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R&D Project Evaluation Index System and Evaluation Model

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Abstract: ***This paper presents the index system for selecting and evaluating the R&D projects. The important factors of R&D should integrate the some relevant resources to select and implicate the feasible projects, which not concerns the innovation and benefits, but does the industrial structures and the sustainable development. R&D process is the complex and multi-objective decision-making, the external indices such as resources analysis, legal evaluation, risk analysis and social environment evaluation for R&D, meanwhile, and the internal these ones as the evaluation of the economic efficiencies, technologies, market and project management for R&D are described in the index system. The theory of the multi-objective fuzzy optimization can be used to develop the model that is shown to be reasonable and effective based on the case study.***

Keywords: R&D project; the evaluation index; Fuzzy optimization; Analytic hierarchy process

1. Problem-Posing

The implementation of R&D project is to improve technological innovation ability of the scientific research institution and the enterprise, thus realizing high-tech's development and industrialization, promoting long-term and sustainable technological development. As the social development system is a comprehensive development system, in which nature, economy and society are closely combined, the implementation of R&D project should consider not only the science and technology innovation level of the project and the promoting effect on economic development, but also the project's effect on the regional economic structure, social development and resource utilization and conservation. We can think that R&D project's evaluation and selection is a complicated multi-factor comprehensive decision-making process.

Foreign research about R&D project assessment began in the 1950s. The main R&D project theory and method to evaluate R&D project have project evaluation technique (Sounder & Mandakovic, 1986), strategic performance evaluation method (Atkinson, 1998) and real option evaluation method (Lint & Pennings, 1998; Newton &Pearson, 1994). Kavadias (2003) studied the new product development project portfolio choice and resource allocation problem, putting forward dynamic selection strategy in the uncertain market environment, Jichang Dong (2004) studied commercial project portfolio strategy based on the markup language technology, and put forward a integrated project portfolio selection model. Lawson (2006) revised a mixed project portfolio selection model which can be used for SMEs (small and medium-sized enterprises) project. Juite Wang etc. (2007) put forward the R&D project portfolio choice's fuzzy 0-1 integer programming model, which can cope with the uncertainty of project portfolio and can handle variable parameter's project portfolio optimization decision problem. Ou Lixiong, Wu Weiren and Fu Yuqi (2008) according to the enterprise R&D project portfolio choice's reality, established R&D project portfolio evaluation index system, including strategy fitness, core competence fitness, the R&D implementation earnings expectations, the R&D costs and benefits and standard deviation of costs, balance of the project portfolio, and gave enterprise R&D project portfolio's assessment and selection method based on the DEA and BSC. The research in our country in recent years has the new development, Guo Peng, Hui Junfe and Du Tao (2008) put forward introducing ecology theory and methods to solve the R&D project portfolio decision problems, and built the R&D project portfolio decision research framework based on ecology theory and method. Kaihua Chen, Mingting Kou & Xiaolan Fu (2017) study evaluation of multi-period regional R&D efficiency. Margaret Kurtha et. Demonstrates a portfolio decision analysis (PDA) approach to support R&D resource allocation decisions for the DOE Office of Fossil Energy's Carbon Capture and Storage R&D program. These studies are about R&D project selection and evaluation from a perspective.

In R&D project building process, how to scientifically and reasonably select R&D project is a key in scientific technology project management. Aiming at the characteristics of R&D project, by establishing R&D projects' comprehensive evaluation index system, using multi-objective decision-making and fuzzy optimization theory, this paper puts forward the theoretical basis of the R&D project evaluation and selection.

2. R&D Project Evaluation Indexes System

The key of R&D projects' comprehensive evaluation and selection lies in establishing a reasonable and effective project evaluation index system. When designing evaluation indexes of R&D project, the high-tech and strong market competitive R&D project, which would affect the regional economic development, improve the industrial structure and promote the social sustainable development, should be considered with priority. The evaluation index system consists of 8 primary indexes, among which economic efficiency evaluation, product technical evaluation, market analysis evaluation and project management evaluation are its own internal factors of R&D project evaluation, as shown in Figure 1.

General objective the first-layer objective the second-layer objective the third-layer objective

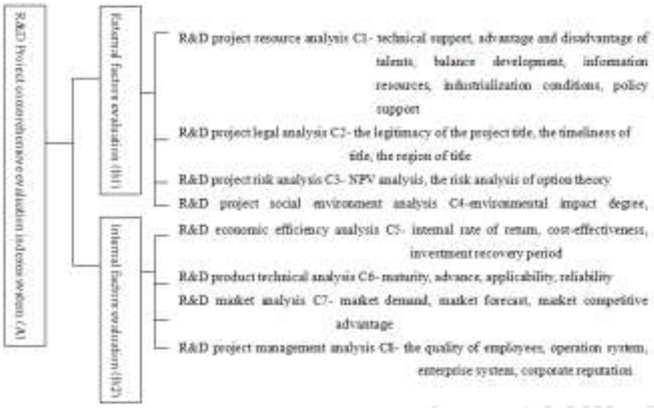

Figure 1: R&D project evaluation indexes system

(1) R&D project resources analysis: R&D activities itself is the process of innovation and resources integration, offering the technical support conditions to the regional economic development. Therefore, the resources advantage of R&D project should be analyzed, making full use of the resources structure complementarity which benefits R&D activities. The evaluation index includes the advantage and disadvantage evaluation of R&D talents, balance development, domestic and foreign technical support conditions, information resources, industrialization conditions and relevant policy support.

(2) R&D project risk analysis: R&D project contains uncertainty and risk factors; therefore, risk analysis is also an important part of R&D project evaluation. The way of estimating the magnitude of general project risk is to calculate NPV and analyze probability distribution of project feasibility through some factors, as project investment in fixed assets, product life cycle, sales income, etc. It is hard to extract from historical date, therefore, the risk analysis method based on options may be used to analyze the R&D project risk, the method considered the investment as bought the market valve of an underlying assets at present price and the value added as put option of executive price, using option pricing method to analyze the project risk and calculate the project probability.

(3) R&D project legal analysis: this part is mainly aimed at the protection and management of the intellectual property of R&D project, it is necessary to analyze the attribute, the timeliness, the region, the legitimacy of scientific project achievements, and to analyze the key technology of project whether it has obtained the patent or whether it has applied for patent protection, and some legal problems, such as the protection of legal time, the effective time, the protection of legal region etc, should be clearly identified.

(4) R&D project social environment analysis: in this analysis part, the important contents are the economic benefit, the environment protection and the realization of social fair. Therefore, it needs to introduce resource consumption value index to revise the traditional cost-benefit analysis, and take the directly or indirectly resource consumption aroused by project as the social costs to calculate social NPV, that could assess and analyze R&D project from the social view.

(5) R&D economic efficiency analysis: from economic view, the main indexes of analyzing R&D project cost required and benefit obtained are financial NPV, investment recovery period, cost-effectiveness, etc. Anyhow, the evaluation standard of economic efficiency should be a R&D project, which is lower investment, higher profit, shorter investment recovery period, higher internal rate of return.

(6) R&D product technical analysis: R&D project should reflect advance, applicability, reliability and maturity. The Key technology should lead the country, main technical parameters and properties of product can have widely application value.

(7) R&D market analysis: this part including some important indexes, like market demand, market forecast, market competitive advantage and entry barrier level, etc. The feasibility of R&D project means the potential market demand is big, and the market share as well as the profits is stable.

(8) R&D projects management analysis: after implementing the project, indexes including the quality of employees, operation system, enterprise system and corporate reputation, should be analyzed.

3. The Model of the Multi-Objective Decision-Making and Fuzzy Optimization

R & D project evaluation is a decision-making process that selects the optimal project based on a variety of evaluation index. Assume that in the system the decision set $D=\{d_1,d_2,\cdots,d_n\}$ is composed of n decision schemes, and the index set $V=\{v_1,v_2,\cdots,v_m\}$ is composed of m evaluating indicators (target) to evaluate the decision-making D (this text m=29). Fuzzy optimization method is aimed at identifying membership for the evaluation of each selected project to the fuzzy concept of "superiority" (relative membership degree for short). Rank the social assessment of a number of decision project in an order of preference according to relative membership degree (Chen Souyi, 1998).

3.1 The concept of relative membership degree index

Definition 1: Index characteristic matrix expresses the evaluation that (m) indicators to (n) decisions, as below:

$$X=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}=\left(x_{ij}\right)_{m\times n} \quad i=1,2,\cdots,m; \; j=1,2,\cdots,n$$

Where, x_{ij} expresses the ith evaluation indexes eigenvalues of the jth decision program.

Generally, eigenvalue indexes can be quantitative or qualitative (Wang Peizhuang. 1981; Li Yuanfu; Xue Bo; Deng Yucai, 2001;Chen Shouyi, 1994)

Definition 2: In order to eliminate the dimension differences between the evaluation target, bigger efficiency indicators are more optimal, the relative membership degree is:

$$r_{ij}=\frac{x_{ij}-\min x_{ij}}{\max x_{ij}-\min x_{ij}} \qquad (1)$$

For cost-type indicator, the smaller, the more optimal. The relative membership degree is expressed as follows:

$$r_{ij}=\frac{\max x_{ij}-x_{ij}}{\max x_{ij}-\min x_{ij}} \qquad (2)$$

Where, r_{ij} expresses the relative membership degree for the jth decision program to the ith evaluation indexes eigenvalues, $\max x_{ij}$ and $\min x_{ij}$ expresses maximum and minimum eigenvalue for the jth decision program to the ith evaluation indexes eigenvalues in decision set respectively.

According to equation (1) and (2), matrix of the indicators eigenvalue converts into indices relative membership degree matrix:

$$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}=\left(r_{ij}\right)_{m\times n}$$

$(i=1,2,\cdots,m; \quad j=1,2,\cdots,n)$

$r_{ij}\in[0,1]$, r_{ij} increasingly closes to 1, the target is getting close to the ideal value.

Definition 3: According to the relativity of decision evaluation, the system's superior vector represents the maximum relative membership degree of decision, and the system's inferior vector the minimum relative membership degree of decision. The expressions are:

$$G=\left(\max_{j=1}^{n} r_{1j},\max_{j=1}^{n} r_{2j},\ldots,\max_{j=1}^{n} r_{mj}\right)^{r}=(g_1,g_2,\ldots,g_m)^{r} \quad (3)$$

$$H=\left(\min_{j=1}^{n} r_{1j},\min_{j=1}^{n} r_{2j},\ldots,\min_{j=1}^{n} r_{mj}\right)^{r}=(h_1,h_2,\ldots,h_m)^{r} \quad (4)$$

The difference between the jth decision program and superior vector can be represented by superior degree (the distance from the superior):

$$d(R,G)=\left[\sum_{i=1}^{m}\left(w_i\left|g_i-r_{ij}\right|\right)^p\right]^{\frac{1}{p}} \qquad (5)$$

Similarly, the difference between the jth decision program and inferior vector can be represented by inferior degree (the distance from the inferior):

$$d(R,H)=\left[\sum_{i=1}^{m}\left(w_i\left|r_{ji}-h_i\right|\right)^p\right]^{\frac{1}{p}} \qquad (6)$$

Where, w_i is the weight of the ith evaluation indexes, $\sum_{i=1}^{m} w_i \approx 1$, p is generalized distance parameter, $p=1$ is hamming distance, $p=2$ is euclidean distance, $W=(w_1,w_2,\cdots,w_m)^T$ is (m) weight vectors.

In practice, membership in the fuzzy set theory can also be defined as the weight. Suppose u_j is the membership that the jth decision program is subordinate to superior vector G, and $(1-u_j)$ is the membership that the jth decision program is subordinate to inferior vector H. In order to prefectly express the difference between the j[th] decision program and superior vector, the superior degree $d(R,G)$ chooses u_j as its weight and the inferior degree $d(R,H)$ chooses $(1-u_j)$ as its weight. So they can form weighted superior degree $D(R,G)$ and weighted inferior degree $D(R,H)$:

$$D(R,G) = u_j d(R,G) \quad (7)$$

$$D(R,H) = (1-u_j) d(R,H) \quad (8)$$

3.2 Define optimal solution of relative membership degree vector

Vectors, which are made of u_j and $(1-u_j)$ in all options, are the vectors of superior degree and inferior degree for decision projects. For solving the optimal value of u_j, we establish the following objective function (Chen Shouyi, 1994) :

$$\min\{F(u_j)\} = \min\{[D(R,G)]^2 + [D(R,H)]^2 = u_j^2\left[\sum_{i=1}^{m} w_i(g_i - r_{ij})\right]^2 + (1-u_j)^2\left[\sum_{i=1}^{m} w_i(r_{ij} - h_i)\right]^2\}$$

and make $\frac{dF(u_j)}{du_j} = 0$

Get the relative membership degree of the j[th] decision program:

$$u_j = \frac{1}{1 + \left[\frac{\sum_{i=1}^{m}\left(w_i\left|g_i - r_{ij}\right|\right)^p}{\sum_{i=1}^{m}\left(w_i\left|r_{ij} - h_i\right|\right)^p}\right]^{\frac{2}{p}}} \quad (9)$$

equation (9) is the fuzzy optimization model, and we can get the membership degree for each decision program being subjected to superior degree. So the relative membership degree vector $U = \{u_1, u_2, \cdots, u_n\}$, which is made of (n) decision programs.

In the decision set-D satisfied constraint, the largest decision of relative membership degree u_j is satisfying with the decision. u_j being ranged in size is the satisfied sequence.

4. The determination of index weight through AHP

The correctness of choosing project is affected not only by indexes but also by relative importance influence of each index. Here, the weight of each index is given by the Analytical Hierarchy Process (AHP).

4.1 The process of calculating weights by AHP

The first step is to establish a cascade tree structure model: this model is based on the figure 1 of R&D project evaluation indexes system

The second step is to construct judgment matrix: using paired comparison method to grade the related pair wise elements, several pair comparison judgment matrixes can be gotten according to indexes in the intermediate layer,

$$\bar{A}_{ij} = [a_{ij}] \qquad (i = 1, \cdots, m, \qquad j = 1, \cdots, m)$$

Among them, a_{ij} is determined by Scaling method [as shown in Table1], $a_{ij} \cdot a_{ji} = 1$, $a_{ij} = \frac{1}{a_{ji}}$

Table 1: The quantitative scale is determined by comparing two factors

Scale	Meaning
1	That means two factors compared with equal importance : $a_{ij} = 1$
3	That means two factors compared, one factor is slightly important than the other: $a_{ij} = 3$, $a_{ji} = 1/3$
5	That means two factors compared, one factor is obviously important than the other: $a_{ij} = 5$, $a_{ji} = 1/5$
7	That means two factors compared, one factor is mightily important than the other: $a_{ij} = 7$, $a_{ji} = 1/7$
9	That means two factors compared, one factor is extremely important than the other: $a_{ij} = 9$, $a_{ji} = 1/9$
2，4，6，8	The value of the above two adjacent judgments

Reciprocal	The scale of factor i to j is a_{ij}, than scale of j to i is $a_{ji}=\frac{1}{a_{ij}}$

The third step is to calculate the weight of indexes:

Regularizing each column of Matrixes will obtain $\overline{a_{ij}}=\frac{a_{ij}}{\sum_{i=1}^{m}a_{ij}}$.

and to calculate the weight of the i index according to $w_i=\frac{\overline{A_i}}{\sum_{i=1}^{m}\overline{A_i}}$, $\overline{A_i}=\sum_{i=1}^{m}\overline{a_{ij}}$ is the scale value of adding the normalized matrix row by row.

The fourth step is consistency checks:

In the whole process of evaluation, due to the fact that the evaluator has a certain unilateralism of recognizing an object and the understanding differences of evaluation criteria, it is commonly impossible for the judgment matrix to maintain consistency completely. Therefore, it is necessary to do consistency check for calculating results. When the judgment matrixes pass the consistency check, the sorting result is the weight of each factor.

Consistency check is:

$$CI=\frac{\lambda_{\max}-m}{m-1}$$

Among it, $\lambda_{\max}=\sum_{i=1}^{m}\frac{(Aw)_i}{nw_i}$ is the maximal eigenvalue of the judgment matrix.

When the judgment matrix is completely consistency, $\lambda_{\max}=m,\quad CI=0$

If $CI\neq 0$, than introducing the random consistency value $CR=\frac{CI}{RI}$ to check, among it, RI is the mean random consistency index, which value is as shown in Table 2.

Table 2: The mean random consistency index

Stage	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

When $CR<0.01$, generally believe that the consistency of judgment matrix is acceptable, otherwise it needs to re-adjust the factors value of judgment matrix (Xu Shubo, 1998; Xu Ruoning & Zhai Xiaoyan, 1988).

4.2 Construct judgment matrix and calculate the weight of each index:

According to the requirement of AHP, all the indexes should be arranged in a table and be delivered to the predetermined experts. Then analyzing and comparing the judgments and opinions given by the experts, the weight of each index would be gotten after several repeated. The calculated results are as shown in Table 3-13.ww T3. The judgment matrix of the first objective aspect T4. The judgment matrix of external factor evaluation

A	B_1	B_2	Weight
B_1	1	1/2	0.333
B_2	2	1	0.667

B_1	C_1	C_2	C_3	C_4	Weight
C_1	1	3	5	1	0.378
C_2	1/3	1	3	1/3	0.177
C_3	1/5	1/3	1	1/5	0.067
C_4	1	3	5	1	0.378

T5. The judgment matrix of internal factor evaluation T6. The judgment matrix of R& resources

B_2	C_5	C_6	C_7	C_8	Weight
C_5	1	1/3	5	3	0.296
C_6	3	1	7	5	0.507
C_7	1/5	1/7	1	1/3	0.053
C_8	1/3	1/5	3	1	0.144

C_1	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	Weight
C_{11}	1	1	2	4	3	4	0.293
C_{12}	1	1	2	4	3	4	0.293
C_{13}	1/2	1/2	1	3	2	3	0.177
C_{14}	1/4	1/4	1/3	1	1/2	1	0.064
C_{15}	1/3	1/3	1/2	2	1	2	0.108
C_{16}	1/4	1/4	1/3	1	1/2	1	0.064

T7. The judgment matrix of R&D project legal factors T8. The judgment matrix of R&D project risk factors

C_2	C_{21}	C_{22}	C_{23}	Weight
C_{21}	1	2	3	0.539
C_{22}	1/2	1	2	0.297
C_{23}	1/3	1/2	1	0.164

C_3	C_{31}	C_{32}	Weight
C_{31}	1	1/2	0.333
C_{32}	2	1	0.667

T9.The judgment matrix of R&D social environment factors T10. The judgment matrix of R&D economic efficiency

C_4	C_{41}	C_{42}	C_{43}	C_{44}	Weight
C_{41}	1	4	4/3	3/4	0.364
C_{42}	1/4	1	1/3	1/3	0.092
C_{43}	3/4	1	1	1	0.272
C_{44}	3/4	3	1	1/5	0.272

C_5	C_{51}	C_{52}	C_{53}	Weight
C_{51}	1	1/3	3	0.258
C_{52}	3	1	2/3	0.637
C_{53}	1/3	2/3	1	0.105

T11. The judgment matrix of R&D product technology evaluation T12. The judgment matrix of R&D market factors

C_6	C_{61}	C_{62}	C_{63}	C_{64}	Weight
C_{61}	1	1/3	5	3	0.296
C_{62}	3	1	7	5	0.507
C_{63}	1/5	1/7	1	1/3	0.053
C_{64}	1/3	1/5	3	1	0.144

C_7	C_{71}	C_{72}	C_{73}	Weight
C_{71}	1	2	3	0.539
C_{72}	1/2	1	2	0.297
C_{73}	1/3	1/2	1	0.164

T13. The judgment matrix of R&D project management

C_8	C_{81}	C_{82}	C_{83}	C_{84}	Weight
C_{81}	1	4	4/3	3/4	0.364
C_{82}	1/4	1	1/3	1/3	0.092
C_{83}	3/4	1	1	1	0.272
C_{84}	3/4	3	1	1/5	0.272

5. Empirical Analysis

Select five provinces' R&D project implementation to give a comprehensive evaluation and select 2 items to give key support. Here, make empirical analysis through inviting six experts with different professional background (among them, 2 economic management experts, 2 technical experts, 1 social experts, 1 legal experts) to evaluate and score a project in the light of the evaluation index system.

Scoring rule adopts the scoring method of 10 cents, the most satisfied with 10 points, and the rest respectively given fraud-probability scores compared to 10 points. In order to make the score was evaluated with objectivity as much as possible; here give the six experts with different weights. Suppose that economic management experts' weight is 0.15, technical experts' weight is 0.25, social experts' and legal experts' weight is each 0.1. According to the experts' scoring and the weight, calculate for each index of eigenvalue. Eigenvalue matrix of each index can be drawn by ordinal analogy. See the table 14 as shown.

Table 14: Multi-objective R&D project assessment system's factor eigenvalues

Target		Index	Weight	Optional project				
				project 1	project 2	project 3	project 4	project 5
R&D Project's Comprehensive evaluation	Resources superiority analysis	Technology support	0.0369	7.45	7.25	8.80	7.90	7.10
		Talent advantages	0.0369	8.35	7.10	8.10	6.85	7.35
		Balance development	0.0223	8.10	7.90	8.20	6.85	8.10
		Information resources	0.0081	7.90	6.50	7.45	7.25	7.00
		Industrialization conditions	0.0136	8.35	7.65	8.10	7.90	8.20
		Policy support	0.0081	8.00	8.35	7.90	8.80	7.90
	Legal analysis	Property right legality	0.0124	8.90	8.65	9.00	7.65	7.90
		Timeliness	0.0068	8.55	7.90	8.80	7.35	7.90
		Region	0.0038	7.35	8.20	8.35	6.85	7.90
	Risk analysis	Net present value	0.0196	7.65	8.35	7.65	8.10	6.90
		Option risk analysis	0.0394	7.90	8.10	7.35	8.00	6.35
	Social environment	Environmental impact *	0.0459	3.00	2.10	3.10	2.25	3.35
		Employment effect	0.0116	7.90	8.00	8.00	7.85	7.65
		Income level	0.0343	8.10	7.65	8.10	7.90	6.90
		Resource consumption value *	0.0343	2.85	2.35	3.00	2.35	3.10
	Economic benefit	Internal revenue	0.0872	7.35	8.10	7.65	8.00	7.10
		Benefit cost ratio	0.2153	8.25	7.90	8.35	8.25	7.65
		Investment payoff period	0.0355	8.00	7.10	7.35	8.10	8.00
	Product technology	Maturity	0.0583	8.50	7.90	8.10	7.10	8.75
		Advancement	0.0999	7.90	7.85	8.25	8.10	8.35
		Applicability	0.0104	7.50	7.65	7.90	8.35	6.90
		Reliability	0.0284	8.35	7.65	8.35	7.35	7.10
	Market analysis	Market demand	0.0189	8.10	8.50	8.25	8.00	8.25
		Market competitive advantage	0.0104	8.35	7.65	8.10	8.35	8.10
		Barriers to entry level *	0.0057	2.35	3.50	2.00	2.85	3.35
	Project management	Personnel quality	0.0350	8.65	6.90	8.50	7.90	8.35
		Operation mechanism	0.0088	7.50	7.35	8.10	8.00	8.35
		Enterprise system	0.0261	8.35	7.65	8.25	7.90	8.50
		Enterprise prestige	0.0261	8.90	8.65	9.00	6.90	7.85

Note: * for cost type index and others are efficiency index.

According to the type (1) and the type (2), after normalization of the index's eigenvalue, we can obtain relative membership degree of each index [see table 15 shown].

Table 15: Multi-objective R&D project assessment system's relative membership degree

Target		Index	Weight	Optional project				
				project 1	project 2	project 3	project 4	project 5
R&D Project's Comprehensive evaluation	Resources superiority analysis	Technology support	0.0369	0.206	0.088	1.000	0.471	0.000
		Talent advantages	0.0369	1.000	0.167	0.833	0.000	0.333
		Balance development	0.0223	0.926	0.777	1.000	0.000	0.926
		Information resources	0.0081	1.000	0.000	0.678	0.536	0.357
		Industrialization conditions	0.0136	1.000	0.000	0.643	0.357	0.786
		Policy support	0.0081	0.111	0.500	0.000	1.000	0.786
	Legal analysis	Property right legality	0.0679	0.926	0.740	1.000	0.000	0.185
		Timeliness	0.0372	0.827	0.379	1.000	0.000	0.379
		Region	0.0207	0.303	1.000	0.909	0.151	0.000
	Risk analysis	Net present value	0.0073	0.517	1.000	0.517	0.828	0.000
		Option risk analysis	0.0147	0.886	1.000	0.571	0.943	0.000
	Social environment	Environmental impact *	0.0215	0.280	1.000	0.200	0.880	0.000
		Employment effect	0.0054	0.714	1.000	1.000	0.571	0.000
		Income level	0.0160	1.000	0.625	1.000	0.000	0.375
		Resource consumption value *	0.0160	0.333	1.000	0.133	1.000	0.000
	Economic benefit	Internal revenue	0.0872	0.250	1.000	0.550	0.900	0.000
		Benefit cost ratio	0.2153	0.857	0.357	1.000	0.857	0.000
		Investment payoff period	0.0355	0.900	0.000	0.250	1.000	0.900
	Product technology	Maturity	0.0059	0.848	0.485	0.606	0.000	1.000
		Advancement	0.1003	0.100	0.000	0.500	0.800	1.000
		Applicability	0.0105	0.000	0.517	0.689	1.000	0.827
		Reliability	0.0285	0.000	0.440	1.000	0.200	0.640
	Market analysis	Market demand	0.0189	0.200	1.000	0.500	0.000	0.500
		Market competitive advantage	0.0104	0.000	1.000	0.778	0.444	0.444
		Barriers to entry level *	0.0057	0.767	0.000	1.000	0.433	0.100
	Project management	Personnel quality	0.0349	1.000	0.000	0.914	0.571	0.828
		Operation mechanism	0.0088	0.150	0.000	0.750	0.650	1.000
		Enterprise system	0.0261	0.823	0.000	0.706	0.294	1.000
		Enterprise prestige	0.0261	0.952	0.833	1.000	0.000	0.452

Take the above indexes' membership degree as the input value, using the type (9) to determine various optional projects' optimal degrees for each main factors .See the table 16.

Table 16: matrix of the main factors

main factors	weight	Optional project's relatively optimal degree				
		project 1	project 2	project 3	project 4	project 5
Resources superiority analysis	0.126	0.840	0.164	0.915	0.126	0.255
Legal analysis	0.126	0.937	0.817	0.999	0.001	0.072
Risk analysis	0.022	0.676	1.000	0.605	0.989	0.000
Social environment	0.059	0.560	0.987	0.446	0.767	0.013
Economic benefit	0.338	0.851	0.494	0.954	0.983	0.011
Product technology	0.198	0.698	0.005	0.912	0.202	0.996
Market analysis	0.035	0.085	0.963	0.787	0.061	0.340
Project management	0.096	0.974	0.001	0.976	0.221	0.932

Take the main factors' optimal degree as the input value, according to the main factors' weight, calculate the optimal sort of international technology cooperation project, see table 17 shown.

Table 17: The optimal degree of the scheme

Optional scheme of Cooperation projects	project 1	project 2	project 3	project 4	project 5
The optimal degree	0.937	0.317	0.989	0.457	0.216

According to table 17's structure, we can judge each item's advantages and disadvantages in each factor. Calculation results show that five optional projects' optimal sort is: {project 1, project 3, project 4, project 2, project 5}, namely project 3 and project 1 are optimal alternative projects.

6. Conclusion

Effective R & D activities depend on selecting the appropriate R & D projects. R & D project evaluation is different from general projects evaluation. It should not only consider the project's technical, economic benefits, but also the integration of resources, industrial structure adjustment and evaluation of impact on the environment. Fuzzy optimization is the model for optimization of complex multi-factor decision, and the method has been successfully applied to many comparison and selection for evaluating some projects. It is a useful attempt to use fuzzy optimization in R & D project evaluation and decision.

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