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Research on Health Status Evaluation of Higher Education Based on Factor Analysis and Projection Pursuit Evaluation Model

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Abstract: Higher education system is an important factor for a country to provide its citizens with further education besides primary and secondary education, each country has different higher education systems, and each country has its own advantages and disadvantages. In order to cultivate higher quality talents, countries should begin to pay attention to the reform of higher education system in order to establish a healthier and sustainable higher education system. Firstly, we set up a national health evaluation model of higher education. The first step is to select 40 countries' data about higher education by consulting relevant literature and OECD database, and use factor analysis to select and process evaluation indicators, Finally, four first-level indicators, such as teachers' strength and learning environment, students' access to education, education financial investment, education level and achievements, and 12 second-level indicators, such as the ratio of institutional educators and international students, the proportion of students' expenditure on education to GDP, and the total expenditure of government educational institutions, are determined. In the second step, we first normalize the index data, and then nest the projection pursuit evaluation model with multiple indexes. We use the evaluation value of every three secondary indicators to represent the corresponding primary indicators, and then calculate the evaluation value of the primary indicators as the final result, so we can get the weight formula of all indicators. The analysis results show that the health status of higher education in Korea is poor, and the evaluation values of most indicators are lower than the average level, so we chose Korea as the follow-up research object and put forward an achievable and reasonable vision for its higher education system.

1. Introduction

Higher education system is an important factor in a country's efforts to further educate its citizens instead of the primary and secondary education it needs, therefore, it is not only an industry itself, but also a source of trained and educated citizens in the national economy.

When we look around the world, from Germany to the United States, from Japan to Australia, we can see the higher education methods of various countries, which not only educate their own students, but also attract a large number of international students every year. Different countries' higher education systems have their own advantages and disadvantages, after the adjustment of the current

global pneumonia epidemic, countries have the opportunity to think about what kind of higher education system is feasible and better. However, change is often difficult. It is necessary to implement this policy for a long time in order to build a healthier and more sustainable system.

Therefore, it is very important to develop a model to measure and evaluate the health status of the national higher education system, to determine a healthy and sustainable state, and to put forward a set of educational policies based on it, which will have a great impact on the progress of human education.

2. Evaluation model of health status of national higher education

We established a projection pursuit evaluation model [1] to evaluate the health status of national higher education. Projection pursuit is a statistical method to deal with complex multi-factor problems, its basic idea is to project high-dimensional data into low-dimensional space, and to study the characteristics of high-dimensional data through the dispersion structure of low-dimensional projection data. Projection pursuit method has been widely used in the study of evaluation problems, According to the characteristics of sample data, it is not affected by subjective factors in the whole operation process, and has the advantages of intuition and strong operability.

The construction of projection pursuit model can usually be divided into four steps

Step1 Standardized treatment of evaluation index

Step2 Construct projection index function Q(a)

Step3 Optimize the projection index function: when the sample set of each index value is given, the projection index function Q(a) only changes with the change of projection direction. Therefore, the optimal projection direction can be estimated by solving the maximization problem of projection index function.

Step4 Classification evaluation: Substituting the obtained optimal projection direction into the following formula, the projection value Z(i) of each sample point can be obtained,Comparing z(i) with z(j), the closer they are, the more samples i and j tend to be classified into the same class. Corresponding one-dimensional linear space projection value z(i):

$$z(i) = \sum_{j=1}^{p} a(j)x(i,j), i = (1,2\cdots,n)$$

In order to better judge the impact of each index on the health status of national higher education, we improved the projection pursuit evaluation model. We project every three of the 12 secondary index values, use the obtained evaluation values to represent the corresponding primary index, and then project the obtained four primary index representative values again to obtain the final evaluation value of the health status of the education system, forming a nested projection pursuit evaluation model, that is, the national higher health education evaluation model. Using this model, we can get the weight ratio of each index.

·Selection of indicators

In order to make the evaluation more scientific, comprehensive and objective, when selecting the evaluation indexes of national higher education health status, we consulted relevant literature [2], adopted the principles of operability, dynamic, routine, systematic and guiding [1], and combined quantitative and qualitative indicators, respectively studied eight university ranking systems including domestic and foreign, official and private university ranking institutions, and compared each evaluation index system,Then, combined with the evaluation indexes of higher education in OECD website, four first-level health evaluation indexes, namely, education level and achievements, students' access to education and participation, education financial investment, teachers and learning

environment, were preliminarily selected, and each major index contained three different second-level evaluation indexes. Teachers' resources and learning environment include institutional educators, teachers' working hours, and average class size,Students' access to education includes enrollment rate, ratio of foreign students, and number of advanced placement students,Educational financial investment includes the proportion of students' expenditure on education to GDP, total expenditure of educational institutions for each student, and total expenditure of government educational institutions,Education level and achievements include income, relative income trend, and labor market conditions.

The following is the corresponding relationship diagram between secondary indicators and primary indicators.

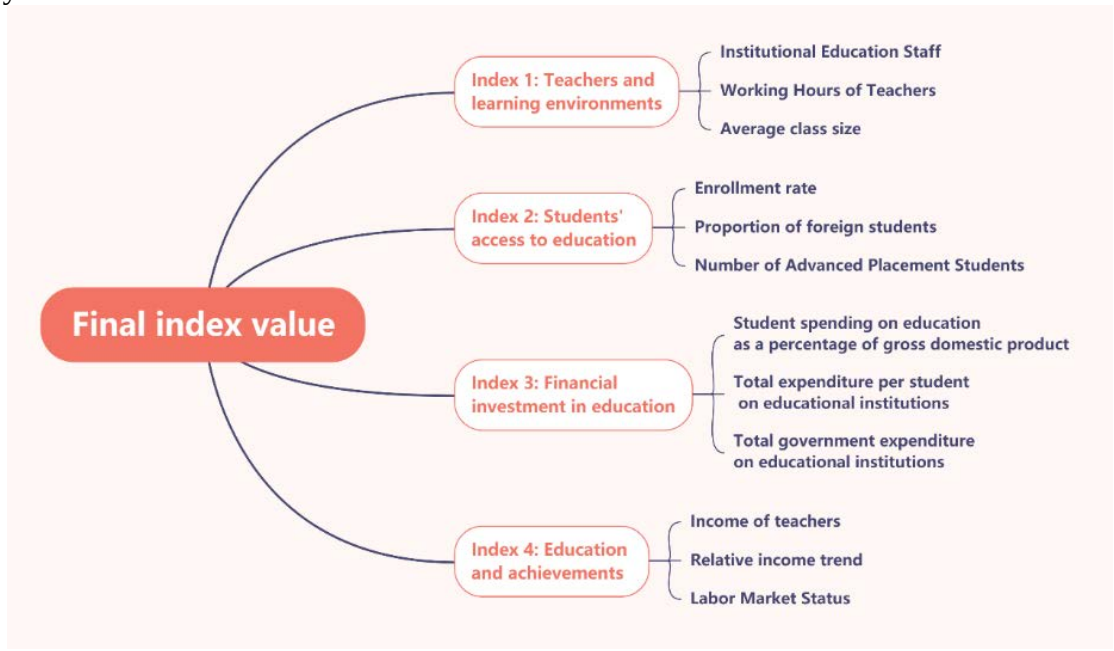

Figure 1: Indicator diagram

Treatment of indicators

In order to ensure the effectiveness and comprehensiveness of the evaluation index, we use factor analysis method to analyze and deal with the evaluation index.

·Factor analysis

The basic purpose of factor analysis is to use a few factors to describe the relationship between many indicators or factors, that is, to classify several closely related variables into the same class, and each type of variable will become a factor, with a few factors reflecting most of the information of the original data.

Let the p-dimensional population $x = (x_1, x_2, \cdots, x_p)'$ mean $u = (u_1, u_2, \cdots, u_p)'$,

The general model of factor analysis is

$$x_1 = u_1 + a_{11}f_1 + a_{12}f_2 + \cdots + a_{1m}f_m + \varepsilon_1$$

$$x_2 = u_2 + a_{21}f_2 + \cdots + a_{2m}f_m + \varepsilon_2$$

$$x_p = u_p + a_{p1}f_1 + f_{p2}f_2 + \cdots + a_{pm}f_m + \varepsilon_p$$

Among them, $f_1, f_2, \cdots, f_m$ are m public factors; ε_i is a special factor unique to the variable x_i $(i = 1,2, \cdots, p)$, they are all unobservable hidden variables. Call $a_{ij}(i = 1,2, \cdots, p; j = 1,2, \cdots, m)$ as the load on the common factor f_i of the variable x_i, which reflects the importance of the common

factor to the variable. It plays an important role in explaining common factors. The above formula can be written in matrix form

$$x = u + Af + \varepsilon$$

Among them is called the factor loading matrix; $f = (f_1, f_2, \cdots, f_m)'$ is the common factor vector; $\varepsilon = (\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_p)$ is called the special factor vector

When the absolute value difference of each element in a certain column of factor load matrix is large, and there are few elements with large absolute value, the common factor is easy to explain, on the contrary, it is difficult to explain the common factor.

Result analysis:

Judging from the estimated lambda of the factor load matrix at this time, the load of every three indicators in their respective common factors is relatively large, which is in line with our predicted index allocation. The contribution rates of the four common factors to the total variance of the original data are 23.3221%, 21.1556%, 24.6522% and 20.5565%, respectively, and the cumulative contribution rate reaches 89.6864%.

From the estimation psi of the special variance matrix, the special variance of each variable is relatively small, and there is no Heywood phenomenon, which shows that the fitting effect of the 4-factor model is good.

According to the model test information stats, the p value of the test is 0.2303>0.05, which shows that the original hypothesis is accepted at the significance level of 0.05, and the original hypothesis H0: m = 4, which means that it is appropriate to fit the original data with the factor model of four common factors.

The analysis results are basically consistent with the selection of our indicators.

3. Model solving

Through consulting a large number of relevant literature [3], after simple classification, we selected 40 countries, counted the specific data related to each evaluation index, and then preprocessed the data, using Newton interpolation method to fill in the missing values, delete the abnormal values, and then normalized them. Then, the data of every three small markers are substituted into the projection pursuit evaluation model, and the corresponding evaluation value and weight formula are obtained, the weight formula is as follows:

0.9975*a1+ 0.9861*a2+0.9960*a3=A

0.9764*b1+ 0.9829*b2+0.9741*b3=B

0.9963 *c1+ 0.9987*c2+0.9903*c3=C

0.9798*d1+ 0.9946*d2+0.9960*d3=D

Then, the four first-level indexes A, B, C and D are substituted into the projection pursuit evaluation model again, and the weight formula, F = 0.9630 * A+0.9479 * B+0.9004 * C+0.9325 * D, is obtained, which can be used to measure the current health status of higher education system in each country.

In order to show the indicators of higher health status in the selected country more intuitively, we will visually analyze and process the first-class indicators and final health status indicators obtained by this model, and the obtained images are shown in the following figure:

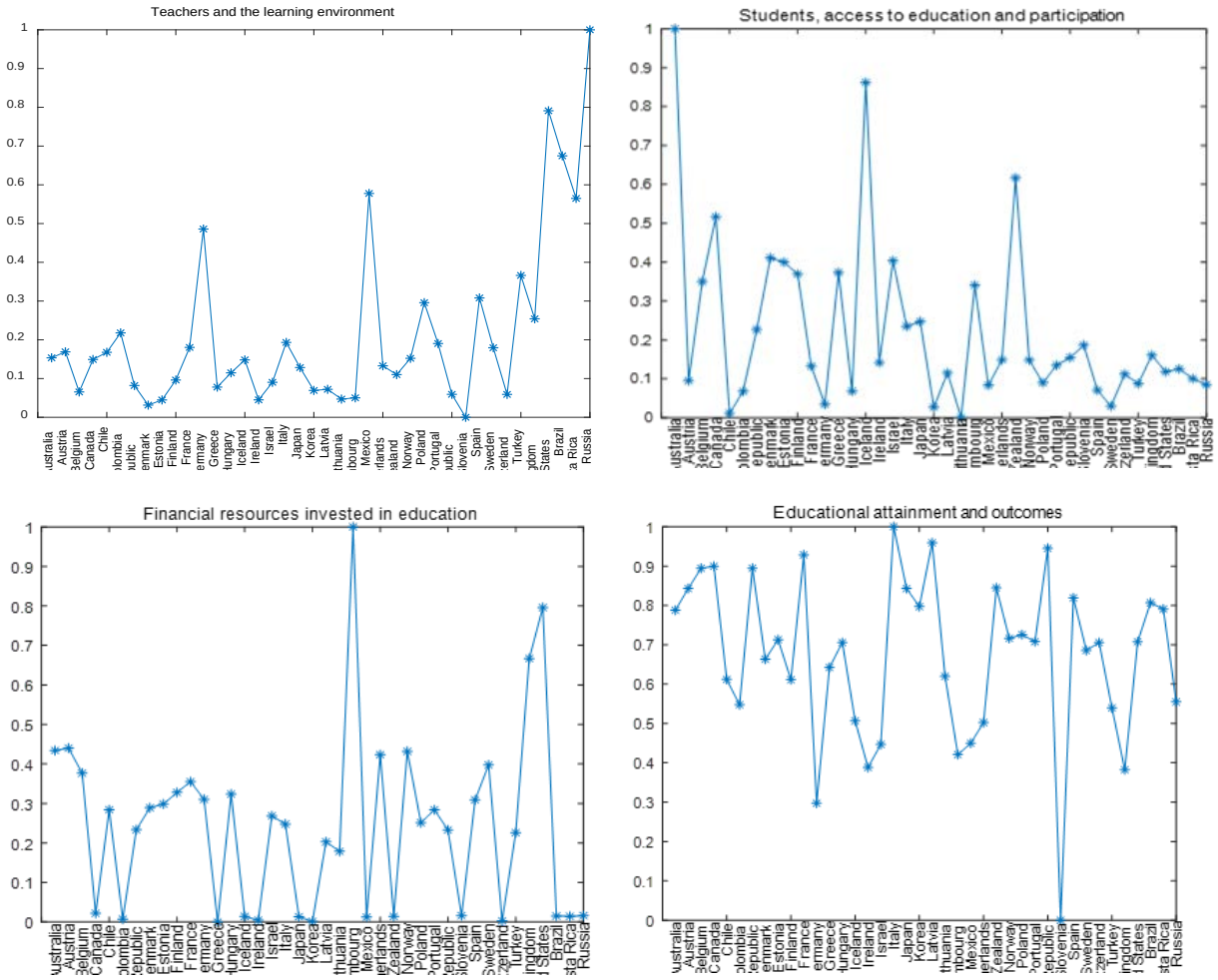

Figure 2: Distribution map of primary indicators

According to the schematic diagram of the above four first-level indicators, it can be seen that the performance of each country is quite different in various aspects, and according to the index value, it can be seen that the national education system presents different advantages and disadvantages. Among them, the index value of financial investment in education in the United States is very high, which shows that the United States attaches more importance to higher education. Russia's teaching staff and learning environment are the highest among 40 countries, it can be seen that in Russia, the quality of teachers is generally high and there is a pleasant learning environment.

4. Conclusion

We can see from the above figure that among the four first-level evaluation indicators: education level and achievement, students' access to education and participation, education financial investment, teachers and learning environment, teachers and learning environment account for the largest proportion, However, on the whole, the weight values of each indicator have little difference and are basically unaffected.

By comparing the evaluation index values of Korea with those of other countries in the above figure, we can see that the higher education system in Korea is generally low in education financial investment, percentage of students' education expenditure in GDP, students' education opportunities, proportion of foreign students, teachers and learning environment,In order to establish a healthy and

sustainable higher education system, We hope that Korea's future higher education system can make greater improvements in education financial investment, percentage of students' education expenditure to GDP, students' access to education, proportion of foreign students, teachers and learning environment, etc., so as to increase education financial investment, increase students' access to education, increase the proportion of foreign students, and improve students' learning environment and teachers' working environment.

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