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

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Abstract: *We construct a global higher education quality evaluation system by using the grey relation analysis method optimized based on the TOPSIS method. According to the data, we obtained the normalized original data matrix and found the optimal and worst solutions. Then we respectively calculated the distance between each evaluation object and the optimal and worst solutions, and obtained the relative closeness of each evaluation object to the optimal solution, as the basis for evaluation. Then we used the gray correlation analysis method. According to the degree of similarity or difference in the development trend between the factors, as another way of measuring the degree of correlation between the factors, we used the combined evaluation method, combining the AHP and the coefficient of variation method. The subjective and objective data are combined to get a more reasonable weight. According to the model, the country can effectively analyze the existing problems. By weighting each indicator, countries can identify major and minor problems and then develop refined solutions.*

Keywords: *TOPSIS; Grey Relational Analysis; Higher Education System*

1. Introduction

The outbreak of Covid-19 has resulted in traffic blockage, university closures, cancellation of online teaching, decreased student flow, and the phenomenon of "local internationalization" is becoming ever more common. Each country begins to pay more attention to the advantages and disadvantages of the internal structure of its higher education system, and pay more attention to the health status, rationality, and sustainability of the higher education system, and whether it will contribute to the future development of its own country and the world. Therefore, it is necessary to measure the health of the higher education system..

We developed a model to measure and assess the health of any nation’s system of higher education.

2. Evaluation Model of the Health of Higher Education System

2.1. Evaluation Index

Table 1: Evaluation index

Level 1	Level 2	Level 3
The health of national higher education	Input (A)	Scientific research expenditure as a percentage of GDP (A1)
		The number of teachers (A2)
		Annual average tuition fees (A3)
		Enrollment rates in higher education (A4)
	Output (B)	The number of scientific papers (B1)
		Graduation rate (B2)
		The employment rate (B3)
	Internationalization (C)	The number of foreign students (C1)
		The number of top 500 scientific research institutions (C2)
		The number of Nobel prize winners (C3)

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2.2. TOPSIS Model

2.2.1. Matrix Constructing

The original data matrix is constructed as $\boldsymbol{X}=(x_{ij})_{n\times m}$. Then construct a weighted normalization matrix, and the index is a vector normalized, each column element is divided by the norm of the current column vector (using the cosine distance metric).

$$z_{ij}=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{n}x_{ij}^2}} \quad (1)$$

Thus, the normalized matrix $\boldsymbol{Z}=(z_{ij})_{n\times m}$ after normalization is obtained.

2.2.2. Extreme Value Establishment

The optimal plan and the worst plan are determined by the normalized initial matrix. The optimal plan z^+ is composed of the maximum value of each column element in Z^+. The worst plan z^- is composed of the minimum value of each column of elements in Z^-.

$$\begin{aligned}Z^+ &= (\max\{z_{11},z_{21},\cdots,z_{n1}\},\ \max\{z_{12},z_{22},\cdots,z_{n2}\},\ \cdots,\ \max\{z_{1m},z_{2m},\cdots,z_{nm}\})\\ &= (Z_1^+,Z_2^+,\cdots,Z_m^+)\end{aligned} \quad (2)$$

$$\begin{aligned}Z^- &= (\min\{z_{11},z_{21},\cdots,z_{n1}\},\ \min\{z_{12},z_{22},\cdots,z_{n2}\},\ \cdots,\ \min\{z_{1m},z_{2m},\cdots,z_{nm}\})\\ &= (Z_1^-,Z_2^-,\cdots,Z_m^-)\end{aligned} \quad (3)$$

2.2.3. Weight Establishment

We use the Analytic Hierarchy Process (AHP) to obtain subjective weights based on the relative importance of the indicators. Then, we calculate the average value, variance, and coefficient of variation of each indicator in each country, and establish the weight of the evaluation indicator w_i (i=1,2..., m). Using the coefficient of variation method, the formula for calculating the coefficient of variation of each indicator is:

$$v_j=\frac{s_j}{|\bar{x}_j|},\ \bar{x}_j=\frac{1}{13}\sum_{i=1}^{13}a_{ij},\ s_j^2=\frac{1}{13-1}\sum_{i=1}^{13}\left(a_{ij}-\bar{x}_j\right)^2 \quad (4)$$

2.2.4. Optimal Result

Finally, the objective weights are obtained. Using the combined evaluation method, combining the subjective weight and the objective weight to get the final weight.

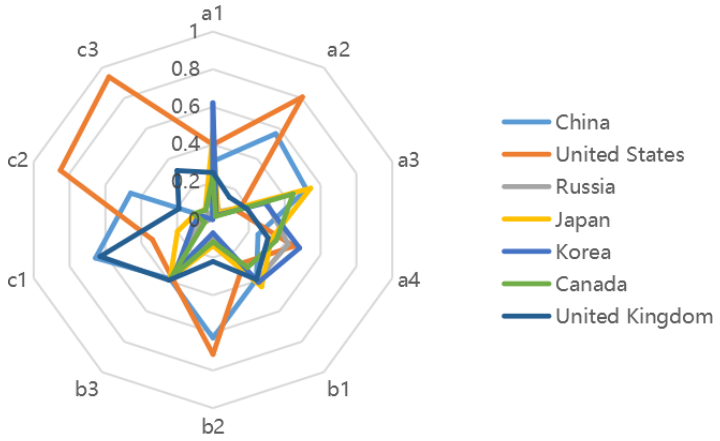

Figure 1: The weight of each country by TOPSIS model

Then, use various indicators, final weight, optimal plan, and worst plan to get a positive ideal solution and a negative ideal solution.

$$s_i^*=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^*)^2},\ \ i=1,2,...,m;\qquad s_i^0=\sqrt{\sum_{j=1}^{n}(c_{ij}-c_j^0)^2},\ \ i=1,2,...,m; \quad (5)$$

Finally, use the positive ideal solution and the negative ideal solution to get the final score. According

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to the TOPSIS scoring model we established, the health status of the higher education system in descending order is the United States, China, the United Kingdom, South Korea, Japan, Russia, and Canada.

Table 2: The score of each country by TOPSIS model

	Final score	Positive ideal solution	Negative ideal solution	Ranking
China	0.49443476	0.31881896	0.311799865	2
United States	0.76143557	0.146996768	0.469175418	1
Russia	0.15900261	0.478000002	0.090372751	6
Japan	0.24809545	0.441342287	0.145623551	5
Korea	0.2503148	0.468927409	0.15657168	4
Canada	0.15873765	0.468837741	0.088464914	7
United Kingdom	0.35357826	0.368372572	0.201491571	3

2.3. Gray Relational Analysis

2.3.1. Matrix Establishment

We directly use the normalized initial matrix processed in the first model to find the largest element in the indicators of each country to form a parent sequence. The parent sequence is $x_0 = \{x_0(1), x_0(2), \ldots, x_0(n)\}$.

2.3.2. Relevance Determination

Calculate the correlation between each indicator and the overall development of the system.

$$\gamma(x_0(k), x_i(k)) = \frac{a + \rho b}{|x_0(k) - x_i(k)| + \rho b}, \forall i, k \quad (6)$$

Then use the obtained index to average the final correlation.

$$\gamma(x_0, x_i) = \frac{\sum_{k=1}^{n} \gamma(x_0(k), x_i(k))}{n} \quad (7)$$

2.3.3. Weight Establishment

Divide the final relevance of a single indicator by the sum of the final relevance of all indicators to get the final weight of each indicator.

Table 3: The weight of each country by Gray Relational Analysis

	a1	a2	a3	a4	b1	b2	b3	c1	c2	c3
China	0.536551187	0.816724021	0.749360106	0.496619795	0.601916262	0.933355152	0.597664275	1	0.670465575	0.380940383
United States	0.425016243	0.751169767	0.333333333	0.449695962	0.376784015	0.639378968	0.413523043	0.398832041	0.819819616	1
Russia	0.60878874	0.52261221	0.771436886	1	0.946027578	0.558272346	0.925439918	0.536190194	0.494288353	0.529451553
Japan	0.823280469	0.444149757	1	0.645218845	0.789414413	0.494558196	0.716567578	0.534862138	0.47320687	0.456365957
Korea	1	0.402381422	0.546214549	0.741570249	0.653212486	0.419108376	0.580767195	0.440565456	0.423117602	0.391558121
Canada	0.655014871	0.484759841	1	0.808624086	0.747725345	0.546939265	0.852924836	0.499037092	0.539367885	0.510580293
United Kingdom	0.513566261	0.453296432	0.475790814	0.552933667	0.626492438	0.494252293	0.630537799	1	0.475995026	0.56615176
Final correlation	0.651745396	0.553584778	0.696590812	0.670666086	0.677367505	0.583694942	0.673917806	0.629926703	0.556608704	0.54786401
The final weight	0.104413468	0.088687557	0.111597969	0.107444675	0.108518282	0.093511383	0.107965619	0.100917985	0.089172007	0.087771056

2.3.4. Optimal Result

Finally, each normalized and standardized matrix and weight is multiplied and added together to obtain the final score of each country.

$$S_k = \sum_{i=1}^{m} z_{ki} w_i \quad (8)$$

Table 4: The score of each country by the gray correlation analysis

	Final score	Ranking
China	0.418511879	2
United States	0.507603764	1
Russia	0.209124582	7
Japan	0.284968365	4
Korea	0.257905198	5
Canada	0.220056439	6
United Kingdom	0.30848713	3

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According to the gray correlation analysis, the health status of the higher education system in descending order is the United States, China, the United Kingdom, Japan, South Korea, Canada, and Russia.

2.4. The Score Comparison of the Two Models

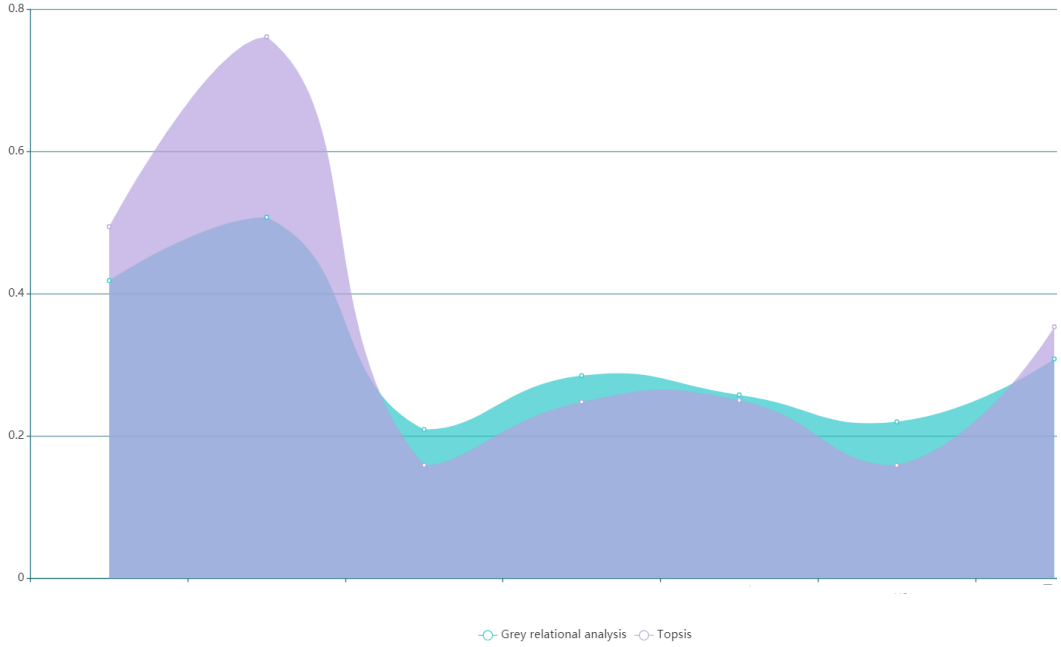

Figure 2: The score comparison of the two models

3. Conclusion

According to the characteristics of global higher education, this paper constructs a "three-dimensional index system" for higher education evaluation and proposes a higher education evaluation model based on TOPSIS and grey correlation theory. For the field of higher education, this evaluation model has good generality. Compared with the Analytic Hierarchy Process (AHP) and fuzzy comprehensive evaluation methods that are currently used in the field of higher education evaluation, the evaluation system constructed in this paper eliminates unnecessary human factors as much as possible, making the evaluation process more objective and scientific. The evaluation is more operable and has a higher promotion value.

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