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Higher Education Evaluation System Based on Factor Analysis

Qixuan Gao, Feilong Jing, Wenqiang Ma

Lanzhou University of technology, Lanzhou, Gansu, 730050

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Abstract: In this era, higher education has entered a stage of rapid development, and the degree of popularization has continued to increase.In this case, a healthy and sustainable system is particularly important.The optimal weight equation of the second-level index was established by the projection tracking method, and the particle swarm algorithm was used to solve it and the projection tracking evaluation model was obtained[1]. In addition, a K-means clustering model was established, and three levels of evaluation criteria were obtained: general, good and excellent. In the end, an evaluation system that can assess the health of any country's higher education system has been formed. Then divide the country through three principles.

1. Background

Nowadays, the popularization of higher education has become a mainstream trend in the development of higher education all over the world. All countries recognize that higher education has had a profound impact on all dimensions of society and economy.From a global perspective, the proportion of people receiving higher education has increased. Statistics from UNESCO show that by 2014, the gross enrollment rate of higher education in 64 countries reached 50%, while only 5 countries reached that rate 20 years ago, and the global gross enrollment rate in higher education exceeded 80%. For a country, having a healthy and sustainable higher education system means having a large number of high-quality talents trained for the country and society.

2. The health evaluation model of higher education

2.1 Data preprocessing

Considering that the dimensions of the indicator data are inconsistent, in order to avoid data overflow in the calculation, We normalized and dimensionless the data before forecasting, Then get a dimensionless unified data standardization process, The original data are all converted into non-dimensional index evaluation values[2]. That is, all index values are at the same quantitative level, and comprehensive evaluation and analysis can be performed.

Due to the different definitions of government indicators, positive and negative indicators are defined when using normalization to process data.

Positive indicators:

$$Z_{ij} = \frac{x_{ij} - min(x_j)}{max(x_j) - min(x_j)} \quad (1)$$

Negative indicators:

$$Z_{ij} = \frac{max(x_j) - x_{ij}}{max(x_j) - min(x_j)} \quad (2)$$

In order to avoid data overflow in the calculation, we standardize the data before forecasting, so that the original data are converted into non-dimensional indicator evaluation values. First, the collected p-dimensional random vector $(X = x_1, x_2, x_3, \dots, x_p)^T n$ samples of $(X = x_{i1}, x_{i2}, x_{i3}, \dots, x_{ip})^T, i = 1,2,3, \dots, n, n > p$ .Construct a sample array,and perform the following standardized transformations on the sample array elements:

$$Z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \quad (3)$$

2.2 Quantitative analysis based on projection tracking method and particle swarm algorithm

Entropy weight method can not consider the actual background of the problem.It may produce a situation of too large or too small.Therefore, we get the optimal solution of the weight through the idea of optimization[3]. Firstly, the calculation model of the optimal weight of the criterion layer is established by the projection pursuit method, and then the particle swarm optimization algorithm is used to solve the optimal value, and the unit projection vector is obtained as the weight then the comprehensive score is obtained.The steps are as follows:

Step 1: Create a linear projection function Supposing the j-th index of the i-th sample is $x_{ij}(i = 1,2, \dots, n, j = 1,2, \dots m$; where n is the number of samples and m is the number of indicators).If$(a_1, a_2, \dots, a_m)$ is an m-dimensional projection vector,the expression of the projected eigenvalue zi of sample i in one-dimensional linear space is:

$$Z_i = \sum_{j=1}^{m} a_j x_{ij} \quad (4)$$

Step 2: Build the objective function,The objective function of the projection pursuit method is

$$Q(a) = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (z_i - \bar{z})^2} \times \sum_{i=1}^{n} \sum_{i=1}^{n} (R - r_{ij}) I (R - r_{ij}) \quad (5)$$

Step 3: Optimize the projection direction.The objective function Q(a) will change according to the change of the projection vector a. The appropriate projection vector a can represent the characteristic structure of high dimensional data to the maximum extent. Therefore, the corresponding projection vector can be obtained by solving the maximum value of the projection objective function a, that is, there is a projection vector. Maximum objective function: maxQ(a).constraint condition:

$$\| a \| = \sum_{i=1}^{m} a_i^2 = 1 \quad (6)$$

Step 4: Establish a solution model based on particle swarm algorithm.

In summary, the formula for calculating the quality of higher education development index *F* is:

$$F = \sum_{i=0}^{4} B_i * W_i \quad (7)$$

2.3 K-means clustering standard setting

In order to qualitatively analyze the quality of higher education development,a suitable standard is needed to evaluate the quality of schooling[4].The data set X includes 4 secondary indicators,and (μk) is the number of the data set itself,which is 3 in this article.The data object is divided into 3 partitions.Let k denote the classification center of the partition,and the square sum of the distance to the classification center is expressed as:

$$J(c_k) = \sum_{x_i \in C_k} \|x_i - \mu_k\|^2 \tag{8}$$

Among them,$J(c_k)$ represents the sum of squares of the distance to the classification center, and the goal is to solve the following optimization problems:

$$min = \sum_{k=1}^{3} \sum_{i=1}^{10} d_{ki}||x_i - \mu_k \|^2 \tag{9}$$

$$\text{s.t.}d_{ki} = \begin{cases} 1, & x_i \in c_i \\ 0, & x_i \notin c_i \end{cases} \tag{10}$$

Depending on the above algorithm of K-means clustering, the data of 7 cities are clustered.first, and two class centers of each index are calculated. Then the mean value of the index center is taken as the standard boundary. Using histograms to describe the standards of each indicator, and qualitatively evaluate the two types of indicators through intervals.We use qualitative descriptive indicators such as"general", "good" and "excellent" to assess the country’s educational development. "Gengeral" refers to the customary or undeveloped national education development. "Good" is that the country has achieved some success in this regard. "Excellent" is the great success of a country.

3. Selection of countries with improve space

By substituting the data of each country into the evaluation model based on factor analysis the factor score, comprehensive score and ranking of each country are obtained as shown in the following Table.

Table 1: 7 Countries common factor score

	UK	US	Japan	Netherlands	Ireland	South Korea	China
F_1	2.4012	2.3834	-0.1735	-0.1115	-0.2155	-0.8718	-0.1251
F_2	1.075	0.065	0.2514	0.8217	-0.2628	-0.2527	-0.5607
F_3	-0.2454	-0.217	2.4383	-0.1249	0.3361	1.438	-0.2339
F_4	1.8732	-0.3456	0.9.35	-0.3986	0.9782	-0.2761	0.9874
F_5	0.122	0.2021	1.3569	0.4522	2.3335	-0.2197	-0.3428
Score	1.3469	1.02333	0.5846	0.1833	-0.0991	-0.1236	-0.2901
Rank	1	2	3	4	5	6	7

Judging from the comprehensive scores in the table, the United Kingdom, the United States, and Japan rank among the top three. The United Kingdom has always maintained its leading position as a powerhouse in higher education.If it is negative, it is lagging behind the top three countries.China ranks seventh, with a large gap with the top three countries, indicating that China’s education has a lot of room for development.

4. Analysis of the Advantages and Disadvantages of Chinese Education

We will qualitatively analyze the pros and cons of the four criterion-level indicators through K-means clustering on the Chinese data we have found,and obtain a radar chart describing the overall situation and a bar chart describing the four indicators are shown Figure 1.

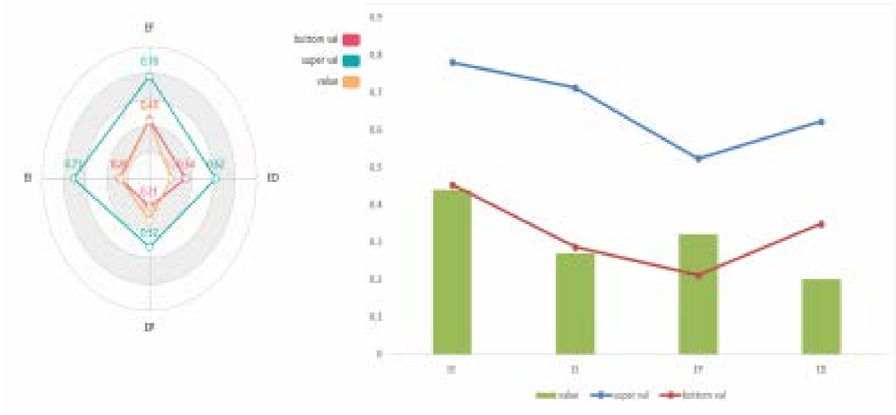

Figure 1: China Qualitative Analysis Map

From the above figure, we can clearly know that the ED and the EI are at the same level, and there is much room for improvement. However, EP and EF indicator has reached an excellent and good level, and we hope that the impact indicators in this area can be stabilized and developed.Introduce professionals and provide more communication platforms. Increase the proportion of education expenditures in GDP, and strengthen cooperation between enterprises and society with universities. Improve teachers' English level, add English courses and improve the enrollment system.

5. Evaluation of Model

5.1 Strengths

The three-layer tree index system of target layer, criterion layer and indicator layer.Each indicator corresponds to each Self-influencing factors make the system structure clear and distinct.And the more data we collect, the more accurate our evaluation of a country will be.

5.2 Weaknesses

The amount of data is not enough.The amount of data in ten years is used as the basis for analysis, and it is not accurate enough to reflect the relationship between various indicators and educational development. The model is based on the ideal situation on the basis of assumptions, while the factors in reality influence each other and the relationship is complicated, so there are errors.

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