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Research on The Vendor Selection of M Company Based on Multi-objective Linear Model

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Abstract: In this paper, we study the problem of logistics service provider selection of M company in Guangzhou city. Firstly, this paper introduces the basic situation of M company in Guangzhou city, and analyzes the main factors that the company has considered in choosing the logistics service providers. Taking the lowest cost, the best quality and the highest delivery rate as the supreme goal, we use positive and negative trapezoidal membership functions to capture the vagueness of these linguistic assessments. And we employ fuzzy multi-objective linear model to handle it. Furthermore, the fuzzy multi-objective programming model is transformed into a linear programming model, the results are compared with the results of theoretical calculation and actual supplier selection, the validity of the fuzzy model is verified. The model and method of this paper provide a theoretical basis for the selection of logistics service provider of M company.

Keywords Functional logistics service supply chain; fuzzy multi-objective programming; vendor selection

INTRODUCTION

Logistics service supply chain refers to the a new supply chain by providing flexible logistics services to ensure the product supply chain logistics operation, regarding integrated logistics service provider as the leading enterprises, and using functional logistics services suppliers - integrated logistics service suppliers – manufacturing, retail enterprises as the basic structure[Yan et al., 2004]. Functional logistics service suppliers are the key member in the supply chain management as they are the actual operator of the logistics business. Thus, functional logistics service supplier selection is critical in the entire logistics supply chain. How to choose these logistics service suppliers to meet customer needs, while achieving a win-win situation and establishing deeper supply chain partnership are the most important problem in the integrated logistics service vendor selection.

Domestic and foreign scholars had done a series of research work on the logistics service supplier selection problem. Menon studied the evaluation system to select the third-party logistics supplier, including: price, management level, delivery on time, reputation, performance ability, financial situation, reactions to unforeseen events [Menon et al., 1998]. Gunasekara studied the selection factors of third-party logistics suppliers such as strategic, tactical, operational and others [Ken et al., 2000]. Fen proposed comprehensive evaluation method of third-party logistics service providers[Ma et al., 2003]. So far, the vendor selection problem has been relatively mature theories and methods. Supplier selection problem is a complex multi-objective decision making problem, and the methods are created including analytic hierarchy process[Jin et al., 2003] , fuzzy AHP method [Wang et al., 2010], data envelopment analysis [Chen et al., 2008], Costing [Wang et al., 2009],Fuzzy planning [Atakan et al., 2004],genetic algorithm [Han et al., 2008]. The method of the fuzzy goal programming become more and more concerned by logistic companies due to the full consideration of factors and the results conform to reality.

In this paper, we will use fuzzy multi-objective linear method to study vendor selection issues of M company in Guangzhou city, under the consideration of the cost, quality, on-time delivery rate and other factors. We can find the optimal supplier selection results by employing fuzzy multi-objective linear model, which provide a theoretical basis for business decision-making.

THE LOGISTICS-RELATED PROFILES OF M COMPANY

M Logistics Enterprises was founded in 1992, and it has established various branches in different regions of the east, the north and the southwest etc. It has established an international logistics and information network in the United States, Thailand and Hong Kong of China, and it has formed strategic alliance with hundreds of well-known domestic and foreign enterprises, including PHILPS, Procter & Gamble, general electric and Amway. It provides integrated logistics services and supply chain service, such as raw materials, accessory procurement, storage, distribution, processing, packaging, distribution and information processing.

M logistics enterprise is a general logistics service contractor with limited own resources, and it is supposed to cooperate with other functional logistics service providers to meet the customer's needs. Presently, the decision-makers in M company select the vendors based on the experience and it is lack of theoretical support, so it is urgent that M company should select a scientific method of vendor selection.

M company provides all-around logistics service contains transportation, warehousing, packaging and processing etc to a large manufacturing enterprise called N company. Let us suppose that there is a logistics service need two kinds outsourcing tasks, including transportation A and warehousing B. After preliminary assessment and screening, several functional logistics service provider are regarded as the potential outsourcing objects, and the relevant information are shown in Table 1. Vendor can bear two logistics tasks include transportation and storage. It is required that the final allocation task of must abide by the requirements of the constraints transportation: storage =2: 1. The deviation of the transportation and storage volume is 10 and 5, respectively. The data in Table 1 is standard.

Table1. The Information of Vendor Logistics Service

The task	Vendor	Price	Quality (damage rate)	Service Satisfaction rate	Maximum Service Capability	Customer Requirements
A	m_1	7	0.05	0.92	170	200
	m_2	8	0.03	0.97	140	
	m_3	9	0.01	0.99	150	
B	m_1	13	0.05	0.92	80	100
	m_4	15	0.04	0.94	70	
	m_5	16	0.02	0.98	90	

FORMULATION OF FUZZY MULTI-OBJECTIVE LINEAR MODEL

The logistics service vendor is supposed to select some critical elements to evaluate the common vendor, such as quality, on time delivery, after sale service and so on. This paper chooses three objective functions-the price, quality and customer service to minimize total monetary cost, maximize total quality and service level of purchased items, respectively. Obviously, vendor selection is a typical multi-objective decision making problem. To simplify the problem, we do not consider the discounts and the shortage of services, and assume that demand is continuous.

Supposing that M company has b logistics outsourcing process, and each outsourcing process corresponds to a certain number of candidate suppliers.

Symbols and variables are defined as follows:

H_j : the number of candidate vendors of the outsourcing processes j;

X_{jk} :the assigned amount for vendor k at the outsourcing processes j（j=1,…,b， k=1,…, H_j）;

D_j: the demand for the outsourcing processes j;

U_{jk}:the maximum processing capacity for vendor k at the outsourcing processes j;

p_{jk} :the price for vendor k at the outsourcing processes j;

Q_{jk} :the quality for vendor k at the outsourcing processes j;

R_{jk} :the timely delivery rate for vendor k at the outsourcing processes j;

In a real-life situation for a vendor selection problem, many input related to target vendor may be ambiguity. If price, quality and timely delivery rate of vendors are fuzzy, we can construct the Fuzzy Linear Programming model (FLP) as follows:

$$\min Z_1 = \sum_{j=1}^{m}\sum_{k=1}^{n} p_{jk} X_{jk} \tilde{\lesssim} Z_1^0 \quad (1)$$

$$\min Z_2 = \sum_{j=1}^{m}\sum_{k=1}^{n} Q_{jk} X_{jk} \tilde{\lesssim} Z_2^0 \quad (2)$$

$$\min Z_3 = \sum_{j=1}^{m}\sum_{k=1}^{n} R_{jk} X_{jk} \tilde{\lesssim} Z_3^0 \quad (3)$$

$$s.t.\begin{cases} g_r(X) = \sum_{j=1}^{m} a_{rj} X_{jk} \tilde{\gtrsim} b_r, & r = 1,2,\cdots,h \\ g_p(X) = \sum_{j=1}^{m} a_{pj} X_{jk} \le b_p, & p = h+1,\cdots,q \end{cases} \quad (4)$$

Z_1 , Z_2 and Z_3 are three distinct objective functions. They are optimal price, quality and timely delivery rate of decision-maker. In formulation (4), $g_r(x)$ are the fuzzy constraints and $g_p(x)$ are the deterministic constraints. b_r and b_p are the right handside constants for fuzzy and deterministic relationships, respectively.

Zimmermann has formulated the fuzzy linear program by separating Z_j into Z_j^+ and Z_j^-. Where Z_j^+ and Z_j^- can be obtained by solving the multi-objective problem as a single objective problem:

$$Z_j^+ = \max Z_j,\quad Z_j^- = \min Z_j$$

From 0 to Z_j^- and Z_j^- to Z_j^+, membership function $u_{zj}(x)$ is shown in Fig.1.

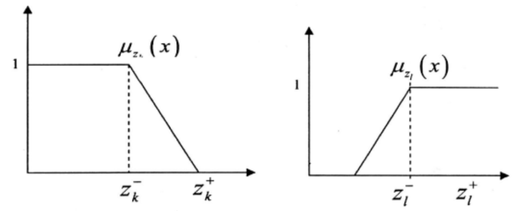

Fig.1. Objective function as fuzzy number: (a) for minimizing objective function Z_k and (b) for maximizing objective function Z_k

The three objective functions and Corresponding membership functions are as follows:

$$\mu_{z_1}(x) = \begin{cases} 1, & Z_1 \le Z_1^- \\ \dfrac{Z_1^+ - Z_k(x)}{Z_1^+ - Z_1^-}, & Z_1^- \le Z_1 \le Z_1^+ \\ 0, & Z_1 \le Z_1^+ \end{cases} \quad (5)$$

$$\mu_{z2}(x) = \begin{cases} 1, & Z_1 \le Z_1^- \\ \dfrac{Z_2(x) - Z_2^-}{Z_2^+ - Z_2^-}, & Z_2^- \le Z_2 \le Z_2^+ \\ 0, & Z_1 \le Z_1^+ \end{cases} \quad (6)$$

$$\mu_{z3}(x) = \begin{cases} 1, & Z_1 \le Z_1^- \\ \dfrac{Z_3(x) - Z_3^-}{Z_3^+ - Z_3^-}, & Z_3^- \le Z_3 \le Z_3^+ \\ 0, & Z_1 \le Z_1^+ \end{cases} \quad (7)$$

$$\mu_{G_1}(x) = \begin{cases} 1, & G_r(x) \ge b_r \\ 1 - \dfrac{G_r(x) - b_r}{d_r}, & b_r \ge G_r(x) \ge b_r - d_r \\ 0, & G_r(x) \ge b_r - d_r \end{cases} \quad (8)$$

d_r is constant set by the manufacturers that represents the limit of the tolerance of the rth inequalities.

This paper employs Zimmermann method to solve Z_k^+ and Z_k^-. Z_k^+ is the maximum value of the objective function for the following problem.

$$\max Z_k(x)$$
$$s.t.\begin{cases} G_r(x) \ge b_r - d_r,\ r = 1,2,\cdots,h \\ G_p(x) \le b_p,\ p = h+1,\cdots,q \end{cases} \quad (9)$$

Z_k^- is the minimum value of the objective function for the following problem.

$$\min Z_k(x)$$
$$s.t.\begin{cases} G_r(x) \ge b_r - d_r,\ r = 1,2,\cdots,h \\ G_p(x) \le b_p,\ p = h+1,\cdots,q \end{cases} \quad (10)$$

The optimal solutions of the fuzzy multi-objective linear problem should satisfy the following equations:

$$\mu_s(x^*) = \max_x \mu_s(x) \quad (11)$$
$$\mu_s(x) = \min(\mu_1(x), \mu_2(x), \mu_3(x), \mu_{g_r}(x),\ r = 1,2,\cdots,h)$$

Supposing $\lambda \le u_s(x)$, the fuzzy linear model can be transformed into certainty equivalent forms as formulation (12).

$$\max \lambda$$
$$\begin{cases} \lambda \le \mu_{z_k}(x) & k = 1,2,3 \\ \lambda \le \mu_{g_r}(x) & r = 1,2,\cdots,h \\ G_p(x) \le b_p & p = h+1,\cdots,q \\ 0 \le \lambda \le 1 \\ x \ge 0 \end{cases} \quad (12)$$

Where $u_s(x)$, $u_{zk}(x)$ and $u_{gr}(x)$ represent the membership functions of solution, objective functions and constraints.

In this solution, there is no difference between the fuzzy and constraints. But in reality, situations in which fuzzy goals and constraints have unequal importance to decision-maker. The weight additive model can be used to solve this problem, and it is presented as follows:

$$\mu_s(x) = \sum_{k=1}^{3} \omega_k \mu_{Z_k}(x) + \sum_{r=1}^{h} \beta_r \mu_{g_r}(x) \quad (13)$$

$$\sum_{k=1}^{3} \omega_k + \sum_{r=1}^{h} \beta_r = 1,$$

ω_k and β_r are weighting coefficients of the fuzzy goals and constraints. So the original fuzzy linear problem can be converted into the following single-objective linear model.

$$\max \sum_{k=1}^{3} \omega_k \lambda_k + \sum_{r=1}^{h} \beta_r V_r$$
$$\begin{cases} \lambda_k \le u_{Z_k(x)} & k = 1,2,3 \\ V_r \le u_{G_r(x)} & r = 1,2,\cdots,h \\ G_p(x) \le b_p & p = h+1,\cdots,q \\ 0 \le \lambda_k \le 1 \\ 0 \le V_k \le 1 \\ x \ge 0 \end{cases} \quad (14)$$

THE SOLUTION OF VENDOR SELECTION OF M COMPANY

According to the data in Table 1, the multi-objective linear model is formulated as follows:

$$\min z_1 = 7x_{11} + 8x_{12} + 9x_{13} + 13x_{21} + 15x_{22} + 16x_{23}$$
$$\min z_2 = 0.05x_{11} + 0.03x_{12} + 0.01x_{13} + 0.05x_{21} + 0.04x_{22} + 0.02x_{23}$$
$$\max z_3 = 0.92x_{11} + 0.97x_{12} + 0.99x_{13} + 0.92x_{21} + 0.94x_{22} + 0.98x_{23}$$

$$\begin{cases} x_{11} + x_{12} + x_{13} = 200 \\ x_{21} + x_{22} + x_{23} = 100 \\ x_{11} - 2x_{12} = 0 \\ 0 \le x_{11} \le 170 \\ 0 \le x_{12} \le 140 \\ 0 \le x_{13} \le 150 \\ 0 \le x_{21} \le 80 \\ 0 \le x_{22} \le 70 \\ 0 \le x_{23} \le 90 \end{cases}$$

x_{11} , x_{12} and x_{13} are freight volume of m1, m2 and m3 respectively. x_{21} , x_{22} and x_{23} are warehousing volume of m1, m4 and m5 respectively. x_{11}, x_{12} , x_{13} x_{21} x_{22} and x_{23} are all integers. We should minimize Z_1 and Z_2 and maximize Z_3 to select appropriate vendors. We use LINGO software to solve the problem and obtain the value of Z_1^+ is 3340.

Similarly,

$$Z_1^- = 2780, \quad Z_2^- = 5.2, \quad Z_2^+ = 14,$$
$$Z_3^- = 294.6, \quad Z_3^+ = 278.4$$

Then we obtain the membership function and fuzzy constraint as follows:

$$u_{Z_1(x)} = \begin{cases} 1, & Z_2 \le 2780 \\ \dfrac{3340 - Z_1(x)}{560}, & 2780 \le Z_2 \le 3340 \\ 0, & Z_2 \ge 3340 \end{cases}$$

$$u_{Z_2(x)} = \begin{cases} 1, & Z_2 \le 5.2 \\ \dfrac{14 - Z_1(x)}{8.8}, & 5.2 \le Z_2 \le 14 \\ 0, & Z_2 \ge 14 \end{cases}$$

$$u_{Z_3(x)} = \begin{cases} 1, & Z_3 \ge 294.6 \\ \dfrac{Z_3(x) - 278.4}{16.2}, & 278.4 \le Z_3 \le 294.6 \\ 0, & Z_3 \le 278.4 \end{cases}$$

$$u_{G_1(x)} = \begin{cases} 0, & G_1(x) \le 200 \\ 1 - \dfrac{G_1(x) - 200}{10}, & 200 \le G_1(x) \le 210 \\ 1, & G_1(x) \ge 210 \end{cases}$$

$$u_{G_2(x)} = \begin{cases} 0, & G_2(x) \le 100 \\ 1 - \dfrac{G_2(x) - 100}{5}, & 100 \le G_2(x) \le 105 \\ 1, & G_2(x) \ge 105 \end{cases}$$

Where $G_1(x) = x_{11} + x_{12} + x_{13}$, $G_2(x) = x_{21} + x_{22} + x_{23}$ $G_1(x)$ and $G_1(x)$ are constraint functions. According to formulation (14), we give the weighting coefficients of the objective function and constraints as

$k_1 = 0.2, k_2 = 0.25, k_3 = 0.15, U_i = 0.2 (i = 1, 2)$

And we obtain the following model.

$$\max f = 0.2\lambda_1 + 0.25\lambda_2 + 0.15\lambda_3 + 0.2\sum_{i=1}^{2} V_i$$

$$\begin{cases} \lambda_1 \le \dfrac{3340 - (7x_{11} + 8x_{12} + 9x_{13} + 13x_{21} + 15_{22} + 16x_{23})}{3340 - 2780} \\ \lambda_2 \le \dfrac{14 - (0.05x_{11} + 0.03x_{12} + 0.01x_{13} + 0.05x_{21} + 0.04x_{22} + 0.02x_{23})}{14 - 5.2} \\ \lambda_3 \le \dfrac{(0.92x_{11} + 0.97x_{12} + 0.99x_{13} + 0.92x_{21} + 0.94x_{22} + 0.98x_{23}) - 278.4}{294.6 - 278.4} \\ V_1 \le 1 - \dfrac{G_1(x) - 200}{10} \\ V_2 \le 1 - \dfrac{G_2(x) - 100}{5} \\ x_{11} + x_{12} + x_{13} = 200 \\ x_{21} + x_{22} + x_{23} = 100 \\ x_{11} \le 170 \\ x_{12} \le 140 \\ x_{13} \le 150 \\ x_{21} \le 80 \\ x_{22} \le 70 \\ x_{23} \le 90 \\ x_{ij} \ge 0 \\ 0 \le \lambda_i \le 1 \\ 0 \le V_i \le 1 \end{cases}$$

We use LINGO software to obtain the following results:

$$f = 0.576, x_{11} = 114, x_{12} = 0,$$
$$x_{13} = 86, x_{21} = 57, x_{22} = 0, x_{23} = 43$$
$$z_1 = 114 \times 7 + 86 \times 9 + 57 \times 13 + 43 \times 16 = 3001$$
$$z_2 = 114 \times 0.05 + 86 \times 0.01 + 57 \times 0.05 + 43 \times 0.02 = 10.27$$
$$z_3 = 114 \times 0.92 + 86 \times 0.99 + 57 \times 0.92 + 43 \times 0.98 = 284.6$$

RESULT ANALYSIS

M company selects vendors through experience. According to the past experience, M company selects 120 trucks and 55 square meters warehousing from vendor m1, 50 trucks from m2, 30 trucks from vendor m3, 20 square meters warehousing from vendor m4 and 20 square meters warehousing from vendor m5. That is to say,

$$x_{11} = 120, x_{12} = 60, x_{13} = 30, x_{21} = 60, x_{22} = 20, x_{23} = 20$$

Now we obtain:

$$z_1 = 120 \times 7 + 50 \times 8 + 30 \times 9 + 60 \times 13 + 20 \times 15 + 20 \times 16 = 2910$$
$$z_2 = 120 \times 0.05 + 50 \times 0.03 + 30 \times 0.01 + 60 \times 0.05 + 20 \times 0.04 + 20 \times 0.02 = 12$$
$$z_3 = 120 \times 0.92 + 50 \times 0.97 + 30 \times 0.99 + 60 \times 0.92 + 20 \times 0.94 + 20 \times 0.98 = 282.2$$

Through comparable results, although we get higher cost by employing fuzzy multi-objective linear model, we enhance higher consumer service satisfaction rate and reduce damage rate to better the revenue. So, we conclude that fuzzy multi-objective linear model is superior to traditional methods.

CONCLUSION

A fuzzy model has been presented in this paper to study the selection and optimization of functional vendors to integrated logistics service provider. It is modeled using linear membership function and the entire formulation is solved by fuzzy multi-objective programming approach. The aim of the model is to reduce cost and damage rate, and enhance consumer service satisfaction rate. From the illustrative example and results, fuzzy multi-objective linear method can behave effective in vendor selection problem.

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REFERENCES

Atakan Y, Ali F G. A, 2011,Weighted Additive Fuzzy Programming Approach for Multi-Criteria Supplier Selection, Expert Systems With Applications, 38 (5): 6281-6286

Chen J, Zhang X, Chen J, 2008, Decision Model And Implementation Of Evaluation And Selection To Supplier, Systems Engineering Theory And Practice, 28 (11) : 149-154 (in Chinese)

Han J , Wang M, Ma X, Wang Y, 2008, Partner Selection Solving Based on a Self-adaptive Genetic Algorithm For Virtual Enterprise, Computer Integrated Manufacturing Systems, 4(1): 118-123(in Chinese)

Jin C, Ji Z, Lin Y, 2003, Strategy on Supplier Selection of Shipbuilding Enterprise, Computer Integrated Manufacturing System, 9(10): 886-890(in chinese)

Ken Ackerman, 2000,How to choose a third-party logistics provider, Material Handling Management, 55: 95-100

Ma X, Liu Y, Sun S, Wu X, 2003,Evaluation and Selection of TPLs in Supply Chain Management, Computer Engineering and Applications, 39(2):7-9(in chinese)

Manoj Kumara, Rem Vratb, Shankarc, 2004 A fuzzy goal programming approach for vendor selection problem in a supply chain, Computers&Industrial Engineering, (46): 69-85

Menon M K, McGinnis M A, 1998,. Selection criteria for providers of third-party logistics services, An Exploratory Study, Journal of Business Logistics, 19(1): 121-137

Wang R, 2010, Study on Choosing Third Party Logistics Serves Based on Fahp, Journal of Shanxi University of Science And Technology28(4):143-146(in chinese)

Wang X, Chen X, 2009,Supplier Selection Mode and Its Improvement On the Basis of Activity-Based Costing, Academic Exchange, (3):139-143(in Chinese)

Yan X, Sun L, Luo B, 2004, Research on Multi-objective Decision Making Method for the Third Party Logistics Service Selection, China Mechanical Engineering,15(12): 1088-1090(in chinese)

Zhao J, Chen H, 2011,Multi-objective Programming Model for the Multi-product Supplier Selection Based on Fuzzy Demand, Fuzzy Systems and Mathematics, 4-0148-08 (in Chinese)