Evaluation of Education Resources Allocation in Beijing Based on Entropy-TOPSIS Method

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Abstract. An entropy-TOPSIS method has been developed in order to evaluate the resources allocation in training education of higher vocational college in Beijing. In the developed method, the entropy method has been introduced into the TOPSIS framework to determine the weight of indexes of education resources allocation. The results indicate that the instruments for practical teaching from companies and the proportion of full-time teacher with bipolar teaching are the highest and least important indexes, respectively. The results of evaluation indicate a decrease in the total allocation of higher vocational colleges in Beijing from 2017 to 2019. And the highest and lowest values of closeness are 0.4247 in the year of 2017 and 0.3809 in the year of 2019, respectively. Moreover, the disparity of training education resources allocation between different higher vocational colleges in Beijing can be achieved, which could be used as a reference for improving the resources allocation and increasing the investment in training education.

1. Introduction
For higher vocational colleges, training education resources are so important that they affect the quality of professional talents cultivation. The evaluation of resources allocation plays a key role in promoting the practice teaching reform. Lots of methodologies have been proposed by the researchers to evaluate the resources in education[1-3]. For example, Zhou used the Data Envelopment Analysis method to analysis the area of China's regional higher education resources allocation[1]. Shen et al. analysed the education and training industry by using the fidelity model[2]. Chi et al. applied TOPSIS method to measure the level of higher education resources in China[3]. Among them, the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method has been widely used with the advantages of simple program and good practicality[4]. However, the evaluate result would be greatly influenced by the determination of weight of indexes in the TOPSIS method. It is necessary to choose a method which can avoid the influence of diversity between different indexes. The entropy method can be used as a measure of weight on a decision making event. Therefore, this study aims to integrate the entropy method into a TOPSIS framework. It would lead to an entropy-TOPSIS method for evaluation of resources allocation in training education.

2. Methodology
Entropy originates from a concept in physics, and then has been widely used in various fields[5]. The entropy method can be used to determine the weight of indexes in the process of decision making and evaluation. The diversity between different indexes could be avoided by using entropy method. Moreover, the hidden information could be revealed.
Let \( m \) and \( n \) be the numbers of targets and indexes, respectively. Then the decision matrix \( X_{ij} \) can be generated, where \( x_{ij} \) represents the value of index \( j \) for target \( i \). The normalization of the decision matrix, \( P_{ij} \), can be formulated. The corresponding value \( p_{ij} \) can be calculated as:

\[
p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}.
\]

(1)

The entropy \( E_j \) can be expressed as:

\[
E_j = - \frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \ln p_{ij}.
\]

(2)

Then the coefficient of diversity \( d_j \) for index \( j \) can be generated by:

\[
d_j = 1 - E_j.
\]

(3)

For a given index \( j \), the coefficient of diversity \( d_j \) decreases as the entropy \( E_j \) increases. The index could be regarded invalid when \( d_j = 1 \). The weight \( \omega_j \) of index \( j \) can be calculated as:

\[
\omega_j = \frac{d_j}{\sum_{j=1}^{n} d_j}.
\]

(4)

The weight \( \omega_j \) increases as the coefficient of diversity \( d_j \) increases.

The entropy-TOPSIS method would be proposed by combining the entropy and TOPSIS methods into a general framework, in which the entropy method will be applied to determine the weight of indexes and the TOPSIS method is used to achieve the evaluation. The procedure of the entropy-TOPSIS method is as follows:

Step 1: Determine the weight of indexes through Equation (1) to (4).

Step 2: Construct the weighted normalization of the decision matrix, \( V_{ij} \). The corresponding value \( v_{ij} \) can be calculated as:

\[
v_{ij} = \omega_j p_{ij}.
\]

(5)

Step 3: Determine the positive and negative ideal solutions, \( A^+ \) and \( A^- \), respectively.

\[
A^+ = \left\{ \max_{1 \leq i \leq m} v_{ij} \mid j = 1, 2, \ldots, n \right\} = \{ a_{1}^+, a_{2}^+, \ldots, a_{n}^+ \},
\]

(6)

\[
A^- = \left\{ \min_{1 \leq i \leq m} v_{ij} \mid j = 1, 2, \ldots, n \right\} = \{ a_{1}^-, a_{2}^-, \ldots, a_{n}^- \}.
\]

(7)

Step 4: Calculate the closeness \( C_i \) between real and ideal solutions:

\[
C_i = \frac{d_i^-}{d_i^+ + d_i^-},
\]

(8)

\[
d_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - a_{ij}^-)^2},
\]

(9)
where $d_j^-$ represents the distance between real and negative ideal solution; $d_j^+$ represents the distance between real and positive ideal solution.

Step 5: Sort the closeness $C_i$ in descending order. For example, the evaluate result $C_1 > C_2 > C_3$ indicates that target 1 is the best with the highest value of closeness and target 3 is the worst with the lowest value of closeness.

3. Application
In an education resources evaluation system, the available resources allocation in training education of higher vocational colleges in Beijing should be considered. The evaluations of training education resources allocation would make contribution to the educational balance between various higher vocational colleges in Beijing. The selection of indexes follows the principles of operability, scientifiity and completeness. The indexes very relevant to training education resources are shown in Table 1. The corresponding data obtained from Quality Annual Reports of Beijing are used in this study.

| Sequence number | Indexes                                                                 |
|-----------------|-------------------------------------------------------------------------|
| 1               | Practical areas (Square metre/Student)                                  |
| 2               | Proportion of full-time teacher with bipolar teaching (%)               |
| 3               | Work position for practical teaching on campus (Unit/Student)           |
| 4               | Value of instruments for scientific research (Yuan/Student)             |
| 5               | Value of instruments for practical teaching from companies (10^4Yuan)   |
| 6               | Teaching time per year of part-time teaching from companies (Hour)      |

The entropy-TOPSIS method has been applied to the evaluation of resources allocation in training education of higher vocational colleges. Based on the data from Quality Annual Reports of Beijing, the weights of indexes can be determined by the entropy method (shown in Figure 1). Results indicate that value of instruments for practical teaching from companies is the most important index, with a value of 0.4663. Proportion of full-time teacher with bipolar teaching is the least important index, with a value of 0.0084.

![Figure 1. Weight of indexes.](image_url)
Figure 2 shows the results of evaluation for total resources allocation in training education in Beijing from 2016 to 2019. The results indicate that (1) there is a decrease in the resources allocation from 2017 to 2019; (2) the highest and lowest values of closeness are 0.4247 in the year of 2017 and 0.3809 in the year of 2019, respectively; (3) the largest percentage decrease occurred in 2018 with a value of 10.39%.

Figure 2. Evaluation of total training education resources allocation in Beijing from 2016 to 2019.

Figure 3 provides the comparison of evaluations between some famous higher vocational colleges in Beijing in the Year of 2019. The results indicate a huge disparity of resources allocation between different higher vocational colleges in Beijing. Among the studied colleges in Beijing, Beijing College of Finance and Commerce got the highest evaluation for training education resources allocation. The corresponding value of closeness is 0.4876. Beijing Vocational College of Labour and Social Security got the second-highest evaluation. The corresponding value of closeness is 0.4268. Beijing Polytechnic got the third-highest evaluation with the value of closeness 0.4200. The distance between various higher vocational colleges in aspect of training education resources allocation can be achieved. The results could be used as a reference for improving the investment and balancing the allocation of training education resources in order to narrow the gap.

Figure 3. Comparison of evaluations between higher vocational colleges in Beijing.
4. Concluding Remarks

In this study, an entropy-TOPSIS model has been developed for evaluation of resources allocation in training education. The evaluations for total resources allocation in training education of higher vocational colleges in Beijing from 2016 to 2019 can be achieved. Moreover, the comparison of evaluations between some famous higher vocational colleges in Beijing in the Year of 2019 can be generated. Results indicate that (1) the value of instruments for practical teaching from companies and the proportion of full-time teacher with bipolar teaching are the highest and least important indexes, respectively; (2) there is a decrease in the resources allocation from 2017 to 2019; (3) the highest and lowest values of closeness are 0.4247 in the year of 2017 and 0.3809 in the year of 2019, respectively; (4) the largest percentage decrease occurred in 2018 with a value of 10.39%; (5) Beijing College of Finance and Commerce, Beijing Vocational College of Labour and Social Security and Beijing Polytechnic got the top three places in the evaluation for training education resources allocation among the studied higher vocational colleges in Beijing.

It can be found that there is a relatively even distribution of training education resources between the studied higher vocational colleges in Beijing. The future allocation of equipment, human talents and financial resources should be considered based on the evaluation of existing resources. And the instruments for practical teaching from companies should be increased to better improve the development of training in higher vocational colleges.

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