Research on the Location of Distribution Center of Agricultural Products

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Abstract: In summary and analysis research's results of agricultural products distribution center location, through introducing mortify cargo damage cost, vehicle refrigerating energy cost and circulation time restriction, this paper attempts to further exploring Location Problem for the Cold Chain Distribution Center that conform to the characteristics of timeliness agricultural products. Then, a mixed-integer nonlinear location model through analysis of the overall cost of the three level-two echelon cold chain is presented. Finally, a contrastive analysis was made between the results of this model and the general location model's through a case, verifying that the location model taking into account the economy and timeliness not only has more advantage in the overall cost but also more consistent with the actual situation of agricultural properties.

***KeyWords*: Cold Chain; Location for the Distribution Center; timeliness; cargo damage; circulation time**

I. INTRODUCTION

As consumers' requirements for timeliness agricultural product safety and quality are increasingly stricter, study on cold chain circulation system matched that consumption becomes more and more important in theory and practice. As the hub of the circulation system, Distribution Center is a multifunctional flow-through node to organize distribution sales or supply and physical distribution. Good cold chain distribution site plan not only can effectively reduce the chain's damage cost and improve distribution quality and efficiency, but also is of great significance to improve value-added ability of timeliness agricultural products during the circulation process.

The paper selects the most optimal location of the new address from viable alternative addresses. In order to reducing the "Bullwhip Effect" impact on the balance between supply and demand, the paper is going to study agricultural products' production base, distribution centers and demand points as three levels and two stages in the supply chain, where always exist cargo damages and energy consumption of refrigeration during the process of transportation and distribution. In addition, considering the shipments of production bases and delivery quantities of distribution centers and the damage on the transportation and distribution way, distribution centers' capacity limits and demand points' requirements should be met. The freshness of timeliness agricultural products can be measured by the circulation time, without referring to retention time in distribution centers, and requirements of each demand point are different. Above all, the paper establishes Mixed Integer Nonlinear Programming Model with cargo damages and energy consumption of refrigeration as decision-making targets and satisfying the requirements for circulation time of the various demand points as a constraint condition.

II. DISTRIBUTION CENTER LOCATION MODEL

Model Assumptions

A. Model Assumptions

2.1.1. The cold chain of agricultural products consists of multiple processing bases, distribution centers and demand points as three levels and two stages;

2.1.2. Consider only the circulation of one kind of agricultural product, that is to say the present model belongs to the location choice model of one agricultural more distribution centers;

2.1.3. The supply capacity and the requirement on demand point of agricultural production base per unit time (a quarter or a year) are predictable and constants;

2.1.4. Confined to investment cost, the biggest choice number of distribution centers is limited, fixed cost and the maximum capacity of each distribution center are known;

2.1.5. The agricultural products storage of a distribution center for a period is its throughput meantime; and the unit of agricultural operating rate is known

2.1.6. Cargo Damages Rates of timeliness agricultural products are constant;

2.1.7. The transportation rates of distribution vehicles are proportional to their volumes and transportation distance.

2.1.8. Have the same transport distribution via road conditions, and vehicle speed can be treated as a same constant

2.1.9. All the agricultural production bases can distribute to demand points through distribution centers, while adjust distributions between distribution centers are left out;

B. Decision Variables

x_{ij} ： The traffic volume from processing bases I to Distribution Center J；

x_{jk} ： the traffic volume from Distribution Center j to requirement point k；

$$Y_j = \begin{cases} 1 & \text{the location j be Chosen} \\ 0 & \text{the location j not be Chosen} \end{cases};$$

Parameter definition:

s_i ： Capacity of processing bases i.

M_j ： Maximum capacity of distribution center j

D_k ： Demand of the requirement point k

p ： Timeliness of agricultural price

c ： Vehicle unit weight per unit distance transport rates.

f_j ： Alternative locations j fixed construction costs.

b_j ：Alternative locations j unit operating costs.

d_{jk} ： Transport distance from distribution center j to requirement point k

d_{ij} ：Transport distance from processing bases i to distribution center j.

θ ： Circulation process timeliness perishable agricultural cargo damage rate

v ：Average vehicle speed of transportation

0 ：Vehicle cooling energy costs per unit of time

t_k ：The time requirements of requirement point k for agricultural products circulation

C. Model

On the basis of the traditional theory of TTT[1] （time．temperature．tolerance），For cargo damage costs during transportation can be calculated as follows：assuming a constant temperature during low temperature distribution ， according to Arrhenius equation，decay rate coefficient θ is constant。The number of good agricultural in transportation time t is

x_{ij} (t), There is perishable transit equations : $\frac{dx_{ij}(t)}{dt} = -\theta[x_{ij}(t)]^n$, Where n is the index of agricultural reaction。For the transport speed is constant under constant conditions v , The amount of cargo damage during transport can be regarded as a function of distance d_{ij} , general meat, aquatic products, which are fungi deterioration caused by microorganisms produce reaction index n=1 , so we can get the loss of production bases to the distribution center for perishable agricultural products in transit P $\sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij}(1-e^{-\theta d_{ij}})$ [2] agricultural products, fresh fruits and vegetables caused by non-microbial fungi reaction Index n=0 [3] , Its perishable agricultural products in transit loss is $P\sum_{i=1}^{I}\sum_{j=1}^{J} d_{ij}\theta$ 。Accordingly, the distribution process can be determined in the loss of perishable cargo damage.

Due to the conditions required for the transport of different agricultural products is inconsistent and in order to simplify the model to facilitate the calculation , In this process, the flow of cooling energy costs deemed relevant to a linear function of the distance (transportation rate constant).That energy costs is $o(\sum_{i=1}^{I}\sum_{j=1}^{J} d_{ij} + \sum_{j=1}^{J}\sum_{k=1}^{K} d_{jk}) \big/ v$

Location Model：

$$Min\{\sum_{j=1}^{J} f_j + \sum_{i=1}^{I}\sum_{j=1}^{J} b_j x_{ij} + p\left[\sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij}(1-e^{-\theta d_{ij}}) + \sum_{j=1}^{J}\sum_{k=1}^{K} x_{jk}(1-e^{-\theta d_{jk}})\right]$$

$$+c(\sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij}d_{ij} + \sum_{j=1}^{J}\sum_{k=1}^{K} x_{jk}d_{jk}) + o(\sum_{i=1}^{I}\sum_{j=1}^{J} d_{ij} + \sum_{j=1}^{J}\sum_{k=1}^{K} d_{jk}) \big/ v\}Y_j$$

$s.t.$ （1） $\sum_{j=1}^{J} Y_j x_{ij} \le S_i \quad i = 1,2 \ldots I$

（2） $\sum_{j=1}^{J} Y_j x_{jk} e^{-\theta d_{jk}} \ge D_k , \quad i = 1,2 \ldots I$

（3） $\sum_{i=1}^{I} x_{ij} e^{-\theta d_{ij}} \le M_j Y_j$ ， $\sum_{k=1}^{K} x_{jk} \le M_j Y_j ,$

$j = 1,2 \ldots J$

（4） $\sum_{i=1}^{I}\sum_{j=1}^{J} Y_j x_{ij} = \sum_{j=1}^{J}\sum_{k=1}^{K} Y_j x_{jk} \quad j = 1,2 \ldots J$

（5） $(d_{ij} + d_{jk}) \big/ v \le t_k \quad k = 1,2 \ldots K$

（6） $\sum_{j=1}^{J} Y_j \le N$

（7） $Y_j \sum_{i=1}^{I} x_{ij} \ge 0 , \quad j = 1,2 \ldots J$

（8） $\sum_{j=1}^{J} Y_j x_{jk} \ge 1 , \quad k = 1,2 \ldots K$

（9） $x_{ij} \ge 0, x_{jk} \ge 0, d_{ij} \ge 0, d_{jk} \ge 0$,

$i = 1,2 \ldots I, \; j = 1,2 \ldots J \; , \; k = 1,2 \ldots K$

The objective function is the minimum value of total cost (including distribution center fixed construction cost, variable operating cost, cost of damage, transportation and distribution costs, refrigeration energy consumption cost).Constraint equation (1) showed that production base shipments are less than the maximum supply capacity; Equation (2) showed that the reaching demand of agricultural products could meet the needs of consumer demand; Equation (3) showed effective traffic transport to the distribution center J, and shipments of J distribution center could meet the capacity limit; Equation (4) said distribution center throughput balance; Equation (5) showed that meet the needs of each customer point on the freshness of (currency) requirements; Equation (6) showed that the largest number of requirements of the new selected distribution center ; Equation (7) showed that at least one production base could distribute for the selected center distribution; Equation (8) said that at least one selected distribution center could distribute for demand point K ; Equation (9) said that transport, delivery and distance are non negative number.

2.4 Solving the model

LAP Location model is a typical NP-hard project. There are two kinds of general solution method, the exact algorithm and heuristic algorithm. The exact algorithm is the most widely used solution. It refers to one algorithm that can find the optimal solution of the problem, using the linear programming (including the branch and bound method, CFLP (Capacitated Facility Location Problem) method and the optimum planning technology etc.) and non-linear programming mathematical techniques to get the optimal solution. When considering the scheduling transport problem on a certain number of demand points by the shortest route or in the shortest time, it is more applicable to use accurate algorithm. The heuristic method is a method of successive approximation to the optimal solution, and this method mainly through repeatedly judging and correcting the computed solution, and setting some filtering conditions to filter out the inferior solution, finally draw a satisfactory solution. It is one solving method after the optimization planning technology, but it is easy to fall into local optimum. LCD (Linear Interactive and General Optimizer) is a linear interactive and general optimizer launched by LINDO systems America, which can be used to solve the nonlinear programming, and it is the best choice for solving optimization model. This model is a mixed integer nonlinear programming model, then take the fruits and vegetables as an example and use LINGO10.0 programming to calculate and analyze the location model.

III. EXAMPLE ANALYSIS

One agricultural products logistics company A in the East-China city B, in order to provide fresh fruits and vegetables for a few designated large supermarkets, plan to build fresh fruits and vegetables distribution center in the right place. Known that there are three fruit and vegetable production base in the suburbs, respectively Q_1, Q_2, Q_3.; five alternative distribution centers ,W_1, W_2, W_3, W_4, W_5; eight designated-distribution supermarkets, H_1, H_2, H_3, H_4, H_5, H_6, H_7, H_8. Based on the company budget constraints, we decide to choose no more than three from five alternative addresses to build fruits and vegetables distribution center. According to the experience and on-the-spot investigation, we get following location data:

TABLE I. RELATED PARAMETER SETTINGS

θ	o	c	p	v
0.018	4.8	500	20	30

TABLE II. d_{ij}

	W_1	W_2	W_3	W_4	W_5	s_i
Q_1	53	49	54	43	46	46
Q_2	44	50	47	48	57	51
Q_3	62	59	51	53	58	55
f_j	1350	900	750	1210	1050	
b_j	27	19	20	26	23	
M_j	45	30	28	40	35	

TABLE III. d_{jk}

	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8
W_1	16	8	15	10	7	19	15	22
W_2	12	11	14	17	15	14	6	25
W_3	28	16	13	12	9	10	17	21
W_4	10	12	23	16	5	21	19	13
W_5	18	16	11	21	12	24	8	7
D_k	20	10	25	5	15	7	12	10
T_k	5	7	6	5	8	5	7	8

After the 5420 model iterations to get a global optimal solution by lingo10.0, That is the cost of cold chain system optimization for 3,202,070 yuan, The selected alternative address is W1,W4,W5 , Specific programs, such as the flow distribution in Table 4 and Table 5.

TABLE IV. x_{ij}

	W_1	W_4	W_5
Q_1	0	21.87	24.13
Q_2	47.862	3.138	0
Q_3	0	17.584	0

TABLE V. x_{jk}

	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8
W_1	0	11.13	16.12	6.36	0	8.58	0	0
W_4	21.51	0	0	0	15.8	0	0	0
W_5	0	0	10.24	0	0	0	13.17	11.58

Regardless of the decay damage and cost, vehicle refrigeration energy consumption and customer requirement on the circulation time, we researched above-mentioned calculation again, then with 573 iterations get alternative address: W_1, W_4. Obviously, in the more comprehensive consideration of actual circumstances, the total cost of cold chain circulation system is not the most economical, in addition, it did not consider the extra pressure on city traffic, environment etc. Therefore, the structure of the cold chain distribution center location model in this paper is more comprehensive and reasonable.

IV. CONCLUSION

We made a brief summary and analysis on the location problem of distribution center of agricultural products, based on the considerations of the decay damage, vehicle refrigeration energy cost and customer requirement on the circulation time ,and established the distribution center location models that is more closer to the timeliness of agricultural products. Through specific examples we found that it is necessary to consider the timeliness in the research of timeliness agricultural products distribution center location. In this paper, the example data is relatively simple compared with the original model, but does not affect the model to evaluate the structure, and hope to provide some useful references on the timeliness of cold chain distribution center location research. However, due to the limitation of time and personal ability, it still needs to further study and discuss.

For example, the location model is a non-competitive static location model based on Single agricultural product, it needs further discussion about dynamic location when considering many varieties of agricultural products distribution, dynamic inventory, random traffic and demand. In addition, distribution planning problem based on competition could adopt Game theory to analyze.

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