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Research on the State of Higher Education System Based on Grey Fuzzy Comprehensive Evaluation Model

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Abstract

Based on the establishment of higher education evaluation system index, this paper will use the gray fuzzy comprehensive evaluation model to evaluate the health of higher education systems in various countries, and analyze the differences between specific country and other countries based on the final scores, and propose rationalizations or policy suggestion.

Keywords

Evaluation Index System; Evaluation Model; Grey Fuzzy Comprehensive Evaluation Model.

1. Introduction

Higher education is an important basis and source of power for social development. In the era of knowledge economy, knowledge and technology have become decisive factors in economic development, and higher education plays an important role in cultivating talents needed for social development. Many high-quality workers cultivated by higher education are indispensable for social development. Education is an important part of sustainable development, and it is also a key factor in implementing sustainable development strategies. Higher education cultivates the concept of sustainable development of all kinds of higher specialized talents through education, so that they have the knowledge and ability to participate in the promotion of social sustainable development strategies, and become professionals, management talents and qualified citizens for the sustainable development of society, thereby promoting society sustainable development.

2. Construction of Index System

Based on existing scholars' related research on higher education, this paper adheres to the principle of objective, dynamic, and combination of qualitative and quantitative, and initially divides the evaluation index system into three levels, namely the individual level, the university level, and the national level. Then, combined with the cost, admission opportunities, equity, funding, degree value, education quality, research level, the exchange of ideas of the world's smartest people, and related literature, the health status and sustainability evaluation of the higher education system are determined the secondary index system and main observation points.

2.1. Personal Level

2.1.1. Access

Entrance opportunity refers to the opportunity for students to enter higher education institutions (colleges/universities) through the college entrance examination and other channels, which mainly depends on the students' abilities. Since the index system established

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in this article is oriented to every country, from the perspective of the country, "Undergraduate Student Acceptance Rate"(USAR) is selected as the main observation point to measure the entrance opportunity of the higher education system.

2.1.2. Equity

The equality of educational opportunity mainly refers to people with the same ability, regardless of their personal and family backgrounds, who have equal opportunities to receive higher education [1].

Since the systems and cultures of each country are different, this article selects "Minority Students as a Percentage of the Total Number of Students" (MSPTNS) and "Gender Difference Index of Access to Higher Education"(GDIAHE). It is the main observation point of the fairness of the higher education system.

The calculation methods of these two indicators are:

MSPTNS=The Number of Minority Students/Total Number of Students

GDIAHE=Higher education enrollment rate of female students/Higher education enrollment rate for male students

2.2. University Level

2.2.1. Value of a Degree

A degree certificate from a prestigious university does not mean that a relatively high-paying career will be found, and high tuition is not linked to a high-paying career [2]. It can be found that the salary of graduates is directly linked to the value of a degree. Therefore, this article selects "Average Salary of Undergraduates" (ASU) as the main observation point of the value of a degree.

2.2.2. Quality of Education

Strengthening the construction of the teaching staff and optimizing the resource allocation of the teaching staff can improve the efficiency of running schools to a certain extent [3]. Based on the dimension of education quality of the higher education system, the "Teacher-student Ratio"(TSR),"Undergraduate Graduation Rate"(UGR) and "Undergraduate Employment Rate"(UER) are selected as the main observation points, and the principle of comprehensiveness is followed, including indicators that affect the quality of education, it also contains indicators for measuring the quality of education.

2.2.3. Level of Research

The research level is equivalent to the output indicators in the higher education system. Therefore, this article selects "The Number of Patents Granted"(NPG) and "SCI Indexed National Papers as a Percentage of the Total Indexed Papers"(NPPTIP) And "Research Funding Input-output Index" (RFIOI) as the main observation point.

RFIOI= (Year-on-year increase in patent authorization. The number of papers included in SCI increased year-on-year)/2*Year-on-year growth in research funding.

2.3. National level

2.3.1. Cost

The cost of entering the higher education system can be interpreted as the expenditure per person per year on higher education. Specifically, this article selects "Per Capita Education Expenditure as a Percentage of Per Capita GDP"(PEPGDP) as the main observation point of the cost.

2.3.2. Funding

Most of the funding sources for higher education come from state/government financial appropriations, private fund-raising, tuition, and miscellaneous fees, of which the largest

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proportion is the state's financial education expenditure. The scale and structure of fiscal expenditure are helpful to the realization of education equity. The balanced accumulation of capital and the realization of education fairness can better bring out the social benefits of education and promote social development [4]. Therefore, this paper selects "Higher Education Expenditure as a Percentage of National Fiscal Expenditure"(HEPNFE) as the main observation point of funds.

2.3.3. Higher Education Investment Output Index

This article selects "Human Capital Stock as a Percentage of GDP"(HSPGDP) as the main observation point of education output to express the contribution of human capital stock to domestic GDP, that is, the education investment output index.

2.3.4. National Education Extent

Human resources are the sum of the labor capacity contained in the total population within a certain social organization, and are also an important source of power for national economic and social development and the ultimate foundation of national wealth [5]. The higher the national quality, the more conducive to the development of the country. Therefore, "Higher education students as a percentage of the total population"(HESPTP) is selected as the observation point of the national education level.

2.4. International Level

2.4.1. Exchange of Ideas of the World's Brightest Minds

This article selects the "Proportion of International Students"(PIS) and "Proportion of international teachers" (PIT) are selected as observation points for the exchange of ideas.

2.4.2. International Recognition

International recognition refers to the degree of international recognition of the quality of higher education in a country. The increase in international recognition in education is also an increase in national image and international influence. An accurate and comprehensive assessment of the health and sustainability of higher education requires further certification from the level of international recognition [6]. Therefore, this article selects "The Number of Nobel Prizes as a Percentage of the Total Winners" (NPPTW) and "The Number of Universities in the Top 200 of QS"(NUTQS) as the observation points of international recognition.

3. Empirical Analysis

3.1. Grey Fuzzy Comprehensive Evaluation Model

Specifically, the gray fuzzy comprehensive evaluation model is an index evaluation method that combines gray relational analysis and fuzzy comprehensive evaluation. It calculates the weight of each index through gray relational analysis, and then brings it into the fuzzy comprehensive evaluation, effectively avoiding relying on it. The subjective problems brought by expert scoring or analytic hierarchy process weighting, and then obtain the comprehensive scores of the higher education system of each country from an objective perspective.

3.1.1. Grey Relation Analysis and Evaluation Model

In the gray relationship analysis, for the factors between two systems, the measure of the correlation size that changes with time or different objects is called the degree of correlation. In the process of system development, if the changing trends of the two factors are consistent, that is, the degree of simultaneous change is higher, it can be said that the two factors have a higher degree of correlation; otherwise, it is lower. Therefore, the gray correlation analysis method is based on the degree of similarity or difference between the development trends of factors, that is, the "grey correlation degree", as a method to measure the degree of correlation between factors. The specific calculation steps are as follows:

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(1) Determine reference series and comparison series

The data sequence that reflects the characteristics of the system's behavior is called the reference sequence. A data sequence composed of factors affecting system behavior is called a comparative sequence.

(2) Dimensionless processing is performed on the reference series and the comparison series

The specific dimensionless processing formula will not be shown in this article, and will be dealt with in the model building.

(3) Find the gray correlation coefficient

The gray correlation degree here mainly refers to the correlation degree between the reference series and the comparison series, which is generally expressed by the formula:

$$\delta = \frac{\Delta(\min)+\rho\Delta(\max)}{\Delta(k)+\rho\Delta(\max)} \quad (1)$$

(4) Find the degree of relevance

The connection number is the value of the correlation between the comparison series and the reference series at each time, so the number is more than one, but the information is too scattered to facilitate the overall comparison, so it is necessary to concentrate the correlation coefficients at each time into one value, that is, to find the average Value, as a quantitative representation of the degree of correlation between the comparison series and the reference series. The formula is:

$$r_i = \frac{1}{N}\sum_{K=1}^{N}\delta(k) \quad (2)$$

Among them, the closer the index of the correlation degree is to 1, the better the correlation.

(5) Relevance ranking

The degree of correlation between factors is mainly described in the order of the degree of correlation, not just the degree of correlation. Arrange the degree of association of M subsequences to the same parent sequence in order of magnitude to form an association sequence.

Summarizing the above steps, the gray correlation analysis method treats the factor values of the research object and influencing factors as points on a line, and compares them with the curve drawn by the factor values of the object to be identified and the influencing factors, and compares their closeness. The degree of relevance between the research object and the object to be identified is calculated, and the degree of closeness between the factors of the research object and the object to be identified is calculated, and the degree of influence of the object to be identified on the research object is judged by comparing the magnitude of the correlation.

3.1.2. Fuzzy Comprehensive Evaluation Model

The fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. It uses the synthetic principle of fuzzy relations to quantify some qualitative data with unclear boundaries and not necessarily quantified for comprehensive evaluation. Theoretically speaking, this model transforms qualitative evaluation into quantitative evaluation based on the membership principle of fuzzy mathematics, and makes a summary evaluation by using objects restricted by multiple factors in fuzzy mathematics. The fuzzy comprehensive evaluation model is usually divided into the target layer and the index layer. Through the fuzzy relationship matrix between the index layer and the evaluation set, that is, the membership degree matrix, the membership vector of the target layer to the evaluation set

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can be obtained, thereby obtaining the target layer Comprehensive evaluation results. The calculation steps are as follows:

(1) Set of factors to determine evaluation objects

Set $U = \{U1, U2 \cdots Um\}$ to indicate the object to be evaluated, which is determined by each specific index system. In this article, it refers to the m evaluation factors of the higher education system of each country, m=22.

(2) Determine the comment set of the evaluation object

Setting $V = \{V1, V2 \cdots Vn\}$ is a set of comment levels composed of various total evaluation results that the evaluator may make to the evaluated object.

(3) Determine the membership function

Generally speaking, the membership function refers to the artificial design of a function for each characteristic index, and the reflected mapping interval is [0,1]. In the selection of the membership function, a variety of methods such as wrapping fuzzy statistics method, using existing objective scale method, assignment method and so on. In this article, we will use the trapezoid method in the assignment method, and according to the positive and negative indicators, we will use the small and large trapezoids respectively.

(4) Determine the weight vector of evaluation factors

Set $A = \{A1, A2 \cdots Am\}$ as the weight distribution fuzzy vector, where are represents the weight of the m- factor, and requirements A1+A2+...+Am=1, A reflect the importance of each factor. Combined with the gray relationship evaluation analysis model introduced above, this article The gray relational analysis and evaluation model is used to determine the weight of each indicator.

(5) Fuzzy comprehensive evaluation

The fuzzy weight vector A and the fuzzy relation matrix R is synthesized by a suitable fuzzy synthesis operator to obtain the fuzzy comprehensive evaluation result vector B of each evaluated object.

$$B = A * R = (a_1, a_2, \mathrm{B}\ a_m) \begin{bmatrix} r_{11} & r_{12} & \mathrm{B} & r_{1n} \\ r_{21} & r_{22} & \mathrm{B} & r_{2n} \\ \mathrm{C} & \mathrm{C} & \mathrm{E} & \mathrm{C} \\ r_{m1} & r_{m2} & \mathrm{B} & r_{mn} \end{bmatrix} = (b_1, b_2, \mathrm{B}\ b_n) \quad (3)$$

(6) Quantitative analysis of fuzzy comprehensive evaluation results

The result of fuzzy comprehensive evaluation is the degree of membership of the evaluated object to each level of fuzzy subsets. It is generally a fuzzy vector, not a value, so it can provide more information than other methods.

3.2. Results of the Model

The above has established a corresponding evaluation and prediction model for the health and sustainability of the higher education system. This paper will further select six countries (China, Germany, the United States, Japan, the United Kingdom, South Africa) to verify the reliability and accuracy of the above model .

After using the grey relational analysis model to obtain the weight of each indicator, according to the principle of the grey fuzzy comprehensive model, the weight matrix and the membership matrix are multiplied to obtain the scores of the higher education system of the six countries for each year from 2010 to 2019. See the following Figure 1.

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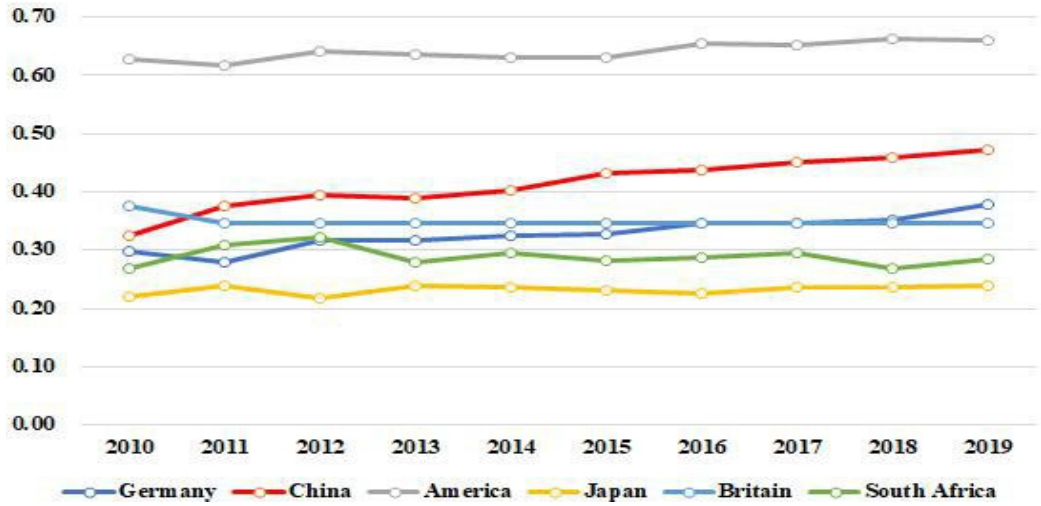

Figure 1. Comprehensive score of higher education system

3.3. Analysis of Results

It can be seen from Figure1 that the health status score of the American higher education system far exceeds that of Germany, China, Japan, the United Kingdom, and South Africa, and has been rising steadily year by year. The health index of China's higher education system ranks second, and after 2014, it has increased significantly. The changes in the health status of the German and British higher education systems in Europe are generally similar, and the changes are relatively stable, but the health status of the British higher education system is declining. The health status of South Africa's higher education system has changed greatly, and it has been increasing year by year from 2010 to 2012. However, after 2012, the health of the South African higher education system has been declining year by year. By 2019, the health of South Africa's higher education system is almost the same as in 2010. The health status score of the Japanese higher education system is the lowest compared to other countries. However, the health of the Japanese higher education system is the most stable.

4. Conclusions and Recommendations

We will select South Africa as the follow-up research object here, and the paper also gives some conclusions and policy suggestions on the status of higher education system in this country.

4.1. Conclusions

Although South Africa's higher education "fair correction" movement, financial appropriation system matching and the development of distance education are remarkable in the process of higher education modernization, the weak educational infrastructure and the shortage of funds and technology have always been the fundamental constraints on the development of higher education in South Africa. Considering the trend of changes in the scores of the health status of the South African higher education system, although his score is higher than that of Japan, compared to Japan, a developed country, South Africa has more room for improvement.

4.2. Recommendations

According to the current situation of higher education in the Republic of South Africa and the domestic and foreign environments in which the country is located, we propose the following reasonable suggestions for the development of higher education in South Africa:

(1) Eliminate poverty, develop rural education, expand vocational and technical education, and improve the higher education system;

(2) To implement new curriculum reforms, especially mathematics teaching curriculum reforms;

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(3) Improve the teacher training plan and raise the scholarship standards for students participating in teacher training;
(4) Increase investment in education to provide conditions and motivation for sustainable development of higher education;

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