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Health Assessment and Sustainability Analysis of Higher Education System

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Abstract

Higher education has great importance for the world. For it, we establish an evaluation model to evaluate health and analyze sustainability of system of higher education. First, to establish health evaluation model, we select eight evaluation indicators and use Entropy Weight Method (EWM) to determine the weight of the chosen evaluation indicators. Then, Technique for sequencing by approximate ideal solution or technique for or- der preference by similarity to ideal solution (TOPSIS) is used to calculate the comprehensive evaluation index. We use the model to evaluate the health level of Germany, England, Vietnam and Switzerland. The results show that Vietnam's health of higher education system is obviously lower than the other three countries. Finally, Gray Forecast Model (GFM) is used to analyze sustainability of system of higher education. The results show that the system of higher education in Germany, England and Switzerland has an upward development trend, the sustainability is good. However, Vietnam has a dcrease development trend, the sustainability is poor. Therefore, we deem that Vietnam's higher education system has a lot of room for improvement.

Keywords

EWM; TOPSIS; GFM.

1. Introduction

A system of higher education has great importance in a nation's efforts to further educate its citizens. It is a complex system determined by many factors. The expansion of higher education has become a mainstream trend in the development worldwide. As we look around the world, we see a variety of national approaches to higher education which have their respective strengths and weaknesses. In the wake of adjustments required during the current pandemic, nations have had the opportunity to reflect on what is working and how to build a more healthy and sustainable system.

The core of this question is to construct a comprehensive evaluation framework to evaluate the health of higher education systems in various countries. Therefore, it is necessary to use comprehensive evaluation methods to construct a comprehensive index to quantify the performance of higher education systems. By combing predecessor's research on comprehensive evaluation methods[1],find that the methods of comprehensive evaluation are mainly divided into four kinds: expert scoring method, operations research and other mathematical methods (Analytic hierarchy process, Fuzzy comprehensive evaluation method, Data envelopment analysis method, etc.), comprehensive evaluation method based on statistics and economy (Rank-sum ratio method, Technique for sequencing by approximate ideal solution or technique for or- der preference by similarity to ideal solution(TOPSIS), Principal component analysis method, etc.), new-type evaluation method (Artificial neural network method, Grey total comprehensive evaluation method, etc.) .

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The analysis of sustainability requires the use of predictive models. By combing predecessor's research on predictive models [1], find that common predictive models include Interpolation and Fitting Model, Neural Networks Model, GFM, Markov Chains Model, Support Vector Machines Model, etc.

2. Selection of Evaluation Indicators

The health of a higher education system is related to many indicators. After consulting the literature [2][3][4], eight aspects are summarized to measure the health of the higher education system. In order to make evaluation model applicable to all countries, there is a need to eliminate the influence of factors that are not related to education such as population size and land area among different countries on the indicators. Finally, we determine eight indicators to measure the health of the higher education system. As shown in Figure 1.

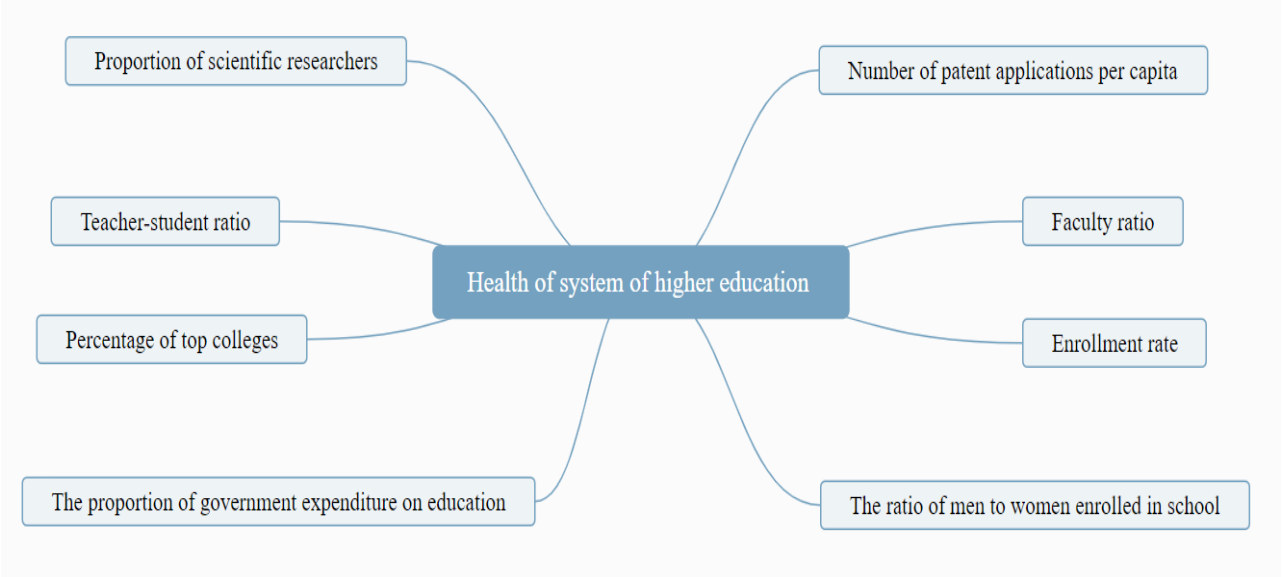

Figure 1. Eight evaluation indicators

For percentage of top colleges, we use the ratio of the number of QS top 200 higher education institutions in a country to the number of all its higher education institutions to measure.

3. Treatment of Data of Evaluation Indicators

Because different evaluation indicators have different dimensions and the properties of different evaluation indicators are also different, it is necessary to process the obtained evaluation indicator data. The steps are as follows:

Step1: Construction of decision matrix X

$$X=\begin{bmatrix} & D_1 & D_2 & D_3 & \dots & D_n \\ M_1 & x_{11} & x_{12} & x_{13} & \dots & x_{1n} \\ M_2 & x_{21} & x_{22} & x_{23} & \dots & x_{2n} \\ M_3 & x_{31} & x_{32} & x_{33} & \dots & x_{3n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ M_m & x_{m1} & x_{m2} & x_{m3} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

In the matrix, M={M1,M2,M3...} represents the collection of objects participating in the evaluation, Each object represents each country in each year. D={D1,D2,D3...} represents the collection of evaluation indicators for each object. Eight evaluation indicators are used in this article, so n=8.And x_{ij} (i=1,2,3..., m; j=1,2,3...,n) represents the value of evaluation object M_i to index D_j.

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Step2: Forward processing

Acorronding to the property of eight indicators, indicators can be divided into two categories. One type is intermediate indicator, which is closer to a certain value the better. the other type is positive indicator, which is the larger the better. In order to unify the property of eight indicators, intermediate indicators should be converted to positive indicators, which is called forward processing. Among eight indicators there is only one intermediate indicator that is the ratio of men to women enrolled in school. And this indicator is closer to 1 the better. The matrix after forward processing is marked as A. For the positive indicators, a_{ij} is equal to x_{ij}. For the intermediate indicator D_j, the corresponding formula of forward processing is as follows:

$$a_{ij} = 1 - \frac{|x_{ij} - x_{best\,j}|}{\max\{|x_{ij} - x_{best\,j}|\}} \tag{2}$$

Step3: Standardization

Standardization is for eliminating the impact on evaluation due to different dimensions of each indicator. The matrix after standardization is marked as Z. The formula of standardization is as follows:

$$z_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \tag{3}$$

Step4: Normalization

Normalization limits the value of the indicators to the range of (0,1), which makes our results easier to interpret. The matrix after normalization is marked as V. The formula of normalization is as follow:

$$v_{ij} = \frac{z_{ij} - \min(z_j)}{\max(z_j) - \min(z_j)} \tag{4}$$

4. EWM determine the weight of the evaluation index

To comprehensively evaluate the system of higher education, It's important to determine the weight of the chosen evaluation indicators. To avoid the influence of subjective factors, Entropy Weight Method (EWM)is adopted to determine the weight of evaluation indicators. The steps are as follows:

Step1: Calculate the character weight

For each indicator, the differences in the value of v_{ij} is bigger, the effect of this indicator on the evaluate object is greater. Just as follow:

$$p_{ij} = \frac{v_{ij}}{\sum_{i=1}^{m} v_{ij}} \tag{5}$$

In the formula, p_{ij} represents the character weight of evaluate object M_i under the indicator D_j.

Step2: Calculate the entropy e_j of indicator D_j:

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \ln(p_{ij}) \tag{6}$$

Step3: Calculate the difference coefficient of indicator D_j:

$$d_j = 1 - e_j \tag{7}$$

Step4: Calulate the entropy weight w_j for each indicator:

$$w_j = \frac{d_j}{\sum_{i=1}^{n} d_j} \tag{8}$$

5. Determination of Comprehensive evaluation index

Among comprehensive evaluation methods, TOPSIS has been adopted by many scholars for its advantages of simplicity, speediness and practicability [5]. According to the weight of each indicator calculated in above, calculate the comprehensive evaluation index of system of higher educationby using TOPSIS. The steps are as follows:

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Step1: Construction of decision matrix with weight

Multiply the weight of indicators *W* by the matrix *V* to obtain the weight decision matrix $R=(r_{ij})_{m\times n}$:

$$r_{ij} = w_j \times v_{ij} \quad (i = 1,2,3 \dots, m; j = 1,2,3 \dots, n) \tag{9}$$

Step2: Calculate the positive and negative ideal solution:

$$\begin{cases} S_j^+ = \max\limits_{1\le i\le m}\{r_{ij}\}, j = 1,2, \dots, n; \\ S_j^- = \min\limits_{1\le i\le m}\{r_{ij}\}, j = 1,2, \dots, n; \end{cases} \tag{10}$$

Step3: Calculate the distance between each evaluate object and ideal solution by using Euclidean distance:

$$Sd_i^+ = \sqrt{\sum_{j=1}^{n}(S_j^+ - r_{ij})^2}, i = 1,2,3\dots, m; Sd_i^- = \sqrt{\sum_{j=1}^{n}(S_j^- - r_{ij})^2}, i = 1,2,3\dots, m \tag{11}$$

Step4: Calculate relative closeness of each evaluation object to positive ideal solution

$$topsis_i = \frac{Sd_i^-}{Sd_i^+ + Sd_{\bar{i}}}, i = 1,2, \dots m \tag{12}$$

The larger the $topsis_i$ is, the closer the evaluation object M_i is to the positive ideal solution, the evaluation is better. Therefore, topsis can be used as comprehensive evaluation index.

6. The Solution of the Health Evaluation Model

In order to verify that the established evaluation model can evaluate the health of the higher education system in any country, we collected data on eight indicators in four countries including Germany, England, Vietnam and Switzerland in past four years [6][7][8][9]. Based on this, the evaluation model is used to calculate the corresponding comprehensive evaluation index. The results is shown in Table 1.

Table 1. Evaluation results in four countries

Nation	Year	Comprehensive evaluation index
Germany	2015	0.0845
Germany	2016	0.0847
Germany	2017	0.0852
Germany	2018	0.0859
England	2014	0.0756
England	2015	0.0759
England	2016	0.0764
England	2017	0.0772
Vietnam	2014	0.0121
Vietnam	2015	0.0100
Vietnam	2016	0.0090
Vietnam	2017	0.0078
Switzerland	2015	0.0785
Switzerland	2016	0.0781
Switzerland	2017	0.0791
Switzerland	2018	0.0795

The higher the comprehensive evaluation index, the higher the health of the higher education system. From the table, It can be found that the health assessment results of Vietnam's higher education system are obviously lower than the other three countries.

7. Sustainability Analysis of System of Higher Education

The health evaluation of system of higher education is an evaluation that focuses on the current. For so-called sustainable, we understand that it's an evaluation of system higher education in the future.

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Predictive models need to be introduced to evaluate the future of the higher education system. Taking into account that only data of past four years are collected for each country, we use Gray Forecast Model (GFM) to forecast in the situation that the amount of data is small. According to the comprehensive evaluation index obtained above, GFM is used to forecast the change trend of the future comprehensive evaluation index. The results are shown in Figure 2.

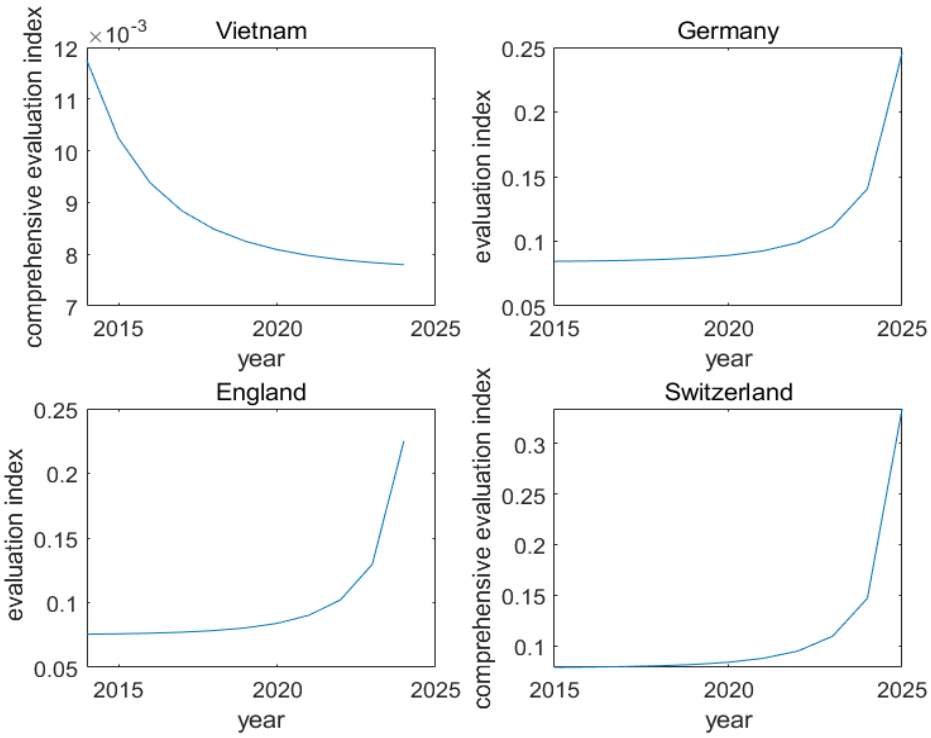

Figure 2. Change trend of comprehensive evaluation index

It can be seen from the figure that comprehensive evaluation index of the system of higher education in Germany, England and Switzerland has an upward trend, so the sustainability is good. However, in Vietnam, not only the current health status is relatively low, but also it has a dcrease trend. To sum up, we deem that Vietnam's higher education system has a lot of room for improvement.

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