Research on the energy saving economical benefits assessment of logistics parks with intuitionistic fuzzy information

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Abstract

With the development of the society and national economy, the logistics industry has become a pillar industry. Many links of logistics activities consume a lot of energy, which has brought the huge pollution to the environment. The logistics park is an important part of logistics system. As an important logistics node, it is the hub of logistics, warehousing, transportation and handling, etc. Its operation needs to consume large amounts of energy. The reinforcement of the logistics park's energy saving and emission reduction has very important significance for reducing energy consumption and pollutant emissions, logistics intensive production, and promoting the sustainable development of society and economy. Therefore, the logistics park is an important "battlefield" of the energy saving and reduction emission of current logistics industry. And the energy saving and emission reduction effects affect the entire situation of the energy saving and emission reduction of logistics industry. The logistics park is a complex system. Its sustainable development is close related to regional economy development, resources and environment. In this paper, we utilize the intuitionistic fuzzy Einstein weighted average (IFEWA) operator for energy saving economical benefits assessment of logistics park to aggregate the intuitionistic fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function of the overall value of the alternatives. Finally, an illustrative example is given.

Keywords

Evaluation, Intuitionistic Fuzzy Numbers, Intuitionistic Fuzzy Einstein Weighted Average (IFEWA) Operator, energy saving, economical benefits assessment, logistics parks.

1. Introduction

With the deepening global economic integration and social division of labor, the emergence of modern integrated logistics park is the product of macroeconomic and micro enterprises sustained and balanced game, but also the continuous application of the new logistics technology and logistics services tend to the inevitable process of specialization. And the formation and development of modern logistics park is the development of modern logistics industry to a certain stage the inevitable outcome of modern logistics industry, high-class, systematic, professional and an important symbol. Planning and construction of modern logistics park will play an important role pushed to improve the city's traffic and ecological environment, optimize the layout of urban functions, carrier functions of the city, promoting the development of the logistics industry, improve logistics and economies of scale. All levels of government and leadership attaches great importance to and actively support the construction and development of the logistics park in China has made a lot of money results, but at the same time we see many of our logistics park still exist many problems in the development process. How to solve these problems exist in China's logistics parks, and effectively improve the economic and social benefits of the park to become an important issue for the revitalization of China's logistics industry, to build a modern logistics park construction project evaluation system is an important part of the subject[1-6].

The aim of this paper is to investigate the problems for energy saving economical benefits assessment of logistics park with intuitionistic fuzzy information. We utilize the intuitionistic fuzzy Einstein weighted average (IFEWA) operator to aggregate the intuitionistic fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function of the overall value of the alternatives. The remainder of this paper is set out as follows. In the next section, we introduce some basic concepts related to intuitionistic fuzzy sets. In Section 3 we introduce the problems for energy saving economical benefits assessment of logistics park with intuitionistic fuzzy information. Then, we utilize the intuitionistic fuzzy Einstein weighted average (IFEWA) operator to aggregate the intuitionistic fuzzy information corresponding to each alternative for energy saving economical benefits assessment of logistics park and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function of the overall value of the alternatives. In Section 4, an illustrative example is pointed out. In Section 5 we conclude the paper and give some remarks.

2. Preliminaries

Based on the intuitionistic fuzzy sets[7-10], Xu &Yager [11] and Xu[12] gave some intuitionistic fuzzy aggregation operators as listed below:

For a collection of IFVs $\tilde{a}_j=(\mu_j,\nu_j)(j=1,2,\cdots,n)$, then

(1) The intuitionistic fuzzy weighted averaging (IFWA) operator [12]:

$$\mathrm{IFWA}_{\omega}(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n)=\mathop{\oplus}_{j=1}^{n}(\omega_j\tilde{a}_j)=\left(1-\prod_{j=1}^{n}(1-\mu_j)^{\omega_j},\prod_{j=1}^{n}\nu_j^{\ \omega_j}\right) \tag{1}$$

where $\omega=(\omega_1,\omega_2,\cdots,\omega_n)^T$ be the weight vector of $\tilde{a}_j\,(j=1,2,\cdots,n)$, and $\omega_j>0$, $\sum_{j=1}^{n}\omega_j=1$.

(2) The intuitionistic fuzzy ordered weighted averaging (IFOWA) operator [12]:

$$\mathrm{IFOWA}_{w}(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n)=\mathop{\oplus}_{j=1}^{n}(w_j\tilde{a}_{\sigma(j)})=\left(1-\prod_{j=1}^{n}(1-\mu_{\sigma(j)})^{w_j},\prod_{j=1}^{n}\nu_{\sigma(j)}^{\ w_j}\right) \tag{2}$$

where $(\sigma(1),\sigma(2),\cdots,\sigma(n))$ is a permutation of $(1,2,\cdots,n)$, such that $\tilde{\alpha}_{\sigma(j-1)}\geq\tilde{\alpha}_{\sigma(j)}$ for all $j=2,\cdots,n$ and $w=(w_1,w_2,\cdots,w_n)^T$ is the aggregation-associated vector such that $w_j\in[0,1]$, $\sum_{j=1}^{n}w_j=1$.

In the following, we shall introduce the Einstein operations on intuitionistic fuzzy sets and analyze some desirable properties of these operations. Motivated by Einstein operations, let the t-norm T and t-conorm S be Einstein product T'' and Einstein sum S'' respectively, then the generalised intersection and union on two IFSs A and B become the Einstein product (denoted by $\tilde{a}_1\otimes_{\varepsilon}\tilde{a}_2$) and Einstein sum (denoted by $\tilde{a}_1\oplus_{\varepsilon}\tilde{a}_2$) on two IVIFSs $\tilde{a}_1$ and $\tilde{a}_2$, respectively, as follows[13-14].

$$\tilde{a}_1\otimes_{\varepsilon}\tilde{a}_2=\left(\frac{\mu_1\mu_2}{1+(1-\mu_1)(1-\mu_2)},\frac{\nu_1+\nu_2}{1+\nu_1\nu_2}\right) \tag{3}$$

$$\tilde{a}_1\oplus_{\varepsilon}\tilde{a}_2=\left(\frac{\mu_1+\mu_2}{1+\mu_1\mu_2},\frac{\nu_1\nu_2}{1+(1-\nu_1)(1-\nu_2)}\right) \tag{4}$$

$$\lambda\tilde{a}_1=\left(\frac{(1+\mu_1)^{\lambda}-(1-\mu_1)^{\lambda}}{(1+\mu_1)^{\lambda}+(1-\mu_1)^{\lambda}},\frac{2\nu_1^{\lambda}}{(2-\nu_1)^{\lambda}+\nu_1^{\lambda}}\right),\lambda>0; \tag{5}$$

$$\left(\tilde{a}_1\right)^\lambda=\left(\frac{2\mu_1^\lambda}{(2-\mu_1)^\lambda+\mu_1^\lambda},\frac{\left(1+\nu_1\right)^\lambda-\left(1-\nu_1\right)^\lambda}{\left(1+\nu_1\right)^\lambda+\left(1-\nu_1\right)^\lambda}\right),\lambda>0\,. \tag{6}$$

Definition 4.[13] Let $\tilde{a}_j=\left(\mu_j,\nu_j\right)\left(j=1,2,\cdots,n\right)$ be a collection of intuitionistic fuzzy values, and let IFEWA: $Q^n\rightarrow Q$, if

$$\begin{aligned}&\text{IFEWA}_\omega\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\\&=\overset{n}{\underset{j=1}{\oplus_\varepsilon}}\left(\omega_j\tilde{a}_j\right)\\&=\left(\frac{\prod_{j=1}^n\left(1+\mu_j\right)^{\omega_j}-\prod_{j=1}^n\left(1-\mu_j\right)^{\omega_j}}{\prod_{j=1}^n\left(1+\mu_j\right)^{\omega_j}+\prod_{j=1}^n\left(1-\mu_j\right)^{\omega_j}},\frac{2\prod_{j=1}^n\nu_j^{\omega_j}}{\prod_{j=1}^n\left(2-\nu_j\right)^{\omega_j}+\prod_{j=1}^n\nu_j^{\omega_j}}\right)\end{aligned} \tag{7}$$

where $\omega=\left(\omega_1,\omega_2,\cdots,\omega_n\right)^T$ be the weight vector of $\tilde{a}_j\left(j=1,2,\cdots,n\right)$, and $\omega_j>0$, $\sum_{j=1}^n\omega_j=1$, then IFEWA is called the intuitionistic fuzzy Einstein weighted averaging (IFEWA) operator.

It can be easily proved that the IFEWA operator has the following properties[13].

Theorem 1. (Idempotency) If all $\tilde{a}_j\left(j=1,2,\cdots,n\right)$ are equal, i.e. $\tilde{a}_j=\tilde{a}$ for all j, then

$$\text{IFEWA}_\omega\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)=\tilde{a} \tag{8}$$

Theorem 2. (Boundedness) Let $\tilde{a}_j\left(j=1,2,\cdots,n\right)$ be a collection of IFVN, and let

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

Then

$$\tilde{a}^-\le\text{IFEWA}_\omega\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\le\tilde{a}^+ \tag{9}$$

Theorem 3. (Monotonicity) Let $\tilde{a}_j\left(j=1,2,\cdots,n\right)$ and $\tilde{a}'_j\left(j=1,2,\cdots,n\right)$ be two set of IFVNs, if $\tilde{a}_j\le\tilde{a}'_j$, for all j, then

$$\text{IFEWA}_\omega\left(\tilde{a}_1,\tilde{a}_2,\cdots,\tilde{a}_n\right)\le\text{IFEWA}_\omega\left(\tilde{a}'_1,\tilde{a}'_2,\cdots,\tilde{a}'_n\right) \tag{10}$$

3. Research on the energy saving economical benefits assessment of logistics parks with intuitionistic fuzzy information

The following assumptions or notations are used to represent the problems for energy saving economical benefits assessment of logistics park with intuitionistic fuzzy information. Let $T=\left\{S_1,S_2,\cdots,S_m\right\}$ be a discrete set of alternatives. Let $G=\left\{G_1,G_2,\cdots,G_n\right\}$ be a set of attributes. The information about attribute weights is completely known. Let $\omega=\left(\omega_1,\omega_2,\cdots,\omega_n\right)$ be the weight vector of attributes, where $\omega_j\ge0$, $j=1,2,\cdots,n$. Suppose that $\tilde{R}=\left(\tilde{r}_{ij}\right)_{n\times m}=\left(\mu_{ij},\nu_{ij}\right)_{n\times m}$ is the intuitionistic fuzzy decision matrix, where μ_{ij} indicates the degree that the alternative A_i satisfies the attribute G_j given by the decision maker, ν_{ij} indicates the degree that the alternative A_i doesn't satisfy the attribute G_j given by the decision maker D_k, $\mu_{ij}\subset\left[0,1\right]$, $\nu_{ij}\subset\left[0,1\right]$, $\mu_{ij}+\nu_{ij}\le1$, $i=1,2,\cdots,m$, $j=1,2,\cdots,n$, $k=1,2,\cdots,t$.

In the following, we apply the IFEWA operator to MADM for energy saving economical benefits assessment of logistics park with intuitionistic fuzzy information.

Step 1. Utilize the decision information given in matrix $\tilde{R}$, and the IFEWA operator

$$\tilde{r}_i=(\mu_i,\nu_i)=\text{IFEWA}_\omega(\tilde{r}_{i1},\tilde{r}_{i2},\cdots,\tilde{r}_{in}),\ i=1,2,\cdots,m. \quad (11)$$

to derive the overall preference values $\tilde{r}_i(i=1,2,\cdots,m)$ of the alternative S_i ,where $\omega=(\omega_1,\omega_2,\cdots,\omega_n)^T$ is the weighting vector of the attributes.

Step 2. Calculate the scores $S(\tilde{r}_i)(i=1,2,\cdots,m)$ of the overall intuitionistic fuzzy preference values $\tilde{r}_i\ (i=1,2,\cdots,m)$ to rank all the alternatives $S_i\ (i=1,2,\cdots,m)$ and then to select the best one(s).

Step 3. Rank all the alternatives $S_i\ (i=1,2,\cdots,m)$ and select the best one(s) in accordance with $S(\tilde{r}_i)$ and $H(\tilde{r}_i)\ (i=1,2,\cdots,m)$.

Step 4. End.

4. Numerical example

The logistics industry, as a significant economic support industry, has consumed a lot of energy, along with air pollution to the environment during logistic activities. The logistics park is an important node in logistics system, which undertakes most of the logistics activities. The logistics park is an important hub for logistics, warehousing, centralized distribution and distribution processing. Its operation needs to consume large amounts of energy. The construction of logistics parks has great significance for logistics intensive production, reducing energy consumption and pollutant emissions. And it is good for sustainable social economic development as well. Therefore, the energy-saving and emission-reducing of the logistics park has become an important strategic objectives of current logistics industry.The logistics park is a complex system. Its sustainable development is closely related to regional economic development, environment and resources. This section presents a numerical example for energy saving economical benefits assessment of logistics parks with uncertain linguistic variables to illustrate the method proposed in this paper. There are five possible logistics parks $A_i\ (i=1,2,3,4,5)$ for four attributes $G_j\ (j=1,2,3,4)$. The four attributes include planning of logistics parks (G_1), construction of logistics parks (G_2), service of logistics parks (G_3) and management of logistics parks (G_4), respectively. The five possible logistics parks $A_i\ (i=1,2,\cdots,5)$ are to be evaluated using the intuitionistic fuzzy information by the decision maker under the above four attributes, as listed in the following matrix.

$$\tilde{\boldsymbol{A}}=\begin{matrix} & G_1 & G_2 & G_3 & G_4 \\ A_1 & (0.6,0.4) & (0.5,0.3) & (0.8,0.1) & (0.5,0.2) \\ A_2 & (0.5,0.3) & (0.7,0.3) & (0.5,0.2) & (0.6,0.2) \\ A_3 & (0.5,0.5) & (0.6,0.3) & (0.8,0.2) & (0.3,0.3) \\ A_4 & (0.7,0.2) & (0.6,0.4) & (0.5,0.3) & (0.6,0.2) \\ A_5 & (0.5,0.4) & (0.5,0.3) & (0.4,0.4) & (0.8,0.2) \end{matrix}$$

Then, we utilize the approach developed for energy saving economical benefits assessment of logistics parks in order to select the best logistics park.

Step 1. Utilize the IFEWA operator, we obtain the overall preference values $\tilde{r}_i$ of the logistics parks $A_i\ (i=1,2,3,4,5)$.

$$\tilde{r}_1=(0.56,0.37),\tilde{r}_2=(0.46,0.32),\tilde{r}_3=(0.59,0.35)$$
$$\tilde{r}_4=(0.67,0.38),\tilde{r}_5=(0.48,0.21)$$

Step 2. Calculate the scores $S(\tilde{r}_i)(i=1,2,3,4,5)$ of the overall intuitionistic fuzzy values $\tilde{r}_i\,(i=1,2,3,4,5)$

$$S(\tilde{r}_1)=0.19, S(\tilde{r}_2)=0.14, S(\tilde{r}_3)=0.24$$
$$S(\tilde{r}_4)=0.29, S(\tilde{r}_5)=0.27$$

Step 3. Rank all the logistics parks $A_i\,(i=1,2,3,4,5)$ in accordance with the scores $S(\tilde{r}_i)$ $(i=1,2,3,4,5)$ of the overall intuitionistic fuzzy values $\tilde{r}_i\,(i=1,2,3,4,5)$: $A_2 \succ A_4 \succ A_5 \succ A_3 \succ A_1$, and thus the most desirable logistics parks is A_2

5. Conclusion

With the development of the society and national economy, the logistics industry has become a pillar industry. Many links of logistics activities consume a lot of energy, which has brought the huge pollution to the environment. The logistics park is an important part of logistics system. As an important logistics node, it is the hub of logistics, warehousing, transportation and handling, etc. Its operation needs to consume large amounts of energy. The reinforcement of the logistics park’s energy saving and emission reduction has very important significance for reducing energy consumption and pollutant emissions, logistics intensive production, and promoting the sustainable development of society and economy. Therefore, the logistics park is an important "battlefield" of the energy saving and reduction emission of current logistics industry. And the energy saving and emission reduction effects affect the entire situation of the energy saving and emission reduction of logistics industry. The logistics park is a complex system. Its sustainable development is close related to regional economy development, resources and environment. In this paper, we utilize the intuitionistic fuzzy Einstein weighted average (IFEWA) operator for energy saving economical benefits assessment of logistics park to aggregate the intuitionistic fuzzy information corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one(s) according to the score function and accuracy function of the overall value of the alternatives. Finally, an illustrative example is given. In the future, we shall extend the models proposed to other domains [14-20].

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