Research on the Ranking of University Education based on Grey-TOPSIS-DEA Method

Abstract—The University is the cradle of the higher education. In the college life, the college students continue to accept the new knowledge and continue to grow. Obviously, the level of the university education will be directly related to the growth for the college students. Therefore, it is an important job to evaluate and order the college education quality. In this paper, we combine the Grey theory, TOPSIS with DEA method. And we propose an improved Grey-TOPSIS-DEA model. Then, we use the model to evaluate the college education quality. Finally, we get the rankings of the college education. In the last part of this paper, we use the method to evaluate the education quality for different colleges. And we verify the validity of the method.

Index Terms—College Education, Evaluation, Ranking.

I. INTRODUCTION

In the modern society, the competition is becoming fierce increasingly. Therefore, if we want to get the better development in this society, we must accept the perfect college education. As the place where we accept the high education, the college education quality plays a very important role. Therefore, it is an important job to evaluate and order the college education quality.

M. Ghonji, Z. Khoshmodifar, S.M. Hosseini and S.M. Mazloumzadeh evaluated the education quality of the agricultural higher education institutions. The results showed that the factors affecting the quality of the agricultural teaching were as follows. (1) lesson plan (19.52%), (2) teaching skill (17.97%), (3) communication skills (17.93%), (4) expertise related to lesson content (10.59%), and (5) individual capabilities of members (9.15%) respectively[1]. Cai Hongmei studied on the research universities. The author made a systematic research on the quality assurance system of undergraduate teaching in research universities. The author made a systematic research on the quality assurance system of undergraduate teaching. It is provided a new way and method for the construction of the undergraduate teaching quality assurance system. And it provided the reference for the college teaching quality management personnel [2]. Dong Haiyan researched on the internationalization of the evaluation index and the security system of the undergraduate teaching quality in China. The author expounded the quality principles of the college and the principles of the evaluation index of the teaching quality and the construction of the assurance system. Then, the author analyzed deeply the status, the key and the characteristics of the whole mechanism for the teaching quality evaluation of the domestic and foreign [3]. Lin Xiaoqing improved the ranking method for the static university. Then, he used the dynamic model of the college ranking and used the mathematical example to verify and explain [4]. Xie Yalan researched on indicators and impact of university rankings [5]. From the perspective of the college ranking, Guo Congbin and Sun Qiming compared the world’s top universities [6].

The Grey theory is a subject which studied the uncertain information. It was proposed by the Chinese scholar Deng Julong. In recent years, the grey theory continued to develop. It had the wide application on the relation field [7-8] and the prediction field [9-10]. TOPSIS method was based on the close degree between the evaluated objects and the ideal target to rank. The method was to make the relative merits for the existing objects [11-12]. DEA method was a kind of quantitative analysis method. It used the linear programming method, multi input indexes and multi output indexes to do the effective evaluation for the same type units [13-14]. TOPSIS method and DEA method were the main evaluation methods. We can combine and improve the two methods [15-16].

To evaluate and rank the college education quality can promote the university to find out their own shortcomings and corrected. At the same time, it can increase the credibility for the university. In this paper, we combine the Grey theory, TOPSIS with DEA method and propose an improved Grey-TOPSIS-DEA method. Then, we apply the method to the college education quality evaluation. The structure of this paper is as follows. The first part is the introduction. The second part is the basic knowledge. In this paper, we introduce the TOPSIS method and the Grey theory. The third part is the improved Grey-TOPSIS-DEA method. In this paper, we combine the Grey theory, TOPSIS with DEA method and propose the new evaluated method. The fourth part is the experiment and the last part is the conclusion.

II. THE BASIC KNOWLEDGE

A. TOPSIS

We assume that the scheme set and the attribute set of the multi attribute decision problem are $A = \{ A_1, A_2, \ldots, A_m \}$ and $F = \{ f_{1i}, f_{2i}, \ldots, f_{ni} \}$. The decision matrix is $B = [b_{ij}]$. The scheme $A_i$ is written as $A_i = (b_{i1}, b_{i2}, \ldots, b_{im})$, $i = 1, 2, \ldots, m$, $b_{ij} \geq 0$. The weight vector of the attribute is $W = (\omega_1, \omega_2, \ldots, \omega_n)^T$ and $\sum_{j=1}^{n} \omega_j = 1, \omega_j \geq 0$, $j = 1, 2, \ldots, n$. The step of the traditional TOPSIS method is as follows.
Firstly, we use the vector norm method to construct the decision matrix $C = (c_{ij})_{m \times n}$. For the benefit attribute,

$$c_{ij} = \frac{b_{ij}}{\sqrt{\sum_{j} b_{ij}^2}}$$  \hspace{1cm} (1)

For the cost attribute,

$$c_{ij} = \frac{1/b_{ij}}{\sqrt{\sum_{j} (1/b_{ij})^2}}$$  \hspace{1cm} (2)

Where, $i = 1, 2, L, m$, $j = 1, 2, L, n$.

Secondly, we weight the normalized decision matrix and get the weighted normalized matrix $Z = (z_{ij})_{m \times n}$. Where $z_{ij} = a_{ij} c_{ij}$, $i = 1, 2, L, m$, $j = 1, 2, L, n$.

The third step is as follows. After we get the normalized matrix, we need to determine the positive ideal solution $A^+$ and the negative ideal solution $A^-$ of each scheme. Then defining two artificial schemes.

The positive ideal scheme and the negative ideal scheme are as follows.

$$A^+ = (z_1^+, z_2^+, L, z_m^+)$$

$$A^- = (z_1^-, z_2^-, L, z_m^-)$$

For the benefit attribute,

$$z_j^+ = \max z_{ij}, j = 1, 2, L, n$$

For the cost attribute,

$$z_j^- = \min z_{ij}, j = 1, 2, L, n$$

The fourth step is to calculate the distance from each scheme to the positive ideal solution $d_i^+$ and the negative ideal solution $d_i^-$. For the benefit attribute,

$$d_i^+ = |z_i - A^+| = \sqrt{\sum_{j} (z_{ij} - z_j^+)^2}$$  \hspace{1cm} (3)

$$d_i^- = |z_i - A^-| = \sqrt{\sum_{j} (z_{ij} - z_j^-)^2}$$  \hspace{1cm} (4)

Where $i = 1, 2, L, m$, $j = 1, 2, L, n$, $z_i = (z_{i1}, z_{i2}, L, z_{im})$.

The fifth step is to calculate the relative closeness $C_i^+$ between each scheme and the positive ideal solution.

$$C_i^+ = \frac{d_i^-}{d_i^+ + d_i^-}$$  \hspace{1cm} (5)

Where, $i = 1, 2, L, m$.

It can be seen if $z_i = A^+$, $C_i^+ = 1$. And if $z_i = A^-$, $C_i^+ = 0$. $0 \leq C_i^+ \leq 1$. When $C_i^+ \rightarrow 1$ the scheme $A_i \rightarrow A^+$. Lastly, we rank $C_i^+$ according to the descending order.

B. Grey relation

The grey system theory provides the index quantitative measurements for the project selection decision. We do the grey correlation degree analysis according to the same factors for each scheme. Then we get the numerical relationship of the same factor for each scheme. The step of the grey correlation method is as follows.

Firstly, we establish the index matrix $A = [x_{ij}]_{m \times n}$. $m$ is the number of the preferred items. $n$ is the number of the index factors. The weight of each index is $W = (w_1, w_2, L, w_n)$.

Secondly, we give the weight on the basis of the index matrix $A$. And we construct the weighted matrix $B : B = A W$.

Thirdly, according to the weighted index matrix, we can get the positive ideal scheme $a^+$ and the negative ideal scheme $a^-$.

The fourth step is to calculate the correlation between each scheme and the positive scheme and the negative scheme.

$$L_j = \min \\min_{j} \left[ \frac{a_{ij} - a^+} {a^+ - a^-} \right] + \theta \max_{j} \left[ \frac{a_{ij} - a^-} {a^+ - a^-} \right]$$  \hspace{1cm} (6)

For $a_{ij}$, $L_j$ is the correlation coefficient at $j$. The value range for the correlation coefficient is $[0, 1]$. If expresses that the similar degree of the two factors which are compared at one point. Where, $\theta$ is the distinguish coefficient. It expresses the distortion that is caused by weakening the biggest absolute difference value. The value range for $\theta$ is $[0, 1]$. According to the experience value, $\theta = 0.5$. $i = 1, 2, L, m$, $j = 1, 2, L, n$. The overall correlation of the scheme is the average of all kinds of the correlation coefficient. That is,

$$R_i = \frac{1}{n} \sum R_j$$  \hspace{1cm} (7)

The fifth step is to calculate the relative close degree between each scheme and the ideal scheme.

$$r_i = \frac{R_i}{R_i + R_{i^-}}$$  \hspace{1cm} (8)

The sixth step is as follows. The optimal scheme is the scheme that the relative degree is bigger. Then we order the alternative scheme according to the size of the close degree.

III. THE IMPROVED GREY-TOPSIS-DEA

We assume that there are $n$ indexes $x_1, x_2, L, x_n$. Correspondingly, it exists the optimal ideal index set $x^+ = \{x_1^+, x_2^+, L, x_n^+\}$ and the worst index set $x^- = \{x_1^-, x_2^-, L, x_n^-\}$. The weight of each index is $a_{i1}, a_{i2}, L, a_{in}$. Now, there are $m$ assessment scheme $y_1, y_2, L, y_m$. The index of each scheme is $\{y_1, y_2, L, y_m\}$. The index of each scheme is $\{x_1^+, x_2^+, L, x_n^+\}$ and $\{x_1^-, x_2^-, L, x_n^-\}$. Where, $x_1^+$ is the maximum index which is processed by the dimensionless and $x_i^+ \in [0, 1]$. $\alpha_i^j$ is the correlation coefficient of the $k$ index for the $i$ scheme and the $k$ optimal ideal index. $\beta_i^j$ is the correlation coefficient of the $k$ index for the $i$ scheme and the $k$ worst ideal index.

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\[ \alpha_i' = \frac{\min_{i,j} \left[ x_{ij} \right] - \max_{i,j} \left[ x_{ij} \right]}{\max_{i,j} \left[ x_{ij} \right] - \min_{i,j} \left[ x_{ij} \right]} \] (9)

\[ \beta_i' = \frac{\min_{i,j} \left[ x_{ij} \right] - \max_{i,j} \left[ x_{ij} \right]}{\max_{i,j} \left[ x_{ij} \right] - \min_{i,j} \left[ x_{ij} \right]} \] (10)

\[ S_i' = \frac{S_i - S_i^*}{S_i^* - S_i} \] (11)

\[ S_i'' = \frac{S_i^* - S_i}{S_i^* - S_i} \] (12)

Where, \( S_i' \) is the distance from the \( i \) scheme which is not processed by the standardized to the optimal ideal index set and \( S_i'' \) is the distance from the \( i \) scheme which is not processed by the standardized to the worst ideal index set.

\[ S_i = \sum_{j=1}^{n} (\omega_j \cdot \beta_j) \] (13)

Where, \( C' \) is the relative closeness degree of the \( i \) scheme for the ideal index set.

\[ C_i' = \frac{S_i'}{S_i^* - S_i'} \] (14)

Where, \( C_i' \) is the evaluation value which is adjusted by the DEA method.

The flow chart is shown in the following figure.

**IV. EXPERIMENT**

In this paper, we rank the universities according to the teaching quality. Firstly, we establish the college teaching quality evaluation system. The college teaching quality evaluation system is as follows.

![Flow chart of the improved Grey-TOPSIS-DEA method](image)

Firstly, we get the weight of each index \( W = (0.21, 0.34, 0.14, 0.23, 0.08) \). Then we rank the teaching quality the six universities \( \{A_1, A_2, A_3, A_4, A_5, A_6\} \).

The decision matrix is as follows.

\[ C = \begin{bmatrix} 8 & 6 & 7 & 9 & 7 \\ 6 & 6 & 9 & 7 & 8 \\ 7 & 8 & 7 & 9 & 8 \\ 7 & 9 & 8 & 6 & 7 \\ 9 & 6 & 7 & 9 & 8 \\ 6 & 7 & 9 & 8 & 6 \end{bmatrix} \]

We can get the evaluation result.

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Before adjustment

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V. CONCLUSIONS

The college education is very important for a person’s growth. The college is not only the place where we study, but also the temple of the knowledge. To evaluate the college education and get the rankings is a very important job. In this paper, we combine the Grey theory, TOPSIS and TOPSIS-DEA method. Then we use the model to evaluate the college education quality and get the rankings of the college education. The main job of this paper is as follows. Firstly, we introduce the background of the university education evaluation. Secondly, we introduce the Grey theory and TOPSIS method. Thirdly, we propose an improved Grey-TOPSIS-DEA model. And we apply the method to the quality evaluation of the college education. The experiment in this paper shows the effectiveness.

REFERENCES


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