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Evaluation Model of higher Education system based on Mathematical Modeling method

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Abstract: The health and sustainability of the Higher Education (HE) system are a vital part of the overall national strength. A healthy and sustainable HE system not only maintains the functions of HE institutions, but also supports the goals of sustainable development by improving the knowledge and skills of its citizens to meet social and economic needs. To evaluate the health and sustainability of any country, we establish a grey relational analysis (GRA) model for 22 countries. Through the World Bank and other reputable public data on the Internet, we select eight indicators for HE, and all data has been preprocessed. We perform principal component analysis (PCA) on eight indicators and reduce the dimension to three principal components. The GRA model is used to obtain an evaluation score that can evaluate the health and sustainability of the HE system.

1. Introduction

The higher education system is an important indicator of a country's comprehensive national strength and development potential [3]. If a country has a healthy and sustainable higher education system, it means that it has strong scientific research capabilities, a high-quality labor force, and the ability to create in high-tech fields. With the development of the world economy, the demand for high-level talents in various countries has increased exponentially. Governments of various countries attach importance to the training of talents and the development of universities. The sustainable development of higher education has become the key development direction of most countries. The quality of higher education depends to a large extent on the quality of higher education evaluation. How to evaluate the level of higher education in the country is a difficult problem that governments of all countries need to face. Only when the mathematical model of national higher education is found, can the government issue targeted policies to improve the level of higher education in the country.

We make the following basic assumptions to simplify the problem. Each of our assumptions is justified and consistent with the basic fact.

- The data we collect in each country is authentic and reliable.
- In addition to the factors we refer to, other factors have negligible impact on the country's higher education level.
- Data is not affected by extreme social events, such as wars, coups, and disasters.
- In the foreseeable future, the country's education level will develop.
- International organizations are objective in evaluating the level of universities in each country.
- Due to the gaps in the data of individual indicators in some countries, the difference between

The data we filled in by some methods and the real data has no major impact on the final model.

2. The Model of National Higher Education Health Index

In the process of establishing the national higher education grade evaluation model, we use three methods to process the collected data.

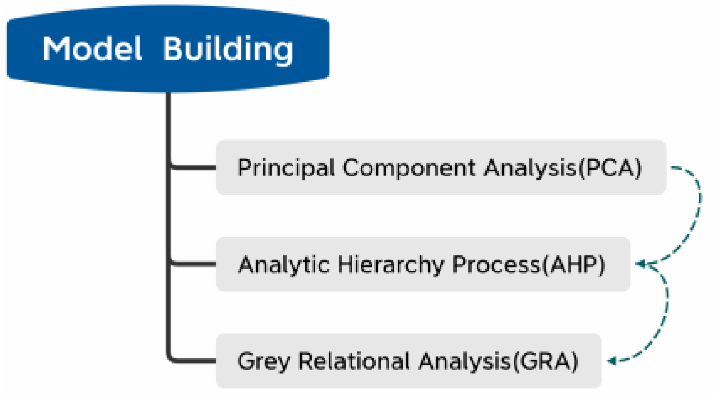

Figure 1: Model Building Process

2.1 Principal Component Analysis (PCA)

At the outset, we perform principal component analysis on the standardized data and reduce the original eight data to a small number of factors to reflect the education and health of each country.

- The standardized data is used to build a matrix X containing m countries and n data. In this matrix, xij represents the jth data of the ith country, then:

$$X = \begin{vmatrix} x_{11} & \cdot & \cdot & \cdot & x_{1n} \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ x_{m1} & \cdot & \cdot & \cdot & x_{mn} \end{vmatrix}$$

- Afterward, finding the correlation coefficient matrix:

$$r_{ij} = \frac{\sum_{k=1}^{n} \mid (x_k - \bar{x}_i) \mid\mid (x_k - \bar{x}_j) \mid}{\sqrt{\sum_{k=1}^{n} (x_{ki} - \bar{x}_i)^2 \sum_{k=1}^{n} ((x_{kj} - \bar{x}_j)^2)}}$$

In this matrix, rij makes the correlation coefficient between the ith index and the jth index of the standardized data [1], thereby obtaining the correlation coefficient matrix R:

$$R = \begin{vmatrix} r_{11} & \cdot & \cdot & \cdot & r_{1n} \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ r_{m1} & \cdot & \cdot & \cdot & r_{mn} \end{vmatrix}$$

2.2 Analytic Hierarchy Process (AHP)

To facilitate comparison, we need to convert these principal components after dimensionality reduction into a value for measurement through a certain weight. We use the analytic hierarchy process to determine the weight. We use cij to calibrate the importance of the ith factor relative to the jth factor. The calibration method is:

Table 1: calibration method

Scaling	Meaning
1	Two factors are equally important
3	Compared with two factors, one factor is slightly more important than the other
5	Compared with two factors, one factor is fairly more important than the other
7	Compared with two factors, one factor is specially more important than the other
9	Compared with two factors, one factor is extremely more important than the other
2,4,6,8	The median of the above two adjacent judgments
reciprocal	If the factor i is compared with j, the judgment c_{ij}, then the factor j is compared with the i judgment $c_{ji} = 1/c_{ij}$

The pairwise comparison matrix C composed of q principal components is:

$$C = \begin{vmatrix} c_{11} & \cdot & \cdot & \cdot & c_{1q} \\ \cdot & \cdot & & & \cdot \\ \cdot & & \cdot & & \cdot \\ \cdot & & & \cdot & \cdot \\ c_{q1} & \cdot & \cdot & \cdot & c_{qq} \end{vmatrix}$$

After normalize the column vectors of the matrix C, we normalize the sum of the row vectors to obtain the weight matrix T:

$$T = \begin{bmatrix} t_1 \\ t_2 \\ \dots \\ t_q \end{bmatrix}$$

Where tn is the weight of the nth principal component.

2.3 Grey Relational Analysis (GRA)

After obtaining the weights of various indicators, we perform gray correlation analysis on each set of data.

• Establish the comparison object and the reference series, there are a total of m countries, q principal component values, and the reference series are recorded asx0 = {x0(k)|k = 1, 2, ..., q }. The comparison sequence is xi = {xi(k)|k = 1, 2, ..., q } , i = 1, 2, ..., m. The reference number is the maximum value of each country’s parameter.

• Calculate the gray correlation coefficient:

$$\xi_i(k) = \frac{\min_s \min_t \mid x_0(t) - x_s(t) \mid + \rho \max_s \max_t \mid x_0(t) - x_s(t) \mid}{\mid x_0(k) - x_i(k) \mid + \rho \max_s \max_t \mid x_0(t) - x_i(t) \mid}$$

The gray correlation coefficient is the correlation coefficient of the comparison series xi to the reference series x0 in the k index. ρ is the resolution coefficient, between 0 and 1. $\min_s \min_t |x0(t) - xs(t)|$ is the minimum difference between the two levels. $\max_s \max_t |x0(t) - xs(t)|$ is the maximum difference between the two levels.

• Calculate the grey weighted correlation degree:

$$r_i = \sum_{k=1}^{q} t_i \xi_i(k)$$

ri is the grey weighted correlation degree of the ith object to the ideal object

• According to the degree of gray weighted relevance, we can compare the relevance between the object and the ideal object. By classifying them according to their relevance, we can establish an association sequence to the evaluation object. The higher the relevance of the object, the better the evaluation result.

3. Conclusion

To evaluate the health and sustainability of any country, we establish a grey relational analysis (GRA) model for 22 countries. Through the World Bank and other reputable public data on the Internet, we select eight indicators for HE, and all data has been preprocessed. We perform principal component analysis (PCA) on eight indicators and reduce the dimension to three principal components. The GRA model is used to obtain an evaluation score that can evaluate the health and sustainability of the HE system.

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