Research on the Decision-Making Model of College Enrollment Target Group Selection Based on AHP Analysis

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Abstract. In view of the decision-making problem of target student source group selection in Colleges and universities, this paper makes a multi-objective feasibility analysis of target student source selection, and finds a method to help colleges and universities optimize the structure of student source. In order to analyze the multiple indicators and feasibility of the selected project, the analytic hierarchy process is used to establish a comprehensive evaluation and analysis structure model of the feasibility study, and the feasibility study conclusion of the target student source group selection decision is obtained. It is found that the model can better study the feasibility of the decision-making of the target group of college enrollment.

Keywords: college enrollment · Target students · Analytic hierarchy process

1 Question Raising

The demand for continuous optimization of the student source structure has gradually become one of the most important needs of colleges and universities in talent training. With the deepening of the comprehensive reform of the college entrance examination, college enrollment is in a situation of fierce competition. In the environment of fierce competition, in order to achieve the goal of optimizing the structure of student sources, colleges and universities must make accurate decisions about the selection of target student source groups.

At present, when selecting the target student source group, domestic universities lack comprehensive analysis, comparison and objective verification of various influencing factors, and usually make subjective judgments based on subjective experience and

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simple data statistics. Therefore, it is often difficult to achieve the goal of optimizing the student source structure in the selection of the target student source group.

Based on the analytic hierarchy process (AHP), this paper makes a multi-objective feasibility study on the decision-making of college enrollment target student source group, and draws a feasibility study conclusion.

2 Introduction to Analytic Hierarchy Process

Analytic hierarchy process (AHP) is a systematic and hierarchical analysis method combining qualitative and quantitative analysis. The characteristic of this method is that on the basis of in-depth study of the nature, influencing factors and internal relations of complex decision-making problems, it makes use of less quantitative information to mathematicize the thinking process of decision-making, thus providing a simple decision-making method for complex decision-making problems with multi-objective, multi criteria or no structural characteristics. It is a model and method for making decisions on complex systems that are difficult to fully quantify [1].

The principle of AHP is that according to the nature of the problem and the overall goal to be achieved, the AHP decomposes the problem into different constituent factors, and aggregates and combines the factors according to different levels according to the mutual correlation and subordination between the factors, forming a multi-level analytical structure model, Thus, the problem is finally reduced to the determination of the relatively important weight of the lowest level (the scheme and measures for decision making) relative to the highest level (the overall goal) or the arrangement of the relative order of advantages and disadvantages.

The steps of the analytic hierarchy process can be roughly divided into four steps when using the analytic hierarchy process to construct a system model: establishing a hierarchical structure model, constructing a judgment (pairwise comparison) matrix, ranking single and its consistency test, and ranking general and its consistency test.

3 Establishment of the Decision-Making Model for the Selection of College Enrollment Target Students

3.1 Establishment of Hierarchy Model

In the analytic hierarchy process, the goal of decision-making, the factors considered (decision criteria) and the objects of decision-making are divided into the highest level, the middle level and the lowest level according to their mutual relations, and the hierarchical structure chart is drawn, as shown in Fig. 1. Among them, the highest level is the target level, which is the purpose of decision-making and the problem to be solved, that is, to select the target source group; The middle layer is the criterion layer, which is the influencing factor and the criterion affecting decision-making that colleges and universities need to consider when selecting the target student source group. It forms the set $F = \{f_1, f_2, \cdots, f_m\}$ [2].

The lowest layer is the scheme layer, which is the alternative source group for colleges and universities when selecting the target source group, which forms the set

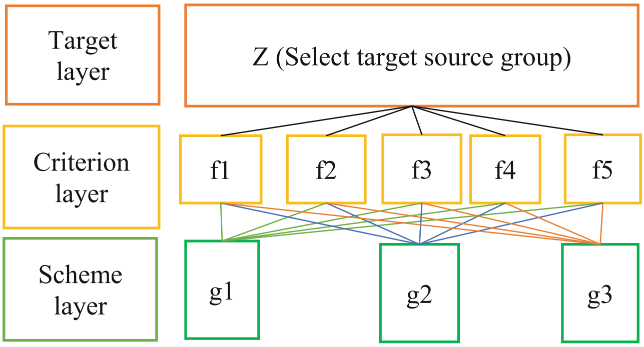

Fig. 1. A decision-making hierarchy model for the selection of target student groups in Colleges and Universities

$G = \{g_1, g_2, \cdots, g_n\}$. In order to facilitate analysis and research, this paper selects the five most critical factors that affect the selection of target students by colleges and universities:

$$f_1 = \text{Comprehensive quality}$$

$$f_2 = \text{Selected subjects}/\mathit{Disciplines}$$

$$f_3 = \text{Academic level}$$

$$f_4 = \text{Simulation test results}$$

$$f_5 = \text{Place of origin}$$

to make decisions for three groups of students:

$$g_1 = \text{Training institution candidates}$$

$$g_2 = \text{On site candidates at the consultation meeting}$$

$$g_3 = \text{Student source base: middle school candidates.}$$

3.2 Construction of Pairwise Comparison Matrix

In order to more accurately select the target student source group, it is necessary to determine the impact degree of each influencing factor at the criterion level, that is, the weight. When determining the weight, it is difficult to obtain accurate results if only qualitative analysis is performed, so quantitative analysis is required. Since it is difficult to comprehensively compare the influencing factors, we should first compare the two factors, and use the relative scale to reduce the difficulty of comparing the factors with different properties and improve the accuracy, so as to construct a comparison matrix. The pairwise comparison matrix represents the comparison of the relative importance of all the influencing factors of the criterion layer to the target layer. The element a_{ij} of the paired comparison matrix represents the comparison result of the i factor with respect to the j factor, that is, $a_{ij} = \left(f_i : f_j\right)$, from which it can be concluded that the paired comparison matrix is

$$A = \left(a_{ij}\right)_{n\times n} = \begin{pmatrix} a_{11} & \ldots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{pmatrix}$$

among $a_{ij} > 0, a_{ij} = \frac{1}{a_{ji}}, a_{ii} = 1$

In order to facilitate the calculation of a_{ij}, the 1–9 scale method proposed by Santy is used to assign the value [3], as shown in Table 1.

Accordingly, in the selection of target student source group, the results of the comparison of the impact of each influencing factor at the criterion level on the target level are as Table 2.

Table 1. Santy 1–9 scale method

aij	Meaning
1	Indicates that the influence of the fi factor is the same as that of the fj factor on the target student source group selected by universities
3	Indicates that the influence of the fi factor is slightly stronger than that of the fj factor on the selection of target student source groups by colleges and universities
5	Indicates that the influence of the fi factor is stronger than that of the fj factor on the selection of target student source groups by colleges and universities
7	Indicates that the influence of the fi factor is obviously stronger than that of the fj factor on the selection of target student source groups by colleges and universities
9	Indicates that the influence of the fi factor is absolutely stronger than that of the fj factor on the selection of target student source groups by colleges and universities
2, 4, 6, 8	Indicates that the influence of the fi influencing factor on the target student source group selected by universities is between the above two adjacent grades compared with the fj influencing factor.

Table 2. Comparison matrix of the influence of each influencing factor of the criterion layer on the target layer Z

Z	**f1**	**f2**	**f3**	**f4**	**f5**
f1	1	1/2	4	3	3
f2	2	1	7	5	5
f3	1/4	1/7	1	1/2	1/3
f4	1/3	1/5	2	1	1
f5	1/3	1/5	3	1	1

According to Table 2, the pairwise comparison matrix can be obtained as follows:

$$A = \begin{Bmatrix} 1, \frac{1}{2}, 4, 3, 3 \\ 2, 1, 7, 5, 5 \\ \frac{1}{4}, \frac{1}{7}, 1, \frac{1}{2}, \frac{1}{3} \\ \frac{1}{3}, \frac{1}{5}, 2, 1, 1 \\ \frac{1}{3}, \frac{1}{5}, 3, 1, 1 \end{Bmatrix}$$

In order to sort these factors, this paper introduces the concept of consistency matrix method proposed by Santy et al., that is, in A of the pairwise comparison matrix, if $a_{ik} \times a_{kj} = a_{ij}$, then A is the consistency matrix [4], and its expression is

$$A = \begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \vdots & & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{pmatrix}$$

where w_i represents the influence weight of the influencing factor f_i on the target student source group selected by the University, and $w_1 + w_2 + \cdots + w_n = 1$.

The consistency matrix A has the following properties [5]:

- $a_{ij} = \frac{1}{a_{ji}}, a_{ii} = 1, i, j = 1, 2, \cdots, n$;
- A^T is also a consistency matrix;
- The rows of A are proportional, then $rank(A) = 1$;
- The maximum characteristic root (value) of A is $\lambda_{\max} = n$, and the other $n - 1$ characteristic roots are all 0;
- Any column (row) of A is the eigenvector corresponding to the eigenroot n;
- The normalized eigenvector of A can be used as the weight vector.

If the pairwise comparison matrix is a consistency matrix, take the normalized eigenvector $\{w_1, w_2, \cdots, w_n\}^T$ corresponding to the largest eigen root n, and the sum of them is 1; If the pairwise comparison matrix is not a consistency matrix, it is suggested to use the normalized eigenvector corresponding to its largest eigen root as the weight vector w [7], then $Aw = \lambda w$, $w = \{w_1, w_2, \cdots, w_n\}^T$ [6].

3.3 Consistency Inspection

When judging whether the paired comparison matrix is a consistency matrix, you can judge its maximum characteristic root $\lambda_{\max}$. Generally speaking, the maximum characteristic root $\lambda_{\max} \geq n$, when and only when $\lambda_{\max} = n$, the paired comparison matrix is a consistency matrix, thus defining the consistency index

$$FI = \frac{\lambda_{\max} - n}{n - 1}$$

The larger the FI, the more serious the inconsistency [8]. Assuming that the random consistency index is RI, the consistency ratio is

$$FR = \frac{FI}{RI}$$

If 500 pairwise comparison matrices $A_1, A_2, \cdots, A_{500}$ are randomly constructed, the consistency index $FI_1, FI_1, \cdots, FI_{500}$ can be obtained, from which

$$RI = \frac{FI_1 + FI_1 + \cdots + FI_{500}}{500} = \frac{\frac{\lambda_1 + \lambda_2 + \cdots + \lambda_{500}}{500} - n}{n - 1}$$

According to statistics, the value of the random consistency index RI can be obtained [9], as shown in Table 3.

In the consistency test, when $RI < 0.1$, it is considered that the consistency test has been passed, and the properties of the consistency matrix can be applied to the pairwise comparison matrix[10].For pairwise comparison matrix

$$A = \begin{Bmatrix} 1, \frac{1}{2}, 4, 3, 3 \\ 2, 1, 7, 5, 5 \\ \frac{1}{4}, \frac{1}{7}, 1, \frac{1}{2}, \frac{1}{3} \\ \frac{1}{3}, \frac{1}{5}, 2, 1, 1 \\ \frac{1}{3}, \frac{1}{5}, 3, 1, 1 \end{Bmatrix}$$

Table 3. Consistency index value

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

its maximum characteristic root $\lambda_{\max} = 5.073$, the weight vector (eigenvector) is

$$w = (0.263, 0.475, 0.055, 0.090, 0.011)^T$$

the consistency index is

$$FI = \frac{5.075 - 5}{5 - 1} = 0.018$$

the random consistency index is $RI = 1.12$, the consistency ratio is $CR = \frac{0.018}{1.12} = 0.016 < 0.1$.

3.4 Hierarchy Ranking and Consistency Inspection

After the consistency check is completed, it is necessary to calculate the combined weight vector [11]. The weight vector of the criterion layer to the target layer is

$$w^{(2)} = \left(w_1^{(2)}, w_2^{(2)}, \cdots, w_n^{(2)}\right)^T = [0.2636, 0.4758, 0.0538, 0.0981, 0.1087]^T$$

and the weight vector of each influencing factor in the scheme layer to the target layer is as follows:

The pairwise comparison matrix of scheme layer pair f_1 is

$$G_1 = \begin{vmatrix} 1, 2, 5 \\ \frac{1}{2}, 1, 2 \\ \frac{1}{5}, \frac{1}{2}, 1 \end{vmatrix}$$

Maximum characteristic root $\lambda_1 = 3.005$, weight vector $w_1^{(3)} = [0.5954, 0.2764, 0.1283]$.

The pairwise comparison matrix of scheme layer pair f_2 is

$$G_2 = \begin{vmatrix} 1, \frac{1}{3}, \frac{1}{8} \\ 3, 1, \frac{1}{3} \\ 8, 3, 1 \end{vmatrix}$$

Maximum characteristic root $\lambda_2 = 3.002$, weight vector $w_2^{(3)} = [0.0819, 0.2363, 0.6817]$.

The pairwise comparison matrix of scheme layer pair f_3 is

$$G_3 = \begin{vmatrix} 1, 1, 3 \\ 1, 1, 3 \\ \frac{1}{3}, \frac{1}{3}, 1 \end{vmatrix}$$

Maximum characteristic root $\lambda_3 = 3.000$, weight vector $w_3^{(3)} = [0.4286, 0.4286, 0.1429]$.

The pairwise comparison matrix of scheme layer pair f_4 is

$$G_4 = \begin{vmatrix} 1, 3, 4 \\ \frac{1}{3}, 1, 1 \\ \frac{1}{4}, 1, 1 \end{vmatrix}$$

Maximum characteristic root $\lambda_4 = 3.009$, weight vector $w_4^{(3)} = [0.6337, 0.1919, 0.1744]$.

The pairwise comparison matrix of scheme layer pair f_5 is

$$G_5 = \begin{vmatrix} 1, 1, \frac{1}{4} \\ 1, 1, \frac{1}{4} \\ 4, 4, 1 \end{vmatrix}$$

Maximum characteristic root $\lambda_5 = 3.000$, weight vector $w_5^{(3)} = [0.1667, 0.1667, 0.6667]$.

The *FI* can be obtained as shown in Table 4.

It is concluded that $RI = 0.58(n = 3)$ and FI_k can pass the consistency test. For the target layer, the combination weight of g_1 for the decision-making of selecting the target student source group of college enrollment is

$$\begin{aligned} Z_1 &= 0.595 \times 0.263 + 0.082 \times 0.475 + 0.429 \times 0.055 \\ &+ 0.633 \times 0.099 + 0.166 \times 0.110 = 0.3 \end{aligned}$$

In the same way, it can be concluded that the combined weight of g_2 on the selection decision-making of college enrollment target student source group is $Z_2 = 0.245$, and the combined weight of g_3 on the selection decision-making of college enrollment target student source group is $Z_3 = 0.455$.

Table 4. FI value

$w^{(2)}$	0.263	0.475	0.055	0.090	0.110
$w_k^{(3)}$	0.595	0.082	0.429	0.633	0.166
λ_k	0.277	0.236	0.429	0.193	0.166
	0.129	0.682	0.142	0.175	0.668
	3.005	3.002	3.000	3.009	3.000
FI_k	0.003	0.001	0.000	0.005	0.000
$w^{(2)}$	0.263	0.475	0.055	0.090	0.110

Therefore, the authority of the scheme layer to the target layer is $\{0.3, 0.245, 0.455\}$, that is, the weight of each scheme is $g_3 > g_1 > g_2$. Therefore, for colleges and universities, middle school candidates in the source base are the best choice decisions for the target source group.

4 Conclusion

This paper uses AHP to build a model for the decision-making problem of target group selection of college enrollment, and carries out multi-objective analysis, evaluation and research. By constructing the pairwise comparison matrix, calculating the weight of the influencing factors and analyzing the consistency, the selection decision of the target group of college enrollment is obtained. The research conclusion of this paper can better guide colleges and universities to select the target student source group, and provide methods for colleges and universities to optimize the student source structure.

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