Evaluation of Higher Education System by TOPSIS Based on Entropy Weight Method

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Abstract. The healthy and sustainable development of the higher education system is of great significance to the progress of a country. Based on public data, this paper uses topsis model based on entropy weight method, simulated annealing algorithm, bp neural network algorithm, fuzzy comprehensive evaluation, establishes a model set, and analyzes different problems. Besides, we also carried out a sensitivity analysis to increase each indicator byin countries other than the policy suggestion country, and then evaluated through our evaluation model. The results showed that our policy model has good stability.

Keywords: Higher education system · Entropy method · TOPSIS · SA-BP neural network

1 Introduction

1.1 Problem Background

Higher education, at the highest level of the education sector, plays a guiding role in the direction of education. [1] Building a higher education system is a problem that every country pays close attention to. At this stage, every country is committed to establishing a healthy and sustainable higher education. The education system [2] not only has industrial value but also has the value of providing high-level talents for the country's economic development. Therefore, it is particularly important to measure and evaluate the health of a country's higher education system [3].

In this paper, we need to establish a model to analyze the health of the higher education [5] system [3], and give appropriate policies to gradually transition from the current state to the ideal state. Of course, we have to admit that the policy change is Very difficult.

2 TOPSIS Comprehensive Evaluation Model Based on Entropy Method

2.1 Model Establishment

2.1.1 Mathematical Model of Entropy Method

We use the mathematical model of entropy method for data processing. Entropy method [5] refers to a mathematical method used to judge the degree of dispersion of an index. The greater the degree of dispersion, the greater the impact of this indicator on the comprehensive evaluation. According to this principle, we use entropy method to assign weight to each indicator, the steps are as follows:

Assuming that there are n objects to be evaluated, the normalization matrix composed of m evaluation indicators (which have been normalized) is as follows:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{1}$$

Then, the standardized matrix is recorded as each element in Z, Each element in Z:

$$z_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{n} x_{ij}^2} \tag{2}$$

We calculate the probability matrix p_{ij}, the calculation formula of each element p_{ij} is as follows:

$$p_{ij} = \bar{z}_{ij} / \sum_{i=1}^{n} \bar{z}_{ij} \tag{3}$$

It is easy to verify: $\sum_{i}^{n} p_{ij} = 1$ that is to ensure that the probability corresponding to each indicator is 1.

For the i-th indicator, the calculation formula of its information entropy is:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) (j = 1, 2, \cdots, m) \tag{4}$$

$$W_i = d_i / \sum_{j=1}^{m} d_i (j = 1, 2, \cdots, m) \tag{5}$$

2.1.2 Comprehensive Evaluation of TOPSIS

TOPSIS comprehensive evaluation method [6] is a decision-making method in the multi-objective decision-making analysis of limited schemes in the system. This method has the

characteristics of simple calculation, reasonable results, and more flexible application. It can be used in the comprehensive evaluation of national higher education health Sort the results.

$$\begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{pmatrix} \tag{6}$$

In order to eliminate the influence of different dimensions on the evaluation results, and to compare multiple indicators of evaluation under the same dimension system, it is necessary to normalize the original data. The processing method is:

$$z_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{n} x_{ij}^2} \tag{7}$$

$$i = 1, 2, \cdots n \qquad j = 1, 2, \cdots m$$

2.2 Application of the Model

2.2.1 Evaluation of the Education Systems

We use the comprehensive evaluation based on entropy weight method and TOPSIS, and use MATLAB to get the following results (Tables 1 and 2).

From the comprehensive ranking and topsis scores in the table, it can be seen that the higher education system [7] in the United States is the most healthy, followed by Denmark and Japan, followed by China and India. It can be seen from the results that both India and China's higher education systems [8] have improved, because China's international influence has increased in recent years, and its role in the international arena has become more and more important. Here we can think that China is countries with room for improvement in the higher education system.

Table 1. The weight ratio of each indicator

Country	USA	Japan	China	India	Denmark
Total ranking	1	3	4	5	2
Topsis score	0.4264	0.1461	0.1312	0.0994	0.197

Table 2. TOPSIS ranking and score

A	B	C	D	E	F	G
0.1003	0.1239	0.0407	0.2866	0.0209	0.3359	0.0917

The ranking results are consistent with the evaluation results of the existing authoritative literature, indicating that our evaluation model can objectively evaluate the higher education systems of various countries.

3 Neural Network Prediction Model

3.1 Model Overview

Suppose the input layer of the BP network has n nodes, the hidden layer has q nodes, and the output layer has m nodes. [9] The weight between the input layer and the hidden layer is v_{jk}, and the weight between the hidden layer and the output layer is w_{jg}, as shown in picture. The transfer function of the hidden layer is f1(x), and the transfer function of the output layer is f2(x), then the output of the hidden layer node is (write the threshold into the sum term) [10]:

The output of the output layer node is:

$$z_k = f_i\left(\sum_{i=1}^{n} v_{ki}x_i\right) \quad k = 1, 2, \cdots, q \tag{8}$$

The output of the output layer node is: (Original figure)

$$y_i = f_2\left(\sum_{i=1}^{n} w_{jk}z_k\right) j = 1, 2, \cdots, m \tag{9}$$

Modeling and simulation use matlab to predict the data and regress the fitted value to the true value. The higher the goodness of fit, the better the fit. According to the results in the Fig. 1, it can be seen that only used for bp neural network to process data, the goodness of fit is low, and the data fitting effect is not good. We need to further optimize the bp neural network model.
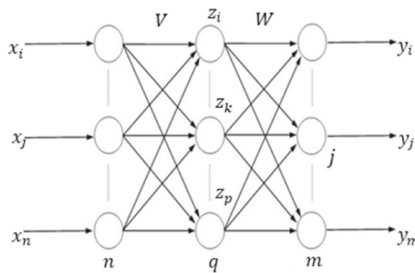

Fig. 1. BP network structure with single hidden layer.

3.2   Simulation Optimization Based on Simulated Annealing (SA-BP Neural Network)

About model optimization (SA-BP neural network):

Because the BP neural network [10] is easy to fall into the local optimal solution, the final value has a large gap with the actual situation. In addition, due to the complexity of the algorithm, the convergence speed of the bp neural network is slow. Use the simulated annealing algorithm to optimize the bp neural network [11], which makes the convergence speed faster and the simulation effect better. Compared with traditional methods such as wavelet and empirical mode decomposition, the BP neural network optimized based on the simulated annealing algorithm has stronger multi-dimensional function mapping capabilities, that is, theoretically, the BP neural network can approximate any nonlinear function, and it has stronger generalization ability, and is more suitable for processing non-linear and non-stationary realization monitoring data [12]. However, the BP neural network uses the negative gradient direction when updating the network weights. When facing the actual high-dimensional surface optimization, the convergence speed is slow, and it is easy to fall into the local minimum. The Simulated Annealing (SA) algorithm has global search capabilities. It can converge to the global optimal solution through multiple iterations. Therefore, using the SA algorithm to optimize the weights and thresholds of the BP neural network can obtain the global optimal solution while improving the convergence speed of the BP neural network.

Modeling and simulation based on the SA-BP neural network, we then use matlab to simulate and predict the data.

3.3   Prediction of the State of the Higher Education System

Data selection: we used the BP neural network to predict the proportion of education investment in GDP and the number of students in school. We used the situation of China from 1991 to 2018 as a data set. We made full considerations when choosing. According to the analysis of China's education data in 2020, it is clear that before 1991, there were a series of political and economic factors that led to greater changes in education levels. During 2019 and 2020, [3] education was caused by the impact of the new crown pneumonia. The career has also been impacted to a certain extent. Therefore, in order to make the model better applicable to the future situation, we choose the education data from 1991–2018 as the sample, and the ratios of the training set, validation set, and test set are 0.7 and 0.15 respectively. When analyzing the results, our model can fit well and the forecast is accurate. Result: We found that with the increase in education funding, the amount of change in the number of students in higher education will not always increase, but with the increase in investment, it will first increase, then decrease, and then stabilize (Figs. 2 and 3).
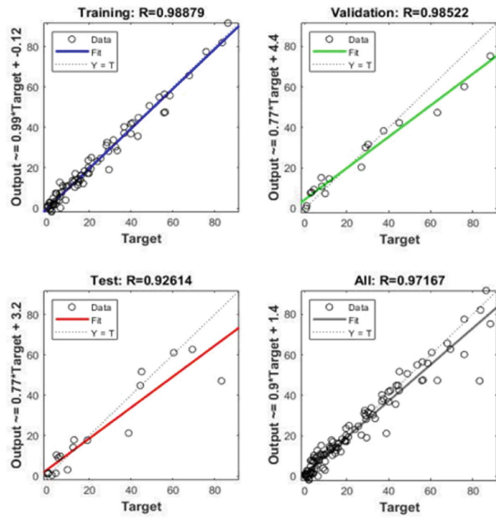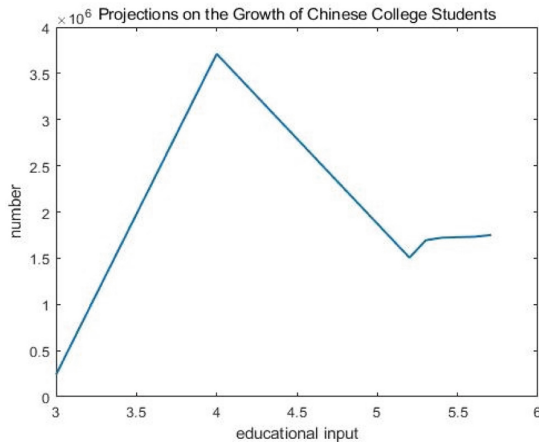
Fig. 2. Result (Original figure)

Fig. 3. The relationship between educational investment and the growth and change of the number of Chinese college students

4   Conclusion

A Topsis evaluation model based on the entropy method is established to evaluate the health and sustainability of higher education in the country. Five countries with different levels of education are selected from China, the United States, Japan, India, and Denmark. In the end, we chose China as a country with room for improvement in the higher education system.

We build the SA-BP neural network model to predict the implementation level of the policy by the number of students in higher education. And establish a fuzzy comprehensive evaluation model to evaluate our policies and determine the score to be [80 85 83 87 89 92]. The overall performance of the policy is good, which confirms the effectiveness of our policy.

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