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Performance evaluation models for logistics service supply Chain based on the marine transportation patterns

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ABSTRACT

In this paper, we investigate the problems for evaluating the performance for logistics service supply chain based on the marine transportation patterns with interval grey linguistic variables. We utilize the interval grey linguistic weighted geometric (IGLWG) operator to aggregate the interval grey linguistic variables corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one (s). Finally, an illustrative example is given.

KEYWORDS

Performance evaluation; Interval grey linguistic variables; Interval grey linguistic variables weighted geometric (IGLWG) operator; Logistics service supply Chain.

INTRODUCTION

Since the 21th century, the sphere of interest has been expanded rapidly all through the world under the dual function of economic globalization and "Ocean Century". As the significant link and solid bridge for international trade, the status and effect of ocean transportation national marine safety have been improved unprecedentedly. Therefore, by exploring the "geographic space" of the evolution pattern of the world ocean transportation and Chinese marine safety guarantee, which are is taken as the research subjects, can make them into an organic whole and some relevant analysis concerning theory, real case and decision-making can be carried through in the hope of providing some references scientific decision services for national strategy and the discipline integration of world geography, traffic geography and economic geography. Ocean transportation is the basis for globalization and the shipping routes on the sea are the important support for national strategic resources and international status; and it is urgent and necessary for China to study on the world ocean transportation system. Firstly, it starts from the analysis of the spatial linkage between regional economic development and economic development through the spatial transportation linkage and economic relation, the transportation's effect on regional development, transportation and industrial location, traffic networks and comprehensive system of traffic follows. Then, three different stages, the international division of labor and international trade have experienced, are elaborated. Besides, it points out that the theory of international trade and international division of labor are the economic theory foundation of ocean transportation, which paves a way for the analysis of the dynamic evolution of global ocean transportation networks in the following parts. In the end, some ideas about the economies of scale theory in container transportation are expounded based on the scale economy in container transportation system, the formation of scale economy and transport system of container port, the differentiation and influence of port function, and the evolution of the transport system of container port. All of these provide the following discussion on container trade among global ports with necessary theoretical support.

The problems for evaluating the performance for logistics service supply chain based on the marine transportation patterns with interval grey linguistic variables is the multiple attribute decision making problems[1-10]. The aim of this paper is to investigate the problems for evaluating the performance for logistics service supply chain based on the marine transportation patterns with interval grey linguistic variables. Then, we utilize the interval grey linguistic variables weighted geometric (IGLWG) operator to aggregate the interval grey linguistic variables corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one (s). Finally, an illustrative example is given. The remainder of this paper is set out as follows. In the next section, we introduce some basic concepts related to interval grey linguistic variables. In Section 3 we introduce the problems for evaluating the performance for logistics service supply chain based on the marine transportation patterns with interval grey linguistic variables. Then, we utilize the interval grey linguistic weighted geometric (IGLWG) operator to aggregate the interval grey linguistic variables corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one (s). In Section 4, an illustrative example is pointed out. In Section 5 we conclude the paper and give some remarks.

PRELIMINARIES

In this section, we briefly review some basic concepts to the interval grey linguistic variables.

Let $S=\left\{s_i \left| i=1,2,\cdots,t\right.\right\}$ be a linguistic term set with odd cardinality. Any label, s_i represents a possible value for a linguistic variable, and it should satisfy the following characteristics[11-14]:①The set is ordered: $s_i > s_j$, if $i > j$; ②There is the negation operator: $neg\left(s_i\right)=s_j$ such that $j=t+1-i$. For example, S can be defined as

$$S=\{s_1=extremely\ poor, s_2=very\ poor, s_3=poor, s_4=medium, \\ s_5=good, s_6=very\ good, s_7=extremely\ good\}$$

Definition 1. Let $\tilde{A}(x)$ be the fuzzy subset in the space $X=\left\{x\right\}$, if the membership degree $\mu_A(x)$ of x to $\tilde{A}(x)$ is the grey in the interval $\left[0,1\right]$, and its grey is $\nu_A(x)$, then $\tilde{A}(x)$ is called the grey fuzzy set in space X (GF set, for short), denoted by $\underset{\otimes}{\tilde{A}}(x)$, as follows:

$$\underset{\otimes}{\tilde{A}}(x)=\left\{(x,\mu_A(x),\nu_A(x))\left| x\in X\right.\right\} \quad (1)$$

The set pair mode is $\underset{\otimes}{\tilde{A}}(x)=(\tilde{A}(x),\underset{\otimes}{A}(x))$, where $\tilde{A}(x)=\left\{(x,\mu_A(x))\middle| x\in X\right\}$ is called the fuzzy part of $\underset{\otimes}{\tilde{A}}(x)$, and $\underset{\otimes}{A}(x)=\left\{\left(x,\nu_A\left(x\right)\right)\middle| x\in X\right\}$ is called the grey part of $\underset{\otimes}{\tilde{A}}(x)$. So the grey fuzzy set is regarded as the generalization of the fuzzy set and the grey set[15].

Definition 2. Let $\underset{\otimes}{\tilde{A}}(x)=(\tilde{A}(x),\underset{\otimes}{A}(x))$ be the grey fuzzy number, if its fuzzy part is a linguistic variable $s_\alpha\in S$, where S is a finite and totally ordered discrete term set, and its grey part $\underset{\otimes}{A}(x)$ is a closed interval $\left[g_A^L,g_A^U\right]$, then $\underset{\otimes}{\tilde{A}}(x)$ is called the interval grey linguistic variable[16].

Supposed that $\underset{\otimes}{\tilde{A}}(x)=\left(s_\alpha,[g_A^L,g_A^U]\right)$, $\underset{\otimes}{\tilde{B}}(x)=\left(s_\beta,\left[g_B^L,g_B^U\right]\right)$ be two interval grey linguistic variables. The continuous ordered weighted averaging (C-OWA, for short) operator which is developed by Yager (2004b) can be usefully applied to aggregate the grey part, the greyness of the grey part would be transformed into a real number, and then the fuzzy part integrates with the grey part. That is to say, the size of the interval grey linguistic variables can get through comparing the size of $s_\alpha\times f_\rho\left(\left[(1-g_A^L),(1-g_A^U)\right]\right)$ and $s_\beta\times f_\rho\left(\left[(1-g_B^L),(1-g_B^U)\right]\right)$. Assume the ordering value $Q(\underset{\otimes}{\tilde{A}}(x))=\alpha\times f_\rho\left(\left[(1-g_A^L),(1-g_A^U)\right]\right)$, $Q(\underset{\otimes}{\tilde{B}}(x))=\beta\times f_\rho([(1-g_B^L),(1-g_B^U)])$, then $Q(\underset{\otimes}{\tilde{A}}(x))=\alpha-\alpha\times\int_0^1\frac{d\rho(y)}{dy}\left(g_A^U+y\left(g_A^L-g_A^U\right)\right)dy$, $Q(\underset{\otimes}{\tilde{B}}(x))=\beta-\beta\times\int_0^1\frac{d\rho(y)}{dy}\left(g_B^U+y\left(g_B^L-g_B^U\right)\right)dy$, which can be obtained based on the continuous ordered weighted averaging (C-OWA) operator, such as $f_p\left(\left[a,b\right]\right)=\int_0^1\frac{d\rho(y)}{dy}(b-y(b-a))dy$.

The operation rules of ranking are defined as follows[16]:

(1) If $Q\left(\underset{\otimes}{\tilde{A}}(x)\right)>Q\left(\underset{\otimes}{\tilde{B}}(x)\right)$, then we have $\underset{\otimes}{\tilde{A}}(x)>\underset{\otimes}{\tilde{B}}(x)$;

(2) If $Q\left(\underset{\otimes}{\tilde{A}}(x)\right)<Q\left(\underset{\otimes}{\tilde{B}}(x)\right)$, then we have $\underset{\otimes}{\tilde{A}}(x)<\underset{\otimes}{\tilde{B}}(x)$;

(3) If $Q\left(\underset{\otimes}{\tilde{A}}(x)\right)=Q\left(\underset{\otimes}{\tilde{B}}(x)\right)$ and $s_\alpha\geq s_\beta$, then we have $\underset{\otimes}{\tilde{A}}(x)\geq\underset{\otimes}{\tilde{B}}(x)$;

(4) If $Q\left(\underset{\otimes}{\tilde{A}}(x)\right)=Q\left(\underset{\otimes}{\tilde{B}}(x)\right)$ and $s_\alpha<s_\beta$, then we have $\underset{\otimes}{\tilde{A}}(x)<\underset{\otimes}{\tilde{B}}(x)$.

The function ρ is denoted as basic unit-interval monotonic (BUM) functions. If $\left(\delta\geq 0\right)$ $\rho(y)=y^\delta$, then we have $Q(\underset{\otimes}{\tilde{A}}(x))=\alpha-\alpha\times\frac{\delta g_A^L+g_A^U}{\delta+1}$ and $Q(\underset{\otimes}{\tilde{B}}(x))=\beta-\beta\times\frac{\delta g_B^L+g_B^U}{\delta+1}$.

The operation rules of the interval grey linguistic variables are defined as follows[20]:

(1) $\underset{\otimes}{\tilde{A}}(x)\times\underset{\otimes}{\tilde{B}}(x)=\left(s_{\alpha\times\beta},\left[\left(1-\left(1-g_A^L\right)\times\left(1-g_B^L\right)\right),\left(1-\left(1-g_A^U\right)\times\left(1-g_B^U\right)\right)\right]\right)$;

(2) $\left(\underset{\otimes}{\tilde{A}}(x)\right)^k=\left(s_{\alpha^k},[g_A^L,g_A^U]\right)$.

In the following, Liu and Fang[16] developed the interval grey linguistic variables weighted geometric (IGLWG) operator to aggregate the interval grey linguistic variables.

Definition 3 [16]. An IGLWG operator of dimension n is a function IGLWG: $\Omega^n \to \Omega$, which has associated a set of weights or weighting vector $w=(\omega_1,\omega_2,\cdots,\omega_n)$ with $\omega_j \in [0,\ 1]$, $\sum_{j=1}^{n}\omega_j = 1$, and is defined to aggregate a list of values $\left\{\underset{\otimes}{\tilde{A}}(x_1),\underset{\otimes}{\tilde{A}}(x_2),\cdots,\underset{\otimes}{\tilde{A}}(x_n)\right\}$ according to the following expression:

$$IGLWG(\underset{\otimes}{\tilde{A}}(x_1),\underset{\otimes}{\tilde{A}}(x_2),\cdots,\underset{\otimes}{\tilde{A}}(x_n)) = \prod_{j=1}^{n}\left(\underset{\otimes}{\tilde{A}}(x_j)\right)^{\omega_j}$$
$$= \left(s_{\prod_{j=1}^{n}(\alpha_j)^{\omega_j}}, \left[\left(1-\prod_{j=1}^{n}\left(1-g_j^L\right)\right), \left(1-\prod_{j=1}^{n}\left(1-g_j^U\right)\right)\right]\right) \quad \textbf{(2)}$$

PERFORMANCE EVALUATION MODELS FOR LOGISTICS SERVICE SUPPLY CHAIN BASED ON THE MARINE TRANSPORTATION PATTERNS

The following assumptions or notations are used to represent the MADM problems for evaluating the performance for logistics service supply chain based on the marine transportation patterns. Let $A=\{A_1,A_2,\cdots,A_m\}$ be a discrete set of alternatives. Let $G=\{G_1,G_2,\cdots,G_n\}$ be a set of attributes. The information about attribute weights is completely known. Let $\omega=(\omega_1,\omega_2,\cdots,\omega_n)$ be the weight vector of attributes, where $\omega_j \geq 0$, $j=1,2,\cdots,n$. Supposed that $\underset{\otimes a_i}{\tilde{A}}(x_j)=\left(s_{\alpha_{ij}},[g_{ij}^L,g_{ij}^U]\right)$ be the attribute value in the attribute set x_j with respect to the alternative a_i which given by experts and $R=\left(\underset{\otimes a_i}{\tilde{A}}(x_j)\right)_{m\times n}$ be the decision making matrix., $i=1,2,\cdots,m$, $j=1,2,\cdots,n$.

In the following, we apply the IGLWG operator to MADM for evaluating the performance for logistics service supply chain based on the marine transportation patterns.

Step 1. Utilize the decision information given in the interval grey linguistic decision matrix $\tilde{R}$, and the IGLWG operator

$$z_i = IGLWG\left(\underset{\otimes a_i}{\tilde{A}}(x_1),\underset{\otimes a_i}{\tilde{A}}(x_2),\cdots,\underset{\otimes a_i}{\tilde{A}}(x_n)\right)$$
$$= \prod_{j=1}^{n}\left(\underset{\otimes}{\tilde{A}}(x_j)\right)^{\omega_j}$$
$$= \left(s_{\prod_{j=1}^{n}(\alpha_j)^{\omega_j}}, \left[\left(1-\prod_{j=1}^{n}\left(1-g_j^L\right)\right), \left(1-\prod_{j=1}^{n}\left(1-g_j^U\right)\right)\right]\right), i=1,2,\cdots,m$$

to derive the overall interval grey linguistic variables $\tilde{r}_i$ of the alternative A_i, where $\omega=(\omega_1,\omega_2,\cdots,\omega_n)$ is the weighting vector of the IGLWG operator, with $\omega_j \in [0,1]$, $\sum_{j=1}^{n}\omega_j = 1$.

Step 2. We rank the above the interval grey linguistic variables by using the method presented in Section 2. The ranking of the alternatives can be gained and the best one can be find out.

Step 3. End.

NUMERICAL EXAMPLE

This section presents a numerical example to illustrate the method proposed in this paper. Suppose a company plans to evaluate the performance for logistics service supply chain based on the marine transportation patterns. There is a panel with three possible marine transportation enterprises $A_i\ (i=1,2,3,4,5)$ to evaluate. The desirability levels of three possible marine transportation enterprises $A_i\left(i=1,2,3\right)$ are evaluated. The team of experts must take a decision according to the following five attributes: G1 is the debt paying ability; G2 is the operation capability; G3 is the earning capacity; G4 is the development capability.⑤G_5 is the scientific research capability. The three marine transportation enterprises $A_i\left(i=1,2,3\right)$ are to be evaluated using the interval grey linguistic variables by the decision maker under the above three attributes whose weighting vector $\omega=\left(0.25,0.20,0.15,0.30,0.10\right)^T$), as listed in the following matrix which is shown in TABLE1.

TABLE 1: Decision matrix

enterprises	A_1	A_2	A_3
G_1	$\left(s_2,\left[0.5,0.6\right]\right)$	$\left(s_5,\left[0.2,0.5\right]\right)$	$\left(s_3,\left[0.5,0.6\right]\right)$
G_2	$\left(s_3,\left[0.6,0.7\right]\right)$	$\left(s_2,\left[0.1,0.2\right]\right)$	$\left(s_4,\left[0.5,0.6\right]\right)$
G_3	$\left(s_3,\left[0.4,0.5\right]\right)$	$\left(s_6,\left[0.3,0.4\right]\right)$	$\left(s_5,\left[0.2,0.3\right]\right)$
G_4	$\left(s_1,\left[0.2,0.3\right]\right)$	$\left(s_6,\left[0.6,0.7\right]\right)$	$\left(s_4,\left[0.7,0.8\right]\right)$
G_5	$\left(s_1,\left[0.2,0.3\right]\right)$	$\left(s_4,\left[0.4,0.5\right]\right)$	$\left(s_5,\left[0.3,0.6\right]\right)$

Then, we utilize the approach developed to evaluate the performance for logistics service supply chain based on the marine transportation patterns with interval grey linguistic variables.

Step 1. Utilize the decision information given in the interval grey linguistic decision matrix $\tilde{R}$, and the IGLWG operator to derive the overall interval grey linguistic variables $\tilde{r}_i$ of the marine transportation enterprises A_i (Let $\omega=\left(0.25,0.20,0.30,0.10,0.15\right)^T$)

$$z_1=\left(s_{4.5},\left[0.2,0.3\right]\right); z_2=\left(s_{3.7},\left[0.4,0.6\right]5\right); z_3=\left(s_{6.3},\left[0.3,0.4\right]\right)$$

Step 2. We rank the above the interval grey linguistic variables by using the method presented in Section 2:

$$Q\left(z_1\right)=s_{4.11}, Q\left(z_2\right)=s_{6.24}, Q\left(z_3\right)=s_{5.75}$$

Step 3. The ranking of the alternatives can be gained: $A_2 \succ A_3 \succ A_1$, A_2 is the best marine transportation enterprises with best performance for logistics service supply chain based on the marine transportation patterns.

CONCLUSION

The aim of this paper is to investigate the problems for evaluating the performance for logistics service supply chain based on the marine transportation patterns with interval grey linguistic variables. Then, we utilize the interval grey linguistic variables weighted geometric (IGLWG) operator to aggregate the interval grey linguistic variables corresponding to each alternative and get the overall value of the alternatives, then rank the alternatives and select the most desirable one (s). Finally, an illustrative example is given.

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