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Research on Evaluation Index System Model of "Third-party" Evaluation Qualification of Science and Technology Assessment

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Abstract

Science and technology assessment system with "Third-party" as the main subject has an important role in science and technology assessment activities. At the present stage of China, science and technology associations are suitable "Third-party" institutions for science and technology assessment. The qualifications of science and technology associations as "Third-party" to carry out science and technology assessment work need to be examined scientifically and objectively. The paper constructs an evaluation index system and model for the qualification of "third-party" assessment of science and technology associations, in order to achieve a comprehensive evaluation of the qualification of "Third-party" assessment of science and technology associations in terms of empirical evidence.

Keywords

"Third-party" Evaluation, Science and Technology Evaluation Qualification, Qualification Evaluation Model.

1. Introduction

The construction of science and technology assessment system is an important manifestation of the modernization of national governance capacity. The development of science and technology level is largely dependent on science and technology management, and a good management of science and technology requires a good assessment system. At this stage, the construction of science and technology assessment system should not only involve the traditional assessment contents, but also take the diversity of assessment categories, the diversity of assessment subjects and the practicality of assessment methods into consideration in the era of "big science". Expanding from the intrinsic value of assessment to social public value and including the development of science and technology assessment results on social economy into the scope of assessment, it requires the participation of "Third-party" in science and technology assessment. At the same time, strengthening the integration with the market in order to enhance the role of evaluation in the transformation of scientific research results.

2. Principles for the selection of evaluation indexes for assessing qualifications

(1) Principle of comprehensiveness and systematicity

The selection of indicators should focus on comprehensiveness, which means that indicators must reflect the factors and indicators of the development of science and technology associations, covering the existing conditions, competitiveness, credibility and future development potential of science and technology associations in conducting science and technology assessment.

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(2) Adhere to the principle of science and technology associations to participate in science and technology assessment as a "third party"

The evaluation qualification of science and technology associations as "Third-party" should be explored.

(3) The principle of representatives

The most important thing in the construction of the indicator system is to select the indicators that can reflect the relevant issues.

(4) Principle of comparability

The construction of the "third party" evaluation qualification index system must be adapted to the categories, disciplines and industries to which different science and technology associations belong.

(5) Principle of independence

There should be no strong correlation between the indicators in the index system, and there should not be too much information inclusion, coverage and overlap of the connotation of the indicators.

(6) Principle of operability

In the design of the indicator system, certain indicators should be selected according to the difficulty of data collection. The indicators that cannot be obtained through efforts should be used sparingly or replaced by similar indicators.

3. Construction of evaluation index system

Based on the relevant information, a large number of indicators are selected for the "third-party" evaluation of science and technology associations. Then based on the expert research method, the experts who are professional in the field were asked for their opinions on the designed evaluation indicators by sending a letter to them. The indicators with strong relevance and duplication were eliminated.

(1) Level 1 Indicator -- "basic conditions"

The basic conditions are the basis for the scientific and technological evaluation, involving the confirmation of the assets, personnel and related construction of the association.

(2) Level 1 Indicator -- "internal management and capacity building"

Internal management and capacity building is an important part of the assessment and self-management of science and technology associations. It includes the internal management and system construction, membership management, leadership level and development plan of the association.

(3) Level 1 Indicator -- "operational activities and experience knowledge accumulation"

Business activities are not only the focus of the work of science and technology associations, but also a reflection of their assessment ability. The level 2 indicators summarize the main business activities and experiences of science and technology associations.

(4) Level 1 Indicator -- "social evaluation and impact"

The examination of social evaluation of science and technology associations is part of external supervision.

The hierarchical structure and detailed description of the indicator system are shown in Table 1.

Table 1: Detailed description of indicators

Level 1 Indicators	Level 2 Indicators	Content

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Basic Conditions A_1	Financial Assets B_1	Fixed assets, current assets, availability of necessary funds for activities, specifically check the amount of net assets at the end of the year on the balance sheet and the amount of funds at the time of registration, etc.
	Practitioners B_2	Number of full-time staff, number of part-time staff (signed contracts, purchase of guarantees, etc.)
	Office Space and Equipment B_3	Office space, office building ownership, number and value of office equipment
	Construction of Assessment Expert Pool B_4	Number of experts in assessment expert pool, number of experts with senior titles or above, the number of people with intermediate titles or above, and the time spent working in the field
Internal Management and Capacity Building A_2	Organizational Structure and System B_5	Reasonable degree of organizational set-up, renewal and general meeting, executive director, council meeting, whether there is a perfect management system
	Membership Management B_6	Number of members of the association, payment of membership fees by association members, etc.
	Leadership Team B_7	Leadership team education and titles, and other descriptions
	Development Planning B_8	Development and implementation of association development plan, work plan in three years
Business Activities and Experience Knowledge Accumulation A_3	Academic Science Activities B_9	Scientific and technical societies to organize domestic and international academic conferences, science lectures, education and training during the last three years
	Business Service Activities B_{10}	Participation in their own business-related activities (title evaluation, results assessment, talent evaluation, results evaluation and awards), etc.
	Participation in Science and Technology Activities B_{11}	Participation in science and technology activities (including government science and technology planning, project evaluation, enterprise planning, etc.), transformation of scientific and technological achievements
	Industry Impact B_{12}	Participation in industry planning and standard setting within three years, suggestions on industry development are adopted, etc.
Social Evaluation and Impact A_4	Government Media and Other Recognition B_{13}	Recognition and awards by government media
	Social Impact Events B_{14}	Social activities carried out during the three years, the influence of the association in the international community
	Public Recognition B_{15}	Participation of the public, volunteers, etc. in the activities of scientific and technical associations, recognition of associations by society
	Social Credibility B_{16}	Whether there is any violation of law or other misconduct in cooperation with enterprises or other organizations because of financial benefits

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4. Determination of indicator weights

4.1. Indicator weighting method

The indicator weights reflect the importance of indicators to a certain extent. The general objective weighting method is to determine the weights by using the characteristics of sample data. In this paper, we use the hierarchical analysis method to determine the weights. Hierarchical analysis was proposed by T.L. Saaty, a famous American operations researcher, in the 1970s. The basic steps are as follows.

(1) Construction of judgment matrix.

Judgments are often quantified in the hierarchical analysis method based on certain ratio scales. The paper adopts the 1~9 scale method, as shown in Table 2.

Table 2: Judgment matrix scale and its meaning

Serial Number	Importance Level	A_{ij} Assignment
1	i,j are equally important	1
2	i is slightly more important than j	3
3	i is obviously more important than j	5
4	i is significantly more important than j	7
5	i is extremely more important than j	9
6	i is slightly less important than j	1/3
7	i is obviously less important than j	1/5
8	i is significantly less important than j	1/7
9	i is extremely less important than j	1/9

Notes: a_{ij}={2,4,6,8,1/2,1/4,1/6,1/8} indicates importance level between a_{ij}={1,3,5,7,9,1/3,1/5,1/7,1/9}, which is determined by experts through experience and judgment.

For a given criterion Ak, the judgment matrix of each indicator Bk at its next level is as follows.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

(2) Consistency test of the judgment matrix

Calculate the maximum eigenvalue of the judgment matrix.

$$\lambda_{max} = \sum_{i=1}^{n} (AW)_i / nw_i \tag{2}$$

Among it:

$$w_i = \frac{\overline{w_i}}{\sum_{i=1}^{n} w_i} \tag{3}$$

$$\overline{w_i} = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \tag{4}$$

Calculate the judgment matrix deviation consistency index

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$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{5}$$

Check whether to meet the requirements of consistency indicators

$$CR = \frac{CI}{RI} \tag{6}$$

When CR < 0.1, the judgment matrix satisfies the consistency. Otherwise the judgment matrix has to be adjusted to satisfy the consistency. The values of RI are taken as shown in Table 3.

Table 3: List of RI values

Order n	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

(3) The weights of each indicator are calculated according to equation (3).

4.2. Process of determining indicators weights

Experts from "third-party" assessment of science and technology associations were selected for comparative scoring. The calculation was done with the help of Yaahp software. The final index weights A calculated are shown in Table 4.

Table 4: Indicators weighting table

	Level 1 Indicators	Level 2 Indicators	Single Hierarchical Ranking	General Hierarchical Ranking
Qualification index system for "third party" assessment of science and technology associations	Basic Conditions A_1 0.4286	Financial Assets B_1	0.1624	0.0696
		Practitioners B_2	0.1580	0.0677
		Office Space and Equipment B_3	0.2329	0.0998
		Construction of Assessment Expert Pool B_4	0.4468	0.1915
	Internal Management and Capacity Building A_2 0.2007	Organizational Structure and System B_5	0.3587	0.0720
		Membership Management B_6	0.2506	0.0503
		Leadership Team B_7	0.2671	0.0536
		Development Planning B_8	0.1096	0.0220
	Business Activities and Experience Knowledge Accumulation A_3 0.1979	Academic Science Activities B_9	0.3876	0.0767
		Business Service Activities B_{10}	0.2436	0.0482
		Participation in Science and Technology Activities B_{11}	0.2471	0.0489
		Industry Impact B_{12}	0.1364	0.0270
	Social Evaluation and Impact A_4 0.1728	Government Media and Other Recognition B_{13}	0.0978	0.0169
		Social Impact Events B_{14}	0.0938	0.0162
		Public Recognition B_{15}	0.2674	0.0462
		Social Credibility B_{16}	0.5411	0.0935

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5. Establishment of "third-party" evaluation qualification model

The selection of the evaluation method for the "third party" evaluation qualification of science and technology associations requires consideration of the fuzzy nature of the evaluation qualification itself. The fuzzy nature is that there are no clear boundaries for objective things. The fuzzy comprehensive evaluation method is suitable for evaluating the qualification of "third party" of science and technology associations.

Steps of fuzzy comprehensive evaluation method:

1. Determine evaluation factors, evaluation levels and evaluation score sets

Let U={u_1,u_2,……,u_m}be the mth factor that portrays the evaluated object, and m is determined by the index system. V={v_1,v_2,……v_n} is the nth decision that portrays the state of each factor, which is also called the evaluation level. In order to better represent the evaluation results in the subsequent calculation, the elements in V are taken as standard scores to form the evaluation score set F.

2. Construct the evaluation matrix R

Firstly, the single factor u_i in the factor set is judged. Then determine the affiliation r_{ij} of v_j from the factor u_i. Finally, the single factor judgment set of the ith factor u_i is derived as follows.

$$r_i = (r_{i1}, r_{i2}, \cdots, r_{in}) \tag{7}$$

The general evaluation matrix R consists of the evaluation set of m factors. Each evaluated object identifies a fuzzy relationship R from U to V.

$$R = (r_{ij})_{m*n} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{8}$$

Where r_{ij} indicates the affiliation degree of v_j from factor u_i.

3. Performing fuzzy synthesis and making decisions

The weights of the indicators have been determined as A. The fuzzy synthesis evaluation vector for each level is calculated using the simple linear weighting method as C.

$$\mathrm{C} = \mathrm{A} * \mathrm{R} = (\mathrm{a}_1, \mathrm{a}_2, \cdots, \mathrm{a}_\mathrm{m}) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} = (\mathrm{c}_1, \mathrm{c}_2, \cdots, \mathrm{c}_\mathrm{n}) \tag{9}$$

4. Calculate the comprehensive evaluation value S

Finally, we calculate the comprehensive evaluation value S. Based on the magnitude of the comprehensive evaluation value S, we can judge the status of the "third party" evaluation qualification of science and technology associations.

$$\mathrm{S} = \mathrm{C} * \mathrm{F} \tag{10}$$

6. Conclusion

This paper constructs a relatively complete set of "third-party" evaluation qualification index system for science and technology associations. Determines the weights of each index using hierarchical analysis and constructs an evaluation model using fuzzy comprehensive evaluation method. In the research, ten science and technology associations were measured according to the principle of maximum affiliation. The results showed that most of them have good qualifications, but the overall strength is not strong, and there is a certain gap between the associations. By investigating the situation of science and technology assessment conducted by science and technology associations in a region, we learned that although science and

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technology associations have conducted few assessments, the situation of participation in science and technology assessment has improved with government support and more attention in recent years. Through the analysis of typical cases, it is clear that "Third-party" can carry out science and technology assessment independently and objectively.

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