Application of Fuzzy Comprehensive Evaluation to Human Resource Value Accounting Measurement

Jinshu Yang

School of Management, Taizhou Vocational & Technical College, Taizhou, 318000, Zhejiang, China

517472771@qq.com

Abstract

In this paper, we study on the multiple attribute decision making problems for evaluating the human resource value accounting measurement with triangular fuzzy information. Inspried by the idea of geometric Bonferroni mean, we develop the triangular fuzzy geometric Bonferroni mean (TFGBM) operator and triangular fuzzy weighted geometric Bonferroni mean (TFWGBM) operator, based on which we design the procedure for multiple attribute decision making under the triangular fuzzy environments. In the end, a practical example for evaluating the human resource value accounting measurement with triangular fuzzy information is given to testify the proposed method.

Keywords

multiple attribute decision making; triangular fuzzy numbers; Bonferroni mean; triangular fuzzy geometric Bonferroni mean (TFGBM) operator; triangular fuzzy weighted geometric Bonferroni mean (TFWGBM) operator; human resource value accounting measurement.

1. Introduction

Along with the management right and ownership separation of modern enterprise, enterprise accounting behavior subject independence issues become more prominent. The beginning of this century, Enron, WorldCom, global communications and Xerox and other well-known large companies financial reports fraud have been disclosed, so that the whole world capital market are shrouded in the financial reporting fraud deep shadow. In recent years, China has also undergone a number of listed companies' financial reporting fraud incident, such as YinGuangXia, Lam tin shares, China Aviation Oil, etc., all are startling. Accountants fraud, financial reporting fraud triggered unprecedented securities market credit crisis, securities market on which the survival and development of credit basis and the principle of "open","fairness","justice" has been challenged, greatly influenced the securities market optimizing the allocation of resources the basic function of the play, thus caused great damage to our country's economic life. Therefore, in order to ensure the independence of accountants, systematic, comprehensive and targeted research enterprise accounting behavior subject independence problem becomes very important, only to ensure that accountants's independence, objective, fair and justice, faithfully reflect the financial position and operating results of enterprises, so that enterprises can be sustained and healthy development, can play to the modern enterprise system of ownership and the right of management separates advantage, to be able to regain the confidence of investors and promote the sustainable development of China's economy[1-12].

In this paper, we research on the multiple attribute decision making problems[13-18] for evaluating the human resource value accounting measurement with triangular fuzzy information. Motivated by the idea of geometric Bonferroni mean, we develop the triangular fuzzy geometric Bonferroni mean (TFGBM) operator and triangular fuzzy weighted geometric Bonferroni mean (TFWGBM) operator, based on which we develop two procedure for multiple attribute decision making for evaluating the human resource value accounting measurement under the triangular fuzzy environments. Finally, a practical example for evaluating the human resource value accounting measurement with triangular fuzzy information is given to testify the proposed algorithm.

2. Preliminaries

In this section, we will simply introduce some basic concepts and basic operational rules, which is corresponding to triangular fuzzy numbers.

Definition 1[19]. A triangular fuzzy numbers $\tilde{a}$ can be defined via a triplet $\left(a^L, a^M, a^U\right)$.The membership function $\mu_{\tilde{a}}\left(x\right)$ is defined as:

$$\mu_{\tilde{a}}\left(x\right)=\begin{cases} 0, & x<a^L, \\ \dfrac{x-a^L}{a^M-a^L}, & a^L\le x\le a^M, \\ \dfrac{x-a^U}{a^M-a^U}, & a^M\le x\le a^U, \\ 0, & x\ge a^U. \end{cases} \tag{1}$$

where $0<a^L\le a^M\le a^U$, a^L and a^U represent the lower and upper values of the support of $\tilde{a}$,respectively, and a^M is used to represent the modal value.

Definition 2[20-23]. Let $\tilde{b}=\left[b^L, b^M, b^U\right]$ and $\tilde{a}=\left[a^L, a^M, a^U\right]$ be two triangular fuzzy numbers, then the degree of possibility of $a\ge b$ is defined as

$$p\left(a\ge b\right)=\lambda\max\left\{1-\max\left[\frac{b^M-a^L}{a^M-a^L+b^M-b^L},0\right],0\right\}+ \\ \left(1-\lambda\right)\max\left\{1-\max\left[\frac{b^U-a^M}{a^U-a^M+b^U-b^M},0\right],0\right\} \tag{2}$$

where the value λ refers to an index of rating attitude, which can reflect the decision maker's risk-bearing attitude. If λ is larger than 0.5, the decision maker is risk lover. If λ is equal to 0.5, the decision maker may be neutral to risk. If the value of parameter λ is smaller than 0.5, the decision maker is risk avertor.

3. TFGBM and TFWGBM operators

In the following, Zhu et al.[24] studied on the geometric Bonferroni mean (GBM) which utilizing both the BM and the geometric mean (GM).

Definition 3[33]. Let $p,q\ge 0$ and $a_i\left(i=1,2,\cdots,n\right)$ be a collection of non-negative real numbers. Then the aggregation functions:

$$GBM^{p,q}\left(a_1,a_2,\cdots,a_n\right) \\ =\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\ i\ne j}}^{n}\left(pa_i+qa_j\right)\right)^{\frac{1}{n(n-1)}} \tag{3}$$

is named the geometric Bonferroni mean (GBM) operator.

But the geometric Bonferroni mean (BM) operator [10] have usually been utilized when inputting arguments are belonged to the non-negative real numbers. Hence, we should expand the GBM operators to make itself suitable to be used in the situations where the input arguments are belonged to triangular fuzzy information. Therefore, we focus on the problem of using the GBM operator under triangular fuzzy environments. Based on Definition 3, we put forward the definition of the triangular fuzzy geometric Bonferroni mean (TFGBM) operator.

Definition 4. Let $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right](i=1,2,\cdots,n)$ be a set of triangular fuzzy numbers, and let $p,q>0$. If

$$TFGBM^{p,q}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)$$
$$=\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(p\tilde{a}_i+q\tilde{a}_j\right)\right)^{\frac{1}{n(n-1)}}$$
$$=\left[\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(pa_i^L+qa_j^L\right)\right)^{\frac{1}{n(n-1)}},\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(pa_i^M+qa_j^M\right)\right)^{\frac{1}{n(n-1)}},\right. \tag{4}$$
$$\left.\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(pa_i^U+qa_j^U\right)\right)^{\frac{1}{n(n-1)}}\right]$$

then $TFGBM^{p,q}$ is called the triangular fuzzy geometric Bonferroni mean (TFGBM) operator.

We can know that the TFGBM operator has the following attributes.

Theorem 1. (Idempotency) Let $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right](i=1,2,\cdots,n)$ be a set of triangular fuzzy numbers. If all $\tilde{a}_j\left(\tilde{a}_j=\left[a_j^L,a_j^M,a_j^U\right]\right)$ are equal, i.e. $\tilde{a}_j\left(\tilde{a}_j=\left[a_j^L,a_j^M,a_j^U\right]\right)=\tilde{a}\left(\tilde{a}=\left[a^L,a^M,a^U\right]\right)$ for all j, then

$$TFGBM^{p,q}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)=\tilde{a} \tag{5}$$

Theorem 2. (Boundedness) Let $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right](i=1,2,\cdots,n)$ be a set of triangular fuzzy numbers, and let

$\tilde{a}^-=\min_j \tilde{a}_j$, $\tilde{a}^+=\min_j \tilde{a}_j$

Then

$$\tilde{a}^-\le TFGBM^{p,q}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\le\tilde{a}^+ \tag{6}$$

Theorem 3. (Monotonicity) Let $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right](i=1,2,\cdots,n)$ and $\tilde{a}_i'=\left[a_i'^L,a_i'^M,a_i'^U\right](i=1,2,\cdots,n)$ be two sets of triangular fuzzy numbers, if $\tilde{a}_j\le\tilde{a}_j'$, for all j, then

$$TFGBM^{p,q}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\le TFGBM^{p,q}\left(\tilde{a}_1',\tilde{a}_2',\cdots,\tilde{a}_n'\right) \tag{7}$$

Theorem 4. (Commutativity) Let $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right](i=1,2,\cdots,n)$ and $\tilde{a}_i'=\left[a_i'^L,a_i'^M,a_i'^U\right](i=1,2,\cdots,n)$ be two sets of triangular fuzzy numbers, where $\tilde{a}_i'=\left[a_i'^L,a_i'^M,a_i'^U\right](i=1,2,\cdots,n)$ is any permutation of $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right](i=1,2,\cdots,n)$, then

$$TFGBM^{p,q}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)=TFGBM^{p,q}\left(\tilde{a}_1',\tilde{a}_2',\cdots,\tilde{a}_n'\right) \tag{8}$$

In the following part, we will discuss some specific problem of the TFGBM with the parameters p and q:

Case 1. If $q\to 0$, then from the TFGBM(15), it yields

$$\begin{aligned}&\lim_{q\to 0} TFGBM^{p,q}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\\&=\lim_{q\to 0}\left(\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(p\tilde{a}_i+q\tilde{a}_j\right)\right)^{\frac{1}{n(n-1)}}\right)\\&=\frac{1}{p}\prod_{i=1}^{n}\left(p\tilde{a}_i\right)^{\frac{1}{n}}\\&=TFGBM^{p,0}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\end{aligned} \tag{9}$$

which is namded as the triangular fuzzy generalized geometric mean (TFGGM) operator.

Case 2. If $p=2$ and $q\to 0$, then by the TFGBM(4), we have

$$TFGBM^{2,0}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)=\frac{1}{2}\prod_{i=1}^{n}\left(2\tilde{a}_i\right)^{\frac{1}{n}} \tag{10}$$

which we call the triangular fuzzy square geometric mean (TFSGM) operator.

Case 3. If $p=1$ and $q\to 0$, then the TFGBM(15) reduces to triangular fuzzy geometric mean (TFGM) operator

$$TFGBM^{1,0}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)=\prod_{i=1}^{n}\left(\tilde{a}_i\right)^{\frac{1}{n}} \tag{11}$$

which we call the triangular fuzzy geometric mean (TFGM) operator.

Case 4. If $p=1$ and $q=1$, then by the TFGBM(15), we have

$$\begin{aligned}&TFGBM^{1,1}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\\&=\frac{1}{2}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(\tilde{a}_i+\tilde{a}_j\right)\right)^{\frac{1}{n(n-1)}}\end{aligned} \tag{12}$$

which we call the triangular fuzzy interrelated square geometric mean (TFISGM) operator.

Because the input arguments have different importance, we present the definition of the triangular fuzzy weighted geoemtric Bonferroni mean (TFWGBM) operator.

Definition 5. $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right]\left(i=1,2,\cdots,n\right)$ be a set of triangular fuzzy numbers and $p,q>0$, $w=\left(w_1,w_2,\cdots,w_n\right)^T$ is the weight vector of $\tilde{a}_i=\left[a_i^L,a_i^M,a_i^U\right]\left(i=1,2,\cdots,n\right)$, where w_i indicates the importance degree of $\tilde{a}_i$, satisfying $w_i>0\left(i=1,2,\cdots,n\right)$, and $\sum_{i=1}^{n}w_i=1$. If

$$\begin{aligned}&TFWGBM_w^{p,q}\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\\&=\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(p\left(\tilde{a}_i\right)^{w_i}+q\left(\tilde{a}_j\right)^{w_j}\right)\right)^{\frac{1}{n(n-1)}}\\&=\left[\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(p\left(a_i^L\right)^{w_i}+q\left(a_j^L\right)\right)^{w_j}\right)^{\frac{1}{n(n-1)}},\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(p\left(a_i^M\right)^{w_i}+q\left(a_j^M\right)\right)^{w_j}\right)^{\frac{1}{n(n-1)}},\right.\\&\qquad\left.\frac{1}{p+q}\left(\prod_{\substack{i,j=1\\i\neq j}}^{n}\left(p\left(a_i^U\right)^{w_i}+q\left(a_j^U\right)\right)^{w_j}\right)^{\frac{1}{n(n-1)}}\right]\end{aligned} \tag{13}$$

then $TFWGBM_{w}^{p,q}$ is named as the triangular fuzzy weighted geometric Bonferroni mean (TFWGBM) operator.

4. The proposed multiple attribute decision making method for evaluating the human resource value accounting measurement with triangular fuzzy information

Based on the above analysis, in this part, we study on the multiple attribute decision making problems for evaluating the human resource value accounting measurement with triangular fuzzy information, let $A=\{A_1,A_2,\cdots,A_m\}$ be a discrete set of alternatives, $G=\{G_1,G_2,\cdots,G_n\}$ be the set of attributes. Suppose that $A=\left(\tilde{a}_{ij}\right)_{m\times n}=\left[a_{ij}^L,a_{ij}^M,a_{ij}^U\right]_{m\times n}$ is the decision making matrix. Then, we exploit the triangular fuzzy weighted geometric Bonferroni mean (TFWGBM) operator to develop an approach for multiple attribute decision making problems:

Step 1. Normalize the value $\tilde{a}_{ij}$ into a corresponding values $\tilde{r}_{ij}$ by using the following formulas:

$$\begin{cases} r_{ij}^L = a_{ij}^L \Big/ \sum_{i=1}^{m} a_{ij}^U \\ r_{ij}^M = a_{ij}^M \Big/ \sum_{i=1}^{m} a_{ij}^M \\ r_{ij}^U = a_{ij}^U \Big/ \sum_{i=1}^{m} a_{ij}^L \end{cases},$$

for benefit attribute G_j,

$$i=1,2,\cdots,m,\ j=1,2,\cdots,n. \tag{14}$$

$$\begin{cases} r_{ij}^L = \left(1/a_{ij}^U\right) \Big/ \sum_{i=1}^{m} \left(1/a_{ij}^L\right) \\ r_{ij}^M = \left(1/a_{ij}^M\right) \Big/ \sum_{i=1}^{m} \left(1/a_{ij}^M\right) \\ r_{ij}^U = \left(\left(1/a_{ij}^L\right)\right) \Big/ \sum_{i=1}^{m} \left(1/a_{ij}^U\right) \end{cases},$$

for cost attribute G_j,

$$i=1,2,\cdots,m,\ j=1,2,\cdots,n. \tag{15}$$

Step 2. Utilize the matrix $\tilde{R}$, and the TFWGBM operator (in general, we let $p=q=1$)

$$\tilde{r}_i=\left(r_i^L,r_i^M,r_i^U\right)=TFWGBM_{w}^{p,q}\left(\tilde{r}_{i1},\tilde{r}_{i2},\cdots,\tilde{r}_{in}\right)$$

$$=\frac{1}{p+q}\left(\prod_{\substack{k,l=1\\k\neq l}}^{n}\left(p\left(\tilde{r}_{ik}\right)^{w_k}+q\left(\tilde{r}_{il}\right)^{w_l}\right)\right)^{\frac{1}{n(n-1)}} \qquad i=1,2,\cdots,m,\ j=1,2,\cdots,n. \tag{16}$$

Step 3. To obtain the ranking score of these collective overall preference values $\tilde{r}_i\left(i=1,2,\cdots,m\right)$ and adding all the elements which is located in each row of the matrix P, we have

$$p_i=\sum_{j=1}^{m}p_{ij}, i=1,2,\cdots,m. \tag{17}$$

Step 4. Ranking all the alternatives $A_i\left(i=1,2,\cdots,m\right)$ and then choose the best element according to the overall preference values $p_i\left(i=1,2,\cdots,m\right)$.

5. Numerical example

In this section, we exploit a practical multiple attribute decision making model for evaluating the human resource value accounting measurement. The evaluating the human resource value accounting measurement is to be evaluated according to four attributes: (1) G1: factors of individual; (2) G2: factors of organization; (3) G3: factors of society; (4) G4: factors of development. The five possible technology enterprises $A_i\left(i=1,2,\cdots,5\right)$ are to be evaluated adopting the triangular fuzzy numbers through the decision makers with the given four attributes (weighting vector of which is $\omega=\left(0.3,0.2,0.4,0.1\right)$), and make up the following matrix $A=\left(\tilde{a}_{ij}\right)_{5\times4}$ is shown in Table 1.

Table 1. Evaluation matrix A

	G_1	G_2	G_3	G_4
A_1	(0.68,0.69,0.71)	(0.64,0.67,0.69)	(0.50,0.52,0.55)	(0.66,0.68,0.75)
A_2	(0.70,0.74,0.80)	(0.67,0.70,0.74)	(0.64,0.66,0.69)	(0.82,0.84,0.88)
A_3	(0.69,0.76,0.82)	(0.73,0.76,0.79)	(0.33,0.40,0.43)	(0.86,0.90,0.92)
A_4	(0.54,0.56,0.60)	(0.68,0.74,0.78)	(0.71,0.72,0.73)	(0.74,0.76,0.79)
A_5	(0.50,0.52,0.56)	(0.55,0.57,0.59)	(0.56,0.58,0.61)	(0.69,0.72,0.76)

In the following, to choose the most suitable cities, the TFWGBM operator is utilized to design a method to multiple attribute decision making problems evaluating the human resource value accounting measurement with triangular fuzzy information, which can be described as following:

Step 1. Computing the normalized decision matrix $\tilde{R}$. The results are illustrated in Table 2.

Table 2.Decision matrix $\tilde{R}$

	G_1	G_2	G_3	G_4
A_1	(0.178,0.194,0.216)	(0.235,0.248,0.265)	(0.151,0.158,0.166)	(0.242,0.246,0.276)
A_2	(0.166,0.175,0.190)	(0.176,0.181,0.217)	(0.168,0.190,0.208)	(0.241,0.248,0.257)
A_3	(0.178,0.190,0.213)	(0.176,0.181,0.191)	(0.178,0.187,0.200)	(0.169,0.178,0.192)
A_4	(0.157,0.168,0.197)	(0.187,0.195,0.213)	(0.164,0.180,0.198)	(0.179,0.187,0.219)
A_5	(0.229,0.233,0.252)	(0.207,0.229,0.258)	(0.195,0.212,0.236)	(0.225,0.238,0.246)

Step 2. Aggregate all triangular fuzzy preference value $\tilde{r}_{ij}\left(j=1,2,\cdots,n\right)$ by using the TFWGBM to derive the overall triangular fuzzy preference values $\tilde{r}_i\left(i=1,2,3,4,5\right)$ of the technology enterprises A_i.

$$\tilde{r}_1=(0.172,0.191,0.212)$$
$$\tilde{r}_2=(0.185,0.202,0.220)$$
$$\tilde{r}_3=(0.212,0.225,0.237)$$
$$\tilde{r}_4=(0.187,0.201,0.217)$$
$$\tilde{r}_5=(0.170,0.179,0.192)$$

Step 3. Utilizing the aggregating results and the equation of degree of possibility (2), ranking all the technology enterprises $A_i\left(i=1,2,3,4,5\right)$ according to scores p_i $\left(i=1,2,\cdots,5\right)$: $A_3 \succ A_5 \succ A_2 \succ A_4 \succ A_1$, and then the most suitable technology enterprises is A_3.

6. Conclusion

In this work, we focus on the multiple attribute decision making problems for evaluating the human resource value accounting measurement with triangular fuzzy information. Inspired by the idea of geometric Bonferroni mean, we develop the triangular fuzzy geometric Bonferroni mean (TFGBM) operator and triangular fuzzy weighted geometric Bonferroni mean (TFWGBM) operator. Using the proposed operator, we propose the program for multiple attribute decision making with the triangular fuzzy environments. In the end, a practical example for evaluating the human resource value accounting measurement with triangular fuzzy information is given to testify the performance of the given approach.

Acknowledgments

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