Under the background of data science, construct the higher education quality evaluation system of civilian-run regular universities in Hubei Province based on the Analytic Hierarchy Process (AHP)

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Abstract. This paper takes the CIPP evaluation mode as the connotation to promote the modernization of university governance ability under the background of national governance modernization, with Hubei Province as an example for the investigation. This paper constructs the indicator system framework from three dimensions of input quality, process quality and output quality of universities. Through the calculation of indicator weights and scientific assignment by analytic hierarchy process (AHP), a set of applicable and operable complete evaluation indicator system is formed, which can be used to evaluate the higher education quality and help the governance modernization of civilian-run universities.

1. Introduction
Civilian-run universities have become a increasingly important part of the university group that cannot be ignored. In view of the requirements of comprehensively deepening the reform and promoting the modernization of national governance system and governance capacity in the field of civilian-run higher education, data science plays an important role in the research field of "university governance", and it has many applications, especially in the evaluation of higher education quality.

Universities pay more and more attention to the process of education quality evaluation. Different educational evaluation methods have different degrees of reflection on the modernization of university governance ability [1-3]. The evaluation of teaching quantity in universities is the value judgment of the whole school running behavior. The evaluation is a complex and systematic project, which needs a set of scientific, objective, standard and operational evaluation system.

This paper takes CIPP as its connotation and analytic hierarchy process as its form. This paper adopts the analytic hierarchy process (AHP), establishes the model and judgment matrix to determine the weight of each evaluation indicator, and carries on the comprehensive evaluation through the fuzzy method, thus constructs a new evaluation system.

2. The construction of the evaluation indicators of higher education quality
The construction of the scientific evaluation indicator system is the basic premise of carrying out the evaluation of higher education quality. At the same time, the construction of evaluation indicator system is also an important content of this paper. The construction of higher education quality evaluation system is mainly divided into the following steps:

2.1. Selection of evaluation indicator

The common methods to construct the evaluation indicators of education quality are questionnaire, expert interview and analytic hierarchy process (AHP) \[4\]. However, it is relatively complex to select the evaluation indicator of higher education quality in civilian-run regular universities. The system should not only reflect the general common characteristics of undergraduate teaching quality of civilian-run universities, but also be different from the evaluation of teaching quality of public universities, to reflect the special characteristics of undergraduate teaching evaluation in civilian-run universities. At the same time, it also needs to be operable in order to provide reference for the teaching quality evaluation of civilian-run universities.

In order to construct the indicator system scientifically, based on the previous research results, this paper investigates 14 civilian-run regular universities in Hubei Province, and visits and studies the school running modes of different universities \[5\]. At the same time, a number of experts who have been engaged in teaching research in universities for a long time were consulted, their opinions were collected, and questionnaires were designed for these experts to score. According to the grading and ranking of experts and two rounds of discussion and research, the members of the group and experts outside the group reached an agreement. Based on the framework of three dimensions of teaching input quality, process quality and output quality, this paper covers five first level indicators: sustention of school running resources, support from teaching design, application of education and teaching, incentive of teaching evaluation and satisfaction degree, which are divided into 15 operable and evaluable secondary indicators: Source of students, talents training mode, school running conditions, talents training scheme, talents training mode, classroom teaching, curriculum construction, specialty construction, scientific research, social service, quality assurance system, teaching incentive system, student satisfaction degree, school satisfaction degree, employer satisfaction degree.

Combined with the teaching characteristics of civilian-run regular universities, the relatively mature evaluation indicator design of western developed countries and the related research results of domestic scholars, the final evaluation indicator system is as follows according to the requirements of the higher education quality concept of civilian-run regular universities:

**Table 1. Higher Education quality Evaluation Indicator system of Civilian-Run Regular Universities in Hubei Province.**

| Evaluation Objective | First level Indicators | Second level Indicators |
|----------------------|------------------------|-------------------------|
| Higher education quality of civilian-run regular universities in Hubei Province | **Input quality** | Sustention of school running resources (γ 1) | Source of students, teaching staff, school running funds, campus construction |
| | **Process quality** | Support from teaching design (γ 2) | Talents training scheme, talents training mode, classroom teaching, curriculum construction, specialty curriculum construction |
| | | Application of education and teaching (γ 3) | Specialty construction, scientific research, social service |
| | | Incentive of teaching evaluation (γ 4) | Quality assurance system, teaching incentive system |
| | **Output quality** | Satisfaction degree(γ 5) | Student satisfaction, school satisfaction, employer satisfaction degree |

2.2. Verification of evaluation indicator system
In order to further verify the effect of the quality evaluation indicator system on the higher education quality of civilian-run regular universities, in this study, questionnaires were designed to collect data extensively, and "test-retest reliability", PLS-SEM statistical technology, reliability of experts to questionnaire and convergent validity were used to verify.

2.2.1. Questionnaire design. According to the purpose of the paper, a questionnaire was designed after consulting much relevant literatures to ensure that the design of questionnaire content is reasonable and effective. After the first draft of the questionnaire was completed, the first draft was distributed to relevant experts and scholars. Then, according to the opinions of experts and scholars, the questionnaire was revised for the second time, and then the second distribution and recovery. After three repeated modifications, the questionnaire was finally formed.

2.2.2. The design of questionnaire content. This survey takes 14 civilian-run universities in Hubei Province as the objects. The survey is highly targeted and meets the basic requirements of "no less than 50 questionnaires". The survey results were true and effective. The questionnaire was designed with Likert Five Grade Scale, with five grades of evaluation criteria listed. Subjects of investigation can choose a score of 1-5 for each quality concept, where score 1 is very dissatisfied, score 5 is very satisfied. If a certain evaluation indicator scores high, it means that people have a higher recognition of it.

2.2.3. Reliability and validity test. In this paper, the reliability of the questionnaire was tested by combining the "test-retest reliability" method with Cronbach' α and CR value measurement.

In the interval of 20 days, "test-retest reliability" method was used to test the reliability of the paper. From 7 civilian-run universities, 30 people were randomly selected to conduct two questionnaire surveys before and after. According to the survey results, within 20 days, 94% of the respondents had the same answer to the two times of questionnaires. In that, the survey of this paper can be carried out.

The validity analysis of the questionnaire mainly includes two parts: one is convergent validity, which is used to express the explanatory power of latent variables to their indicators, which is generally measured by AVE value or outer loadings value of each measurement indicator; The other is discriminant validity, which is used to analyze the differences between different latent variables, which can be measured by Fornell-Larcker criterion method. From the following table (Table 3), we can see that the Cronbach' α value or CR value in this study was greater than 0.7, which means that the questionnaire has good internal consistency and there was a good correlation between the observable variables under the same latent variable. The AVE values of all latent variables were greater than the threshold level of 0.5, indicating that the questionnaire has good convergent validity. Therefore, the evaluation indicator system proposed in this study is scientific and reasonable.

Table 2. Reliability and Validity Test Results.

| Factor | Reliability CR | Cronbach’α | Convergent Validity AVE |
|--------|----------------|------------|------------------------|
| γ 1    | 0.900          | 0.852      | 0.590                  |
| γ 2    | 0.863          | 0.801      | 0.693                  |
| γ 3    | 0.852          | 0.768      | 0.558                  |
| γ 4    | 0.852          | 0.833      | 0.599                  |
| γ 5    | 0.882          | 0.833      | 0.558                  |

2.2.4. Distribution and collection of questionnaires. The subjects of this paper are students, teachers and experts from civilian-run universities in Hubei Province. From the current 14 civilian-run universities, the teachers and students of 7 civilian-run universities, such as Wenhua College, Wuchang Shouyi University, Wuhan University of Bioengineering, Hankou University, Wuhan College, Wuhan Donghu University, Wuhan Technology and Business University, and experts from
educational institutions such as Hubei Provincial Department of Education were randomly selected to conduct field surveys and expert interviews.

When the questionnaire was distributed, the authenticity and collecting rate of the questionnaire was ensured. With the help of the administrators and students of 7 civilian-run universities, the method of random sampling of survey objects on the spot and filling in and collecting the questionnaire on site were adopted to ensure the authenticity and validity of the questionnaire. Then asked experts to test the validity. This paper makes a questionnaire survey on PE teachers and college students in 7 civilian-run universities in Hubei Province. 26 questionnaires were randomly distributed in each university, with 10 for students and 16 for teachers; among them, a total of 70 questionnaires were distributed to civilian-run universities, 112 questionnaires were distributed to teachers of civilian-run universities and 18 questionnaires were distributed to experts of educational institutions. Among the 200 questionnaires that have been filled in, 200 questionnaires have been collected and checked, and there are 200 valid questionnaires.

Table 3. The Structure of the Personnel Structure Analysis table of Higher Education Quality Survey Objects in Civilian-Run Regular Universities in Hubei Province.

| Objects                           | Subtotal (Person) | Ratio |
|----------------------------------|-------------------|-------|
| Students of civilian-run universities | 70                | 35%   |
| Teachers of civilian-run universities  |                   |       |
| Professors                        | 14                | 7%    |
| Associate professors              | 28                | 14%   |
| Lecturers                         | 42                | 21%   |
| Administrative teachers           | 28                | 14%   |
| Experts in educational institutions |                   |       |
| Professors                        | 11                | 5%    |
| Associate professors              | 7                 | 4%    |
| Total                             | 200               | 100%  |

In this study, the evaluation levels of the alternative set were divided into five grades. The questionnaire was designed with Likert Five Grade Scale, with five grades of the evaluation criteria listed. Subjects of investigation can choose a score of 1-5 for each quality concept, where score 1 is very dissatisfied, score 5 is very satisfied. If a certain evaluation indicator scores high, it means that people have a higher recognition of it. All the evaluation factors in the indicator system of higher education quality management in civilian-run universities were put into questionnaires. Let the investigator to judge the relative importance (relative weight) between factors and the evaluation grade of each factor. Using the above comprehensive evaluation steps to calculate and sort out the data, the weight W of each element in the indicator system and the fuzzy relation matrix R were obtained.

3. The Establishment of the weight of higher education quality evaluation indicator in Civilian-Run Regular Universities in Hubei Province

The determination of indicator weight was directly related to the scientificity and the fairness of the evaluation indicator system. Among the effective quantitative methods to calculate the indicator weight, the most commonly used method is the analytic hierarchy process (AHP). Because the method can systematize the complex problems, needs fewer data, is easy to calculate, and can decompose it into multi-level, multi-objective, multi criteria system decision-making problems, the method is widely used. Through the establishment of hierarchical structure model, the judgment matrix was constructed to evaluate scientifically. Specific steps are as follows:

3.1. Construction of structural model

According to the survey data of expert questionnaires, the judgment matrix of each layer of indicators was constructed. In this study, the analytic hierarchy process (AHP) yaahp (Yet another AHP) V10.1 developed by Beijing Foreology Software Co., Ltd. was used for auxiliary calculation. To complete the construction of hierarchical model, the input of judgment matrix data, the calculation of sorting weight and the export of calculated data, the judgment matrix for pairwise comparison of the first level indicators is as follows:
3.1.1. Establishment of hierarchical structure model. The factors involved in complex problems were divided into several levels, and a multi-level hierarchical structure model was established. See Figure 1 for details:

**Figure 1.** Higher Education Quality Evaluation System of Civilian-Run Regular Universities in Hebei Province.

As shown in Figure 1, this study divides the higher education quality evaluation indicator system structure model of civilian-run regular universities in Hebei Province into three model sections, sets sub sections under each model section, and studies the indicator weight of each section by constructing judgment matrix.

3.1.2. Construction of judgment matrix. Assuming that there are N indicators in a certain layer, in order to reduce the difficulty and uncertainty of comparing multiple indicators with different properties and improve the accuracy, this study uses 1-7 scale to make pairwise comparison of different indicators, and then calculates and tests the matrix weight through the calculation formula of weight, maximum eigenvalue, consistency indicator and random consistency indicator proportion. The specific formula is shown in the following five formulas:

\[
\overline{W}_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}} \quad (i = 1, 2, \ldots, n)
\]
3.1.3. Obtain of matrix weight. The sustention of school running resources (B), support from teaching design (B) incentive of teaching evaluation (B), and satisfaction degree (B) five indicators were established as the basis of evaluation. In view of this factor, the education quality of 14 universities is evaluated.

The objective of comprehensive evaluation of university education quality (target level) was decomposed into various component factors (criterion level), and the joint action of these factors would have an impact on the evaluation results of university education quality. The bottom layer is the 14 universities (scheme level) to be comprehensively evaluated. Aiming at the target level of higher education quality, the five criteria level indicators are sustention of school running resources, support from teaching design, application of education and teaching, incentive of teaching evaluation and satisfaction degree. The importance of each factor in the criterion layer relative to the target layer was compared, and the quantitative analysis was carried out according to Satty's 1-9 scale table. When the scale values are 1, 3, 5, 7, 9 respectively, it means that the importance of each factor in the criterion layer relative to the target layer is the same, slightly stronger, stronger, obviously stronger, and absolutely stronger; when the scale values are 2, 4, 6, 8 respectively, it means that the influence of factor ai relative to factor aj is between two adjacent levels.

According to the above formula, the indicator matrix and weight of each level were obtained, as shown in Table 4, table 5, table 6, table 7, table 8 and table 9, and the corresponding hierarchy weights were obtained: According to the feedback of the questionnaires and the opinions of experts, the detection matrix was as follows, and the weights were calculated.

**Table 4.** The Judgment Matrix and Weights of the First level Indicator of Higher Education Quality Evaluation of Civilian-Run Regular Universities in Hubei Province.

| Higher education quality evaluation of civilian-run regular universities in Hubei Province | Sustention of school running resources | Support from teaching design | Application of education and teaching | Incentive of teaching evaluation | Satisfaction degree | \( W_i \) |
|---|---|---|---|---|---|---|
| Sustention of school running resources | 1 | 2 | 2 | 1/2 | 1/2 | 0.1738 |
| Support from teaching design | 1/2 | 1 | 1 | 1/2 | 1/3 | 0.0981 |
| Application of education and teaching | 1/2 | 1 | 1 | 1/4 | 1/3 | 0.1122 |
| Incentive of teaching evaluation | 2 | 2 | 4 | 1 | 1 | 0.3075 |
| Satisfaction degree | 1/2 | 3 | 3 | 1 | 1 | 0.3085 |
Table 5. The Judgment Matrix and Weights of the Second level Indicator Sustention of School Running Resources

| Sustention of School Running Resources | Source of students | Talents Training Mode | School Running Conditions | \( W_i \) |
|--------------------------------------|-------------------|----------------------|--------------------------|--------|
| Source of students                   | 1                 | 8                    | 3                        | 0.1142 |
| Talents training mode                | 1/8               | 1                    | 1/5                      | 0.0119 |
| School running conditions            | 1/3               | 5                    | 1                        | 0.0477 |

CR=0.0352

Table 6. The Judgment Matrix and Weights of the Second level Indicator Support from Teaching Design.

| Support from Teaching Design | Talents Training Scheme | Classroom Teaching | Curriculum Construction | \( W_i \) |
|------------------------------|-------------------------|-------------------|-------------------------|--------|
| Talents training scheme      | 1                       | 1/4               | 1/2                     | 0.0135 |
| Classroom teaching           | 4                       | 1                 | 3                       | 0.0611 |
| Curriculum construction      | 2                       | 1/3               | 1                       | 0.0235 |

CR=0.0427

Table 7. The Judgment Matrix and Weights of the Second level Indicator Application of Education and Teaching.

| Application of education and teaching | Specialty construction | Social service | Application of scientific research | \( W_i \) |
|---------------------------------------|------------------------|---------------|----------------------------------|--------|
| Specialty construction               | 1                      | 4             | 1                                | 0.0513 |
| Social service                        | 1/4                    | 1             | 1/3                              | 0.0467 |
| Application of scientific research    | 1                      | 3             | 1                                | 0.0142 |

CR=0.0308

Table 8. The Judgment Matrix and Weights of the Second level Indicator Incentive of Teaching Evaluation.

| Incentive of Teaching Evaluation | Quality Assurance System | Teaching Incentive System | \( W_i \) |
|----------------------------------|---------------------------|---------------------------|--------|
| Quality assurance system         | 1                         | 7                         | 0.2691 |
| Teaching incentive system        | 1/7                       | 1                         | 0.0384 |

CR=0.0089

Table 9. The judgment matrix and weights of the second level indicator satisfaction degree.

| Satisfaction degree | Student satisfaction degree | School satisfaction degree | Employer satisfaction degree | \( W_i \) |
|---------------------|-----------------------------|-----------------------------|------------------------------|--------|
| Student satisfaction degree | 1                          | 1                           | 1/3                          | 0.1011 |
| School satisfaction degree         | 1                          | 1                           | 1                            | 0.0806 |
| Employer satisfaction degree       | 1                          | 3                           | 1                            | 0.1268 |

CR=0.0000

3.1.4. Validity. Because there are some deviations between the subjective judgment and the objective ideal, it is necessary to check the consistency of the comparative judgment matrix established by each expert to check whether the eigenvector (weight) of the constructed judgment matrix is reasonable. Taking the consistency ratio CR as the judgment basis, the smaller the CR, the better the consistency of the judgment matrix, and the stronger the acceptability of the weight. The formula of calculation is: CR=CI/ RI. CR is the random consistency ratio of judgment matrix, where CI=( \( \lambda \) max - n)/(n -1), and
RI is the average random consistency indicator of judgment matrix. For RI value, please refer to the average random consistency indicator value of the analytic hierarchy process.

The results showed that: CR = 0.0352, CR = 0.0427, CR = 0.0308, CR = 0.0089, CR = 0.0000, CR = 0.0000. The consistency ratio of judgment matrix was less than 0.1, which showed that the six judgment matrices had good consistencies and passed the compatibility test of matrix. Therefore, the calculated weight is reasonable. The weights of indicators at all levels are shown in table 10:

Table 10. Weight Summary Table Higher Education Quality Evaluation System of Civilian-Run Regular Universities in Hubei Province.

| First level indicators                  | Second level indicators                  | Weights |
|----------------------------------------|------------------------------------------|---------|
| Sustention of school running resources | Source of students                       | 0.1142  |
| 0.1738                                 | Talents training mode                    | 0.0119  |
|                                       | School running conditions                | 0.0477  |
| Support from teaching design           | Talents training scheme                  | 0.0135  |
| 0.0981                                 | Classroom teaching                       | 0.0611  |
|                                       | Curriculum construction                  | 0.0235  |
| Application of education and teaching  | Specialty construction                   | 0.0513  |
| 0.1122                                 | Application of scientific research       | 0.0467  |
|                                       | Social service                           | 0.0142  |
| Incentive of teaching evaluation       | Quality assurance system                 | 0.2691  |
| 0.3075                                 | Teaching incentive system                | 0.0384  |
| Satisfaction                           | Student satisfaction degree              | 0.1011  |
| 0.3085                                 | School satisfaction degree               | 0.0806  |
|                                       | Employer satisfaction degree             | 0.1268  |

4. Research achievements and contributions
This paper focuses on the teaching quality of civilian-run regular universities in Hubei Province, and takes 14 civilian-run regular universities approved by the Ministry of Education as the research objects. Based on the concept of education quality, using the methods of expert interview, questionnaire and analytic hierarchy process, this paper constructs the teaching quality evaluation indicator system of civilian-run regular universities in Hubei Province, and carries out scientific assignment, to finally form a set of operable and applicable teaching quality evaluation system in Hubei Province. The main contributions of the research results are as follows:

4.1. The research results have scientific significance
Based on the concept of education quality, the reliability and validity of the questionnaire used to collect evaluation indicators were tested to ensure the rationality of the quality evaluation indicator system in evaluating the teaching quality of civilian-run universities; Based on PLS-SEMM verification analysis, the correlation between the first level indicators and the second level indicators in the indicator system was tested, and the analytic hierarchy process (AHP) was used to scientifically assign the indicators, which ensures the scientificity of this study;

4.2. The research results have practical significance
Starting from the actual situation of civilian-run universities in Hubei Province, the paper fills in the blank in the evaluation of the teaching quality of civilian-run universities in Hubei Province. The research results are realistic and diagnostic with positive significance in guiding the practice of civilian-run universities. At the same time, the research results will lay a theoretical foundation for the modernization of the governance of civilian-run universities in Hubei Province, and can be used for reference by similar universities, to promote the rapid and better development of civilian-run universities in Hubei Province.
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