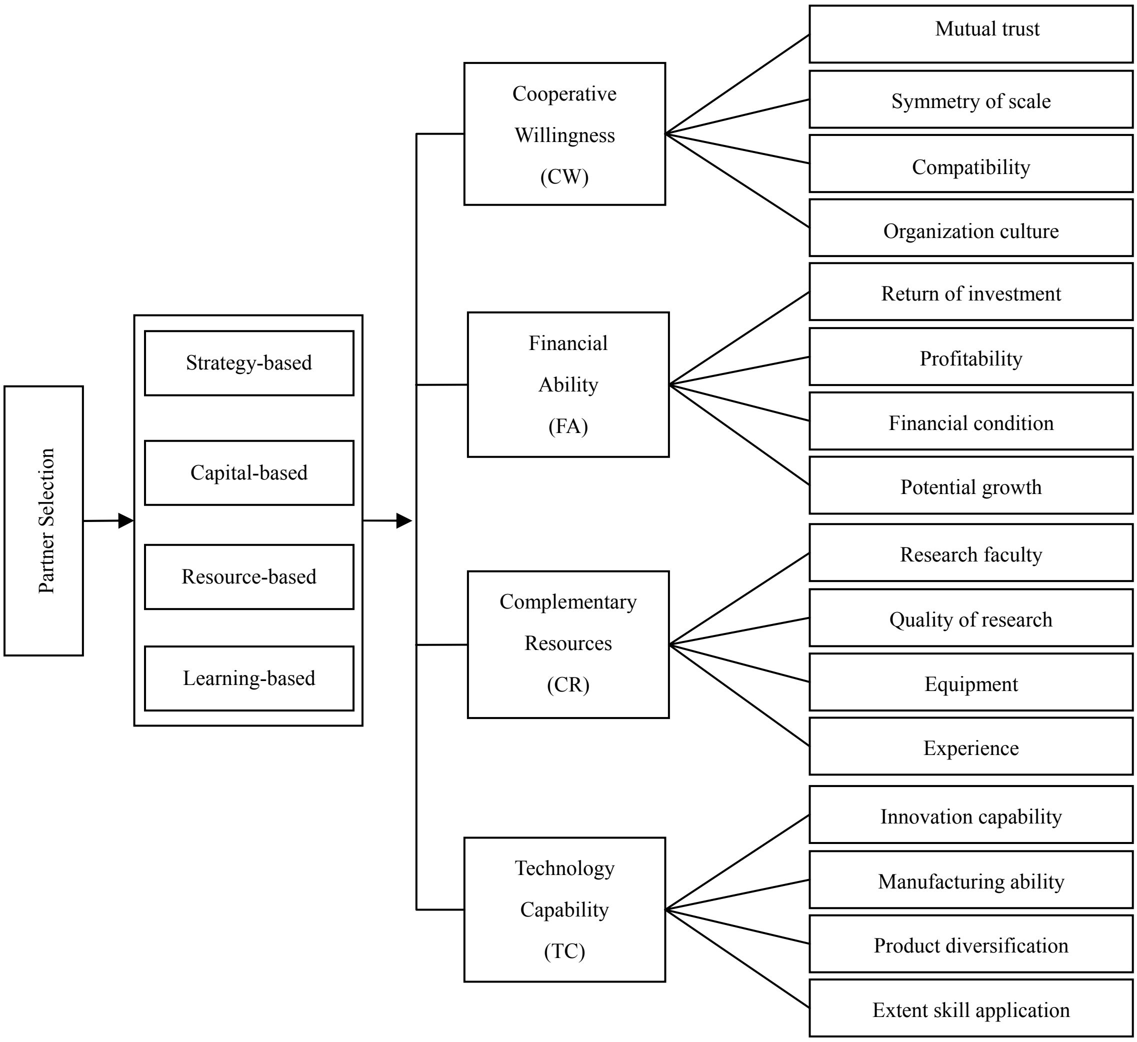

Figure 1. AHP model for partner selection

III. THE PROPOSED FUZZY AHP MODOL

This paper proposes fuzzy AHP to solve the problem of multiple criteria decision-making. The framework of evaluation in this study is designed by AHP, which must be settled before these methods are effectively employed to assess. However, weight setting and partners are selected by pair-wise comparison, which is composed of the linguistic variables defined as fuzzy numbers. The process of weight setting and evaluation is composed of the following steps:

Step 1: Determine the intensities of each characteristic by combining the scores from all decision makers.

Step 2: Identify the relative importance of the criteria with respect to characteristics and calculate the composite weights of relative importance of criteria.

Step 3: Calculate the composite weights of sub-criteria as last step.

Step 4: Use the pair-comparison matrices to evaluate the performance of candidate with each other according to the measurable sub-criteria. Linguistic variables are used in this step.

Step 5: Synthesize the suitability index of each candidate by summing up the results of multiplying the normalized weight score of each criterion with the normalized relative importance of this criterion.

During this process, we apply an approximate method of Yager's to deal with the multiplication of fuzzy number [16]. This method can rank the fuzzy number and also ensure to properly reflect the evaluations from decision maker. It diminishes the load of calculation compare to the conventional method.

A. Method for Weight Determination

Innovation alliance may have members with different kinds of characteristics according to the needs of innovation in term of the particularity and complexity of national mega project, each of whom might play a special role during the process of innovation. Thus, the launcher of alliance has to realize what type of partner is the most needed for conducting the collaboration innovation activities. And different intensities of organizational characteristics will affect the weight set for the criteria importance. For the convenience of illustration, we assume there are k experts who are involved in a partner selection issue. A unit scales is employed to express the degrees of intensity ranging from very unimportant, unimportant, moderate and important, to very important and denoted by consecutive decimal numbers from 0 to 1. For example, suppose the number x_{ip} is the evaluation from the i th expert for the degree of intensity of p th organizational characteristic. By combining the scores of all experts, the composite fuzzy weight of the p th organizational characteristic could be expressed by the following triangular fuzzy number[17]:

$$\widetilde{X}_p = (a_p, b_p, c_p) \tag{1}$$

In which

$$a_p = \min_i(x_{ip}),\ \ c_p = \max_i(x_{ip}),$$

$$b_p = \left(\frac{\Pi_{i=1}^{k} x_{ip}}{a_p \times c_p}\right)^{\frac{1}{k-2}},\ \ p = 1,\ldots,p$$

The following step is to determine the relative importance of the four criteria relating to each organizational characteristic. Adjusting the weight for importance of the criteria is emphasized as a particular organizational characteristic, which can also make sure that the most satisfied candidate for the particular organizational characteristic preference of alliance should be considered as a partner firstly. Similar as the previous step, suppose q represents the criteria and y_{ipq} means the evaluation from the i th expert for the q th criteria with regard to the p th organizational characteristic. Therefore, the composite relative importance is obtained as following:

$$\widetilde{Y}_{pq} = (d_{pq}, e_{pq}, f_{pq}) \tag{2}$$

In which

$$d_p = \min(y_{ipq}),\ e_p = \max(y_{ipq}),$$

$$f_p = \left(\frac{\Pi_{i=1}^{k} y_{ipq}}{d_{pq} \times f_{pq}}\right)^{\frac{1}{k-2}},\ \ p = 1,\ldots,p;\ q = 1,\ldots,Q$$

Accordingly, multiplying the Eq. (1) with Eq. (2) can obtain the composite fuzzy relative importance for the q th criterion as follow:

$$\widetilde{Z}_q = \sum_{p=1}^{p} \widetilde{X}_p \otimes \widetilde{Y}_{pq},\ q = 1,\ldots,Q \tag{3}$$

With reference to the extension principle of fuzzy sets and the definition of the triangular fuzzy number, $\widetilde{Z}_q$ is still a fuzzy number. For simplicity, the relationship function of fuzzy number can be expressed as a non-fuzzy number by using the approximation formula, as follow:

$$\widetilde{Z}_q = \sum_{p=1}^{p} \widetilde{X}_p \otimes \widetilde{Y}_{pq} \cong (c_{q1} = c_1, c_{q2} = c_{2,}\ c_{q3} = c_3) \tag{4}$$

For diminish the load of calculation, we applied the centroid ranking method, which was proposed by Yager, for rank the fuzzy number. After some mathematical rearrangement, the centroid rank value of the approximated triangular fuzzy number is:

$$R(\widetilde{Z}_q) = \frac{1}{4}(c_{q1} + 2c_{q2} + c_{q3}),\ q = 1,\ldots,Q \tag{5}$$

B. Fuzzy evaluation for candidate partners

Each criterion must assess each potential partner via a set of measurable sub-criteria. The relative importance of four sub-criteria related with its upper criterion must be determined before conducting the evaluation. Similarly, the composite relative importance for the s th sub-criterion with respect to its upper q th criterion for the expert members could be expressed as the following triangular fuzzy number:

$$\widetilde{L}_{qs} = (a_{qs}, b_{qs}, c_{qs}) \tag{6}$$

In which,

$$a_{qs} = \min(l_{iqs}),\ c_{ps} = \max(l_{iqs}),\ b_{ps} = \left(\frac{\Pi_{i=1}^{k} l_{iqs}}{a_{qs} \times c_{qs}}\right)^{\frac{1}{k-2}}$$

$$q = 1,\ldots,Q;\ s = 1,\ldots,S$$

According to the definition of each sub-criterion, each expert conducts a series of pair-wise comparisons to evaluate the performance of these candidates in the next step. A seven-point linguistic scale is employed to express their relative performance. The relationship functions of the linguistic values are shown in Figure 2, and defined as follows:

Extremely poor (EP): (0, 0, 0.1)
Very poor (VP): (0.05, 0.2, 0.35)
Poor (P): (0.2, 0.35, 0.5)
Mediate (M): (0.35, 0.5, 0.65)
Good (G): (0.5, 0.65, 0.8)
Very good (VG): (0.65, 0.8, 0.95)
Extremely good (EG): (0.9, 1, 1)

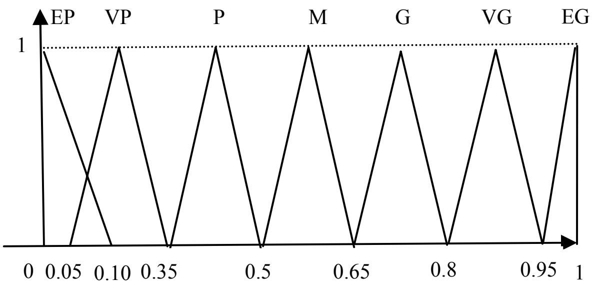

Figure 2. Linguistic variables for criteria rating

The results about the linguistic variable of pair-wise comparison are described as a matrix form. The decision makers just gives their own opinion in the right part of the matrix according to each criterion. The left part then is obtained automatically as the "reciprocal" of the right part of the matrix. For the convenience of calculation let $\widetilde{A}=[\widetilde{m}]_{T\times T}$ be the comparison matrix. The arithmetic average of each row can be calculated as the performance evaluation of the t th candidate partner on the s th sub-criterion of its upper-level criterion, which evaluated by the i th expert. This average can be denoted by the triangular fuzzy number

$$\widetilde{P}_{iqst}=\frac{1}{T}\sum_{v=1}^{T}\widetilde{m}_{tv}=(m_{at},\ m_{bt},\ m_{ct}),\ \ t=1,...,T$$

Similarly, the composite performance evaluation of one candidate for a sub-criterion from experts could be expressed as:

$$\widetilde{M}_{qst}=\frac{1}{K}\sum_{i=1}^{k}\widetilde{P}_{iqst}=(d_{pq},e_{pq},f_{pq}) \quad (7)$$
$$t=1,...,T$$

Then, the composite weighted performance evaluation of the t th candidate on the q th criterion can be calculated:

$$\widetilde{N}_{qt}=\frac{1}{K}\sum_{s=1}^{qs}\widetilde{L}_{qs}\otimes\widetilde{M}_{qst} \quad (8)$$
$$q=1,...,Q;\ t=1,...,T$$

The centroid ranking method can be used again, as foll

$$R(\widetilde{N}_{qt})=\frac{1}{4}(c_{qt1}+2c_{qt2}+c_{qt3}) \quad (9)$$
$$q=1,...,Q;\ t=1,...,T$$

Finally, the suitability index is employed to compare the performance of these candidates and indicates which one is the most suitable partner, each of which could be synthesized the product of multiplying the composite performance on each criterion with its relevant composite important weight as following equation:

$$S_t=\sum_{q=1}^{Q}R(\widetilde{Z}_q)\otimes R(\widetilde{N}_{qt}) \quad t=1,...,T \quad (10)$$

IV. Illustrative Example

The proposed model for the innovation alliance partner selection is used in one project, which provides the theoretical support for the decision maker. This project is one of the important parts about electric vehicle. The car industry currently is an important part of Chinese economic system. Many organizations are throwing themselves into the innovation activities of new energy vehicles. Like some developed counties, Lots of Chinese institutions and organizations are also eager to be involved in car energy programs as the bright market prospects. Along with the rapid development of Chinese car industry, low-cost, high-quality, and customer-oriented new products are needed to satisfy the requirement of customers agilely. The organization for innovation can effectively employ the product development and innovation capacity of the members within alliance. Therefore, the case company set up an expert group for select appropriate partner for innovation, which consists of different fields, such as technique, product, financial, innovation and strategy. We suppose there are five experts in the group, who held meeting to discuss the issue of partner selection following the steps detailed in the previous sections, and trying to gain a consensus by giving their own opinion about each criterion.

As seen in the data of Table 1, the left part depicts the weight distribution of each characteristic from five experts' opinion respectively. The fuzzy intensity index for four characteristics was calculated by Eq. (1) in the right three columns. The fuzzy index illustrates that the most important characteristic of organization is resource-based, followed by learning-based, which means that the objective of launcher for establishing alliance is mainly looking for a partner with complementary resources for innovation.

TABLE I.
The Intensity Index For Each Characteristic

	E.1	***E.2***	***E.3***	***E.4***	***E.5***	***Fuzzy intensity***		
						a_p	b_p	c_p
Strategy-based	0.350	0.205	0.122	0.200	0.215	0.122	0.207	0.350
Capital-based	0.180	0.340	0.136	0.160	0.225	0.136	0.186	0.340
Resourced-based	0.300	0.230	0.422	0.310	0.335	0.230	0.315	0.422
Learning-based	0.170	0.225	0.320	0.330	0.225	0.170	0.253	0.330

Same as the last step, after collecting and normalized the data from experts, the relative importance of four criteria relating to each characteristic are obtained by Eq. (2). We summarize the fuzzy weight for these criteria with different organizational characteristics in Table 2. Following this step, the composite importance weights of criteria are available by Eq. (3) with data in Table 1 and Table 2. It can be seen in Table 3 that defuzzified weight of each criterion is established by the mathematical rearrangement by means of Eq. (5). Apparently, complementary resources and technology capability are emphasized, which might be affected by the fuzzy intensity of characteristic. Additionally, the normalized weight in Table 3 is employed in the final step of evaluation.

In the next phase, the sub-criteria of each criterion are used to evaluate the performance of the candidate partners. The relative weights of importance of the sub-criteria about the upper criterion from which they develop must be determined before they can be applied to the evaluation process. Eq. (7) is employed to set up the fuzzy weights of these sub-criteria with respect to their upper-level criterion. Table 4 describes the composite

TABLE II.
THE APPROXIMATED FUZZY RELATIVE IMPORTANCE WEIGHT OF THE CRITERIA FOR CHARACTERISTICS

	Strategy-based			***Capital-based***			***Resourced-based***			***Learning-based***		
	a_p	b_p	c_p	a_p	b_p	c_p	a_p	b_p	c_p	a_p	b_p	c_p
Cooperative Willingness	0.190	0.239	0.320	0.220	0.303	0.330	0.220	0.237	0.260	0.150	0.192	0.260
Financial Ability	0.240	0.293	0.360	0.125	0.168	0.220	0.160	0.196	0.215	0.150	0.165	0.200
Complementary Resource	0.100	0.189	0.310	0.240	0.260	0.330	0.250	0.280	0.340	0.280	0.344	0.450
Technology Capability	0.220	0.243	0.350	0.240	0.272	0.280	0.230	0.288	0.320	0.250	0.270	0.340

TABLE III.
THE COMPOSITE FUZZY WEIGHTS OF THE RELATIVE IMPORTANCE OF CRITERIA

	Composite fuzzy weight			***Defuzzified weight***	***Normalized weight***
	C_{q1}	C_{q2}	C_{q3}		
Cooperative Willingness	0.129	0.229	0.420	0.252	0.240
Financial Ability	0.109	0.195	0.358	0.214	0.204
Complementary Resources	0.150	0.263	0.513	0.297	0.284
Technology Capability	0.155	0.260	0.465	0.285	0.272

TABLE IV.
COMPOSITE FUZZY WEIGHTS OF EACH SUB-CRITERION

	Cooperative Willingness				***Financial Ability***				***Complementary Resource***				***Technology Capability***		
	a_p	b_p	c_p		a_p	b_p	c_p		a_p	b_p	c_p		a_p	b_p	c_p
CW1	0.160	0.250	0.400	***FA1***	0.185	0.258	0.310	***CR1***	0.180	0.233	0.325	***TC1***	0.150	0.219	0.320
CW2	0.175	0.263	0.360	***FA2***	0.170	0.300	0.360	***CR2***	0.210	0.256	0.300	***TC2***	0.210	0.282	0.330
CW3	0.170	0.193	0.340	***FA3***	0.185	0.235	0.340	***CR3***	0.140	0.239	0.320	***TC3***	0.165	0.248	0.375
CW4	0.150	0.253	0.350	***FA4***	0.150	0.196	0.320	***CR4***	0.185	0.259	0.360	***TC4***	0.160	0.207	0.400

TABLE V.
PAIR-WISE COMPARISON OF A SUB-CRITERION

	C1	***C2***	***C3***	***C4***	***Fuzzy Performance***		
					m_{at}	m_{bt}	m_{ct}
Candidate 1	I	VP	P	VG	0.475	0.588	0.700
Candidate 2	VG	I	G	EG	0.763	0.863	0.938
Candidate 3	G	P	I	VG	0.588	0.700	0.813
Candidate 4	VP	EP	VP	I	0.275	0.350	0.450

TABLE VI.
COMPOSITE PERFORMANCE EVALUATION FIE THE CANDIDATE PARTNERS

	Candidate 1			Candidate 2			Candidate 3			Candidate 4		
	d_{qs1}	e_{qs1}	f_{qs1}	d_{qs1}	e_{qs1}	f_{qs1}	d_{qs1}	e_{qs1}	f_{qs1}	d_{qs1}	e_{qs1}	f_{qs1}
CW1	0.605	0.713	0.810	0.483	0.608	0.708	0.623	0.733	0.838	0.350	0.448	0.555
CW2	0.568	0.675	0.773	0.495	0.600	0.710	0.628	0.735	0.833	0.403	0.500	0.608
CW3	0.558	0.658	0.753	0.513	0.625	0.738	0.615	0.725	0.830	0.395	0.493	0.600
CW4	0.565	0.672	0.790	0.465	0.575	0.680	0.668	0.778	0.883	0.385	0.460	0.555
FA1	0.683	0.793	0.898	0.615	0.725	0.830	0.423	0.535	0.648	0.328	0.425	0.533
FA2	0.680	0.788	0.885	0.483	0.595	0.708	0.468	0.580	0.693	0.443	0.548	0.658
FA3	0.653	0.763	0.868	0.513	0.625	0.738	0.493	0.595	0.698	0.413	0.518	0.628
FA4	0.713	0.815	0.898	0.543	0.655	0.768	0.513	0.625	0.738	0.323	0.405	0.508
CR1	0.333	0.423	0.528	0.758	0.860	0.943	0.528	0.655	0.768	0.460	0.573	0.685
CR2	0.305	0.380	0.480	0.750	0.853	0.935	0.600	0.710	0.815	0.445	0.558	0.670
CR3	0.343	0.440	0.548	0.695	0.803	0.900	0.573	0.685	0.798	0.438	0.550	0.663
CR4	0.300	0.383	0.485	0.693	0.798	0.888	0.623	0.733	0.838	0.475	0.588	0.700
TC1	0.470	0.573	0.675	0.645	0.755	0.860	0.388	0.485	0.593	0.578	0.688	0.793
TC2	0.505	0.580	0.693	0.650	0.758	0.855	0.340	0.430	0.535	0.588	0.700	0.813
TC3	0.460	0.573	0.685	0.733	0.840	0.938	0.325	0.415	0.520	0.550	0.663	0.775
TC4	0.468	0.563	0.663	0.660	0.770	0.875	0.368	0.535	0.648	0.518	0.623	0.733

TABLE VII.
COMPOSITE WEIGHTED PERFORMANCE EVALUATION FOR THE CANDIDATE PARTNERS

Candidate / *Criterion*	*C.1*			*C.2*			*C.3*			*C.4*		
	C_{q11}	C_{q12}	C_{q13}	C_{q21}	C_{q22}	C_{q23}	C_{q31}	C_{q32}	C_{q33}	C_{q41}	C_{q42}	C_{q43}
CW	0.376	0.653	1.135	0.321	0.576	1.028	0.414	0.713	1.226	0.251	0.455	0.839
FA	0.470	0.780	1.179	0.372	0.641	1.009	0.326	0.574	0.924	0.261	0.475	0.778
CR	0.228	0.400	0.666	0.519	0.817	1.195	0.417	0.688	1.051	0.325	0.560	0.888
TC	0.327	0.548	0.967	0.460	0.747	1.256	0.242	0.441	0.821	0.384	0.641	1.106

TABLE VIII
NORMALIZED SCORE AND SUITABILITY INDEXATION OF ERCH CANDIDATE

Candidate / *Criterion*	*C.1*	*C.2*	*C.3*	*C.4*
CW(0.240)	0.278	0.213	0.298	0.220
FA(0.204)	0.317	0.228	0.234	0.219
CR(0.284)	0.168	0.285	0.277	0.256
TC(0.272)	0.237	0.274	0.190	0.305
Suitability	**0.244**	**0.253**	**0.249**	**0.253**

fuzzy weights for these sub-criteria from the experts group.According to the 16 sub-criteria, the composite fuzzy performance of the candidate partners was calculated by Eq. (8) in Table 6. In Table 7, the defuzzified score of each candidate about each criterion is obtained by Eq. (10).

After the calculation of the composite fuzzy weights for these sub-criteria, we use the method of pair-wise comparison as above mentioned to evaluate the performance for comparing each candidate with others. Table 5 shows the result according to one sub-criterion.

The normalized score for each candidate of each criterion is also calculated and given. The suitability indexation of each candidate is calculated by summing up the product of normalized score of each criterion with the weight of importance of this criterion, which is shown in the last row of Table 8. We can see that candidate 2 and candidate 4 have the same suitability score, which is higher than the other 2 candidates and prove both of them are qualified partners. Furthermore, we can also select the most satisfied partner between these two candidates, which has the most needed organizational characteristic stronger than the other one if the launcher only needs one partner.

To select an appropriate partner for conducting the activities of innovation is not a simply work in some complicated projects due to the vary needs and purposes. But the launcher of alliance has to have a clear and definite goal of what organizational characteristic is the key one for further collaborative innovation. The suitable index could be considered as an important reference for partner selection, but to conduct a comprehensive and comparative analysis of the candidates is much more necessary.

V. CONCLUSIONS

An effective and efficient partner selection approach is one of the most fundamental steps before building partnerships system. What characteristic of partner is the most needed for innovation has to be identified before partner selection, in spite of the innovation alliance is constituted of members with different backgrounds, each of whom may play a special role during the collaborative innovation process. In this study, we proposed a fuzzy AHP method to solve the problem of partner selection, which has considered the priority of organizational characteristics as the factors of the weighting process of criteria and integrate the merits of each candidate into the evaluation criteria. Linguistic variables then are applied to pair-wise comparisons for weighting criteria and evaluating the performance of candidates. This approach is able to avoid the vagueness and effectively solve multi-criteria decision making issues. Finally, the suitability index for each candidate is acquired by an approximate method, which diminish the load of calculation compared to other fuzzy AHP methods. Although the model is developed and tested for serving in one particular innovation alliance, it can also be used with slight modification in any alliance.

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