

Optimization Decision Method for Undergraduate Teaching Evaluation with Hybrid Data Information

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Abstract

Undergraduate teaching evaluation plays an important role in promoting the educational management and improving the teaching quality in colleges and universities. In this paper, considering the uncertainty and fuzziness in undergraduate teaching evaluation, we translate the problem of undergraduate teaching evaluation into a hybrid multi-attribute decision making with hybrid data which the attribute values integrate with real numbers, interval numbers and fuzzy numbers. To evaluate and rank the undergraduate teaching level for multiple alternative universities, we propose a novel optimization decision method based on grey relational analysis. Moreover, an application decision making example is given to highlight the implementation, availability, and feasibility of this optimization decision method.

Keywords

Undergraduate Teaching Evaluation; Hybrid Multi-attribute Decision Making; Hybrid Data Information; Grey relational Degree

Introduction

In the 21st century, with the rapid progress in economic globalization and science and technology, the comprehensive national strength competition is increasingly fierce. To vigorously improve school-running level, the teaching quality of universities has become the theme of the times, and also has become the urgent task of higher education reform and development. Undergraduate education is the basis and the main body of higher education and the undergraduate teaching is the key to improve the quality of the whole higher education.

Since 1994, the Ministry of Education of China has organized the undergraduate teaching evaluation for the colleges and universities. By the end of 2004, a total of 350 colleges and universities had accepted the undergraduate teaching evaluation. This evaluation

plays an important role in promoting the educational management and improving the teaching quality in colleges and universities. This effect is reflected in two basic aspects. The first one is to promote the construction of the colleges and universities effectively. The second is to enhance the school's self-discipline consciousness and self-discipline effectively. The most direct effect of undergraduate teaching evaluation is to promote the construction of schools, and let the schools focus on increasing investment and improve the teaching conditions. Also, it makes further clear guiding ideology of running school, improves the level of management, strengthens the construction of teaching staff and promotes the reform of teaching. In a word, it has played a very important role in the improvement of teaching, talent training and education quality (Stronge, 2006).

Generally, in the practical undergraduate teaching evaluation, the expert group often gives a score for each evaluation attribute for all alternative universities, and then uses the weighted average method to give a comprehensive score of teaching level for each university. This method is simple, but it has some problems (Wei, 2012), for example, due to the restrictions of profession and experience, the score which is given by the experts in the form of real number has a certain subjective randomness, and sometimes the comprehensive evaluation results are unfair. The evaluation workload is great, but the evaluation results must be given in a short time, thus it will affect the objectivity and the accuracy of evaluation results in some extent.

Undergraduate teaching evaluation is a complex system which involves with multiple attributes. In August 2004, the ministry of education of China issued the "Evaluation scheme of undergraduate teaching evaluation". In this scheme, seven first-class

attributes are given to evaluate the undergraduate teaching level, i.e., university guiding ideology, teaching staff, teaching conditions, specialty construction and teaching reform, teaching management, study style, and teaching effect. These first-class attributes include 19 sub-attributes, i.e., the university orientation, educational ideas, the teachers' number and structure, the quantity of master teacher, the basic facilities for teaching, teaching funds, specialty, curriculum, teaching practice, the management team, teaching quality control, the teacher demeanor, learning culture, basic theory and basic skills, graduation thesis or graduation design, the ideological and political moral culture, sports, social reputation and employment. When we use these attributes to evaluate a university's teaching level, there are a lot of fuzziness and uncertainty in the evaluation process. As in the 19 sub-attributes, the values of some qualitative attributes such as university orientation and educational ideas are often given in the form of linguistic fuzzy variables, such as "worst, worse, bad, common, good, better, best" or "lowest, lower, low, common, high, higher, highest" (Xu, 2004; Rao and Peng, 2009; Rao and Zhao, 2009). And the values of the quantity of master teacher and the percent of doctorates in all teachers often can be determined by real numbers. In addition, for some special attributes, such as teaching funds, the value can not be given by a real number because of the overlapping inputs for many kinds of funds using, and can only be given by a value range, i.e., interval number. Thus, in the undergraduate teaching evaluation, the precise values, interval numbers and the linguistic fuzzy variables coexist simultaneously (Rao and Peng, 2009; Xu, 1999). Considering this hybrid data information, we translate the problem of undergraduate teaching evaluation into a hybrid multi-attribute decision making with hybrid data which the values of attributes integrate with real numbers, interval numbers and fuzzy numbers, and propose a novel optimization decision method based on grey relational analysis to rank the teaching level for all alternative universities. We try to provide a new quantitative method for undergraduate teaching evaluation under uncertain information environment.

The rest of the paper is organized as follows. Section 2 proposes a novel optimization decision method based on grey relational analysis to rank the teaching level for all alternative universities. Section 3 gives the decision making process description. Section 4 presents a numerical application example to show the

feasibility of the proposed decision method. Section 5 concludes the paper.

Decision Making Method

The problem of undergraduate teaching evaluation can be described as the following hybrid multi-attribute decision making with hybrid data. We suppose that an expert group wants to evaluate the teaching level for m alternative universities. n evaluation attributes such as university orientation, educational ideas, the teachers' number and structure, etc. form the evaluation system. The attribute set is denoted as $P = \{p_1, p_2, \dots, p_n\}$. $W = (w_1, w_2, \dots, w_n)$ is the weight vector of attributes such that $0 \leq w_j \leq 1$ and $\sum_{j=1}^n w_j = 1$. The original hybrid decision making matrix is denoted as $A = (a_{ij})_{m \times n}$, where a_{ij} is the attribute value of alternative x_i ($i = 1, 2, \dots, m$) on attribute p_j , $j = 1, 2, \dots, n$. We denote:

$$N = \{1, 2, \dots, n\}, N_1 = \{1, 2, \dots, n_1\},$$

$$N_2 = \{n_1 + 1, n_1 + 2, \dots, n_2\}, N_3 = \{n_2 + 1, n_2 + 2, \dots, n\},$$

where N_1, N_2, N_3 denote the sets of three kinds of attributes with real numbers, linguistic fuzzy variables, interval numbers, respectively. When $j \in N_1$, $a_{ij} \in R$ is a real number. When $j \in N_2$, a_{ij} are interval numbers $a_{ij} = [a_{ij}^L, a_{ij}^U]$. When $j \in N_3$, a_{ij} is a linguistic fuzzy variable. All values of a_{ij} are formed an original hybrid decision making matrix $A = (a_{ij})_{m \times n}$. Now we need to make evaluation and rank the teaching level of all alternative universities.

Data Processing

In hybrid multi-attribute decision making, when some attribute values are given in the form of linguistic fuzzy variables, we can transform them into triangle fuzzy numbers. The transfer method is given as follows.

Definition 1. Suppose that $S_a = \{\text{worst, worse, bad, common, good, better, best}\}$ or $S_b = \{\text{lowest, lower, low, common, high, higher, highest}\}$, then S_a and S_b are called the set of linguistic fuzzy numbers, they are denoted as $S_a = \{s_1, s_2, \dots, s_7\}$, $S_b = \{s'_1, s'_2, \dots, s'_7\}$, and their corresponding triangle fuzzy numbers are defined as follows. For the type of revenue attributes, we denote

$$s_1 = (0, 0, 0.1); s_2 = (0, 0.1, 0.2); s_3 = (0.2, 0.3, 0.4);$$

$$s_4=(0.4,0.5,0.6); s_5=(0.6,0.7,0.8); s_6=(0.8,0.9,1);$$

$$s_7=(0.9,1,1).$$

For the type of cost attributes, we denote

$$s_1=(0.9,1,1); s_2=(0.8,0.9,1); s_3=(0.6,0.7,0.8);$$

$$s_4=(0.4,0.5,0.6); s_5=(0.2,0.3,0.4); s_6=(0,0.1,0.2);$$

$$s_7=(0,0,0.1),$$

the corresponding triangle fuzzy numbers for S_b are the same as S_a .

When the values of attribute $j \in N_3$ are all transformed into triangle fuzzy numbers, a new hybrid decision making matrix can be obtained, it is denoted as $X = (x_{ij})_{m \times n}$.

We denote the benefit type attribute as I_1 , and denote the cost type attribute as I_2 , and $M = \{1, 2, L, m\}$, $N = \{1, 2, L, n\}$. The algorithms of normalizing the real numbers, interval numbers and triangular fuzzy numbers refer to Xu (1999, 2004), Xiao et al. (2005). Suppose the matrix X is transformed into normalized matrix $Y = (y_{ij})_{m \times n}$, where

$$y_{ij} = y_{ij}, \quad i \in M, j \in N_1;$$

$$y_{ij} = [y_{ij}^L, y_{ij}^U], \quad i \in M, j \in N_2;$$

$$y_{ij} = [y_{ij}^L, y_{ij}^M, y_{ij}^U], \quad i \in M, j \in N_3.$$

Grey Relational Analysis Method of Hybrid Sequences

In this section, we give an algorithm based on grey relational degree to deal with the problem of undergraduate teaching evaluation. Firstly, some definitions are given.

Definition 2. Suppose $a_1 = [a_1^L, a_1^M, a_1^U]$, $a_2 = [a_2^L, a_2^M, a_2^U]$ are two triangle fuzzy numbers, then the Hausdorff distance between a_1 and a_2 are defined:

$$D_H(a_1, a_2) = \max\{|a_1^L - a_2^L|, |a_1^M - a_2^M|, |a_1^U - a_2^U|\}.$$

Definition 3. Suppose $a_1 = [a_1^L, a_1^U]$, $a_2 = [a_2^L, a_2^U]$ are two positive interval numbers, then the distance between these two interval numbers are defined:

$$D(a_1, a_2) = \frac{\sqrt{2}}{2} \sqrt{(a_1^L - a_2^L)^2 + (a_1^U - a_2^U)^2}.$$

Definition 4. Let $\alpha = (\alpha(1), \alpha(2), L, \alpha(n))$ be an n-dimensional data sequence. If the real numbers, interval numbers and triangular fuzzy numbers are coexistent in the values of $\alpha(1), \alpha(2), L, \alpha(n)$, then α

is called a hybrid sequence.

For the hybrid decision making matrix $Y = (y_{ij})_{m \times n}$, the elements of each row constitute a hybrid sequence y_i , where

$$y_i = (y_{i1}, y_{i2}, L, y_{i,n_1}, [y_{i,n_1+1}^L, y_{i,n_1+1}^U], L, [y_{i,n_2}^L, y_{i,n_2}^U],$$

$$L, [y_{i,n_2+1}^L, y_{i,n_2+1}^M, y_{i,n_2+1}^U], L, [y_{i,n}^L, y_{i,n}^M, y_{i,n}^U]) \quad (1)$$

Definition 5. Let $Y = (y_{ij})_{m \times n}$ be a hybrid making matrix, then

$$f = (f_1, f_2, L, f_n)$$

$$= (\max_{1 \leq i \leq m} y_{i1}, \max_{1 \leq i \leq m} y_{i2}, L, \max_{1 \leq i \leq m} y_{i,n_1}, [\max_{1 \leq i \leq m} y_{i,n_1+1}^L, \max_{1 \leq i \leq m} y_{i,n_1+1}^U],$$

$$L, [\max_{1 \leq i \leq m} y_{i,n_2}^L, \max_{1 \leq i \leq m} y_{i,n_2}^U], [\max_{1 \leq i \leq m} y_{i,n_2+1}^L, \max_{1 \leq i \leq m} y_{i,n_2+1}^M, \max_{1 \leq i \leq m} y_{i,n_2+1}^U],$$

$$L, [\max_{1 \leq i \leq m} y_{in}^L, \max_{1 \leq i \leq m} y_{in}^M, \max_{1 \leq i \leq m} y_{in}^U]) \quad (2)$$

is called positive ideal solution.

Based on Definitions 2-5, the following Definition 6 defines grey relational degree of hybrid sequences.

Definition 6. Suppose y_1, y_2, L, y_m are hybrid attribute sequences, $y_0 = f$ is reference sequence, y_i are compared sequences, $i = 1, 2, L, m$, where f and y_i are expressed by (2) and (1), respectively. Then the grey relational coefficient of hybrid attribute sequences is defined:

$$r(f_j, y_{ij}) = \frac{\rho \max_i \max_j \Delta(f_j, y_{ij})}{\Delta(f_j, y_{ij}) + \rho \max_i \max_j \Delta(f_j, y_{ij})} \quad (3)$$

The grey relational degree of hybrid attribute sequences is defined:

$$r(y_0, y_i) = \sum_{j=1}^n w_j r(f_j, y_{ij}) \quad (4)$$

Where $\Delta(f_j, y_{ij})$ is the difference information at the j -th point of y_i to f . When $j \in N_1$,

$$\Delta(f_j, y_{ij}) = \left| \max_{1 \leq i \leq m} y_{ij} - y_{ij} \right|;$$

When $j \in N_2$,

$$\Delta(f_j, y_{ij}) = \frac{\sqrt{2}}{2} \sqrt{(\max_{1 \leq i \leq m} y_{ij}^L - y_{ij}^L)^2 + (\max_{1 \leq i \leq m} y_{ij}^U - y_{ij}^U)^2};$$

When $j \in N_3$,

$$\Delta(f_j, y_{ij}) = D_H(f_j, y_{ij})$$

$$= \max\left\{ \left| \max_{1 \leq i \leq m} y_{ij}^L - y_{ij}^L \right|, \left| \max_{1 \leq i \leq m} y_{ij}^M - y_{ij}^M \right|, \left| \max_{1 \leq i \leq m} y_{ij}^U - y_{ij}^U \right| \right\}.$$

ρ is the distinguishing coefficient, generally, we set $\rho = 0.5$; w_j is the weight of the j -th attribute p_j , $j = 1, 2, L, n$.

The Decision Making Process Description

In this section, we give the detail steps for evaluating and ranking the teaching level of all alternative universities.

Step 1: The expert group determines the original hybrid decision making matrix $A = (a_{ij})_{m \times n}$, where a_{ij} is the attribute value of alternative x_i ($i = 1, 2, L, m$) on attribute p_j ($j = 1, 2, L, n$).

Step 2: Use Definition 1 to transform linguistic fuzzy variables into triangle fuzzy numbers, then a new hybrid decision making matrix $X = (x_{ij})_{m \times n}$ is obtained.

Step 3: Normalize the real numbers, interval numbers and triangular fuzzy numbers refer to Xu (2004), then we get the normalized matrix $Y = (y_{ij})_{m \times n}$, where

$$y_{ij} = y_{ij}, \quad i \in M, j \in N_1; \quad y_{ij} = [y_{ij}^L, y_{ij}^U], \quad i \in M, j \in N_2; \\ y_{ij} = [y_{ij}^L, y_{ij}^M, y_{ij}^U], \quad i \in M, j \in N_3.$$

Step 4: Use (2) to determine the positive ideal solution, i.e., reference sequence.

Step 5: Use (3) and (4) to compute the grey relational degree $r(y_0, y_i)$.

Step 6: Rank the teaching level of all the alternative universities in accordance with $r(y_0, y_i)$.

An Application Example

Here let us suppose that a expert group wants to evaluate the teaching level of four alternative universities (U_1, U_2, U_3, U_4) by considering the following five attributes, i.e., the percent of doctorates in all teachers (p_1) (%), the quantity of master teacher with senior professional post (p_2), teaching funds (p_3)(10^4 Yuan), teaching quality control (p_4), learning culture (p_5). The data information are listed in Table 1. Let the vector of attribute weights be $W=(0.25, 0.15, 0.15,$

TABLE 1 ORIGINAL DECISION MATRIX

| University | p_1 | p_2 | p_3 | p_4 | p_5 |
|------------|-------|-------|----------|--------|--------|
| U_1 | 19 | 480 | [50, 60] | high | good |
| U_2 | 24 | 530 | [35, 45] | low | common |
| U_3 | 17 | 490 | [55, 65] | good | better |
| U_4 | 21 | 500 | [40, 50] | common | common |

0.15, 0.2). Our task is to evaluate the teaching level of four alternative universities according the given information in Table 1.

(1) Transform the linguistic fuzzy variables into triangle fuzzy numbers, and normalize the data, and then use (2) to determine the positive ideal solution, i.e., reference sequence

$$f = (1, 1, [0.462, 0.836], (0.492, 0.698, 0.990), (0.533, 0.688, 0.893)).$$

(2) Using (3) and (4) to compute the grey relational degree $r(y_0, y_i)$, $i = 1, 2, 3, 4$,

$$r(y_0, y_1) = 0.732; r(y_0, y_2) = 0.580; \\ r(y_0, y_3) = 0.822; r(y_0, y_4) = 0.597.$$

(3) Rank the teaching level of all the alternative universities in accordance with $r(y_0, y_i)$.

Because $r(y_0, y_3) > r(y_0, y_1) > r(y_0, y_4) > r(y_0, y_2)$, then the teaching level of four alternative universities are ranked as follows: $U_3 \succ U_1 \succ U_4 \succ U_2$.

Conclusions

In this paper, we propose an optimization decision method based on grey relational degree of hybrid sequences to evaluate the undergraduate teaching level of universities. There are several valuable work in this paper, i.e., the new definition of hybrid sequence is given, and the grey relational degree of hybrid sequences is presented based on Professor Deng' grey relational analysis method. Therefore, it provides an effective way to deal with the problems of hybrid multi-attribute decision making.

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REFERENCES

Rao, C.J., Peng, J. "Group decision making model based on grey relational analysis." The Journal of Grey System 21 (2009): 15–24.
 Rao, C.J., Zhao, Y. "Multi-attribute decision making model based on optimal membership and relative entropy." Journal of Systems Engineering and Electronics 20 (2009):

- 537–542.
- Stronge, J.H. "Evaluating Teaching." Thousand Oaks, CA: Corwin Press, 2006.
- Wei, Z.H. "Research on Comprehensive Evaluation of College Teachers' Teaching Performance." PhD diss., North China Electric Power University, 2012.
- Xu, Z.S. "Uncertain Multiple Attribute Decision Making: Methods and Applications." New York: Springer-Verlag, 1999.
- Xu, Z.S. "Uncertain Multiple Attribute Decision Making: Methods and Applications." Beijing: Tsinghua University Press, 2004.
- Xia, Y., Wu, Q. "A technique of order preference by similarity to ideal solution for hybrid multiple attribute decision making problems." *Journal of Systems Engineering* 19 (2004): 630–634.
- Xiao, X.P., Song, Z.M., & Li, F. "Grey Technology and Its Application." Beijing: Science Press, 2005.
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