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Assessment of Organization Performance in the Human Resource Management

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It is widely accepted that human resource management is very important in a company. Hereinto, Human resources represent, and for sure will represent also in the future, the greatest potential competitive advantage of companies. In addition, organization performance in human resource management is a key point that can influence the development of a company. Thus, how to assess organization performance in the human resource management is a new challenge that a company have to face. In this paper, interval valued intuitionistic fuzzy numbers are introduced to express the assessments of the decision maker for the organization performance of a company, which can be constructed based on some criteria or attributes. Then, the TOPSIS method is proposed to solve this assessment problem. The application of the proposed method is also demonstrated in this paper by considering a real problem.

1. Introduction

With the appearance of knowledge economy time, the administration and supervision authorities of an organization start to realize the importance of human resource management. Human resources represent, and for sure will represent also in the future, the greatest potential competitive advantage of companies. The condition of the materialization of this prerequisite is an effective management of human resources, such as careful planning, organizing, leading and controlling (Cech et al., 2016). The literature review of the human resource and its management will be signified in the next section.

In human resource management, with the increasing complexity and changes of business environment, the enterprises are confronted with more and more severe challenges about increasing their organization performance. Obviously, it has been a significant problem for the enterprise to decide that how to promote their or organization performance such as abilities of adjusting, innovating, operating and adding their values. However, in real case, more and more enterprises have realized that those elements including capital and technology, which used to be their competitive advantages, are copied by their competitors quite soon or weeded out faster and faster. Thus, how to assess organization performance in the human resource management is a new challenge that a company have to face.

In order to assess the organization performance in the human resource management, the decision maker who is often an expert in this field is needed to be invited. But how to express the assessments of the decision maker objectively is difficult. Many ways have been proposed including interval valued numbers, triangle fuzzy numbers, trapezoidal fuzzy numbers (Xu et al., 2010), general fuzzy numbers (Zadeh, 1965), intuitionistic fuzzy numbers (Atanassov, 1986) and especially interval valued intuitionistic fuzzy numbers (Tan, 2011; Tan and Chen, 2010; Long and Geng, 2015). Thus, interval valued intuitionistic fuzzy number as a popular way is introduced in this paper to help the decision maker construct the decision matrix based on their preferences. Then, TOPSIS method which is based on distance measure is proposed in this paper to help aggregate assessment with interval valued intuitionistic fuzzy numbers on each attribute. As we known, TOPSIS developed by Hwang and Yoon can represent that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS). Many researchers devoted to the development of TOPSIS method. Baky (2014) extended the concept of the technique for order preference by similarity to ideal solution (TOPSIS) to develop a methodology for solving multi-level non-linear multi-objective decision-making (MLN-MODM) problems of maximization-type. Chen (2000) extended the

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concept of TOPSIS to develop a methodology for solving multi-person multi-criteria decision-making problems in a fuzzy environment and he defined the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS). In the final, the proposed method is applied to a real problem which demonstrates the scientific and applicability of this method.
The rest of the paper is organized as follows: Section 2 reviews the literatures related to the human resource management. Section 3 and Section 4 show the proposed TOPSIS method with interval valued intuitionistic fuzzy numbers. Section 5 applies the proposed method in a real case. Section 6 concludes this paper.

2. The literature review

As demonstrated in Introduction, human resource management is very important in a company (Voegtlin and Greenwood, 2016). Many research and literature in the area of human resource management focuses on the positive impact of human resource management practices. Results such as employee well-being, organizational effectiveness and wider societal contributions have long been the focus to argue that human resource management can make a positive contribution to the organization and society (Becker and Smidt, 2016). In addition, considering the fact that the modern development trend of an organization is firmly based on the paradigm of innovativeness, an interest in practices aimed at directing human resource management to innovativeness becomes increasing. Moreover, risk and risk management related to human resource management is another topic attracting much attention from the researchers. Some researchers held that in a world of complexity and rapidly changing environments, effective risk management may be a source of competitive advantage in human resource management.

3. Preliminaries

As mentioned in Section 1 and Section 2, base on the concepts of intuitionistic fuzzy sets, interval valued intuitionisitc fuzzy sets are proposed to express the preferences of the decision makers more objectively.
Definition 1(Atanassov. 1986). Given a finite set *X*, an intuitionisitc fuzzy set *A* in *X* can be defined in the following:

$$A=\left\{\left\langle x,u_A(x),v_A(x)\right\rangle \middle| x\in X\right\}, \tag{1}$$

where $u_A : X \to [0,1]$ denotes the degree of membership and $v_A : X \to [0,1]$ denotes the degree of non-membership with the condition: $0 \le u_A + v_A \le 1$, for all elements *x* in the set *X*.
For each intuitionistic fuzzy set *A* in *X*, if the amount

$\pi_A(x)=1-u_A(x)-v_A(x), \forall x \in X$. Here, $0 \le \pi_A(x) \le 1$.

Although the mentioned intuitionistic fuzzy sets can deal with many situations, it cannot be applied in all situations, especially the preferences of the decision maker are interval value such as interval valued intuitionistic fuzzy sets (Wang and Li, 1998) below.
Definition 2 (Atanassov and Gargo, 1989). Given an ordinary finite non-empty set *X*, an interval valued intuitionisitc fuzzy set $\overline{A}$ in *X* can be defined in the following:

$$\overline{A}=\left\{\left\langle x,u_{\overline{A}}(x),v_{\overline{A}}(x)\right\rangle \middle| x\in X\right\}, \tag{2}$$

where $u_{\overline{A}} : X \to [0,1]$ denotes the degree of membership and $v_{\overline{A}} : X \to [0,1]$ denotes the degree of non-membership for all elements in the set *X*.

Here, $0 \le \sup\left(u_{\overline{A}}(x)\right)+\sup\left(v_{\overline{A}}(x)\right) \le 1$.

For each $x \in X$, $u_{\overline{A}}(x)$ and $v_{\overline{A}}(x)$ can be represented as closed intervals lower and upper points denoted by $u^-_{\overline{A}}(x)$, $u^+_{\overline{A}}(x)$, $v^-_{\overline{A}}(x)$ and $v^+_{\overline{A}}(x)$, respectively.
Thus, the hesitation (or uncertainty) degree of interval valued intuitionistic fuzzy sets can be obtained as

$\pi_{\overline{A}\inf(x)}=1-\sup u(x)-\sup v(x)$ and $\pi_{\overline{A}\ \sup(x)}=1-\inf u(x)-\inf v(x)$.

Here $\pi_{\bar{A}}^{-}(x)$ is equal to $\pi_{\bar{A}\inf(x)}$ and $\pi_{\bar{A}}^{+}(x)$ is equal to $\pi_{\bar{A}\ \sup(x)}$, where $(\pi_{\bar{A}}^{-}(x),\ \pi_{\bar{A}}^{+}(x)) \in D[0,1]$.

Firstly, the operational laws of interval valued intuitionistic fuzzy numbers are defined as follows.

Definition 3. Let $a_1 = ([u_1^-, u_1^+], [v_1^-, v_1^+])$ and $a_2 = ([u_2^-, u_2^+], [v_2^-, v_2^+])$ be two interval valued intuitionistic fuzzy numbers, then the following operational laws are valid.

(1) $a_1 \oplus a_2 = ([u_1^- + u_2^- - u_1^- u_2^-, u_1^+ + u_2^+ - u_1^+ u_2^+], [v_1^- v_2^-, v_1^+ v_2^+])$;

(2) $a_1 \otimes a_2 = ([u_1^- u_2^-, u_1^+ u_2^+], [v_1^- + v_2^- - v_1^- v_2^-, v_1^+ + v_2^+ - v_1^+ v_2^+])$;

(3) $\lambda a_1 = ([1-(1-u_1^-)^\lambda, 1-(1-u_1^+)^\lambda], [(v_1^-)^\lambda, (v_1^+)^\lambda])\ \lambda > 0$;

(4) $(a_1)^\lambda = ([(u_1^-)^\lambda, (u_1^+)^\lambda], [1-(1-v_1^-)^\lambda, 1-(1-v_1^+)^\lambda])\ \lambda > 0$;

(5) $(a_1)^\lambda = ([(v_1^-)^\lambda, (v_1^+)^\lambda], [(u_1^-)^\lambda, (u_1^+)^\lambda])\ \lambda > 0$.

Definition 4. Let $a_1 = ([u_1^-, u_1^+], [v_1^-, v_1^+])$ and $a_2 = ([u_2^-, u_2^+], [v_2^-, v_2^+])$ be two interval valued intuitionistic fuzzy numbers, then the following operations are valid.

(1) $a_1 \oplus a_2 = a_2 \oplus a_1$;

(2) $\lambda_1 (a_1 \oplus a_2) = \lambda_1 a_1 \oplus \lambda_1 a_2$;

(3) $\lambda_1 a_1 \oplus \lambda_2 a_1 = (\lambda_1 + \lambda_2) a_1$.

The proof of the Definitions 3 and 4 can refer to the corresponding concepts in (Long and Geng, 2015).

4. The proposed method based on hesitant fuzzy sets

After the definition and the introduction of operational laws of interval valued intuitionistic fuzzy numbers, the proposed method to assess the performance of organizations can be proposed in this section. Hereinto, the model of the assessment is defined at first, then the distance measure is designed and the TOPSIS method is introduced.

4.1 The model of the proposed method

For an assessment problem, firstly a decision matrix $D = [a_{ij}]_{m\times n}$, where all the assessments a_{ij} (*i* = 1, 2, ..., *m*; *j* = 1, 2, ..., *n*) are interval value intuitionistic fuzzy numbers provided by a decision maker who is often invited from famous experts. For each alternative A_i (*i* = 1, 2, ..., *m*), the decision maker is required to express his/her preference on each attribute C_j (*j* = 1, 2, ..., *n*) which is constructed by the specific problem. Then, the decision maker specifies the attribute weights of the *n* attributes denoted as $w = (w_1, w_2, \ldots, w_n)^T$ with $0 \le w_j \le 1$ (*j* = 1, 2, ..., *n*) and $\sum_{i=1}^{n} w_j = 1$.

Finally, according to preference of the decision maker, a normal decision making matrix can be generated in the following, which is obvious the base of the next method:

$$D_{m\times n} = \begin{matrix} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \\ \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{pmatrix} \end{matrix}. \tag{3}$$

4.2 Distance measure

Distance measure, as a popular tool to measure the deviation of two objects has been widely applied in many fields, such as decision making, pattern recognition, machine learning and marker prediction (Ahn, 2011; Joshi and Kumar, 2016). In this paper, we introduce a generalized distance measure between two interval valued intuitionisitc fuzzy numbers in order to measure the differences between these two numbers. Firstly, an axiom is demonstrated in the following.

Definition 5. Let A_1, A_2 and A_3 be three interval valued intuitionisitc fuzzy sets on $X = \{x_1, x_2, ..., x_n\}$, then the distance measure between A_1 and A_2 is defined as $d(A_1, A_2)$, which satisfies the following properties:

(1) $0 \le d(A_1, A_2) \le 1$;

(2) $d(A_1, A_2) = 0$, if and only if $A_1 = A_2$;

(3) $d(A_1, A_2) = d(A_2, A_1)$;

(4) if $A_1 \in A_2 \in A_3$, then $d\ A_1, A_3\ \ge d\ A_1, A_2$.

Definition 6. Let A_i and A_k be two interval valued intuitionistic fuzzy sets on the alternatives A_i and A_k (i, k = 1, 2, ..., m), then the generalized weighted distance measure between alternatives A_i and A_k can be defined as follows:

$$d(A_i, A_k) = \left\{ \frac{1}{4n} \sum_{j=1}^{n} w_j \left(\left|u_{ij}^+ - u_{kj}^+\right|^\lambda + \left|u_{ij}^- - u_{kj}^-\right|^\lambda + \left|v_{ij}^+ - v_{kj}^+\right|^\lambda + \left|v_{ij}^- - v_{kj}^-\right|^\lambda \right) \right\}^{1/\lambda}, \tag{4}$$

where $\lambda > 0$, which can be obtained according to the decision maker's risk attitude.

When $\lambda = 2$, the generalized weighted distance measure reduces to the weighted Euclidean distance between A_i and A_k as follows:

$$d(A_i, A_k) = \left\{ \frac{1}{4n} \sum_{j=1}^{n} w_j \left(\left|u_{ij}^+ - u_{kj}^+\right|^2 + \left|u_{ij}^- - u_{kj}^-\right|^2 + \left|v_{ij}^+ - v_{kj}^+\right|^2 + \left|v_{ij}^- - v_{kj}^-\right|^2 \right) \right\}^{1/2}, \tag{5}$$

When $\lambda = 1$, the generalized weighted distance measure reduces to the weighted Hamming distance between A_i and A_k as follows:

$$d(A_i, A_k) = \left\{ \frac{1}{4n} \sum_{j=1}^{n} w_j \left(\left|u_{ij}^+ - u_{kj}^+\right| + \left|u_{ij}^- - u_{kj}^-\right| + \left|v_{ij}^+ - v_{kj}^+\right| + \left|v_{ij}^- - v_{kj}^-\right| \right) \right\}. \tag{6}$$

Obviously, the defined distance measure in Definition 6 satisfies the properties in Definition 5. So, the proof is omitted here.

4.3 The TOPSIS method

Technique for order preference by similarity to ideal solution (TOPSIS) proposed by Hwang and Yoon (1981), one of known classical decision making method, bases upon the concept that the chosen alternative should have the shortest distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS). In this paper, based on the characteristic of interval valued intuitionisitc fuzzy sets, we use the ideal of TOPSIS to select the alternative with the shortest distance from the positive ideal solution (PIS).

In interval valued intuitionisitc fuzzy context, the interval valued intuitionisitc fuzzy ideal position solution PIS, denoted by A^+ and negative ideal solution NIS A^- can be defined below.

$$A^+ = \left\{ x_i, \left(\left[u_j^{*L}, u_j^{*U}\right], \left[v_j^{*L}, v_j^{*U}\right] \right) \middle| j = 1, 2, \cdots, n \right\}. \tag{7}$$

Here, $\left[u_j^{*L}, u_j^{*U}\right] = \left[\max_i\left(u_{ij}^L\right), \max_i\left(u_{ij}^U\right)\right]$ and $\left[v_j^{*L}, v_j^{*U}\right] = \left[\min_i\left(v_{ij}^L\right), \min_i\left(v_{ij}^U\right)\right]$

$$A^- = \left\{ x_i, \left(\left[u_j^{\wedge L}, u_j^{\wedge U}\right], \left[v_j^{\wedge L}, v_j^{\wedge U}\right] \right) \middle| j = 1, 2, \cdots, n \right\} \tag{8}$$

Here, $\left[u_j^{\wedge L}, u_j^{\wedge U}\right] = \left[\min_i\left(u_{ij}^L\right), \min_i\left(u_{ij}^U\right)\right]$ and $\left[v_j^{\wedge L}, v_j^{\wedge U}\right] = \left[\max_i\left(v_{ij}^L\right), \max_i\left(v_{ij}^U\right)\right]$

The relative closeness coefficient of an alternative A_i with respect to the hesitant fuzzy PIS A^+ and NIS A^- is expressed as follows:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-}, \tag{9}$$

where $0 \le CC_i \le 1, i = 1, 2, ...m$.

Obviously, when an alternative A_i is closer to the interval valued intuitionisitc fuzzy PIS, CC_i will be closer to 1. Thus, based on the closeness coefficient CC_i, the ranking of all alternatives can be determined and the best alternative can be selected.

4.4 The process of the proposed method

The procedure based on mentioned proposed methods is demonstrated in the following figure.

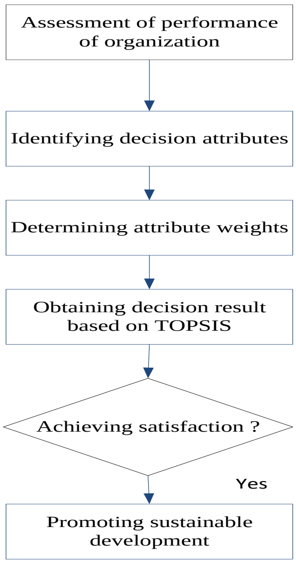

Figure 1: The framework of green supply chain coordination mechanism

5. A real problem

Based on the analysis in Section 1 and Section 2, we introduce a real problem to help some companies assess their organization performance by using the proposed method in Section 3 and Section 4. In this problem, firstly we invite an expert as the decision maker to implement process of assessment. Three companies are selected as alternatives denoted by A_1, A_2 and A_3. Then the decision maker identifies four attributes denoted as C_1, C_2, C_3 and C_4.

Table 1: Description of the four attributes

Attributes	Descriptions
C_1	risk management
C_2	organization design
C_3	staff management and training
C_4	innovation and social responsibility

The attributes are generated from the analysis about existing literature. The decision maker gives assessments of each alternative on each attribute, respectively. Therefore, a decision matrix $D = [a_{ij}]_{3\times 4}$ can be constructed in Table 2. In addition, the attribute weight can be determined as w = (0.2, 0.25, 0.25, 0.2)^T by the decision maker.

Table 2: Interval valued intuitionistic fuzzy decision matrix

	A_1	A_2	A_3
C_1	{[0.3,0.5],[0.4,0.5]}	{[0.1,0.4], [0.2, 0.5]}	{[0.3,0.5],[0.4,0.5]}
C_2	{[0.5,0.6],[0.2,0.4]}	{[0.1,0.4],[0.4,0.5]}	{[0.2,0.3],[0.5,0.6]}
C_3	{[0.5,0.7],[0.1,0.2]}	{[0.3,0.6],[0.1,0.2]}	{[0.7,0.8],[0.1,0.2]}
C_4	{[0.6,0.8],[0.1,0.2]}	{[0.2,0.6],[0.1,0.3]}	{[0.1,0.2],[0.5,0.7]}

According to Eqs. (4)-(9), assessments on each attribute can be aggregated into that on each alternative. Thus, the ranking order is demonstrated as $A_1 \succ A_3 \succ A_2$ which indicates that A_2 is the optimum company.

6. Conclusion

In general, human resource management is very important in a company. Hereinto, Human resources represent, and for sure will represent also in the future, the greatest potential competitive advantage of companies. In addition, organization performance in human resource management is a key point that can influence the development of a company. Thus, how to assess organization performance in the human resource management is a new challenge that a company have to face. In this paper, interval valued intuitionistic fuzzy numbers are introduced to express the assessments of the decision maker for the organization performance of a company, which can be constructed based on some criteria or attributes. Then, the TOPSIS method is proposed to solve this assessment problem. In the final, the proposed method is applied to a real problem which demonstrates the scientific and applicability of this method.
In the future, this proposed method may be applied in more and more organizations to help them improve the organization performance from the perspective of the human resource management.

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