Advances in Educational Technology and Psychology (2021) 5: 15-19
Clausius Scientific Press, Canada
DOI: 10.23977/aetp.2021.52003
ISSN 2371-9400

Evaluation Model of Health Degree and Sustainability of Higher Education System

Haiyang Kong, Xinzhi Sun, Xiaocheng Deng

School of Management, Shandong University, Jinan, Shandong 250100

Keywords: Higher Education System, Sustainable, Health, PCA, CA, TOPSIS, FCE

Abstract: Education should be regarded as the foundation for a project of vital and lasting importance. Based on extensive literature review and reference to indicators used in academic rankings made by major institutions, we have collected data which span from 2000 to 2015. After the quantitative processing of indicator data, we divided the entities into three categories by cluster analysis, and used PCA to select several indicators that have a significant impact. After sorting the entities by TOPSIS, we finally selected six indicators. Gross enrolment rate, gender ratios and government investment were used to measure the health of the higher education system, while the proportion of international students and the average age of students at school were used to measure the sustainability of the system. For an entity-specific analysis, we selected Australia, Japan the United Kingdom China and India according to the clustering results. In this section, the fuzzy comprehensive evaluation method was used to score the current higher education system in five countries. The evaluation result met the macro part of the evaluation model. The evaluation model is fully data based with few subjective or arbitrary decision rules. The indicators involved in the model are published statistically by countries around the world so that the model has extremely strong universality. In addition, this model uses lots of methods to make the results more comprehensive and accurate.

1. Introduction

System of higher education is an important element in a nation’s efforts to further educate its citizens beyond required primary and secondary education, and therefore has value both as an industry itself and as a source of trained and educated citizens for the nation’s economy.

Actually, scholars have carried out many discussions on this issue. It is worth mentioning that Chinese scholars have made a great deal of research on the evaluation of the health and sustainability of China's higher education system. Qiang Zha [1] and Jianxi Chi [2] explored the health and sustainability of China’s current higher education system from the perspective of educational equity. The latter hopes that the Chinese government will increase its investment in education and introduce laws and regulations to protect educational equity and promote the healthy and sustainable development of the education system; Hong Zhao and Liujun Guan discuss the sustainability of China’s higher education system with the help of IFE and EFE matrices, putting forward a proposal to change the concept of education, increase the investment in education and guarantee the education system effectively... However, these studies have the distinct feature of evaluating the higher

education system only from a one-sided perspective.

So, this paper puts forward a model which is made up of macroscopic part and microscopic part to evaluate the higher education system of any entity.

2. Indicator Selection and Data Processing

A total of 16 indicators are used in the modeling process of the partial model.

1. Government expenditure on tertiary education by country
2. Enrollment rate of higher education in the world
3. Gpi tertiary education
4. School life expectancy from primary to tertiary education
5. Share of students from abroad
6. Outbound mobility ratio
7. The proportion of people receiving higher education in the world
8. Proportion of education expenditure in government expenditure
9. Government expenditure per student tertiary of GDP per capita
10. Projects of the share of the population aged 15 educated to degree level by country
11. Percentage of all students in tertiary education enabled in ISCED 6 both sexes
12. Precent enrolled in private institutions at the tertiary education level
13. Share of people-who-agree-university is more important for boys
14. Share of the population with a completed post-secondary-education
15. Share of the population with secondary education but no tertiary education
16. Number of papers

The data of 289 entities we used come from the https://ourworldindata.org/grapher. However, since not every country has the complete data above, so we used the method of linear regression and averaging to deal with the vacancy years.

Given that assessing the education of different entities in later years is more representative of the country's current true level, our weighting table should give greater weight to the later years. So, the formula for calculating indicator for country i is:

$$X_{ij} = \frac{\sum(m-1950)X_{ijm}}{\sum(m-1950)} \tag{1}$$

Letter m represents the year in which the indicator is located. The data processed in this way can be integrated with the information of the year as a whole and is more likely to be combined with a representative value of all subsequent years, such an indicator could therefore be used as an average to divide the data into different ranges for subsequent years.

2.1 Principal Component Analysis

We analyzed the Bartlett sphericity test firstly. We found that the value of P is less than 0.05 and the value of KMO is close to 0.7, so it is suitable for principal component analysis. In order to make the cumulative rate of variance close to 80%, we select 5 principal components. The results show that the commonness of all items is higher than 0.4, which means that there is a strong correlation between the items and the principal components.

It is found that six indexes, "Percentage of students admitted into colleges", "Government expenditure on tertiary education", "Inbound mobility rate", "Number of Papers", "School life expectancy" and "Sex ratio of students at school", have relatively prominent weights.

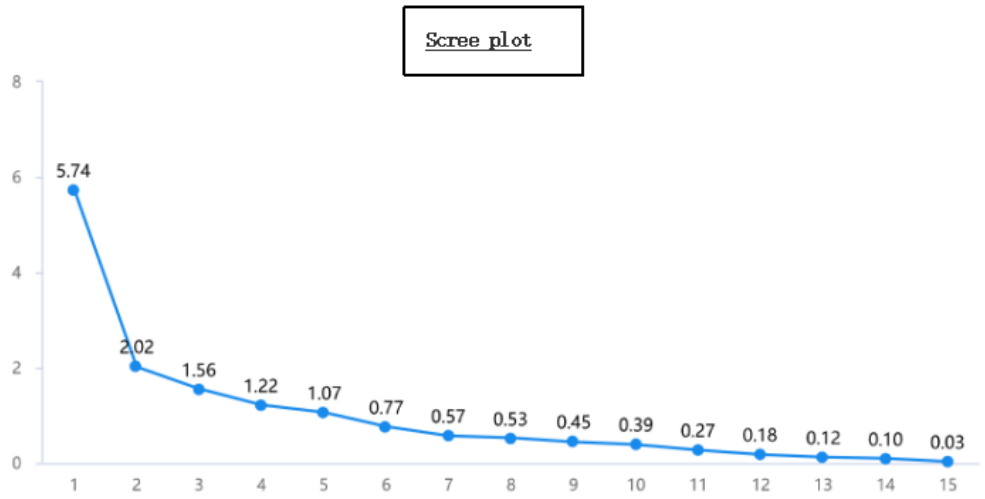

Figure 1: Scree Plot Graph Generated by Principal Component Analysis

Besides, we carry on the principal component analysis again to get the respective weight of these six indicators, which can be used in the fuzzy analysis later.

2.2 Cluster Analysis

Considering that cluster analysis is not suitable for multi-dimensional data analysis, in the results of principal component analysis, we use several influential indicators to cluster. We have divided entities into three categories: 102 entities in the first category, 117 entities in the second category, and 8 entities in the third category. A cross-sectional survey of one category of entities has found that the similarity and clustering of their educational realities are very consistent.

The following graphs show that our clustering has very satisfactory results.

k-Means - Centroid Table

Number of Clusters: 3
Distance Measure: Squared Euclidean Distance
Average Cluster Distance: 162.798
Davies-Bouldin Index: 0.698

Cluster	Enrollment rate of higher ...	government-expenditure-...	gpi-tertiary-education	school-life-expectancy-fr...	share-of-students-from-a...
Cluster 0	8.529	0.726	0.620	8.293	3.833
Cluster 1	35.334	1.058	1.268	13.219	4.894
Cluster 2	21.655	0.663	1.794	13.100	60.147

Figure 2: Result of Cluster Analysis

2.3 TOPSIS Analysis

Among the six indexes we selected, the four with the biggest weight in principal component analysis are tested by a TOPSIS model, it shows that these four indicators are representative.

We list the top five and bottom five of the 140 entities participating in the TOPSIS assessment as follows: 1Liechtenstein; 2Curacao; 3Macao; 4Saint Kitts and Nevis; 5Grenada; 136Angola; 137Burkina Faso; 138Tanzania; 139Chad; 140Eritrea.

In our research, we found that the rankings were surprisingly consistent with the state of education in these entities. We also found that the results of fuzzy comprehensive analysis is consistent with it. To some extent, this makes our two models corroborate each other, and proves that our data after principal component selection and processing have strong adaptability to different models.

3. Fuzzy Comprehensive Evaluation

We used the six indexes selected by TOPSIS as evaluation set to construct evaluation indexes, and optimized the evaluation method based on fuzzy comprehensive evaluation with the result of cluster analysis. We have obtained the weight of each index through the principal component analysis. In order to ensure the fairness of the weight, the algorithm is aimed at most countries in the world. The resulting weight matrix $\boldsymbol{W}$ is:

$$\boldsymbol{W} = (0.17352\ 0.00528\ 0.18336\ 0.2\ 0.22744\ 0.2104)$$

From left to right are psa, ge, im, np, se and sr.

The weight matrix is calculated as 20% of the weight defined and 80% of the rest. Due to the factors of acquisition and processing, the paper cannot be given objective weight value by principal component analysis, so the method of estimation is adopted.

Here are the scores of the UK, India, China, Japan and Australia selected according to the results of CA.

1. UK

Comprehensive membership vector: $(0.2321 \quad 0.5293 \quad 0.2363 \quad 0.0023 \quad 0)$

Health and sustainability scores: $\boldsymbol{S}_1 = (0.5911 \quad 0.3867 \quad 0.0124 \quad 0.0097 \quad 0)$,
$\boldsymbol{S}_2 = (0 \quad 0.6179 \quad 0.3821 \quad 0 \quad 0)$;

The composite score of UK is 3.9122. UK has a health score of 4.5589 and a sustainability score of 3.6179.

2. India

Comprehensive membership vector: $(0 \quad 0.2354 \quad 0.2036 \quad 0.3126 \quad 0.2484)$

Health and sustainability scores: $\boldsymbol{S}_1 = (0 \quad 0.5358 \quad 0.0373 \quad 0.2611 \quad 0.1658)$,
$\boldsymbol{S}_2 = (0 \quad 0.0410 \quad 0.3117 \quad 0.3470 \quad 0.3003)$;

The composite score of India is 2.4263. India has a health score of 2.9431 and a sustainability score of 2.0934.

3. China

Comprehensive membership vector: $(0.0658 \quad 0.3532 \quad 0.2288 \quad 0.1652 \quad 0.1870)$

Health and sustainability scores: $\boldsymbol{S}_1 = (0.5911 \quad 0.3867 \quad 0.0124 \quad 0.0097 \quad 0)$,
$\boldsymbol{S}_2 = (0 \quad 0.6179 \quad 0.3821 \quad 0 \quad 0)$;

The composite score of China is 2.9456. China has a health score of 3.3901 and a sustainability score of 2.6505.

4. Japan

Comprehensive membership vector: $(0.1036 \quad 0.6452 \quad 0.0625 \quad 0.1303 \quad 0.0583)$

Health and sustainability scores: $\boldsymbol{S}_1 = (0.5911 \quad 0.3867 \quad 0.0124 \quad 0.0097 \quad 0)$,
$\boldsymbol{S}_2 = (0 \quad 0.6179 \quad 0.3821 \quad 0 \quad 0)$;

The composite score of Japan is 3.6052. Japan has a health score of 4.0346 and a sustainability score of 3.3192.

5. Australia

Comprehensive membership vector: $(0.6114 \quad 0.0375 \quad 0.2761 \quad 0.0750 \quad 0)$

Health and sustainability scores: $\boldsymbol{S}_1 = (0.5911 \quad 0.3867 \quad 0.0124 \quad 0.0097 \quad 0)$,
$\boldsymbol{S}_2 = (0 \quad 0.6179 \quad 0.3821 \quad 0 \quad 0)$;

The composite score of Australia is 4.1853. Australia has a health score of 4.9337 and a sustainability score of 3.6832.

4. Conclusions

This paper used PCA and CA to rank the higher education system of different entities on a macro level, FCE to score the health and sustainability of a specific entity. With the TOPSIS served as a bridge, we finally put forward a macro-micro evaluation model of health degree and sustainability of higher education system. The evaluation model is fully data based with few subjective or arbitrary decision rules. The indicators involved in the model are published statistically by countries around the world so that the model has extremely strong universality. Thus, the evaluation result of the model is highly consistent with the reality, and has a good use value. Unfortunately, some excellent indicators and typical countries do not appear in this modeling due to the lack of data.

References

[1] Zha, Q. (2020). Equality and Equity in Chinese Higher Education in the Post-massification Era: An Analysis Based on Chinese Scholarly Literature. The China Quarterly, 244, 1056-1077. Doi: 10.1017/S0305741020001241
[2]C Ding, X He. (2004).K-means clustering via principal component analysis. DOI: 10.1145/1015330.1015408