

Research on the Evaluation Model of the Health of the Higher Education System Based on EWM and FCE

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Abstract: We established a model for evaluating the health of the higher education system and apply it to many countries. Firstly, we built a comprehensive evaluation index system to evaluate the health of the higher education system based on the five systems and 16 indicators. We have selected six countries with different higher education cultures to evaluate. After analyzing the correlation degree of each indicator with gray correlation, we used the expert evaluation method and the entropy weight method (EWM) in contrast. The income weights are combined subjectively and objectively. Finally, through the fuzzy comprehensive evaluation (FCE) method, the health of the higher education system of each country is obtained.

1. Introduction

The higher education system is of great significance in the development of the country. Under the current circumstance, all countries are reflecting on the advantages and disadvantages of their higher education systems which need changing by preparing to implement policies. To evaluate and improve the health of the higher education system, this paper constructs an "evaluation prediction model" of the health of the higher education system.

2. Evaluation Model of the Health of Higher Education System

We proposed three levels of evaluation index to evaluate the health of the higher education system from five systems: research system, value system, talent system, education system, and policy support, and then refine the five systems to obtain the following evaluation index system architecture diagram in Figure 1.

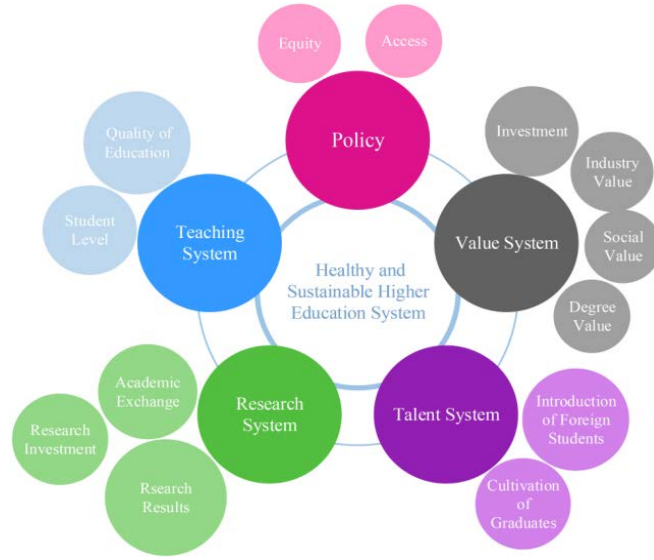


Figure 1: Index System Architecture Diagram

2.1 Study the importance of each index by EWM

According to the proposed quantitative indicators, four developed countries with different higher education methods are selected: the USA in America, Japan in Asia, Germany in Europe, and Australia. Select China as the representative of developed developing countries and Vietnam as the representative of underdeveloped countries. Check relevant information to collect research investment, number of SCI publications, natural index, number of ICCA meetings, state input, personal investment, profits of the higher education industry, number of bachelor degrees or above, the average tax paid in these six countries in 2019 by highly educated citizens and average tax paid by citizens without higher education and other data.

Process the data in the matrix to get the normalization evaluation matrix. The proportion of each sample in this indicator is $p_{mn} = \frac{x_{mn}}{\sum_{m=1}^6 x_{mn}}$, where m represents country and n represents the indicator. From the specific gravity p_{mn} , the entropy value e_n of the n th index can be calculated, and the uncertainty degree of the quantitative index data can be expressed in numerical form.

$$e_n = -k \sum_{m=1}^6 p_{mn} \ln p_{mn} \quad (k = 1/\ln 6, e_n \geq 0) \quad (1)$$

$d_n=1-e_n$ is the information utility value used to represent the deviation of e_n . Based on entropy [5], the weight index obtained by the entropy weight method (EWM) for each index is $w_n = \frac{d_n}{\sum_{n=1}^{16} d_n}$.

Looking at the weight index [6] from the information perspective, the weight index reflects the extent to which an indicator provides useful information for evaluating the health of the system.

Table 1: Weight table of each system

	Research System			Value System		Talent System		Teaching System		Policy	
	RI	RR	AE	I	V	FS	G	SL	QE	E	A
Weight	0.042	0.07	0.052	0.097	0.221	0.05	0.039	0.1	0.166	0.087	0.076
	0.164			0.318		0.089		0.266		0.163	

2.2 Gray Relational Analysis

We choose the first indicator in each system as the reference series.

$$x_0' = (x_0'(1), x_0'(2), \dots, x_0'(6))$$

Use the value of the remaining indicators in the system as a comparison sequence.

$$x_i' = (x_i'(1), x_i'(2), \dots, x_i'(6)) \quad (i = 1, 2, \dots, n - 1)$$

Then we define the correlation coefficient of the comparison series to the reference series, which describes the correlation degree between the comparison series x_i' and the reference series x_0' .

$$\zeta_i(m) = \left(\frac{\min_i \min_k |x_0'(m) - x_i'(m)| + \rho \cdot \max_i \max_m |x_0'(m) - x_i'(m)|}{|x_0'(m) - x_i'(m)| + \rho \cdot \max_i \max_m |x_0'(m) - x_i'(m)|} \right) \quad (2)$$

In formula (2), resolution coefficient $\rho \in [0, 1]$, $\min_i \min_k |x_0'(m) - x_i'(m)|$ means the two-level minimum difference and $\max_i \max_m |x_0'(m) - x_i'(m)|$ means the two-level maximum difference.

The evaluation index system contains three levels of evaluation indicators. To reduce the number of judgments required in the evaluation, we combine the correlation coefficients of small indicators to calculate the correlation coefficients for each country in the five major systems. The results are shown in the following figure.

Table 2: Table of Index Coefficients by Countries in 2019

	Research System	Value System	Talent System	Teaching System	Policy
USA	0.3074	0.3385	0.3446	0.1845	0.1500
CHINA	0.1775	0.1421	0.3208	0.1572	0.1695
GERMANY	0.2342	0.1198	0.0999	0.1272	0.1858
JAPAN	0.1732	0.1447	0.0954	0.2110	0.1735
AUSTRALIA	0.0892	0.1798	0.1298	0.2019	0.1704
VIETNAM	0.0186	0.0751	0.0094	0.1182	0.1508

2.3 Construct evaluation model by FCE

We describe the health status of the higher education system as healthy, sub-healthy, unhealthy, critical, and dead based on the analogy of human health, as shown in Figure 2.



Figure 2: Health Rating Chart

According to the index coefficients of each country obtained in the index dimensionality reduction process, we use the expert scoring method to vote on the performance of each country in the index system and obtain statistics on the votes of each country in the five major index systems in Table 3.

Table 3: Experts' scores of countries

	Research System	Value System	Talents System	Education System	Policy
USA	10 0 0 0 0	10 0 0 0 0	9 1 0 0 0	6 3 1 0 0	1 3 4 2 0
CHINA	4 5 1 0 0	4 6 0 0 0	8 2 0 0 0	3 3 3 1 0	3 3 4 0 0
GERMANY	6 4 0 0 0	2 5 3 0 0	2 7 1 0 0	1 5 2 2 0	9 1 0 0 0
JAPAN	4 4 2 0 0	5 5 0 0 0	1 6 3 0 0	8 2 0 0 0	4 4 2 0 0
AUSTRALIA	0 3 4 3 0	7 3 0 0 0	4 5 1 0 0	7 3 0 0 0	3 4 3 0 0
VIETNAM	0 0 0 3 7	0 1 6 2 1	0 0 1 5 4	0 3 4 2 1	2 4 2 2 0
	H S U C D	H S U C D	H S U C D	H S U C D	H S U C D

We determine the measurement index of country m on the index system s as r_{ms} , thereby constructing a total fuzzy evaluation matrix $R=(r_{ms})_{m \times s}$. Then we take the weight index w_n obtained by the EWM to construct the weight coefficient matrix $W (w_1, w_2, \dots, w_5)$ to perform fuzzy comprehensive evaluation (FCE). Through the fuzzy transformation of the weight coefficient matrix W and the evaluation matrix R , we obtained the judgment matrix $B=W \times R$. According to the judgment matrix, we analyze the results of a fuzzy comprehensive evaluation to get the health status of the national higher education system.

Table 4: Ranking table of national indicators

	Healthy	Sub-healthy	Unhealthy	Critical	Dead
USA	0.738	0.1376	0.0918	0.0326	0
CHINA	0.393	0.4193	0.1614	0.0266	0
GERMANY	0.3531	0.4362	0.1575	0.0532	0
JAPAN	0.5115	0.3964	0.0921	0	0
AUSTRALIA	0.4933	0.3341	0.1234	0.0492	0
VIETNAM	0.0326	0.1768	0.3387	0.2431	0.2088

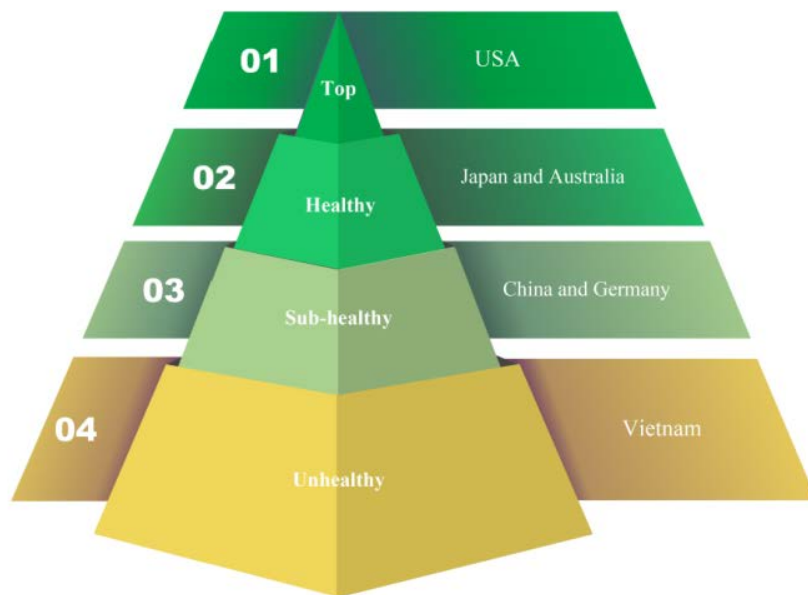


Figure 3: Rating results of the six countries

3. Evaluation and promotion of the model

The results obtained through the evaluation model of this article are in line with the degree of development of countries in the world.

Because of the limited indicators we proposed, our model can only be judged based on the changes in the indicators we proposed.

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