Project Evaluation and Analysis of Metrological Verification Regulation Based on Fuzzy Comprehensive Analysis Method

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Abstract. The technical specification of highway engineering measurement has been applied as an independent field since 2016. But at present, there is a lack of concrete evaluation methods in the process of project establishment. Within the scope of Highway Engineering Metrology Technical system table, starting from the technical attributes of instruments and equipment such as road engineering, bridge and tunnel engineering, traffic engineering, and combining with the demand of future highway metrology management, it is one of the important means to evaluate the whole process of Highway Engineering Metrology Technical specification scientifically. Based on the fuzzy comprehensive analysis method, this paper tries to simulate the quantitative analysis and evaluation of a metrological verification regulation project, identifies the main factors of the project evaluation, carries out the weight analysis, and finally obtains the quantitative evaluation results. The analysis results show that the evaluation index of metrological verification regulation project is divided into three levels. The first level index is the evaluation of research project. The second level index mainly includes five contents: the necessity of project establishment, the main content and the research scheme, the expected benefit, the research supporting conditions and the risk. The third level index project evaluation content is included in the sub-content. The capacity includes 22 categories, which fully reflects the main factors of project evaluation. The maximum value of the comprehensive quantitative total evaluation element is 0.471, which belongs to the "excellent" evaluation grade, and the project evaluation control effect belongs to the excellent grade.

1. Introduction

The scientific and rational evaluation of scientific research projects is helpful to the scientific selection of projects. Highway Engineering Metrology Technical Specification Project Establishment Evaluation is mostly based on qualitative analysis, as well as other scientific research project evaluation. The comprehensive opinions of appraisal experts are used to make subjective evaluation on each index of project establishment. To a certain extent, this method optimizes the index of project establishment and realizes a more standardized evaluation process, but due to the influence of subjective factors, the evaluation results often have a certain degree of one-sided [1,2]. How to scientifically achieve project evaluation has become one of the research areas of some researchers. At present, some domestic researchers have carried out a number of analysis around the project evaluation. In quantitative analysis, Sun Jing and others have carried out a hierarchical-entropy combination weighting method for the evaluation of agricultural science and technology projects. The innovation value of agricultural development projects is divided into several primary and secondary indicators, and combined with
variance maximization. The weight value of weight method is compared and analyzed to verify the feasibility of the method [3]. Zhang Ruifeng and others have constructed the evaluation index of metrological scientific research project, and carried on the index weight analysis under the analytic hierarchy process, and obtained the reasonable result [4]. Based on extension theory, Bao Haijun established an extension evaluation model [5] for scientific research projects.

In this paper, the metrological verification rules for the project as the analysis object, based on fuzzy analytic hierarchy process (AHP) to establish a project evaluation index system for quantitative evaluation, aiming to better guide the practice of such projects through evaluation.

2. The basic principle of Fuzzy Analytic Hierarchy Process (AHP)

2.1. Use AHP to determine index weight.

The overall idea of evaluation is to establish sub-analysis indicators under different research schemes, determine the importance of the indicators with expert scores, and then get the weights of different factors. Finally, the total scores of various schemes are calculated according to the weights of all indicators. The highest total score is the selected target.

The process of AHP is as follows: [4]:

1) Identify the influencing factors of the target.

The main analysis factors are identified according to the selected content. If \( C \) is used to represent the set of all the factors, there is \( C = \{C_1, C_2, C_3, ..., C_n\} \) a factor.

2) Establish index scoring system.

According to the selected content, the main analysis factors are identified. If \( C \) is used to represent the set of all factors, there is \( P = \{P_1, P_2, P_3, ..., P_n\} \), and \( P_i (i = 1, 2, 3, ..., n) \) is one of the factors.

3) Establish multiple evaluation systems.

Using three-tier index system, namely \( U_1, U_{ij}, U_{ijk} \), respectively, the first, second and third tiers, the specific relationship is as follows:

\[
\begin{align*}
(U_1, U_2, U_3, ..., U_m), & \quad i = 1, 2, 3, ..., m \\
(U_{ij}, U_{i2}, U_{i3}, ..., U_{ij}), & \quad j = 1, 2, 3, ..., n \\
(U_{ijk}, U_{ij2}, U_{ij3}, ..., U_{ijk}), & \quad k = 1, 2, 3, ..., o
\end{align*}
\]

4) Calculate index weight

The basic content of AHP is used to calculate the index weight. Firstly, all the factors are compared in pairs. Then the judgment matrix is established according to the comparison results between the factors. Then the maximum eigenvalue of the judgment matrix is solved and its consistency is checked. Finally, the weights of the comparative factors are obtained.

Index evaluation system is composed of several levels, and different levels of judgment matrix should be constructed. In a three-level index system, the judgment matrix of each level is calculated according to the level of each level, and then the index weights of each level are obtained. If the index weights of the lower level are multiplied by the index weights of the higher level, the weights of the lower level indexes relative to the higher level indexes can be obtained. Each low level index weight can be expressed quantitatively at the same level.

If \( A \) is used to represent the judgment matrix of a certain level, the maximum eigenvalue and eigenvector of \( A \) are calculated first, and then the consistency of the judgment matrix is checked. The basic steps of AHP are described in detail.

2.2. Fuzzy comprehensive analysis and evaluation

Fuzzy comprehensive analysis method considers a variety of factors, uses membership function and membership degree to describe the excessive information of intermediary, divides risk based on factor threshold, and obtains quantitative analysis results based on mathematical calculation. The process of fuzzy comprehensive analysis is as follows:
3. metrological verification regulation project evaluation

3.1. Project background
Metrological verification regulations refer to the technical documents with national statutory nature which are used to evaluate the metering performance of measuring instruments and as the basis for verification. It is engaged in metrological verification work of the technical basis, is a national technical regulations to ensure the accuracy and consistency of measuring instruments. There are three kinds of metrological verification regulations: national metrological verification regulations, departmental metrological verification regulations and local metrological verification regulations. Its contents mainly include: the scope of application of the verification regulations; measurement performance; verification items; verification conditions; verification methods; verification cycle and the treatment of verification results. At present, more than 90 items of metrological verification regulations in the field of highway metrology have been published with statistics, and more than 20 items are under study, and they are increasing at the rate of 5-8 items per year. The system table is an important reference material for the declaration of verification regulations, and most of its range professional testing equipment are composite parameters, comprehensive quantity, dynamic on-line measuring equipment. With the development of testing technology, professional testing equipment is replaced quickly, and the operation of equipment is becoming more and more complex. The formulation of corresponding measurement technical specifications should be improved at any time according to the situation. Therefore, it is urgent to evaluate the urgency of setting up a project of instrument and equipment from the instrument and project itself in order to ensure the quality of measurement work continuously.

3.2. Index system of project evaluation for metrological verification regulation
The evaluation index system is divided into three levels: the first level is the evaluation of research projects, the second level is the basic content of the evaluation of research projects, including the
necessity of project establishment, main contents and research programs, expected benefits, research support conditions, risk, and the third level is the evaluation content of project establishment. The sub economy of the project is shown in Table 1.

| First level evaluation index | Two level index | Three level index |
|------------------------------|-----------------|------------------|
| Research project evaluation  | B               |                  |
| Project necessary            | $B_1$           |                  |
| Demand of science and technology | $B_{12}$    |                  |
| Demand of society            | $B_{13}$        |                  |
| Agreement with the formation, upgrading and development of regional industries | $B_{14}$ |                  |
| Advanced research target     | $B_{21}$        |                  |
| Quality of feasibility study report | $B_{22}$ |                  |
| Main contents and research plan | $B_2$          |                  |
| The expected benefits        | $B_3$           |                  |
| Economic benefits            | $B_{31}$        |                  |
| Social benefits              | $B_{32}$        |                  |
| Environmental benefits       | $B_{33}$        |                  |
| Industrialization prospect   | $B_{34}$        |                  |
| Research support conditions  | $B_4$           |                  |
| The person in charge of the project quality | $B_{43}$ |                  |
| Comprehensive quality of project team | $B_{43}$ |                  |
| Financing and budgetary arrangements | $B_{45}$ |                  |
| Technical risk               | $B_{51}$        |                  |
| Management risk              | $B_{52}$        |                  |
| Policy risk                  | $B_{53}$        |                  |
| Market risk                  | $B_{54}$        |                  |

20 experts (experienced senior engineers, project evaluation personnel, government departments, etc.) were invited to evaluate the project evaluation index of the verification regulation. The evaluation results were five grades, namely, excellent, good, general and qualified. Unqualified, the corresponding evaluation criteria are divided into 100 points, 90 points, 70 points, 60 points, 0 points, the final evaluation results will be formed by statistics, as shown in Table 2 below.

3.3. determine the membership matrix and carry out fuzzy comprehensive evaluation.

(1) determining membership degree matrix

According to the results of expert scoring and the relative importance of different evaluation indicators, the membership degree of single factor indicators of different evaluation indicators is obtained by AHP, as shown in Table 3 below.

Table 2 the membership of single factor index of different evaluation indexes
The matrix of the two level index is obtained from table 3, that is:

\[
R_{B1} = \begin{pmatrix}
0.5 & 0.3 & 0.2 & 0 & 0 \\
0.8 & 0.2 & 0 & 0 & 0 \\
0.4 & 0.4 & 0.2 & 0 & 0 \\
0 & 0 & 1 & 0 & 0
\end{pmatrix}, \quad R_{B2} = \begin{pmatrix}
0 & 0.7 & 0.2 & 0.1 & 0 \\
0.2 & 0.4 & 0.3 & 0.1 & 0 \\
1 & 0 & 0 & 0 & 0 \\
0 & 0.1 & 0.3 & 0.2 & 0.4 \\
0.3 & 0.4 & 0.2 & 0.1 & 0
\end{pmatrix};
\]

\[
R_{B3} = \begin{pmatrix}
0.7 & 0.3 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0.8 & 0.1 & 0.1 & 0 & 0
\end{pmatrix}, \quad R_{B4} = \begin{pmatrix}
0.8 & 0.2 & 0 & 0 & 0 \\
0 & 0.2 & 0.4 & 0.1 & 0.3 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0.2 & 0.7 & 0 & 0 \\
0 & 0.2 & 0.4 & 0.4 & 0
\end{pmatrix};
\]

\[
R_{B5} = \begin{pmatrix}
0.2 & 0.4 & 0.4 & 0 & 0 \\
0.1 & 0.2 & 0.3 & 0.4 & 0 \\
0.3 & 0.3 & 0.4 & 0 & 0 \\
0 & 0.3 & 0.2 & 0.5 & 0
\end{pmatrix};
\]

(2) fuzzy comprehensive evaluation
The weight of evaluation indicators at all levels is calculated by analytic hierarchy process. Based on the expert group consultation, through many debugging and improving the evaluation data, the second-level index judgment matrix is finally obtained, as shown in Table 3 below.

| B  | B₁  | B₂  | B₃  | B₄  | B₅  | W  | CR |
|----|-----|-----|-----|-----|-----|----|----|
| B₁ | 1   | 1/3 | 1/4 | 1/2 | 1/3 | 0.131 |
| B₂ | 3   | 1   | 1/2 | 1/2 | 1   | 0.266 |
| B₃ | 4   | 2   | 1   | 1/2 | 3   | 0.189 0.017 |
| B₄ | 2   | 2   | 2   | 1   | 2   | 0.178 |
| B₅ | 3   | 1   | 1/3 | 1/2 | 1   | 0.236 |

The feasibility judgment matrix of project feasibility can be obtained from Table 3.

\[ W = [0.131,0.266,0.189,0.178,0.236] \]

Similarly, the judgment matrix under the two level index is as follows:

\[ W_{B_i} = [0.301,0.301,0.277,0.121] ; \quad W_{B_j} = [0.102,0.138,0.302,0.324,0.134] ; \quad W_{B_k} = [0.305,0.205,0.277,0.213] ; \quad W_{B_l} = [0.222,0.258,0.192,0.198,0.130] ; \quad W_{B_m} = [0.331,0.331,0.213,0.125] \]

According to the content of fuzzy comprehensive analysis, the comprehensive evaluation vector is obtained. \( A \), That is,

\[
A_{B_1} = W_{B_1} \cdot R_{B_1} = [0.301,0.301,0.277,0.121] \cdot \begin{bmatrix} 0.5 & 0.3 & 0.2 & 0 & 0 \\ 0.8 & 0.2 & 0 & 0 & 0 \\ 0.4 & 0.4 & 0.2 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix} = (0.6,0.33,0.07,0,0) ;
\]

The same reason can be obtained: \( A_{B_2} = (0.156,0.768,0.076,0,0) ; \quad A_{B_3} = (0.193,0.73,0.077,0,0) ; \quad A_{B_4} = (0.123,0.712,0.135,0.03,0) ; \quad A_{B_5} = (0.137,0.675,0.135,0.063,0) \) .

The matrix of the two level index single factor is synthesized.

\[
R_B = \begin{bmatrix} 0.6 & 0.33 & 0.07 & 0 & 0 \\ 0.156 & 0.768 & 0.076 & 0 & 0 \\ 0.193 & 0.73 & 0.077 & 0 & 0 \\ 0.123 & 0.712 & 0.135 & 0.03 & 0 \\ 0.137 & 0.675 & 0.135 & 0.063 & 0 \end{bmatrix}
\]

Calculate the overall evaluation index evaluation matrix results: \( A = R_B \cdot W = (0.471,0.322,0.203,0.004) \)

(3) determine the evaluation results.

Comparing the result of the total evaluation matrix with that of \( V \), the maximum value of the element is 0.471, which corresponds to the grade of "excellent" evaluation. It can be seen that the process of setting up the project achieves the control effect of excellent grade.

4. Conclusions
Based on the fuzzy analytic hierarchy process (FAHP), this paper analyzes the project evaluation of a specific metrological verification regulation, analyzes the weight of the identified evaluation index system, and carries out fuzzy comprehensive calculation, and obtains quantitative evaluation results. The main conclusions of this paper are as follows:
(1) The evaluation index of metrological verification regulations is divided into three levels. The first level is the evaluation of the project. The second level mainly includes five categories, namely, the necessity of the project, the main contents and research programs, the expected benefits, the supporting conditions and the risks. The sub-categories of the evaluation content of the third level include The 22 category. The three level indicators fully reflect the main factors of project evaluation.

(2) the effect of the project control in the metrological verification regulation is excellent grade.

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