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Research on Higher Education Evaluation Based on Decision Tree and AHP

Tongzhenzhi Su

Institute of Control Science and Engineering, North China Electric Power University, Baoding, Hebei, China

Abstract: *Higher education is of great significance in a country, both for the value of the industry and for the economy. First, we use the decision tree and AHP to establish an evaluation model based on the weight of criteria layer, which can evaluate the health degree of any country. Meanwhile, we conduct sensitivity analysis on the weight results. Then, we apply our model in the United States, Japan and South Korea for evaluation, compare the evaluation results of the TOPSIS evaluation model, further verify the correctness of the model, and obtain the evaluation scores of higher education health of the three countries. In the process of modeling, the correlation between various factors is emphasized, and quantifiable values are used as the link as far as possible. Through the relationship between each layer in the decision tree, we combine it with the weight to ensure research direction of the problem and the predicted index. This research method helps us to determine the best research direction in the evaluation of the higher education system with many influencing factors, and eliminates the interference of too many factors, so that our analysis and proposed policies are more targeted. Intuitive graphs also help us analyze the problem more effectively.*

Keywords: *Decision tree; AHP; TOPSIS model*

1. Introduction

With the economy globalizing and the modernization process accelerating, the enhancement of a country's comprehensive strength and the improvement of its status are increasingly inseparable from the development of its educational level. Then, a healthy, sustainable higher education system plays an important role in the cultivation of social talents and the promotion of social economy. [1]

The higher education system, the main social activity for cultivating senior professionals, counts a lot in a country's citizens' vocational education based on their completing secondary education. It is often said that knowledge can change destiny. A healthy education system can not only affect the fate of individuals, but also has the value of industry and cultivating multi-level and high-level talents for the country. This means that higher education has a great influence on of a country's politics, economy, culture, military and other aspects of a country. [2]

2. Higher Education Evaluation Model Based on AHP

In order to establish a comprehensive and detailed higher education evaluation system, we need to clarify higher education's essential evaluation indicators and influencing factors. According to the research data of Pan Xingxia and others [3], we consider that the establishment of a scientific and reasonable evaluation system has the following principles: the scientific nature of the evaluation goal, the rationality of the process, the achievement degree of the goal and the long-term effect. Therefore, our group decide to set five criterions of a healthy and sustainable higher education system as listed:

B_1: economic level

B_2: the quality higher education

B_3: research level

B_4: industrial structure level

Considering that our target model is affected by multiple factors and it is difficult to make a complete quantitative or qualitative analysis, we decide to adopt the Analytic Hierarchy Process to obtain the

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weight of each influencing factor. The general steps of AHP are shown in Figure 1.

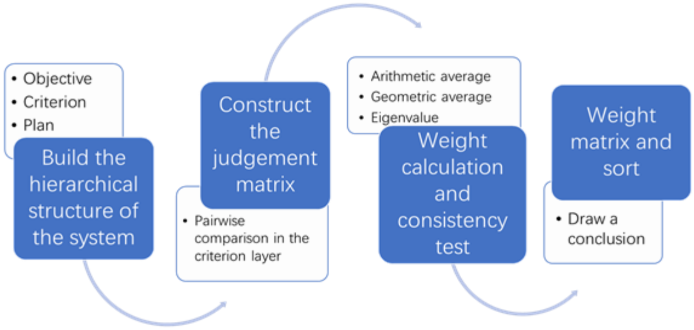

Figure 1: Analytic Hierarchy Process analysis steps

We decompose the decision model into three levels. We try to reduce the collinearity of elements in the criterion layer B in the selection process, and we obey the following principles when selecting the scheme layer. First, make sure that they reflect different levels of social indicators as far as possible. Next, try to find a social indicator that is highly relevant to each indicator of the scheme level. These principles make it easy for us to quantify them in subsequent evaluations and use our model to calculate their scores.

The hierarchical structure model we finally established is in Figure 2:

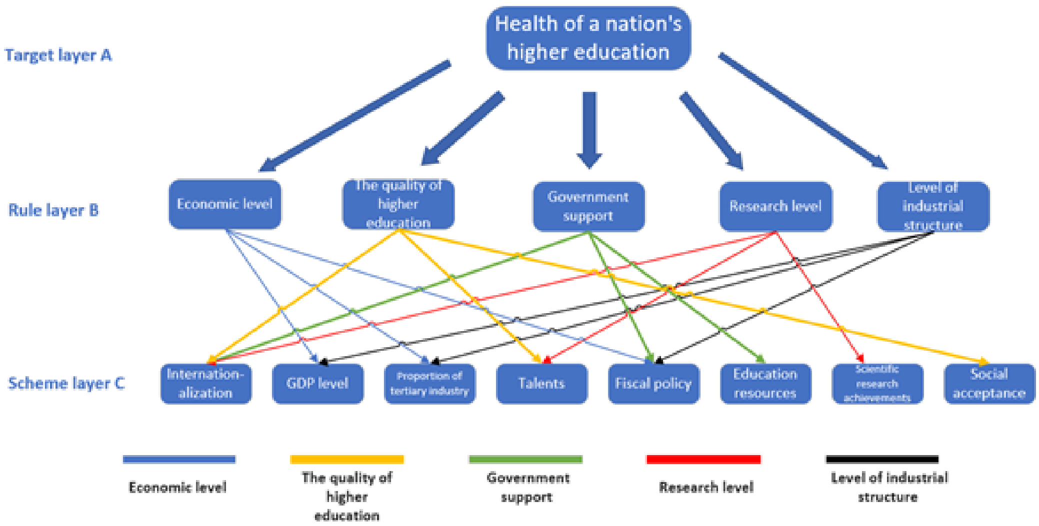

Figure 2: Education impact hierarchical chart

Using expert analysis, we make pairwise comparison of five elements in rule layer B with respect to the importance of target layer A, and we get a paired comparison matrix as follows.

Table 1: Judgment matrix

	x1	***x2***	***x3***	***x4***	***x5***
x1	1	7	2	2	5
x2	1/7	1	1/3	1/3	1/2
x3	1/2	3	1	1	2
x4	1/2	3	1	1	2
x5	1/5	2	1/2	1/2	1

Note:

Scale	**Meaning**
1	Equal importance
3	A little important
5	Obviously important
7	Highly important
2,4,6	The median of the above two adjacent judgments
Reciprocal	If A is compared with B if the scale is 3, then B is 1/3 compared with A

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Then, we solve the eigenvalue A, get the maximum eigenvalue

$$\lambda_{max} = 5.0176 \tag{1}$$

The weight vector w_i:

$$w_i = (0.4341,0.0616,0.2011,0.2011,0.1022)^T \tag{2}$$

Calculated by

$$\mathrm{CI} = \frac{\lambda_{max} - n}{\mathrm{n} - 1} \tag{3}$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{4}$$

We get CR=0.0039, so we pass the consistency test.

Therefore, we obtain the respective weights of the five evaluation indicators at the rule layer. Next, we use the sensitivity analysis of the black start scheme [4] based on the fuzzy analytic hierarchy process, and calculate the marginal weight $w_{r'}$ and $w_{s'}$.

$$\begin{cases} w_r' = \overline{w}_r - \dfrac{f(\bar{S}_p) - f(\bar{S}_q)}{[\bar{x}_{pr} - \bar{x}_{qr} - (\bar{x}_{ps} - \bar{x}_{qs})]} \\ w_{s'} = \overline{w}_s - \dfrac{f(\bar{S}_p) - f(\bar{S}_q)}{[\bar{x}_{ps} - \bar{x}_{qs} - (x_{pr} - \bar{x}_{qr})]} \end{cases} \tag{5}$$

According to the principle of sensitivity analysis, we conduct a sensitivity analysis on the weight of the criterion layer towards the overall goal, and calculate the attribute value of each scheme relative criterion. The Eq.5 is used to obtain the marginal weight that makes the marginal weight that makes the comprehensive evaluation value of S_p and S_q equal, as shown in Table 3. The specific calculation steps are as follows:

Table 2: Rule layer indicator hypothesis value

	B1	**B2**	**B3**	**B4**	**B5**
S_p	1	3	4	5	7
S_q	2	5	6	1	4

$$f(\cdot) = 0.4341 * B1 + 0.0616 * B2 + 0.2011 * B3 + 0.2011 * B4 + 0.1022 * B5 \tag{6}$$

$$f(S_p) = 0.4341 * 1 + 0.0616 * 3 + 0.2011 * 4 + 0.2011 * 5 + 0.1022 * 7 = 3.1442 \tag{7}$$

$$f(S_q) = 0.4341 * 2 + 0.0616 * 5 + 0.2011 * 6 + 0.2011 * 1 + 0.1022 * 4 = 2.9927 \tag{8}$$

Table 3: Marginal weight table

Adjustment criterion layer	**Marginal weight**	
Bi, Bj	***Bi'***	***Bj'***
B1, B2	0.9214	-0.4257
B1, B3	5.1833	-4.5481
B1, B4	0.5564	-0.0788
B1, B5	0.6386	-0.1023
B2, B3	-0.4814	0.7441
B2, B4	0.2249	-0.0378
B2, B5	0.4141	-0.2502
B3, B4	0.3267	-0.0755
B3, B5	0.4149	-0.1115
B4, B5	-0.1032	0.40653

It can be seen from Table 3 that each group of marginal weights has a negative number or a number greater than 1, that is to say the marginal weights are not within the allowable value range of actual weights, so it can be known that the weights are insensitive. So the ranking of scheme S_p and scheme S_q cannot be changed no matter how the weight changes within the actual allowable range. Therefore, the calculated results are consistent with the actual situation.

We have discussed the rationality of our index and weight, and now we will give our evaluation index.

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If the score of B_1, B_2, B_3, B_4 and B_5 is X_1, X_2, X_3, X_4, X_5, and their weight is P_1, P_2, P_3, P_4, P_5, then we can score the educational development status of a country.

$$S = P1 * X1 + P2 * X2 + P3 * X3 + P4 * X4 + P5 * X5 \tag{9}$$

Our model's evaluation criterion for national health status indicators is based on the product of the national education development status score S in the Eq.9 and the weighted economic correction coefficient.

$$\eta_1 = \frac{\sum_{i=2}^{5} p_i X_i}{p_1 X_1} \tag{10}$$

$$H = S * \eta_1 \tag{11}$$

Therefore, we complete the establishment of the health status evaluation model for national higher education.

We have carried out sensitivity analysis on the decision tree AHP model to verify the feasibility of the results. Later, we will further verify the rationality of the results of the AHP model by taking advantage of the objectivity advantage of TOPSIS model in weight allocation after data introduction.

3. Model Solving

Next, we will use our model to evaluate the education and health status of the United States, Japan, and South Korea. In the five indicators in the three national standard layers, we select the five components in the scheme layer that are linearly positively correlated with them, which are GDP per capita, higher education scores, cost of higher education high-end, scientific research, the proportion of the tertiary industry. They respectively correspond to economic level, the quality of education, government support, research level, level of industrial structure.

Although they cannot reflect the full appearance of the five criteria, they can objectively reflect the degree of excellence of countries in the criteria through the mathematically good linear correlation with them. Checking the website, we get the five aspects of data from three countries as follows: [5][6][7][8]

Table 4: Data indicators for three countries

Country	GDP per capita	Higher Education Scores	Cost of Higher Education	High-end scientific research	The proportion of the tertiary industry
Japan	4.02	78.51	20.60%	4.16%	69%
The United States	6.51	100.2	19%	33%	77%
Korea	3.18	80.11	15.00%	3.74%	57%

Where, the unit of GDP is ten thousand (dollars), and the ratio of higher education expenses to GDP per capita is used to quantify the cost of higher education indicator. In addition, we notice that Cost of Higher Education is a minimal type indicator (the smaller the value, the better), so we take the reciprocal of their value in the evaluation as their original score. We also note that High-end scientific research requires the introduction of national population numbers to make a rough correction so that it can be relativized and compared. Therefore, the column value is divided by the country's population as the original score for this column. From this, we get normalized score table.

Furthermore, we use matlab for evaluation to obtain the standardized scoring matrix under the TOPSIS model.

Table 5: Standardized scoring matrix for three countries

Country	GDP per capita	Higher Education Scores	Cost of Higher Education	High-end scientific research	The proportion of the tertiary industry
Japan	0.485172983	0.521992838	0.49617647	0.254504107	0.583615171
The United States	0.785690578	0.666204081	0.538121285	0.782481571	0.654663974
Korea	0.383793554	0.532630828	0.681347483	0.56828712	0.480425242

Similar to the weighted economic correction coefficient in the AHP evaluation model, we define the following standardized GDP correction coefficient:

$$\eta_2 = \frac{\sum_{i=2}^{5} X_i}{X_1} \tag{12}$$

Due to the characteristics of matrix standardized calculation in the TOPSIS model, weights have been

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introduced in the process. Thus, this formula has no weight. Similarly, standardized scoring matrix of higher education under the national health score is:

$$H = S * \eta_2 \tag{13}$$

In the end, we get the normalized scores of Japan, the United States, and South Korea under two evaluation methods:

Table 6: Corrected normalized scores for the three countries

Country	TOPSIS	Our model
Japan	0.1758	0.205
The United States	0.4722	0.4701
Korea	0.3519	0.3248

It is easy to find that the scoring results of the two are very close in the end. This not only directly gives an intuitive conclusion on the development of higher education health in Japan, the United States and South Korea, but also further confirms the rationality of our model.

4. Conclusion

In this paper, we established an evaluation model for the healthy and sustainable development of higher education, measure the health of a country's higher education system. Based on the model test and analysis of Japan, The United States and Korea, we found that Japanese industrial structure level is relatively consistent with health standards. However, there is still much room for improvement in the quality of higher education, government support, and scientific research. We propose the following suggestions to help Japan achieve sustainable and healthy development of the higher education system:

Pay attention to scientific management. The management system is the basic pillar of the school management system, and it is also the guarantee to ensure the orderly and efficient operation of the school's various tasks. Scientific and innovative are the inherent requirements of the management system. With the deepening of higher education teaching reform and the advancement of new curriculum experiments, the original management system is so difficult to adapt to new conditions and new requirements that it is imperative to adjust, enrich, improve and innovate the management system. The merits of a school lie not only in the sound management system, but also in the fact that these systems are truly in place, and the staffs have a strong sense of objecting the relevant policy.

Focus on teacher-education-level development. Teaching faculty is the key to deepening teaching reform and ensuring education quality. Increasing teaching investment is the fundamental guarantee and basic prerequisite for talent training. Therefore, schools and governments should implement the scientific concept of higher education development, firmly establish the central position of talent training, and adhere to the development path centered on stabilizing scale, optimizing structure and improving quality.

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