

The Construction And Study Of The Evaluation Index System For Scientific And Technological Achievements Of Applied Technology

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Abstract. In this paper, the application technology achievement evaluation index system framework is built up based on the analysis of the connotation and characteristics of the scientific and technological achievements of applied technology. By using fuzzy comprehensive evaluation method, the construction of the evaluation index system is carried out, as well as the detailed analysis of the contents and criteria for each index. Experimental results show that the proposed method could be effective in the evaluation for scientific and technological achievements of applied Technology.

1. Introduction

With the continuous progress of science and technology, it has become an important criterion to measure the independent innovation capability as well as the overall level of technology development for a country or region that whether scientific and technological achievements are converted into practical productivity. The premise and foundation of scientific and technology achievements transformation is the evaluation. Therefore, building up a scientific, reasonable and operable evaluation index system for scientific and technological achievements is of great theoretical and practical significance. The achievements of applied technology occupy a large proportion of scientific and technological achievements in China, and the transformation and application of those could directly affect the economy and society development of our country. In this paper, the basic framework of evaluation index system is constructed based on the construction principles of evaluation index system for application technology. And then the fuzzy comprehensive evaluation method is used to complete the evaluation system.

2. The connotation and characteristics of the scientific and technological achievements of applied technology

According to “Tentative Measures for the evaluation of scientific and technological achievements”, scientific and technological achievements refer to new discoveries, new theories, new methods and new technology, new products, new varieties and new technology etc., completed by the organization or individual in the projects, with academic value or application value as well as scientific, creative and advanced properties [1]. The scientific and technological achievements could be classified into three categories, which are basic research achievements, applied technology achievements and software science research achievements.

Applied technology achievements mainly refer to those of practical value which are produced by scientific research, technological development, follow-up experiments and application promotion to improve productivity and promote social welfare undertakings. This kind of achievement occupies a considerable proportion in the scientific and technological achievements of our country, the transformation and application of which have a direct impact on the economic and social benefits.

3. Design rules and construction of evaluation index system

3.1 Design rules for evaluation index

The construction of the index system needs to conform to the characteristics of the applied technology achievements. Therefore, the following principles should be followed.

1) Scientificity

The scientific principle is the foundation of establishing the evaluation index system of the applied technology achievement. The evaluation index system should objectively and truly reflect the value and level of scientific and technological achievements.

2) Systematicness

The evaluation index system should be able to totally and completely reflect all aspects of scientific and technological achievements, which not only reflect the comprehensive level of scientific and technological achievements, but also reflect the other different aspects [2].

3) Purposiveness

This principle is to establish the starting point of the evaluation index system for the applied technology achievements. Research on applied technology achievements is a scientific and technological activity that transforms the basic research results into practical application, which has a strong purpose, and could measure the true quality and value.

4) Feasibility

The data and related information of the indicators included in the evaluation index system must be simple and plane, and the calculation of relevant data is evidence-based. The availability of index information as well as the flexibility of execution and the reliability must be taken into consideration when designing the evaluation index system.

3.2 Construction of evaluation index system

The frame of the evaluation index system is shown in Figure 1. First of all, the evaluation should be clear according to the characteristics of applied technology achievement [3]. And then the qualitative indicators should be collected and preliminary screened through qualitative method. After that the indicators should be further screened to refine and complete the whole evaluation index system.

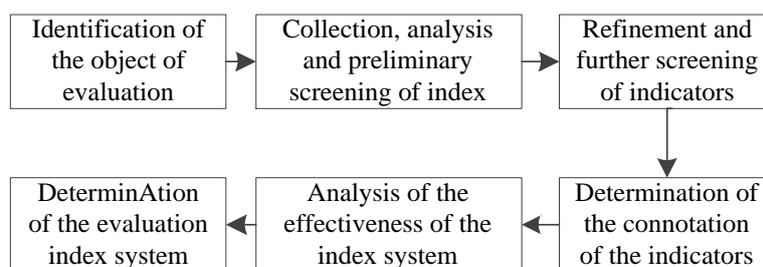


Fig. 1. The frame of the evaluation index system

Combining with applied technology achievement appraisal work of the research institute, and considering the all kinds of factors influencing transformation, a 5 first level indexes with 14 second level indexes evaluation system is proposed, using qualitative and quantitative evaluation method [4].

The index system makes a specific analysis and clear explanation from five aspects: input level, technical level, application, benefits and impacts, and risk. Every index and its meaning are shown in Table 1. At the same time, the method of fuzzy mathematics is adopted to set the weight of each index. The weights can be adjusted according to the characteristics of the technical results and the focus of the evaluation.

Table 1. The index and its meaning

First level	Weight	Second Level	Weight	Meaning	
The evaluation for scientific and technological achievements of applied technology <i>E</i>	Input Level <i>e</i> ₁	Funds <i>e</i> ₁₁	0.4	The cost of a scientific research project from beginning to completion	
		Manpower <i>e</i> ₁₂	0.3	The number of researchers joining the scientific research project	
		Materials <i>e</i> ₁₃	0.1	Resources used for the research and development of the scientific research project, including factory, laboratory, scientific instrument, equipment, etc.	
		Time <i>e</i> ₁₄	0.1	The sum of all the effective time invested in the research project	
	Technological Level <i>e</i> ₂	0.3	Innovativeness <i>e</i> ₂₁	0.5	Some breakthroughs in new technology, new research methods, design ideas and technological characteristics, and the innovation complexity and difficulty degree of the technical achievements
			Advancement <i>e</i> ₂₂	0.3	The international and domestic level achieved compared with the most advanced indicators, and Strategy and foresight of technology
			Stability and reproducibility <i>e</i> ₂₃	0.2	The reliability, the updating frequency, the degree of renewal and the life cycle of the technology
	Application <i>e</i> ₃	0.15	Applicability <i>e</i> ₃₁	0.5	The degree of adaptation in social, scientific, economic and other aspects
			Market <i>e</i> ₃₂	0.5	Market demand, occupancy rate, annual sales and sales trends
	Benefits and impacts <i>e</i> ₄	0.25	Economic Benefit <i>e</i> ₄₁	0.4	The actual or expected cost effectiveness and cost- benefit ratio after using the achievements
			Social Benefit <i>e</i> ₄₂	0.3	The effect of promoting the coordination of science and technology, economy and society and sustainable development
			Promoting the research field <i>e</i> ₄₃	0.3	The impetus of the proposed theory, method and point of view on the development of the research field
	Risk <i>e</i> ₅	0.1	Technology Risk <i>e</i> ₅₁	0.5	Uncertain factors caused by technical maturity, intellectual property rights and technical secrets
			Market Risk <i>e</i> ₅₂	0.5	The factors such as Whether scientific and technological achievements are difficult to enter the market or not, and so on.

4. Fuzzy comprehensive evaluation method

The fuzzy comprehensive evaluation method is based on the theory of fuzzy set theory, which carries out a comprehensive evaluation of the achievement [5].

In this paper, the proposed calculation method of fuzzy comprehensive evaluation method for scientific and technological achievements in applied technology is as follows:

- 1) Define the evaluation index set *E*:

$$E = \{e_1, e_2, \dots, e_n\} \tag{1}$$

- 2) Determine the rating set *L*:

$$L = \{l_1, l_2, \dots, l_m\} \tag{2}$$

- 3) Establish the fuzzy mapping matrix *R*:

R is the mapping matrix of the evaluation index E and the fuzzy mapping matrix R . The element R_{ij} represents the probability of the j grade for the evaluated result for the i index.

The fuzzy mapping matrix can be expressed as:

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \vdots & \vdots & & \vdots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} \quad (3)$$

4) Determine the weight of the evaluation index:

$\{W(e_i)\}$ ($i = 1, 2, \dots, n$), which represent the weight of the evaluation index e_i in E . The degree of membership of e_i to W is expressed by $W(e_i)$. Generally, set $W(e_i)$ as (4):

$$\sum_{i=1}^n W(e_i) = 1 \quad (4)$$

5) Fuzzy mapping:

The comprehensive evaluation model of fuzzy mapping is $M = W \times R$. Then the comprehensive evaluation could be given according to M .

5. Experimental Results

The above fuzzy evaluation method is used to evaluate the achievements of a certain achievement. 20 experts in the related field are employed to form an assessment group to evaluate the achievement. The detailed process is as follows:

1) Define the evaluation index set E :

$E = \{e_1, e_2, e_3, e_4, e_5\}$, $e_1 = \{e_{11}, e_{12}, e_{13}, e_{14}\}$, $e_2 = \{e_{21}, e_{22}, e_{23}\}$, $e_3 = \{e_{31}, e_{32}\}$, $e_4 = \{e_{41}, e_{42}, e_{43}\}$, $e_5 = \{e_{51}, e_{52}\}$, which is shown in Table 1.

2) Determine the rating set L :

$L = \{\text{excellent, good, mediocre, poor}\}$.

3) Establish the fuzzy mapping matrix R :

According to the statistical analysis and processing of the comments given by 20 experts for each e_{ij} evaluation index, a fuzzy evaluation matrix is constructed.

For example, for e_{11} in the second level evaluation index of funds, there are 4 expert comments as “excellent”, 8 experts comments as “good”, 6 experts comment as “mediocre”, 2 experts comments as “poor”, and then a fuzzy set is (0.2 0.4 0.3 0.1) for the index on L . Therefore, input level e_1 , technological level e_2 , application e_3 , benefits and impacts e_4 , and risk e_5 are as (5)~(9):

$$R_1 = \begin{bmatrix} 0.2 & 0.4 & 0.3 & 0.1 \\ 0.2 & 0.5 & 0.3 & 0 \\ 0.1 & 0.6 & 0 & 0.3 \\ 0.5 & 0.3 & 0.2 & 0 \end{bmatrix} \quad (5)$$

$$R_2 = \begin{bmatrix} 0.3 & 0.1 & 0.2 & 0.4 \\ 0.1 & 0 & 0.5 & 0.4 \\ 0.3 & 0.2 & 0.4 & 0.1 \end{bmatrix} \quad (6)$$

$$R_3 = \begin{bmatrix} 0.5 & 0.3 & 0.2 & 0 \\ 0.3 & 0.2 & 0.5 & 0 \end{bmatrix} \quad (7)$$

$$R_4 = \begin{bmatrix} 0.6 & 0.4 & 0 & 0 \\ 0.5 & 0.5 & 0 & 0 \end{bmatrix} \quad (8)$$

$$R_5 = \begin{bmatrix} 0.4 & 0.5 & 0.1 & 0 \\ 0.3 & 0.4 & 0.2 & 0.1 \\ 0.6 & 0.4 & 0 & 0 \end{bmatrix} \quad (9)$$

4) The weight matrix for each index:

The weight matrix of first index is $W = [0.2 \ 0.3 \ 0.15 \ 0.25 \ 0.1]$.

The weight matrixes for second index are $W_1 = [0.4 \ 0.3 \ 0.1 \ 0.1]$, $W_2 = [0.5 \ 0.3 \ 0.2]$, $W_3 = [0.5 \ 0.5]$, $W_4 = [0.4 \ 0.3 \ 0.3]$, $W_5 = [0.5 \ 0.5]$.

5) Fuzzy evaluation for second level index:

The fuzzy evaluation for second level index can be expressed by (10)~(14)

$$M_1 = W_1 \times R_1 = [0.20 \ 0.40 \ 0.23 \ 0.07] \quad (10)$$

$$M_2 = W_2 \times R_2 = [0.24 \ 0.09 \ 0.33 \ 0.34] \quad (11)$$

$$M_3 = W_3 \times R_3 = [0.40 \ 0.16 \ 0.35 \ 0] \quad (12)$$

$$M_4 = W_4 \times R_4 = [0.51 \ 0.46 \ 0.03 \ 0] \quad (13)$$

$$M_5 = W_5 \times R_5 = [0.45 \ 0.40 \ 0.10 \ 0.05] \quad (14)$$

6) Final fuzzy evaluation:

From the calculations above, the fuzzy evaluation matrix of this achievement is $R = [M_1 \ M_2 \ M_3 \ M_4 \ M_5]^T$. With the weight matrix of first index $W = [0.2 \ 0.3 \ 0.15 \ 0.25 \ 0.1]$, the final evaluation matrix can be figured out:

$$M = W \times R = [0.2 \ 0.3 \ 0.15 \ 0.25 \ 0.1] \times \begin{bmatrix} 0.20 & 0.40 & 0.23 & 0.07 \\ 0.24 & 0.09 & 0.33 & 0.34 \\ 0.40 & 0.16 & 0.35 & 0 \\ 0.51 & 0.46 & 0.03 & 0 \\ 0.45 & 0.40 & 0.10 & 0.05 \end{bmatrix} \quad (16)$$

$$[0.3445 \ 0.346 \ 0.215 \ 0.121]$$

After the above calculation, the maximum value of the final matrix M is taken, and the final evaluation level of this achievement is “good”.

According to the corresponding index in Table 1, for further analysis, the assessment of the investment level is “good”, which means that it is of good cost control. Technology level assessment is “poor”, which means that it needs further enhancement. Benefits and effects assessment is “excellent”, which means that it is of good economic and social benefits. Risk assessment is “good”.

In the above fuzzy evaluation method of scientific and technological achievements, the levels granularity can be divided more finely, and the weight of all levels of indicators could be adjusted according to different concerns.

6. Summary

In this paper, a fuzzy mathematics comprehensive evaluation method is proposed to construct the evaluation index system for applied technology achievements, from a theoretical point of view. It could play a guiding role, and meet the demands of evaluation for applied technological achievements.

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