Research on Post Evaluation Index System of Applied Science and Technology Projects Based on AHP

Wensheng Yang[1, a], Wanxin Gao[2, b, *]

[1]School of economics and management, Dalian University, China
[2]School of economics and management, Dalian University, China
[a]e-mail: yangwsh@126.com
[b, *]e-mail: 1337959089@qq.com

Abstract
With the country's vigorous implementation of the innovation-driven strategy, the role of science and technology projects in promoting my country's technological innovation and progress has gradually become significant. To this end, this article will build a post-evaluation index system for applied science and technology projects from five aspects: project acceptance, academic value, technical value, economic and social benefits, and continuous impact based on the characteristics of science and technology projects. Combining expert opinions to construct a comparison and judgment matrix to achieve the quantification of indicators. On this basis, the analytic hierarchy process is used to determine the weights of indicators at all levels and give a scoring method. It provides theoretical basis and decision-making reference for the scientific research management department to connect the new project initiation and project management.

***Keywords**-Science and technology project; Post evaluation; Index system; Analytic hierarchy process*

1. INTRODUCTION

The 18th CPC National Congress proposed that scientific and technological innovation is the strategic support for improving social productivity and comprehensive national strength, and clearly stressed that to adhere to the path of independent innovation with Chinese characteristics, scientific and technological innovation must be placed at the core of the overall situation of national development. With the vigorous implementation of the innovation driven development strategy, science and technology projects play an increasingly significant role in promoting China's scientific and technological progress and innovation. Therefore, it is of great significance to do a good job in the post-evaluation of science and technology projects, to feed back and guide the planning of science and technology projects based on the evaluation results, and to provide references for future support for the development of science and technology projects.

2. NECESSITY OF POST EVALUATION OF SCIENCE AND TECHNOLOGY PROJECTS

The purpose of post evaluation is to comprehensively evaluate the completed projects. Summarize experience in the practice of post-evaluation, obtain effective information, find problems, give feedback on this, and apply the gained experience to project decision-making and management. The post-assessment of science and technology projects is a comprehensive, objective and systematic evaluation and summary of completed science and technology projects, and analyzes whether the project has completed the project objectives, achieved better benefits, and whether there are defects in the implementation process [1]. As an important part of the closed-loop management of science and technology projects, we should do a good job in the post-evaluation of science and technology projects and strictly evaluate whether the projects achieve economic, social and ecological benefits in accordance with the objectives. It can greatly improve the application quality of future scientific research projects and the effect of managing scientific research projects, so as to provide experience and reference for managers' decision-making.

With the rapid development of contemporary economy and science and technology, scientific research institutes and scientific and technological enterprises have a deeper pursuit of the development of scientific research tasks, and their main driving force will be to improve market competitiveness and market share. At

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present, the state pays more attention to the closed-loop management of the whole process of scientific research projects, and science and technology enterprises also respond to the call to pay attention to and implement closed-loop management. At present, the state pays more attention to the closed-loop management of the whole process of scientific research projects, and science and technology enterprises also respond to the call to pay attention to and implement closed-loop management. Most science and technology enterprises have formed a standardized and systematic management mode, which is reflected in goal setting, process implementation, final acceptance, application promotion and so on, so as to improve the quality of project development. It has had a beneficial impact on the improvement of project investment efficiency, decision-making and management level.

3. ANALYSIS ON THE DEVELOPMENT OF POST EVALUATION OF SCIENCE AND TECHNOLOGY PROJECTS

3.1 Research on the construction of performance evaluation index system of science and technology projects

In terms of constructing the performance evaluation index system of science and technology projects, scholars propose to establish the performance evaluation index system according to the characteristics of different science and technology projects, and study the performance evaluation index system of financial expenditure as a whole. Zhou Yiliang divides science and technology evaluation into four categories according to the process of scientific research management, classifies the performance evaluation as financial public expenditure performance evaluation, and designs a general performance evaluation model for general science and technology projects [2]; Xiao Li believes that science and technology projects are diverse, and puts forward four necessary prerequisites for science and technology project evaluation, namely, correct classification of science and technology projects, clarifying evaluation objectives, positioning evaluation subjects and standardizing evaluation procedures. The method of classification before evaluation must be adopted to evaluate science and technology projects [3]; Zhang Junguo, Ren Hao and Xie Fuquan established a financial science and technology project performance evaluation system including the overall performance index system of the project and the sub index system of four different projects from the perspective of post evaluation [4]; Zhang Xiaojing divided the local science and technology plan projects into two categories, namely, technology development and science and technology support. Using the multi index comprehensive evaluation model, he constructed a performance evaluation index system including two primary indicators of benefit and management and several secondary and tertiary indicators [5].

3.2 Research on the construction of post evaluation index system of science and technology projects

In terms of constructing the post evaluation index system of science and technology projects, scholars' research direction is to evaluate the performance of science and technology projects first, and then compare the projects horizontally according to the performance evaluation results. Based on the perspective of project life cycle, Wang Mingming constructed the post evaluation system of science and technology support plan project, including project objectives, process, economic and social benefits and sustainable impact [6]; Gaoshan Bu uses the analytic hierarchy process to establish a post-evaluation indicator system for pipeline application research projects, including four first-level indicators of project preliminary investigation and project approval, project implementation process, project completion status, and project promotion and application status; Zeng Libo and others used the Analytic Hierarchy Process to establish a post-evaluation index system based on the characteristics of the project's research and development goals and results. The pipeline technology projects were divided into five categories, including basic and advanced categories, general application categories, product categories, economic information and standard categories.

By analyzing the current research status at home and abroad, it can be known that scholars at home and abroad have done a lot of analysis and research on the research methods and research process of project post-evaluation.Compared with domestic, post-evaluation work in foreign countries started earlier, and a relatively complete post-evaluation theory has been formed so far. For China, the existing research still has the following deficiencies: there is no systematic and complete theoretical support for the selection of post evaluation indicators of science and technology projects, there are few post evaluation studies on science and technology projects, and there is no systematic evaluation mechanism in the post evaluation management of science and technology projects.

4. DESIGN OF POST EVALUATION INDEX SYSTEM FOR APPLIED SCIENCE AND TECHNOLOGY PROJECTS

4.1 Construction principles of index system

4.1.1.Scientific principle

The design of evaluation indicators should select appropriate evaluation methods according to the principle of scientific and objective, so as to ensure that the evaluation system can truly and objectively reflect the impact and evaluation objectives of science and technology projects in all aspects.

4.1.2.Principle of operability

In order to ensure the operability and practicability of the evaluation index system after science and technology project approval, the construction of the evaluation index system must ensure the scientificity of the method and simplify the specific content. It should also be easy to collect data, and the cost of data collection is not high. The weight of the index system should be clear and standard.

4.1.3.Principle of comparability

Compared with natural science, the content of social science is more complex. In the process of determining the indicators, we should use the combination of qualitative and quantitative methods to make a general judgment on the indicators, quantify the indicators, and then obtain more reasonable evaluation results

4.1.4.Guiding principle

The evaluation of science and technology projects is not to evaluate the performance of a project separately, but to take certain guiding measures to make it move in the right direction according to the current situation and evaluation results of the evaluated project, and then feed back the evaluation results and plan the development direction of the future project. The research object of this paper is aimed at the science and technology projects supported by the government. Therefore, in the design of indicators, we must consider whether the indicators can play a guiding role in the regulation of financial funds.

4.2 Construction index system

Scientific and technological projects have the characteristics of diversity, and their emergence is based on scientific and technological activities. Therefore, to evaluate scientific and technological projects, we must first classify them and then evaluate them (Xiao Li, 2004). Taking applied research projects as an example, this paper constructs the post evaluation index system, gives the weight and scoring method of each index, and provides a theoretical reference for the post evaluation management of science and technology projects. Application-oriented science and technology projects have the characteristics of pertinence and practicality, including new technologies, new products, new processes, new methods, new resources and other applied technologies that can be directly used in production or direct production. The evaluation focuses on practical value, focusing on technical level, technological achievements, theoretical innovation, potential economic and social value, and the impact of topic extension and derivative effects. Therefore, this article selects the most representative indicator elements under the above key points for measurement. The indicator system is listed in three-level indicators. The first-level indicators include project acceptance, academic value, technical value, economic and social benefits, and continuous impact. Each indicator also includes several secondary indicators. The post evaluation index system of Applied Science and technology projects is shown in Table 1.

TABLE 1 POST EVALUATION INDEX OF APPLIED RESEARCH PROJECTS

Target layer	Primary index	Secondary index	Tertiary indicators
Post evaluation index of applied research projects A	Project acceptance A1	Project completion status A11	Completion of project contract indicators
		Effectiveness of project acceptance A12	Compliance of acceptance procedure and authority of acceptance organization

	Academic value A2	Theoretical innovation A21	Scientific discovery, technological breakthrough, new laws and new ideas
		academic achievements A22	Level of academic papers, reports and publications; Number of published monographs
	Technical value A3	technical level A31	Technological innovation, advanced nature, maturity and feasibility; Whether it has become a national standard, industrial standard and local standard
		technological achievements A32	New products, new technologies, new processes, new materials and practical patents; Other intellectual property rights (such as software copyright)
	Economic and social benefits A4	Cultivation of scientific and technological talents A41	Number of talents trained by the project; Talent level (doctor, master, bachelor, etc.)
		Potential economic benefits A42	The potential role of the project research content in promoting economic development and productivity improvement
		Potential social benefits A43	The impact of the project research content on the social environment (energy conservation and emission reduction, resource utilization, social culture, and promoting the coordinated development of economy, society and natural environment)
	Persistent impact A5	Impact on academic research A51	The number of citations and reprints of representative papers; The social and economic impact of academic reports; Circulation and citation of monographs; Transfer of intellectual property rights; Academic reputation

		Impact on improving competitiveness A52	Leading emerging industries and driving industrial technology upgrading; Intellectual property conversion rate, number of intellectual property acquisition and income from technology transfer; Industrialization degree and prospect; Potential size of technology market;
		Promoting the regional economy A53	Effectiveness of guiding emerging industries, combining with industrial policies, driving industrial technology upgrading and docking with the market
		Promotion of local science and technology A54	Promote local science and technology and promote sustainable social development
		Topic extension and derivative effect A55	Based on the research results of this project, the project applicant and project team members will be invited to carry out extended research in this field or derive other topics

5. STANDARDIZATION OF POST EVALUATION SYSTEM FOR APPLIED TECHNOLOGY PROJECTS

5.1 Steps of determining the weight of evaluation index by analytic hierarchy process

AHP is also called multi-objective decision-making method. It is a systematic and hierarchical analysis method combining qualitative and quantitative. This method can divide the interrelated elements into complex problems according to a certain level, so as to simplify and organize the problems. The key link is that the judgment matrix can be constructed by comparing the elements of the same level with each other in combination with expert suggestions or experience, and the weight of each index in this level can be calculated by mathematical method. For science and technology projects, this method can quantify the indicators that cannot be quantified. At the same time, the indicators after pairwise comparison are more objective and fair. The basic steps of weight calculation are as follows:

5.1.1.Establish problem level relationship

For the problems studied above, the logical relationship between indicators has been clarified and a hierarchical relationship has been formed. At present, the evaluation index system is mainly divided into two levels, primary index and secondary index.

5.1.2.Establish the judgment matrix of pairwise comparison

After the hierarchical structure is established, we can compare the importance of elements at the same level with those at the previous level through pairwise comparison to form a comparison judgment matrix. Then invite experts in this field to quantify the importance of each index by using the 1-9 scale method to realize qualitative to quantitative. The definition of the introduced nine-level scaling method is shown in Table 2, and the n-order judgment matrix A is established.

TABLE 2 SPECIFICATION FOR QUANTITATIVE VALUE OF INDEX PAIRWISE COMPARISON

Scale value	Scoring rules
1	i Compared with j, the i factor is equally important than the j element
3	i Compared with j, the i factor is slightly more important than the j element
5	i Compared with j, the i factor is obviously important than the j element
7	i Compared with j, the i factor is more important than the j element
9	i Compared with j, the i factor is extremely important than the j element
2,4,6,8	The comparison between factor I and factor j is between the above two results
reciprocal	The factor i is compared with the factor j to get the scale a, then the factor j and the factor i are compared to get the scale 1/a

The form of pairwise comparison matrix is as follows:

$$A = (A_{ij})_{m\times n} = \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \cdots & A_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ A_{n1} & A_{n2} & \cdots & A_{nn} \end{bmatrix} \quad (1)$$

Where: Aij (i, j ∈ n) represents the comparison result of the i-th index and the j-th index based on the comparison scale.

Calculate index weight

Use the square root method to calculate the weight of the judgment matrix, first calculate the product of one row of the judgment matrix and then open the nth root, where n is the order, and normalize the square root result by column to get the index weight.

$$W_i = \frac{\sqrt[n]{\prod_{j=1}^{n} A_{ij}}}{\sum_{i=1}^{n} \sqrt[n]{\prod_{j=1}^{n} A_{ij}}} \quad (2)$$

5.1.3.Consistency test

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{[AW]_i}{n \cdot w_i} \quad (3)$$

Calculate the maximum eigenvalue of the judgment matrix A according to formula (3), compare the random consistency index and the consistency index, verify the degree of deviation, and define the consistency index:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (4)$$

Consistency ratio:

$$CR = \frac{CI}{RI} \quad (5)$$

The average random consistency index is introduced, and the value table is shown in Table 3:

TABLE 3 VALUE OF RANDOM CONSISTENCY INDEX RI

1	2	3	4	5	6	7	8	9
0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

When the value of the calculated judgment matrix is less than or equal to 0.10, it means that the judgment matrix has passed the consistency test, otherwise the judgment matrix needs to be adjusted. Only the W calculated through the consistency test can be used as the weight.

5.2 Calculation of post evaluation index weight

5.2.1. Determination of primary index weight

According to expert consultation, the primary index judgment matrix is obtained, and the scale index and index weight are calculated according to formula 2.

TABLE 4 JUDGMENT MATRIX -I

A	A1	A2	A3	A4	A5	W
A1	1	1/2	1/3	1/2	1/4	0.0777
A2	2	1	1/3	1/2	1/3	0.1086
A3	3	3	1	2	1/2	0.2616
A4	2	2	1/2	1	1/3	0.1555
A5	4	3	2	3	1	0.3965

According to formula 3-5: , , , . In conclusion, it passed the consistency test.

5.2.2.Determination of secondary index weight

a) Secondary index weight of project acceptance

TABLE 5 JUDGMENT MATRIX -

A1	A11	A12	W
A11	1	3	0.7500
A12	1/3	1	0.2500

According to formula 3-5: , , , . In conclusion, it passed the consistency test.

b) Secondary index weight of academic value

TABLE 6 JUDGMENT MATRIX -

A2	A21	A22	W
A21	1	2	0.6667
A22	1/2	1	0.3333

According to formula 3-5: , , , . In conclusion, it passed the consistency test.

c) Secondary index weight of technical value

TABLE 7 JUDGMENT MATRIX -

A3	A31	A32	W
A31	1	2	0.6667
A32	1/2	1	0.3333

According to formula 3-5: . In conclusion, it passed the consistency test.

d) Secondary index weight of economic and social benefits

TABLE 8 JUDGMENT MATRIX -

A4	A41	A42	A43	W
A41	1	1/3	1/3	0.1429
A42	3	1	1	0.4286
A43	3	1	1	0.4286

According to formula 3-5: . In conclusion, it passed the consistency test.

e) Secondary index weight of sustainability impact

TABLE 9 JUDGMENT MATRIX -

A	A1	A2	A3	A4	A5	W
A1	1	1	3	3	1	0.2723
A2	1	1	3	3	1	0.2723
A3	1/3	1/3	1	2	1/3	0.1042
A4	1/3	1/3	1/2	1	1/3	0.0790
A5	1	1	3	3	1	0.2723

According to formula 3-5: . In conclusion, it passed the consistency test.

5.2.3.Summary of evaluation index weights

The weight of to is , and the weight of to the target layer is . The weights are summarized as follows:

(,,,,)=(0.0777,0.1086,0.2616,0.1555)

(,)=(0.7500,0.2500)

(,)=(0.6667,0.3333)

(,)=(0.6667,0.3333)

(,,)=(0.1429,0.4286,0.4286)

(,,,,)=(0.2723,0.2723,0.1042,0.1090,0.2723)

5.3.Scoring method

In order to simplify the post evaluation score calculation process and improve operability, the project score is calculated by ordinary weighting method, and the formula is as follows:

$$M = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i X_{ij} w_{ij} \quad (5)$$

In the formula, is the final score of the project, is the weight of the i-th criterion layer index, is the score value of the j-th criterion layer in the i-th criterion layer, and is the weight of the j-th index.

6. CONCLUDING REMARKS

Taking the applied science and technology project as an example, this paper constructs the post evaluation index system of science and technology project and gives the post evaluation scoring method. When studying the literature, it is found that generally, scholars will carry out the post evaluation of the project in combination with the process and results. Such an evaluation process will make the post evaluation index system lose focus. When selecting indicators, this article focuses on the economic benefits, social benefits, and the impact of the sustainability of the results after the project is completed, which is more in line with the requirements of post-project evaluation. In the evaluation method, the analytic hierarchy process is selected to determine the index weight, and experts are invited to compare the importance of the selected indicators to form quantitative indicators, so as to realize the transformation from qualitative to quantitative. The post-evaluation index system established in this article can provide a theoretical reference for scientific research management departments to inspect the implementation and application of scientific and technological projects, and provide theoretical references for scientific researchers to find problems in the project in time and make corresponding improvements. It is helpful for scientific research units to summarize scientific research management experience and improve the quality of project implementation. And finally realize the reasonable arrangement of financial funds, and increase the input-output ratio of scientific research activities.

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