The Application of C-W Algorithm in Tobacco Logistic Distribution and Delivery

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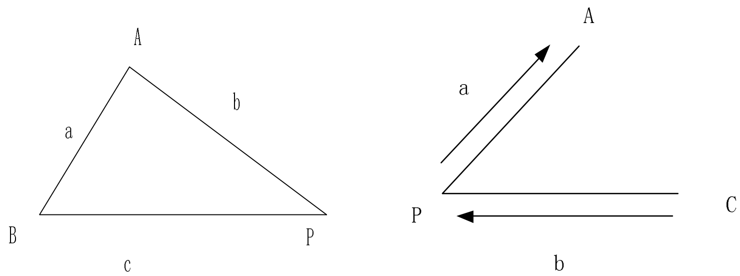
Abstract: Tobacco logistics distribution is key link of tobacco supply chain, it plays a decisive role in improving efficiency , benefit and service level of tobacco companies. On uncertainty and fuzziness existing in the tobacco distribution field, we research on the application of correction C-W saving algorithm applied in the field of tobacco distribution. Establish tobacco logistics distribution optimization model with the minimum cost , and built fixed C-W saving algorithm of distribution route optimization problems under uncertain conditions.By example calculating, give the fuzzy sort of cost saving value between customers of tobacco logistics center,get the optimized distribution network basing on the minimum fuzzy cost,and finally get fuzzy cost saving value after Distribution network optimization.The result show that, fixed C-W saving algorithm basing on the centroid and deviation sorting is an effective algorithm,and it can be well applied to cigarette distribution network optimization problem.

Keywords: Logistics Engineering;Fuzzy cost saving;Fixed C-W saving algorithm;Tobacco distribution;Centroid and deviation sorting

1. INTRODUCTION

In recent years,the development of China's tobacco industry is facing the grim situation of dual pressure at home and abroad,where the expansion and penetration of international tobacco giants should be resisted, the fierce market competition with domestic logistics company with high-speed development should be made. Fuzzy cost is referred to the method of Three-point estimate and triangular fuzzy number to explain virtual execution cost.Savings Algorithm is put forward by Clark and Wright in 1964,which is the heuristic algorithm to solve the problem of VPR.Using saving algorithm in a series of customer demand point,satisfying certain constraint conditions(such as demands for goods ,quantity of delivering goods ,delivery time,vehicle capacity limit,time limit),design appropriate routes to achieve a certain goal optimization(such as the shortest mileage,the least cost, vehicle scale which is as low as possible,high vehicle efficiency),and make the vehicle orderly go through them.

The basic idea is as shown below in Figure1. P is the location of distribution center , A and B are sites for customers.The distance between them are respectively a,b,c .The most simple distribution method is that two cars are used to delivery respectively, and the delivery line is as shown in Figure1-2, vehicle running distance is $2a+2b$ .If one car tour delivery is instead,running distance is $a+b+c$. If there is no particular conditions of roads, the saving running distance is $(2a+2b)-(a+b+c)=a+b-c$ .In practical operation, due to the quantity of the need for distribution customer, the shortest distance between each other including distribution center should be calculated first. Calculate the saving running distance between customers, connect the distribution sites according to the order of saving distance.,and it is the planning transport routes.



1-1 1-2

Figure1. Distribution center distribution route choice

2. TOBACCO DISTRIBUTION OPTIMIZATION MODEL WITH FUZZY COST COEFFICIENT

2.1 Problem Description

The delivery of goods from tobacco logistics center to the customer (or secondary stand distribution) v_i ($i = 1,2,3......m$) is completed by vehicles whose load capacity is p_i from tobacco logistics distribution center. The distribution quantity of goods from distribution center to customers (or secondary distribution stand) v_i ($i = 1,2,3......m$) is l_i ,even $p_i \le l_i$, fuzzy distribution costs from v_i to v_j is q_{ij} ,and the problem is transformed into the minimum cost distribution path with a car delivery to meet tobacco logistics center transport demand.

2.2 Parameter Definitions and Condition Assumptions

Set that the position of a logistics center and customer (or secondary distribution stand) has been known, and the distance between logistics center and customer (or secondary distribution stand) is known and fixed.Time conditions of customer demands and traffic flow are not limited. The goods for each customer can be mixed loading. The distribution vehicle starts from logistics center,and return to the logistics center after complete a mission. Model parameters are defined as follows:

V ($v_1, v_2, ... v_i$) :the customer or transfer station muster;

K :vehicle muster, $k \in K$;

O :tobacco logistics distribution center;

P_k :the maximum load for the distribution vehicle;

l_i :the distribution quantities from distribution center to the customer (or secondary stand distribution);

L_k :the maximum distance of vehicles in distribution cycle;

q_{ij} :the fuzzy distribution costs from v_i to v_j ;

$$y_{ik} = \begin{cases} 1 & \textit{The delivery task of customer } v_i \textit{ is completed by vehicle } k \\ 0 & \textit{Otherwise} \end{cases}$$

$$x_{ijk} = \begin{cases} 1 & Vehicle \ \ k \ travels \ \ from \ \ v_i \ to \ v_j \\ 0 & Otherwise \end{cases}$$

2.3 Model Building

The tobacco distribution optimization model with fuzzy cost coefficient basing on the minimum cost is built as follows:

$$\min \ M = \sum_i \sum_j \sum_k q_{ij} x_{ijk} \tag{1}$$

$$s.t. \quad \sum_i l_i y_{ik} \le p_i \tag{2}$$

$$\sum_i \sum_j l_{ij} x_{ijk} \le l_k \tag{3}$$

$$\sum_k y_{ik} = 1 \qquad i = 0,1 \ldots\ldots m \tag{4}$$

$$\sum_i x_{ijk} = y_{jk} \qquad j = 0,1,2 \ldots\ldots m \tag{5}$$

$$\sum_j x_{ijk} = y_{ik} \qquad i = 0,1,2 \ldots\ldots m \tag{6}$$

$$y_{ik} = 0 \ or \ 1 \qquad i = 0,1,2 \ldots\ldots m \tag{7}$$

$$x_{ijk} = 0 \ or \ 1 \qquad i, \ j = 0,1,2 \ldots\ldots m \tag{8}$$

Type (2) shows that the distribution quantities of goods for customers (or transfer stations) in each line is limited by vehicle loading. Type (3) shows that the distribution distance of Vehicle k is not more than a maximum distance of distribution cycle. Type (4) shows that there is only one car of delivery for each customer (or transfer station). Type (5) shows that Vehicle k must travels from i to j if it travels to j.Type (6) shows that k must be in another point after delivering the goods in this point, if k travels to j to deliver the goods. Type (7) and Type (8) are variable value constraints.

3. FIXED C-W SAVING ALGORITHM WITH FUZZY COST COEFFICIENT

C-W saving algorithm agreed: the delivery line($0 \to i \to 0$) which has only one delivery point is called the initial line; the delivery line($0 \to 1 \to 2 \to \ldots\ldots \to i \to j \to \ldots.. \to 0$) which contains two or more than two delivery point is called combination lines.The fixed C-W saving algorithm with fuzzy cost coefficient is structured as follows:

(1)Connect customers ,transfer station and tobacco logistics distribution center together, form m initial lines, fuzzy expenses value of line i is as follows:

$$M_i = q_{0i} + q_{i0} \tag{9}$$

(2)Set that connect customer i and customer j , constitute a combinational line($0 \to i \to j \to 0$), cost saving value is S_{ij} ,and S_{ij} constitutes a collection Z ,then

$$S_{ij} = q_{i0} + q_{0j} - q_{ij} \tag{10}$$

$$S_{ji} = q_{j0} + q_{0i} - q_{ji} \tag{11}$$

If cost coefficient matrix is symmetrical,then $S_{ij} = S_{ji}$,and then

$$S_{ji} = S_{ij} = q_{i0} + q_{0j} - q_{ij} \tag{12}$$

(3)Sort S_{ij} using method of the centroid and deviation sorting[4][5] for fuzzy numbers

Set that $\overline{x}(S_{ij})+\overline{y}(S_{ij})$ and $\overline{D}(S_{ij})$ are respectively centroid index and deviation index.Then

$$\overline{x}(S_{ij})=\frac{a+b+c}{3}, \quad \overline{y}(S_{ij})=\frac{1}{3} \tag{13}$$

$$\overline{D}(S_{ij})=\frac{1}{3}(L_s(S_{ij})+T_s(S_{ij})) \tag{14}$$

Thereinto,

$$L_s(S_{ij})=\sqrt{\frac{1}{2}\{[a-L_M(S_{ij})]^2+[b-L_M(S_{ij})]^2\}} \tag{15}$$

$$L_M(S_{ij})=\frac{1}{2}(a+b) \tag{16}$$

$$T_S(S_{ij})=\sqrt{\frac{1}{4}\{[a-T_M(S_{ij})]^2+[b-T_M(S_{ij})]+2[c-T_M(S_{ij})]\}} \tag{17}$$

$$T_M(S_{ij})=\frac{a+b+2c}{4} \tag{18}$$

If there is obvious difference of size between centroid index of fuzzy numbers, choose the method of centroid sorting:

1)If $\overline{x}(S_{ij})>\overline{x}(S_{mn})$, then $S_{ij}>S_{mn}$;

2)If $\overline{x}(S_{ij})<\overline{x}(S_{mn})$, then $S_{ij}<S_{mn}$;

3)If $\overline{x}(S_{ij})=\overline{x}(S_{mn})$, then $S_{ij}\sim S_{mn}$.

When the centroid index is similar, order combining to the deviation index, the optimal fuzzy number is the one that centroid index is greater and deviation index is smaller:

If $\overline{x}(S_{ij})>\overline{x}(S_{mn})$, $D(S_{ij})<D(S_{mn})$, $S_{ij}>S_{mn}$,then comprehensive order index of fuzzy numbers is as follows:

$$Q(S_{ij})=\alpha[\beta\overline{x}(S_{ij})+1-\beta]+(1-\alpha)\left[\beta L_S(S_{ij})+(1-\beta)L_M(S_{ij})-\frac{1}{3}(1-\beta)L_S(S_{ij})+T_s(S_{ij})\right] \tag{19}$$

α is the weight coefficient of centroid index; β is optimistic coefficient of decision makers.

The comprehensive sorting method of fuzzy numbers basing on centroid index and deviation index is as follows:

1)If $Q(S_{ij})>Q(S_{mn})$,then $S_{ij}>S_{mn}$;

2)If $Q(S_{ij})<Q(S_{mn})$, then $S_{ij}<S_{mn}$.

(4)Order S_{ij} according to the method above,the greater S_{ij} is,the more saving cost will be get when connect customer i and j,therefore connecting i and j should be given the priority[6]Examine whether customers of tobacco distribution meet one of the following conditions:

1)i and j are in the initial line;

2)One of i and j is in the initial line,the other is in the combination circuit;

3)i and j is respectively in two combination circuits.

If meet then turn steps (5), otherwise turn steps (6).

(5) l_i and l_j have been known,calculate whether vehicle loads meet the constraints (2) when connect i, j .If meet then turn steps (7), otherwise turn steps (6).

(6)Choose the vehicle of the greater load models from collection K , then turn steps (5), if it has reached the limit load of available models, then turn steps (9).

(7)Calculate total running distance of vehicles, check whether meet the constraints (3)If meet then turn steps (8), otherwise turn steps (9).

(8)Connect $i \text{ and } j$,form new combination lines.

(9)Cancel the elements of S_{ij} from collection Z ,if $Z \neq \Phi$, then algorithm is ended up,otherwise turn steps (4), and continue to explore the scheme of distribution route optimization.

4. THE COMPUTATIONAL EXAMPLE

Take a tobacco logistics distribution center as an example, the available vehicle models of the distribution center is the van that the maximum load is eight.Considering the stop time in the point of customers (or transfer station) when distributing the cigarette, limit per running distance within 60 km , choose the 7 local representative customers, the geographical position and commodity demand are shown as Figure 2. M is the location of tobacco logistics center, $C \sim I$ is the locations of customers (or transfer station), the numbers in brackets is the demand for cigarette for the customer cycle, signify with weight, the Numbers on the line is road distance,use km as its unit. The transport cost between tobacco logistics distribution center and customers, between customers is as shown in Table1, use a modified C-W algorithm to solve the distribution route optimization problems.

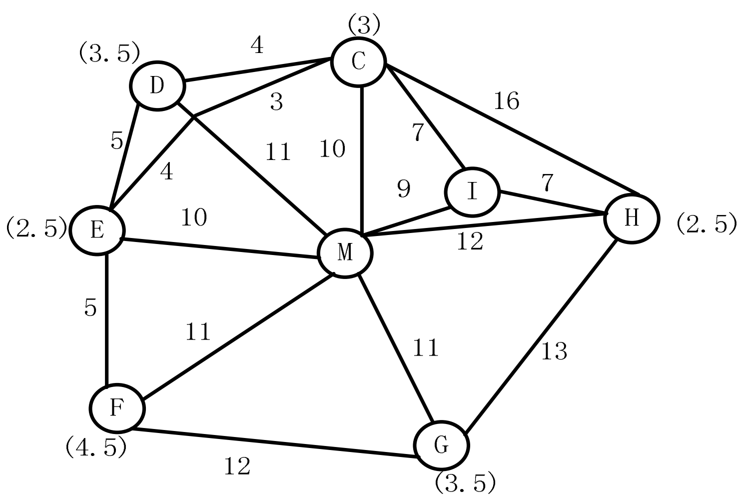


Figure 2.Tobacco logistics center distribution route network

	M	C	D	E	F	G	H	I
M	0							
C	(31,35,37)	0						
D	(28,30,34)	(28,28,28)	0					
E	(11,13,18)	(20,21,27)	(23,26,30)	0				
F	(6,9,12)	(29,49,63)	(18,21,29)	(8,9,12)	0			
G	(13,18,24)	(49,56,60)	(26,31,32)	(22,30,40)	(13,20,27)	0		
	(16,24,29)	(48,56,63)	(38,48,58)	(29,34,38)	(27,30,36)	(18,20,36)	0	
	(27,30,32)	(32,40,48)	(48,54,57)	(22,25,30)	(30,34,38)	(43,49,58)	(36,39,47)	0

Tabel1. Fuzzy cost between two spots

According to Type(10), connect $i \text{ and } j$, fuzzy cost saving value is shown as Tabel2.

Tabel2. The table of fuzzy cost saving

(i,j)	(C,D)	(C,E)	(C,F)	(C,G)	(C,H)	(C,I)	(D,E)	(D,F)	(D,G)	(D,H)
S_{ij}	(31,37,43)	(22,27,28)	(8,-5,-14)	(-5,-3,1)	(-1,3,3)	(26,25,21)	(16,17,12)	(16,18,7)	(15,17,16)	(6,6-5)
(i,j)	(D,I)	(E,F)	(E,G)	(E,H)	(E,I)	(F,G)	(F,H)	(F,I)	(G,H)	(H,I)
S_{ij}	(7,6,-1)	(9,13,18)	(2,1,2)	(-2,3,25)	(16,15,20)	(6,7,9)	(-5,3,7)	(3,5,6)	(11,22,12)	(7,15,14)

Use the centroid and deviation synthesis method to order fuzzy cost saving value, just as shown in Tabel3.

Tabel3. The ordering table of fuzzy cost saving

(i,j)	(C,D)	(C,E)	(C,I)	(E,I)	(D,F)	(D,G)	(D,E)	(G,H)	(E,F)	(H,I)
S_{ij}	(31,37,43)	(22,27,28)	(26,25,21)	(16,15,20)	(16,18,7)	(15,17,16)	(16,17,12)	(11,22,12)	(9,13,18)	(7,15,14)
$\overline{X}$	37	25.67	24	17	17	16	15	15	13.33	12
$\overline{D}$				0.55	1.37		0.93	1.44		
(i,j)	(E,H)	(F,G)	(F,I)	(D,I)	(D,H)	(E,G)	(C,H)	(F,H)	(C,G)	(C,F)
S_{ij}	(-2,3,25)	(6,7,9)	(3,5,6)	(7,6,-1)	(6,6-5)	(2,1,2)	(-1,3,3)	(-5,3,7)	(-5,-3,1)	(8,-5,-14)
$\overline{X}$	8.67	7.33	4.67	4	2.33	1.67	1.67	1.67	-2.33	-3.67
$\overline{D}$						0.31	1.24	2.12		

According to sorting table of the fuzzy cost saving value, use the fixed C-W algorithm, test the constraint conditions of running distance and loading capability of vehicles, just as shown in Tabel4.; and get the tobacco distribution optimization route network, just as shown in Figure3.

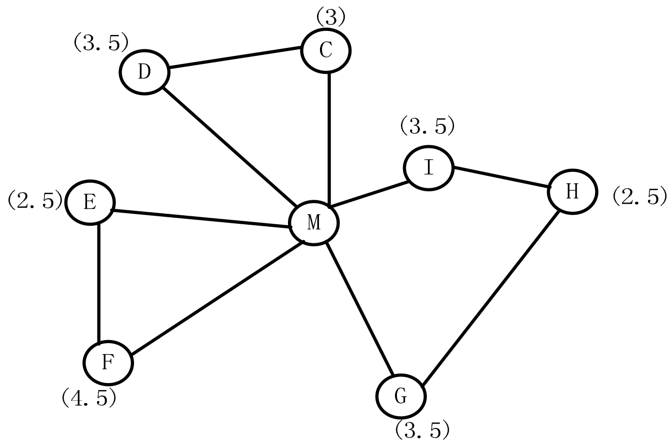


Figure3.Tobacco distribution circuit network optimization basing on cost saving

Table4. Route Optimism Obtained by using Modified C-W Algorithm

Number	Initial line	The Optimization Line	Distance Examine $(D-60)/km$	Loading Examine $(q-8)/t$
1	C,D,E,F,G,H,I			
2	E,F,G H,I	$M\to C\to D\to M$	-36	-1.5
3	$E,F,$	$M\to C\to D\to M$ $M\to G\to H\to I\to M$	-36 -20	-1.5 -0.5
4		$M\to C\to D\to M$ $M\to G\to H\to I\to M$ $M\to E\to F\to M$	-36 -20 -34	-1.5 -0.5 -1

Calculate fuzzy cost saving value of the optimization line, just as shown in Table5.

Table 5. Fuzzy cost After Route Optimism

The Optimization Line	Fuzzy Cost Saving Value	Total Fuzzy Cost Saving Value	Fuzzy Cost	Total Fuzzy Cost
$M\to C\to D\to M$	(31,37,43)		(87,93,99)	
$M\to G\to H\to I\to M$	(18,37,36)	(53,87,85)	(94,107,109)	(206,231,280)
$M\to E\to F\to M$	(9,13,8)		(25,31,42)	

According to Table5, using modified C-W saving algorithm we can get saving transport cost of tobacco logistics distribution optimization route , total fuzzy cost saving value is （53,87,85), the optimizing total fuzzy cost is (206,231,280).

5. CONCLUSION

Basing on the brief analysis of the traditional C-W saving algorithm and the application in tobacco distribution area, the method of centroid and deviation sorting in the fuzzy number is applied in C-W saving algorithm, suggest fixed C-W saving algorithm to solve the problem of uncertain cost in tobacco distribution field. In the end, the conclusion has been verified through an example, the method can be rapidly used to solve the problem of tobacco distribution path optimization with fuzzy cost coefficient.

The paper briefly introduced the single model of vehicle scheduling problem with fuzzy cost, it is not involved that of the more complex vehicle scheduling problem with constraint problems such as muti vehicle, a fuzzy demand and time window. Solving these problems with intelligent algorithm is the further direction. .

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