

Research on Higher Education System Based on Weighted Average Operator and Factor Analysis

Rujun Ao, Jinxuan Pan, Lingli Gao, Jianzhou Wei*

College of Science, Gansu Agricultural University, Lanzhou, Gansu, 7340070, China

*Corresponding author

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Abstract: In the higher education system, students go through various stages of training and competition, and finally become high-end talents. Around this process, according to the different degree of perfection of higher education system in different countries, this paper establishes the detection model and comprehensive evaluation model of higher education system. Based on the dynamic comprehensive evaluation model of time series weighted average (TOWA) operator and factor analysis, a comprehensive evaluation and detection model is constructed. By collecting the indicators of China, Australia, Germany, Canada and Japan from 2010 to 2019 (taking China as an example), the algorithm is used to calculate the comprehensive evaluation index. The higher the index value, the higher the degree of perfection of the higher education system. On the contrary, the lower the degree of perfection of the higher education system. The simulation results show that the German higher education system is sustainable, but it is in a state of sub-health and needs to be reformed urgently.

1. Introduction

Education is not only the soul of a country and a nation, but also the fundamental cause of a country's revitalization and development. In the higher education system, it is very important to have a healthy and sustainable higher education system. Taking into account the actual situation of the country^[1] and social needs, according to the different national conditions of different countries to carry out corresponding system reform, in order to achieve the healthy and sustainable development of the higher education system, which is of great significance to the ultimate realization of national prosperity. At present, there are a considerable number of research results on the evaluation system^[2] of higher education, but most of them are the qualitative analysis of the indicators and the relevant suggestions on the system strategy.

In this paper, we are committed to the establishment of higher education system testing model and policy quantitative analysis model, and further put forward the corresponding improvement policies, so as to measure and evaluate the health and sustainability of the national higher education system.

2. Higher education system detection model

This paper chooses the time series weighted average operator (TOWA) in the field of management

to deal with the test model to establish the model.

2.1 Dynamic comprehensive evaluation model based on TOWA operator

(1) The standardization of data processing: Here we use the standardized processing method^[3].

$$x' = \frac{x_i - \min_{1 \leq j \leq n} \{x_j\}}{\max_{1 \leq j \leq n} \{x_j\} - \min_{1 \leq j \leq n} \{x_j\}} \quad (1)$$

In the formula, x is the index value, and x' is the standardized index value.

(2) Determination of the correlation coefficient of indicators using the average of indicators as a reference sequence: The correlation coefficient is calculated as

$$\sigma_{0i} = \frac{\Delta \min + \rho \Delta \max}{\Delta_{0i} + \rho \Delta \max} \quad (2)$$

σ_{0i} is the correlation coefficient, ρ is the resolution coefficient, and the resolution coefficient is introduced to reduce the distortion caused by the absolute value of the maximum difference sequence.

(3) The time weight vector expresses the degree of attention to different moments: The definitions of entropy T and 'time degree' λ of time weight vector are as follows^[4]:

$$T = - \sum_{j=1}^n w_j \ln w_j \quad (3)$$

The "time degree" λ reflects the degree of attention to the time series in the process of operator aggregation. The smaller the value of λ is between 0-1, indicates that the evaluator pays more attention to the recent data from the evaluation time; on the contrary, the more attention is paid to the long-term data from the evaluation time.

According to the actual situation, we set the value of "time degree" λ to 0.8, which is suitable for the dynamic evaluation.

$$\begin{cases} \max[-\sum_{j=1}^n w_j \ln w_j] \\ \text{s. t. } \lambda = \sum_{j=1}^n \frac{n-j}{n-1} w_j \\ \text{s. t. } \begin{cases} \sum_{j=1}^n w_j = 0.8 \\ w_j \geq 0, n = 10 \end{cases} \end{cases} \quad (4)$$

The solution is:

$$W = (0.00000001, 0.00001, 0.00215, 0.01, 0.02512, 0.04642, 0.07197, 0.1, 0.12915, 0.15849)$$

Then the first set of standardized data is aggregated to obtain the comprehensive index values of each country from 2010 to 2019. Then the evaluation object, evaluation index and time are combined to form three-dimensional data. The TOWA operator is introduced to aggregate the "time dimension" of the data for the second time:

2.2 Strategy analysis-factor analysis evaluation model

In the process of analyzing specific problems, a large amount of data can provide more information for the analysis, and improve the accuracy of the analysis. In this paper, the core of factor analysis is to analyze several comprehensive indexes.

$$\begin{cases} x_1 = \alpha_{11}f_1 + \alpha_{12}f_2 + \dots + \alpha_{1k}f_k + \beta_1 \\ x_2 = \alpha_{21}f_1 + \alpha_{22}f_2 + \dots + \alpha_{2k}f_k + \beta_2 \\ \dots\dots\dots \\ x_p = \alpha_{p1}f_1 + \alpha_{p2}f_2 + \dots + \alpha_{pk}f_k + \beta_p \end{cases} \quad (k \leq p) \quad (5)$$

First of all, the original data are standardized to eliminate the differences between variables in quantity and dimension, to calculate the correlation matrix of standardized data, the eigenvalues and Eigenvectors of correlation matrix, and to calculate variance contribution rate and cumulative variance contribution rate. after factor rotation, the factor score is solved, and the comprehensive evaluation index function is obtained.

$$F = (w_1F_1 + w_2F_2 + \dots + w_mF_m)/(w_1 + w_2 + \dots + w_m) \quad (6)$$

3. Testing index system of higher education system

3.1 Choice of indicators

The influence of higher education is reflected in all aspects of a country, so the selection of indicators in this paper only needs to follow the following rules:

Table 1: Index system

Indicators	Explanation
Personnel training	Whether there are enough personnel to participate in education and teaching, whether the research results support teaching activities, and whether there are a lot of funds to support teaching activities.
Scientific research	whether there are sufficient funds for scientific research and the usefulness of new technologies for teaching activities.
Economic development	whether economic performance has been improved, whether sales revenue or profits have been increased to obtain financing opportunities, and whether there are good changes in people's income and consumption.
The construction of teachers	Whether the level of teachers has been improved, whether the structure of teachers is reasonable, and whether the number of first-class scientists and discipline leaders has developed healthily.
Social service	Whether the quality of talent training is highly recognized by the society, and what is the feedback from the employment rate and recruitment units.
Cultural inheritance	Whether new cultural works of art have been created, whether there is sufficient protection for traditional culture, and the number of visitors to exhibitions, events and performances
International exchanges	Whether there is academic cooperation with high-level universities in the world, and whether there is a joint action to train students and jointly tackle key scientific problems.

According to the above seven rules, we collected the data from 2010 to 2019 and constructed the China data sheet.

Table 2: China Data Sheet

Talent cultivation	Number of undergraduate graduates	Construction of teaching staff	Number of undergraduate graduates
	Number of Junior College Graduates		Number of faculty and staff of undergraduate institutions
	Students studying abroad		Number of faculty and staff in colleges and universities
	Returnees who have completed their studies		Number of staff and staff of regular high schools
	Number of high school graduates	Social work	quantity of employment
	general institutes of higher education		unemployment rate
	Other private colleges and universities		The number of urban minimum living allowances
	educational fund		All kinds of school education funds social donation funds
Scientific research	R&D expenditure of institutions of higher learning	International exchange	Number of community service institutions
	Number of R&D projects (subjects) in universities		Number of foreign contracted projects
	The expenditure of R&D projects (subjects) in institutions of higher learning		China's net direct investment in the world
	Number of scientific and technological papers published by institutions of higher learning		Turnover of China's Contracted Projects to the World
	Institutions of higher learning publish scientific and technological works		Contracted use of foreign capital projects
	Number of authorized patent applications by institutions of higher learning		The exchange rate of the RMB against the US dollar
Economic development	GDP	Culture succession	Number of cultural heritage institutions
	Per capita disposable income		Number of cultural relic practitioners
	Per capita consumption expenditure		Number of Museum Institutions
	fiscal revenue		Types of Newspaper Published
	fiscal expenditure		Seat number of state-owned art performance venues

3.2 Dynamic comprehensive evaluation of China, Australia, Germany, Japan and Canada

Table 3: 2010-2019 Comprehensive Evaluation Index of Higher Education System Testing

Evaluation object	Comprehensive evaluation index	The index value corresponding to each indicator						
		B ₁	B ₂	B ₃	B ₄	B ₅	B ₆	B ₇
China	0.239	0.173	0.014	0.018	0.008	0.006	0.010	0.011
Australia	0.179	0.026	0.005	0.002	0.114	0.029	0.008	
Canada	0.145	0.033	0.021	0.017	0.018	0.002	0.045	0.010
Japan	0.072	0.103	0.484	0.076	0.014	0.035	0.012	
German	0.031	0.000	0.284	0.016	0.018	0.012	0.016	0.002

According to table.3, we can see that China's higher education system has the highest composite index, Australia and Canada have similar composite index values, and Germany has the lowest composite evaluation index. Therefore, according to the preliminary analysis, there is still room for

improvement in Germany 's higher education system, and we need to conduct in-depth analysis of the specific situation of German

4. Conclusion

Aiming at the higher education evaluation system test, this paper constructively divides the higher education system test model into two parts: the basic test and the strategy analysis, from which the dynamic comprehensive analysis evaluation model is established. The dynamic comprehensive evaluation model of TOWA operator and factor analysis is used to evaluate the indicators of each country, and it is concluded that the higher the degree of perfection of the higher education system is. On the contrary, the lower the degree of perfection of the higher education system, the German higher education system is sustainable, but it is in a state of sub-health and needs to be reformed urgently.

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