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Country's Higher Education Assessment System

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Abstract: *The higher education system is an important part of a country, based on this, a comprehensive model that allows analyzing the higher education system of any country was developed. Each aspect is evaluated by a small model, and different methods are used to analyze them according to the different influencing factors and their interralationships, The final scores were summed up by the weights calculated by the hierarchical this analysis method and percentaged to obtain the total score.And then we analyze how the model reflects the health and sustainability of the education system. Using this model, we obtained scores for the United States, Japan, Australia and China. With this model, we can not only know the health of the whole higher education system, but also the development and sustainability of the system in all aspects, so that we can plan accordingly.*

Keywords: *Higher education assessment, hierarchical analysis, principal component analysis*

1. Models

1.1 Model 1: Evaluation of colleges and universities based on PCA

The total number of students enrolled in higher education institutions, the number of students enrolled per million population, the number of staff per million population, the number of higher education institutions per million population, the number of schools in the top 100 of the Times World University Rankings, the number of top 100 universities per 1,000 universities and the score of the highest ranked university on the list as evaluation indicators.

1.1.1 Data Processing

Considering national conditions, differences in economic development and the completeness of available data, we choose China, Germany, the United States, Japan, and the United Kingdom as samples .The above data are normalized.

1.1.2 Calculations and Results

Correlation analysis was performed on these data to obtain the correlation matrix. According to the gravel plot and the total variance interpretation table, components 1 and 2 were taken as principal components, with a cumulative variance percentage of 82.692, which holds a major role in evaluating this indicator for schools.

Table 1: Total variance explained

	Initial Eigenvalue			Extraction of the sum of squares of loads		
Ingredients	Total	Percentage of variance	Accumulation %	Total	Percentage of variance	Accumulation %
1	4.056	57.941	57.941	4.056	57.941	57.941
2	1.733	24.751	82.692	1.733	24.751	82.692
3	.749	10.705	93.397			
4	.462	6.603	100.000			
5	1.523E-16	2.176E-15	100.000			
6	-1.354E-16	-1.935E-15	100.000			
7	-3.500E-16	-4.999E-15	100.000			

Extraction Method:Principal component analysis

The normalized processing matrix was multiplied by the component score coefficient matrix to obtain the Fa1 and Fa2 data in the table below. The proportion of component 1 in the sum of components 1 and 2 Pa1 = 0.899940324 and the proportion of component 2 Pa2 = 0.100048825. From the formula:

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$$\mathrm{Fa} = \mathrm{Fa}_1 \times Pa_1 + \mathrm{Fa}_2 \times Pa_2 \tag{1}$$

The degree value scores Fa were obtained for different countries.

Table 2: F1 score by country

	Fa1	Fa2	Fa	F1
China	-1.0883679	-0.663438267	-0.96117986	55.00
Germany	-0.373888177	1.223354792	0.104191452	79.15
America	1.038545966	-0.484738271	0.582603334	90.00
Japan	-0.758249287	-0.867237361	-0.790871111	58.86
England	0.038601507	-0.692633352	-0.180268444	72.70

Given the intuitive nature of the presentation and the fact that the selected countries are above the medium level of school development in the world, list the formul

$$\mathrm{F}_1 = \frac{(\mathrm{F}a - Fa\min)}{Fa\max - Fa\min} \times 35 + 55 \tag{2}$$

The F1 score, calculated as a percentage, is the final school indicator score for a given country.

Note: Famax, Famin in the formula are the highest and lowest Fa scores in the countries shown in the table above.3

1.2 Model 2: Research level assessment based on grey correlation analysis

We select 25 representative countries as benchmark countries, and use the total number of publications, the number of hot papers and the cumulative number of Nobel Prizes as the main indicators to conduct gray correlation analysis and obtain their ranking Fc1.Data comes from ISI Essential Science Indicators.The scores Fc2 are based on the formula:

$$\mathrm{Fc}_2 = 1 - \frac{Fc_1 - 1}{25 - 1} \times 0.7 + 0.05 \tag{3}$$

The number of Fields Prize and Turing Award winners are counted as additional items in the score, which is calculated by the formula,

$$\mathrm{Fc} = \left(\frac{Fc_3}{Fc_3\max} + \frac{Fc_4}{Fc_{4\max}}\right) \times 0.3 + Fc_2 \tag{4}$$

Where Fc_3, Fc_4 are the number of Turing Award and Fields Prize winners, $\mathrm{Fc}_3\max$, $\mathrm{Fc}_4\max$ are the current highest Turing Award and Fields Prize winners, respectively, and this model takes the highest number of Fields Prize winners and the highest number of Turing Award winners as the available data of 18 and 52 in the United States, respectively.Lastly, calculation results by the formula:

$$\mathrm{F}_3 = \frac{(Fc - Fc\min)}{Fc\max - Fc\min} \times 50 + 40 \tag{5}$$

Is Scientific Research total score F3. For countries other than the benchmark countries, we still use gray correlation analysis to compare with the benchmark countries and take their Fc2 scores as the average of the countries above and below them to calculate the Fc2 scores. The reference data for Fc2 calculation are shown in the following table:

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Table 3: F3 score by country

	hot paper(10years)	Number of Nobel Laureates	web of science document	Ranking	F3
America	69450	377	3773427	1	0.75
France	10747	69	697105	2	0.720833333
Russia	1445	26	307293	6	0.604166667
Germany	16252	108	988153	4	0.6625
China	19614	8	2027780	3	0.691666667
India	2595	10	469564	5	0.633333333
Japan	6703	28	844743	7	0.575
Canda	10484	26	605129	8	0.545833333
Italy	8207	20	582608	9	0.516666667
witzerlan	6448	26	250553	10	0.4875
Sweden	4261	31	230482	11	0.458333333
Holland	7911	21	346329	12	0.429166667
Belgium	3888	11	190464	13	0.4
Espana	6645	1	496756	14	0.370833333
Austria	2469	21	129750	15	0.341666667
Brizal	1863	1	346807	16	0.3125
Danmark	3301	13	139659	17	0.283333333
Israel	1973	12	132545	18	0.254166667
Hungary	831	13	63925	19	0.225
Turkey	1220	1	237216	20	0.195833333
Iran	1037	1	190008	21	0.166666667
ew Zealar	1285	0	80218	22	0.1375
Ireland	1367	8	69508	23	0.108333333
outh Afric	1207	10	89247	24	0.079166667
Greece	1407	2	110602	25	0.05

1.3 Model 3: Funding input rating based on principal component analysis

1.3.1 Data processing

The data were obtained from the official websites of the ministries of education and the World Bank, and the data were normalized using SPSS.

1.3.2 Calculations and Results

Table 4: Total variance explained

	Initial Eigenvalue			Extraction of the sum of squares of loads		
Ingredients	Total	Percentage of variance	Accumulation %	Total	Percentage of variance	Accumulation %
1	1.606	53.543	53.543	1.606	53.543	53.543
2	.941	31.351	84.893	.941	31.351	84.893
3	.453	15.107	100.000			

Extraction Method:Principal component analysis

The data were then subjected to correlation analysis to obtain the correlation matrix. According to the gravel plot and the total variance interpretation table, components 1 and 2 were taken as principal components with a cumulative variance percentage of 84.893, which holds a major role in evaluating this indicator of funding input. Define the funding input score Fe.

Table 5: F5 score by country

	Fe1	Fe2	Fe	F5
America	2.2151789	-0.9478143	1.047098708	90.00
France	0.2128348	1.7969207	0.797831114	84.03
England	0.9688448	-0.0182414	0.604317985	79.40
Belgium	-0.0167934	1.4611548	0.529006704	77.59
South Korea	0.2923975	0.2830619	0.288949902	71.85
Australia	0.38464	-0.093488	0.208069324	69.91
Germany	-0.4902089	-0.0641753	-0.332876469	56.96
Portugal	-0.7759651	0.2746434	-0.387979764	55.64
Spain	-0.8542599	-0.5519229	-0.742608107	47.15
Japan	-0.5037492	-1.7686798	-0.970882793	41.68
China	-1.4329667	-0.3716559	-1.04102905	40.00

Taking into account the intuitive nature of the presentation and the degree of development of the indicator in the selected countries, the F5 score on the percentage scale is calculated by the following formula:

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$$F_5 = \frac{(Fe - Fe\min)}{Fe\max - Fe\min} \times 50 + 40 \quad (6)$$

Which is the final indicator score for schools in a given country.

Note: Femax and Femin in the formula are the highest and lowest Fe scores for the countries shown in the table above.

2. Testing the Model

We chose to score the higher education systems of the United States, China, Australia and Japan using the model built in the previous section

2.1 Model Applications

The process described above yielded percentiles for each indicator for China, the United States, and Japan, and the model was tested for reliability and applicability using Australia as an example. The Australian indicators were collected, and the research, funding, school, and equity items were calculated directly by the formula given above, while the research indicator items were ranked by grey correlation analysis with the data of the 25 countries given above, and the scores of Australia were calculated by the formula after the ranking scores were given. Similarly, the model can be applied to any country's higher education "health check", and the composite scores of the four countries are shown in the figure below.

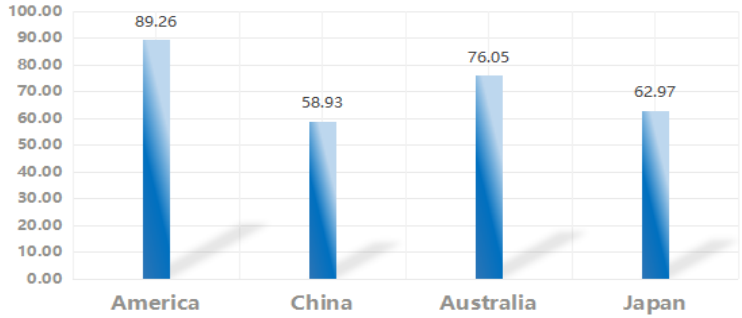

Figure 1: Total score by country

The overall results show that the United States has the best comprehensive education status, Australia is the second best, and Japan is better than China.

2.2 Healthiness Analysis

•The United States: The United States ranks first in most indicators, especially in scientific research, which is far ahead of other countries. A good positive cycle is formed between its high funding and high scientific research output, and a good social culture of higher education is formed. The figure shows that although the U.S. colleges and universities are ranked first in the four countries as well as other indicators, they are not as ahead of other countries as other items, and need to strengthen school construction.

•Australia: Australia's higher education is generally in good shape, with excellent overall scores and high scores in the areas of university construction. The country is in good shape in terms of research, but has not been able to produce more cutting-edge output and could use more funding.

•Japan: Japanese higher education is stable in terms of university construction, degree value and research, and good in terms of equity, but Japan could increase funding to promote its positive cycle.

•China: Chinese higher education has the lowest score among the above countries. This is due to its late start in higher education and oversized population, but it also covers a major deficiency in the health of Chinese higher education, and there is significant room for improvement in several areas.

2.3 Sustainability Analysis

An important part of the sustainability of higher education in the country is the formation of a positive relationship between funding inputs and research outputs, which in turn needs to be supported by a certain

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social ethos of schooling and academic value formation. It is possible to evaluate the input-output relationship of the national higher education system initially by calculating the state funding, the total rating, and the long-term development of the national higher education. However, it is not enough to simply assess its sustainability through sub-data.

Comprehensive above-mentioned countries, the sustainability of higher education system is not only reflected in the assessment of the final score of the country, but requires that its indicators score is more balanced, there is no obvious depression, otherwise an indicator is too low will certainly affect its long-term development, so that the specific indicators can be further analyzed to predict the overall stability and sustainability of the national higher education system to support the adjustment of education policy, to achieve the purpose of comprehensive and stable development of the higher education system

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