

# *Research on the Model of higher Education system based on Fuzzy Comprehensive Evaluation of Multi-index system*

Jingyun Su\*, Yin Rui

*Beijing Jiaotong University, Beijing, 100044, China*

\*Corresponding author

**Keywords:** The entropy method, The analytic hierarchy process, The fuzzy comprehensive evaluation method

**Abstract:** Higher education is one of the important indicators of national development. It not only has its own industrial value, but also trains high-quality citizens for the country. The research around this theme can provide effective help for the development of national higher education and the improvement of national higher education level. In order to analyze the health status of higher education in each country, all countries are divided into four categories: high-income, high-and middle-income, low-and middle-income countries. There are three aspects of comprehensive evaluation. First of all, statistics are made on 11 factors, such as enrollment rate, employment rate, graduate rate and total national education expenditure, which are used as indicators to analyze the health status of the national education system. Then the entropy method and analytic hierarchy process are used to distribute the weight of each index, and then the fuzzy comprehensive evaluation method is used to determine the quality of the national higher education system.

## 1. Introduction

Education is related to the growth of individuals and the rise and fall of the nation, and is the foundation of major projects for people's livelihood and the prosperity of the country [1]. Looking around the world, different countries have different higher education systems. However, in the context of the global fourth industrial revolution and the raging new crown epidemic, the higher education systems of many countries have been unable to adapt to the status. The reform of higher education is the only way for every country to develop. Countries have made different attempts, like classify teaching, online teaching and so on [2]. The higher education system is facing unprecedented challenges. How to reform and whether reform can break through difficulties and effectively advance has become a new problem.

## 2. Entropy weighting method

Use the data of various indicators in the last ten years to calculate and observe the degree of variation of each indicator. The smaller the degree of variation, the less the amount of information

reflected and the lower the corresponding weight. First, data and evaluation indicators form matrix D, as follows:

$$D = \begin{bmatrix} d_{11} & d_{12} & \dots & d_{1j} \\ d_{21} & d_{22} & \dots & d_{2j} \end{bmatrix} \quad (1)$$

The calculation formula for each element is:

$$s_{ij} = d_{ij} / \sqrt{\sum_{i=1}^n d_{ij}^2} \quad (2)$$

According to the calculation result, the matrix S is obtained. Then calculate the probability matrix P, where each element is calculated as:

$$p_{ij} = \frac{S_{ij}}{\sum_{i=1}^n S_{ij}} \quad (3)$$

After normalizing the information utility value, the entropy weight of each indicator is obtained.

### 3. Analytic hierarchy process and comprehensive evaluation model

#### 3.1 Establishment of Analytic hierarchy process Model

The analytic hierarchy process is used to calculate the weights of individuals, schools and countries [3]. Compare the three elements in pairs to get the following judgment matrix:

$$C = \begin{bmatrix} 1 & 5 & 8 \\ \frac{1}{5} & 1 & 1 \\ \frac{1}{8} & 1 & 1 \end{bmatrix} \quad (4)$$

Element of it satisfies  $c_{ij} = 1/c_{ji} (i, j = 1, 2, \dots, n)$ . Solving for the eigenvalues of C, we get  $\lambda_{\max} = 3.0246$ , calculate the consistency index  $CI = \frac{\lambda_{\max} - n}{n - 1}$ , according to  $CR = 0.0236 < 0.1$ , passed the consistency test.

Table 1: The relationship between n and RI

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58	1.59

The result of the arithmetic average method for weighting is: (0.7563, 0.1313, 0.1124). The result of the geometric average method to calculate the weight is: (0.7592, 0.1298, 0.1110). The result of eigenvalue method for weighting is: (0.7592, 0.1298, 0.1110)

#### 3.2 Carrying out fuzzy comprehensive evaluation

First, establish an evaluation system [4], classify each evaluation index and determine the factor set of each layer.

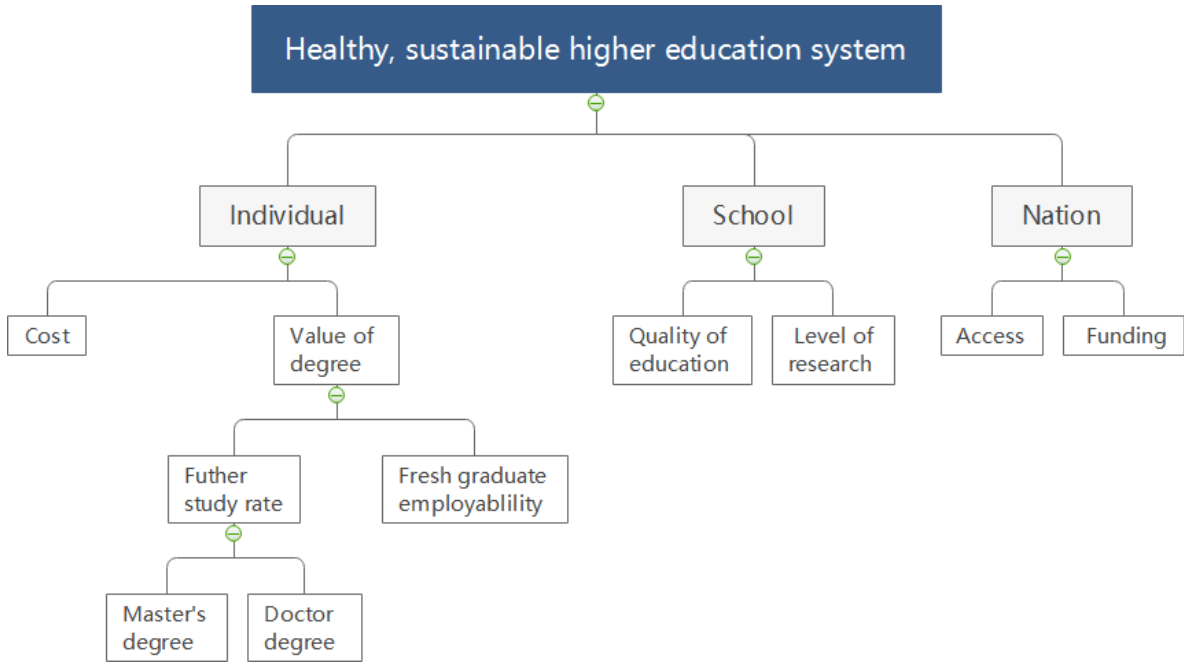


Figure 1: Higher Education System Evaluation Model Based on Fuzzy Comprehensive Evaluation Method

Determine the fuzzy set  $V = \{1, 2, 3, 4\}$ . Then establish membership function. We divide the collected data into four levels, the parameter  $\alpha_1, \alpha_2, \alpha_3, \alpha_4$  is the division index and the following function is established based on the survey data (here take ri1 as an example.):

$$r_{i1} = \begin{cases} 1, & x \leq \alpha_1 \\ \frac{\alpha_2 - x}{\alpha_2 - \alpha_1}, & \alpha_1 < x < \alpha_2 \\ 0, & x \geq \alpha_2 \end{cases} \quad (5)$$

Calculate the membership degree corresponding to each index through the membership function and get the single factor evaluation [5] [6] matrix R. In the previous calculation, there is the weight matrix W, hence the final evaluation score is:

$$B = U \cdot W \cdot R = [b_1, b_2, b_3, b_4] \quad (6)$$

$$En = \sum_{i=1}^4 b_i \quad (7)$$

#### 4. Model result

Here, take high-income countries as an example.

Table 2: High income countries

Country (0.7592)	Access(0.3172) Funding(0.6828)
School (0.1298)	School quality(0.4521) Research level(0.5479)
Individual (0.1110)	Cost(0.2196) Degree(0.7804) Employ ability(0.0103) Further study rate(0.9897) Doctor(0.5084) Master(0.4916)

By using the model above, we can calculate the subject of each item. Here is an example of the results.

Table 3: Subjection of Mexico

Nation					School				
Item	1	2	3	4	Item	1	2	3	4
Access	0	0.1508	0.8492	0	School quality	1	0	0	0
Funding	0	0.3031	0.6969	0	Research level	1	0	0	0
Individual									
Item	1	2	3	4	Item	1	2	3	4
Cost	0	0	0.2808	0.7192	Employ ability	1	0	0	0
Degree	1	0	0	0	Further study rate	1	0	0	0
Doctor	1	0	0	0					
Master	1	0	0	0					

After calculation, we arrive at the final evaluation results of the education system of four countries

Table 4: Final Results

	Nation	School	Individual	Final
UK	80.575	81.525	253.5625	99.9
Australia	20.218	9.641	195.8975	90.9225
Germany	15.7655	57.42	193.27	87.5825
Mexico	68.2425	25	127.2625	71.7975

## 5. Conclusion

Higher education not only has its own important value, but also trains high-quality citizens for the country. In this paper, according to the collected data to explore the health status of higher education in each country, and according to the income situation, each country is divided into four aspects: high-income, high-and middle-income, low-and middle-income and low-income countries. And select the enrollment rate, employment rate, graduate rate, total national education expenditure and other factors for statistics, and use this as an index to analyze the health status of the national education system. Then the entropy method and analytic hierarchy process are used to distribute the weight of each

index, and then the fuzzy comprehensive evaluation method is used to determine the quality of the national higher education system. To provide a complete and reasonable evaluation model for the health of the higher education system.

## References

- [1] HAVELOCK, R. G., HUBER, J. C., & ZIMMERMAN, S. (1969). *Major works on change in education: an annotated bibliography with author and subject indices*. Ann Arbor, Center for Research on Utilization of Scientific Knowledge, University of Michigan.
- [2] Kashiwase, H., et al. "World Bank Open Data." Data, 5 Feb. 2021, [data.worldbank.org/](http://data.worldbank.org/).
- [3] "QS Stars University Ratings." TopUniversities, 13 Dec. 2019, [www.topuniversities.com/qs-stars](http://www.topuniversities.com/qs-stars).
- [4] "Scilit - Scientific Literature." A Database of Scientific Literature, [www.scilit.net/](http://www.scilit.net/).
- [5] "Diario Oficial De La Federación." DOF, [dof.gob.mx/](http://dof.gob.mx/).
- [6] Guglielmo, Martina. "On the Failing Mexican Educational System." Open Americas, 24 July 2017, [openamericas.org/2017/07/24/on-the-failing-mexican-educational-system/](http://openamericas.org/2017/07/24/on-the-failing-mexican-educational-system/).