Logistics Mode Selection Model Based on Fuzzy multi-objective Programming

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ABSTRACT

Logistics mode selection is one of the most important activities of supply chain management. An important way to make competitor advantage is select an optimal Logistics mode for the enterprise. Logistics mode selection is a multi-criterion decision making problem in which criteria have different relative importance. In practice, many input information are known precisely. The fuzzy set theories can be used due to the imprecision of information. In this paper, a fuzzy multi-objective decision-making model which is equivalent to solving crisp model by using max-min approach is developed to handle effectively the vagueness of input data in the process of Logistics mode selection. Also, an additive model taking into account the objectives' weights is presented further in the end of this paper.

Indexing terms/Keywords

Fuzzy multi-objective decision-making; Logistics mode selection; max-min model;

Academic Discipline And Sub-Disciplines

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SUBJECT CLASSIFICATION

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1. INTRODUCTION

Modern logistics is considered to be the third source of profit to enterprise. Logistic mode is the synthesis of logistics system operating mode, forms of structural organization and the services. Domestic logistics business has experienced so far the first party logistics (self-logistics), the second party logistics (part of the equipment or rental of logistics services form), third-party logistics (logistics outsourcing) and fourth-party logistics. With the higher increasing demand for logistics services, fourth party logistics mode was made in 1996 by Accenture. It is the enterprise in the global supply chain, outsourcing capital flow, business flow, information flow and technology services to a unified one-stop integrated service provider, which is an integrated logistics mode, and focus on their business core business.Fourth party logistics mode as new modes of operation, is a breakthrough in theory and practice, and already enhance the efficiency and mode of innovation.They co-exist and promote the development of each other.

There is a great deal of confusion to select the appropriate logistics business mode with The rapid development of logistics service mode. It have to be decide thatwhich is to choose from self-logistics, logistics outsourcing, third party logistics or integrated logistics service mode, or according to the business adjust their strategic orientation is the use of lean logistics, on-time logistics, rapid response logistics or agile logistics. It is necessary to consider internal and external factors, and may in some of the factors under conditions of uncertainty, a comprehensive evaluation, in order to choose their own mode of logistics services, and to enhance competitive advantage and competitiveness.

Therefore, the scientific effective way to select the most requested logistics enterprise has bee become the most important issue for decision-makers [3-4]. Logistics modeselection involves the evaluation criteria and evaluation methods of choice. William [5] and other supplier summary the selection criteria about dozens of types, the most widely followed by quality, cost, delivery, service, management, technology and research and development; the selection of suppliers, there are mainly DEA , AHP, ANP, linear programming, as well as their integration.

In this paper, for the first time, afuzzy multi-objective programming model has been developedfor logistics mode selection,in which the vague criteria and constraints of the logistics mode selection. At the same time, the max-min operator is developed to handle effectively the vagueness and imprecision of input data. Finally, the paper proposed how to further optimize the solution when considering target weight, so that the objectives and factors taken into account the ambiguity of the role and influence of varying sizes, to better ensure the right to re-order and higher degree of membership sort of consistency, to help decision-making who better to pick out the logistics service provider.

The paper is organized as follows: in Section 2 the basic theories are given; Section 3 the fuzzy multi-objective model and crisp formulation for the logistics mode selection problem is presented in which the objectives are equally important and have the same weights. First, a general linear multi-objective formulation for this problem is considered and then an appropriate approach for solving the problem is discussed. Finally, the concluding remarks are presented in Section 4.

2. PRELIMINARIES

2.1 Multi-objective programming theory

The method of Multi-objective optimization is presented firstly by the French economist Pareto in 1896.According to Weber and Current[6], a general multi-objective model for the supplier selection problem can be started as follows:

$$Min Z_1, Z_2, ..., Z_K \text{ (1)}$$

$$Max Z_{K+1}, Z_{K+2}, ..., Z_P \text{ (2)}$$

$$subject\ to$$

$$x \in X_d \quad X_d = \{x / g_s(x) \le b_s, s = 1, 2, ..., m\} \text{ (3)}$$

In the above model, $Z_1, Z_2, ..., Z_k$ is the negative objective for minimization like cost, late delivery, etc. and $Z_{k+1}, Z_{k+2}, ..., Z_p$ are the positiveobjectives for maximization such as quality, on time delivery, after sale service and so on. X_d is the set of feasible solutions that satisfy the set of system and policy constrains.

In practical decision-making, decision-making criteria or decision on the impact of qualification, completely accurate information did not been get by decision makers, such as the level of cost, quality good or bad, service level. These are some of the more vague concept, which need to combine the theory of fuzzy decision optimization model.

2.2 Fuzzy decision theory

Fuzzy theory is developed on the basis of the University of fuzzy set by L.A.zadeh from California in 1965[7].For the purpose of clarity, definitions of the related terms are given as follows.

Definition 1: Fuzzy sets (Zadeh 1965)Let X be a universe of discourse, A is a fuzzy subset of X if for all, there is a $\mu_A : X \rightarrow [0,1], \mu \rightarrow \mu_A(x)$ assigned to represent the membership of x to A, and $\mu_A(x)$ is called the membership function of A, that is an application from X in [0,1]. In other words, the fuzzy subset A of X is characterized by a membership function $\mu_A(x)$ association a real member in the interval[0,1] to each point of X. The value of $\mu_A(x)$ represents the degree of belonging of x to A. If A is an ordinary set, its membership function can then take only the values of 0 and 1.

Definition 2: λ -cut(Zimmermann 1991; Kaufmann and gupta 1985).The λ -cut of the fuzzy number A is defined $A_\lambda = \{\mu \in X \ / \ A(x) \geq \lambda\}$, where $\lambda \in [0,1]$ and A is a non-empty bounded closed interval contained in X and it can be denoted by $A = \left[a_\alpha^l, a_\alpha^h \right]$, and a_α^l and a_α^h are the lower and upper bounds of the closed interval, respectively.

Definition 3:

$$(A \bigcup B)(\mu) = \max\{A(\mu), B(\mu)\} = A(\mu) \vee B(\mu), \forall \mu \in X \quad (A \bigcap B)(\mu) = \max\{A(\mu), B(\mu)\} = A(\mu) \vee B(\mu), \forall \mu \in X$$

Definition 4: Half trapezoidal membership functions. Suppose the domain X, subject to the fuzzy set a ladder-type fuzzy division.

$$A(x,a) = \begin{cases} 1, x \leq a \\ \dfrac{b-x}{b-a}, a < x \leq b \\ 0, b < x \end{cases}$$

Right half of the trapezoidal membership function :

$$A(x,a) = \begin{cases} 1, x \leq a \\ \dfrac{x-a}{b-a}, a < x \leq b \\ 0, b < x \end{cases}$$

Left half of the trapezoidal membership function :

3. FUZZY MULTI-OBJECTIVE MODEL FOR LOGISTICS MODE SELECTION

3.1 Normal or Body Text Multi-objective programming model

The rapid development of modern logistics industry was more consolidated its third profit source as an important business position, and each company should choose their own single logistics mode or integrated logistics modefrom the self-logistics mode, logistics outsourcing mode, third-party mode and the emerging fourth party logistics mode based on their own development strategies and macro environment. The evaluationof each logistic mode, which is a multi-objective decision-making problem,can be assessed from the cost of the service (or product), efficiency, portability, and so many angles. In this process, the cost of self-logistics modelcan be measuredby the opportunity cost.

To have a typical model, the criteria of logistic modeor logistic product are assumed tobe quality, net price and delivery in this paper, that is to say, decision-makers assume that other factors, such as decision-makers preferences, the macroeconomic environment are fixed in the process of the mode selection for logistics. In order to formulate this model, the following notations are defined:

D demand over period

X_i the number of units logistics product from the ith supplier

P_i Per unit net cost from supplier i

C_i Capacity of ith supplier

F_i Percentage of quality level of ith supplier

S_i Percentage of service level of ith supplier

n number of suppliers r

$$MinZ_1 = \sum_{i=1}^{n} p_i x_i \quad (4)$$

$$MaxZ_2 = \sum_{i=1}^{n} f_i x_i \quad (5)$$

$$MaxZ_3 = \sum_{i=1}^{n} d_i x_i \quad (6)$$

ST.

$$\sum_{i=1}^{n} x_i \geq D \quad (7)$$

$$x_i \leq C_i, i = 1, 2, ..., n \quad (8)$$

$$x_i \geq 0, i = 1, 2, ..., n \quad (9)$$

In this model, three objective functions are considered.They are minimizing the total cost of logistics mode (including self-logistic mode) and maximizingthe servicelevel and the level of delivery on time.Three constraints are also considered. Constraint (7) ensures that demand is satisfied. Constraint set(8) means that the use service quantities to each logistics service provider can not exceed its service capacity. Constraint (9) requires that all decision variables meet the non-negative.

3.2 Fuzzy multi-objective programming model

In a real situation for a logistics mode selection problem, all objectives might not be achieved simultaneously under the system constraints, and the decision maker may define a tolerance limit. This is a vague concept. Meanwhile, the restrictions in some of the factors may not be clear. So the proposed general multi-objective programming model (1) - (3) (Weber and Current) to express the multi-objective program problem will become a fuzzy multi-objective program problem. At this point, the determination of the general multi-objective programming model can be expressed as the following general form of fuzzy multi-objective model:

The objective functions:

$$\tilde{Z}_k = \sum_{i=1}^{n} c_{ki} x_i \leq\sim Z_k^0, k = 1, 2, ..., p \quad (10)$$

$$\tilde{Z}_l = \sum_{i=1}^{n} c_{li} x_i \leq\sim Z_l^0, l = p+1, p+2, ..., q \quad (11)$$

The constrains :

$$\tilde{g}_i(x) = \sum_{i-1}^{n} a_{ri} x_i \leq\sim b_r, r = 1, 2, ..., h \quad (12)$$

$$\tilde{g}_p(x) = \sum_{i-1}^{n} a_{pi} x_i \leq\sim b_p, p = h+1, h+2, ..., m \quad (13)$$

$$x_i \geq 0, i-1, 2, ..., n. \quad (14)$$

In this model, the sign ~ indicates the fuzzy environment. The symbol $\leq\sim$ in the constraints set demotes the fuzzified version of $\leq$ and has linguistic interpretation "essentially smaller than or equal to" and the symbol $\geq\sim$ has linguistic interpretation "essentially greater than or equal to". $\tilde{Z}_k$ and $\tilde{Z}_l$ are the minimization function and the maximization

function, respectively. Z_k^0 and Z_l^0 are the aspiration levels that the decision-maker wants to reach. $\tilde{g}_i(x)$ and $\tilde{g}_p(x)$ stand for fuzzy constraints and deterministic constraints, respectively. x_i are not negative.

Zimmermann[12](1978) has solved the above problem by using fuzzy linear programming. He formulated the fuzzy linear program by separating every objectives function Z_j into its maximum Z_j^+ and minimum Z_j^- value by solving (15) and (16):

$$Z_k^+ = \max Z_k, x \in X_d, \quad Z_k^- = \min Z_k, x \in X_d \quad (15)$$

$$Z_l^+ = \max Z_l, x \in X_d, \quad Z_l^- = \min Z_l, x \in X_d \quad (16)$$

In this model, for every objectivesfunction Z_j, its value will change linearly from its minimum Z_j^- value to its maximum Z_j^+ value. Z_k^- and Z_l^+ will be obtained through solving the multi-objective problem as a single objective using, each time, only one objective. That may be considered as a fuzzy number with the membership function as follows:

$$\mu_{zk}(x) = \begin{cases} 1, for Z_k \leq Z_k^- \\ (Z_k^+ - Z_k(x))/(Z_k^+ - Z_k^-), for Z_K^- \leq Z_k(x) \leq Z_k^+, k = 1,2,...,p \\ 0, for Z_k \geq Z_k^+ \end{cases} \quad (17)$$

$$\mu_{zl}(x) = \begin{cases} 1, for Z_l \geq Z_l^+ \\ (Z_l(x) - Z_l^-)/(Z_l^+ - Z_l^-), for Z_l^- \leq Z_l(x) \leq Z_l^+, l = p+1, p+2,...,q \\ 0, for Z_l \leq Z_l^- \end{cases} \quad (18)$$

$$\mu_{gr}(x) = \begin{cases} 1, for g_r(x) \leq b_r \\ 1 - (g_r(x) - b_r)/d_r, for b_r \leq g_r(x) \leq b_r + d_r, r = 1,2,...,h \\ 0, for g_r(x) \geq b_r + d_r \end{cases} \quad (19)$$

In this paper, assuming that $\mu_{zk}(x)$ and $\mu_{zl}(x)$ are linear membership function for minimization goals Z_k and maximization goals Z_j, respectively; $\mu_{gr}(x)$ stands for the linear membership function for the fuzzy constraints; d_r is the subjectively chosen constraints expressing the limit of the admissible violation.

4. THE SOLUTION FOR FMOPM

In fuzzy programming modeling, using Zimmerman's max-min approach, a fuzzy solution is given by the intersection of all the fuzzy sets representing either fuzzy objective of fuzzy constraints. The fuzzy solution for all fuzzy objectives and h fuzzy constraints may be given as (20):

$$\mu_D(x) = \left\{ \left\{ \bigcap_{j=1}^{q} \mu_{Z_j}(x) \right\} \cap \left\{ \bigcap_{r=1}^{h} \mu_{g_r}(x) \right\} \right\} \quad (20)$$

Based on fuzzy decision theory, according to Bellman and Zadeh's fuzzy decision-making methods, you can solve the herdsman on behalf of all fuzzy goals and fuzzy constraints were to determine the intersection or union. (10) - (14) to express the fuzzy multi-objective planning of the optimal solution {X *}, can, through the expression (21) to get.

$$\mu_D(x^*) = \max_{x \in X_d} \mu_D(x) = \max_{x \in X_d} \min \left[\min_{j=1,2,...q} \mu_{Z_j}(x), \min_{r=1,2...h} \mu_{g_r}(x) \right] (21)$$

So, the optimal solution (x^*) in the above fuzzy model can be found by solving the following crisp model (Zimmermann, 1978) :

$Maximize \lambda$

$S.T.:$

$$\lambda \le \mu_{z_j}(x), j = 1, 2, ..., q \quad (22)$$

$$\lambda \le \mu_{g_r}(x), r = 1, 2, ..., h \quad (23)$$

$$g_p(x) \le b_p, p = h+1, ..., m \quad (24)$$

$$x_i \ge 0, i - 1, 2, ..., n. \text{ And } \lambda \in [0,1] \quad (25)$$

Where $\mu_D(X), \mu_{zj}(x), \mu_{gr}(x)$ represent the membership functions of solution, objective functions and constraints.

5. CONCLUSION

In this paper, a fuzzy multi-objective decision-making evaluation method is presented to help decision makers choose a more appropriate logistic mode on the basis ofgiving the target of choice logistics mode diversity and the vague impact of factors ambiguity. In practice, when decision-makers consider the objectives and constraints, in the process of decision-making not only including the multi-attribute and ambiguity, but also needing to take into account the same weight of their own. This paper using a same weighted approach to evaluation, and assumes when the impact of each objective or constraint is not the same situation, different weight need to be considered after further analysis.

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