Study on the Distribution Center Location and Path Optimization of HL Company FMCG Agricultural Products

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***Abstract*—This paper mainly studies the distribution center location of FMCG agricultural products. It assumes that the decayed rate of perishable products is linearly changing, and builds FMCG agricultural products distribution center location model of the lowest total cost. Filter the optimal distribution center using the combination of qualitative and quantitative analysis, with approximation algorithm. It performs an example analysis combined with Daqing City HL company warehouse layout and optimizes the distribution path. Through the research of this paper, it provides theoretical basis for HL company's distribution center location in Daqing and other cities, which is of great significance for the distribution center node location of FMCG agricultural products of other enterprises in China.**

***Index Terms*—distribution center, location, path optimization**

I. INTRODUCTION

Distribution center location and path optimization has a key role to speed up the flow of goods, ensure the distribution timeliness, reduce operating costs, keep food freshness and reduce the damage cost caused by discoloration, deterioration and decay, and to a large extent increases the income of logistics enterprises. FMCG agricultural products distribution center location has an important impact on transport efficiency, quality in transit, distribution costs, economic benefits and other aspects, and promotes the rapid development of agricultural products logistics industry. QuQing[1] constructed a double-level multi-objectives planning cost model to solve the problem of logistics distribution center location. According to the important factors of cold chain logistics distribution center location, such as fresh food demand, economic level, traffic condition, educational background, investment cost and so on, Guan Fei, Zhang Qiang[2] used analytic hierarchy process, Delphi method, fuzzy matrix and other methods to filter the location. Li Jingfeng[3] took into account the possible emergencies in the logistics node location, and gave the contingency plan so that the cost of loss to a minimum. Yu Rong.et al.[4] gave the evaluation index of logistics node location according to the influencing factors, determined the weight ratio by AHP, and then evaluated the factors using the fuzzy comprehensive evaluation method and selected the best node location. Tang Xiuying, Yang Linlin, Shi Jie, etc.[5]analyzed the distribution of fresh agricultural products supply, radiated the service scope of logistics nodes according to the business district theory, and filtered the specific location. Zhu Rongrong, Hu Dawei[6]considered the total logistics cost and logistics service satisfaction, built gravity location model of the cold chain logistics distribution center. Zhu Jie[7]considered local policy, economic level and traffic conditions in the distribution center to select the alternative address points, and then through the discrete mathematical model to determine the final cold chain distribution center.

II. CONSTRUCTIONOF THE DISTRIBUTION CENTER LOCATION MODEL OF HL COMPANYFMCG AGRICULTURAL PRODUCTS

A. Analysis of Distribution Center Location Model

1. Transportation costs of distribution vehicles

The transportation cost of the distribution vehicles consists of fixed costs and variable costs. Fixed cost is generally constant and is not necessarily linked to the total mileage of the transport and the customer volume. For easy calculation, it is not considered here. The variable cost of the distribution vehicle is proportional to the total mileage of the vehicle being traveled. If knowing the product unit freight rate, delivery requirements and delivery time, it can be obtained distribution vehicle transportation costs. As shown in formula (1):

$$X = \sum_{j=1}^{m} \sum_{i=m+1}^{m+n} \alpha x_{ij} t_{ij} Q_j \qquad (1)$$

2. Damage costs in the distribution process

There are many factors influencing the perishable of FMCG agricultural products. In order to facilitate the quantitative calculation of the decayed products at all times, regardless of the other influencing factors, it is assumed that the relatively constant interior temperature can be maintained during the distribution. The degree of decay of food is only linearly related to the distribution time. That is, assuming that the decayed rate is $F(t) = \theta t_{ij}$. The transport costintransit is shown in (2):

$$Y = \sum_{j=1}^{m}\sum_{i=m+1}^{m+n} x_{ij}\theta t_{ij}\omega Q_j \quad (2)$$

3. Construction Costs of Alternative Distribution Center

The optimal choice point of the distribution center is selected by the combination of qualitative and quantitative analysis, and then the distribution center to be built is selected from the alternative distribution point of the distribution center so that the total cost is minimum and the rigidity requirements of demand point to the service time is met. The expansion cost of the alternative point v_i of the distribution center is denoted asc_i, c_1, c_2, $c_3$are 450,000, 500,000 and 600,000 respectively. As shown in formula (3):

$$Z = \sum_{i=m+1}^{m+n} y_i c_i \quad (3)$$

B. Assumptions of Distribution Center Location Model

Given an undirected transport network $G(V, E)$,where $V = \{V', V"\}$, $V' = \{V_j\}(j = 1,2\ldots m)$ represents warehousepoint set, $V" = \{V_i\}(i = m+1, m+2, m+n)$ represents the distribution center alternative point set. The demand for the warehouse$v_j$is Q_j,and the product is decayed during the distribution process, and the decayed rate is linearly variable, assuming the decayed rate is$F(t) = \theta t_{ij}$. The expansion cost of the alternative pointv_i is c_i.The question is how to select the optimal node from the alternative points so that the overall cost is the lowest and satisfy the rigidity requirements of the reaction time to be delivered. The assumptions are given following:

(1) The product is simply delivered;

(2) The vehicle does not exist overload situation, the vehicle speed is constant, each vehicle carrying weight is less than its own load limit;

(3) The storage capacity of each warehouse point can be adjusted according to the actual needs after the location of the model;

(4) Only consider the straight line distance between the warehouses because of the relative position is fixed;

(5) The demand for each distribution center is known, by a car to service the distribution of all customers;

(6) Product delivery time interval must be strictly in accordance with customer requirements.

C. Establishment of Distribution Center Location Model

The model objective function based on the integrated transportation cost is as follows:

$$minw = \sum_{j=1}^{m}\sum_{i=m+1}^{m+n} \alpha x_{ij} t_{ij} Q_j + \sum_{j=1}^{m}\sum_{i=m+1}^{m+n} x_{ij}\theta t_{ij}\omega Q_j + \sum_{i=m+1}^{m+n} y_i\, c_i \quad (4)$$

$$x_{ij} t_{ij} \le T_j$$

$$(i = m+1, m+2, \ldots,\ m+n; j = 1,2,\ldots,m) \quad (5)$$

$$\sum_{i=m+1}^{m+n} x_{ij} = 1 (j = 1.2 \ldots m) \quad (6)$$

$$x_{ij} \epsilon [0.1] \quad (7)$$

$$\sum_{i=m+1}^{m+n} x_{ij} Q_j\, q \le q \quad (8)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij} = n \quad (9)$$

Constraints are described below: the objective function (4) refers to the minimum total cost; constraints (5) refers to the rigidity requirements of service time of each warehouse to be delivered to the center point ;constraints (6) means that each warehouse to be delivered is only served once; constraints (7) are 0-1 variables, when the value is 1, the distribution center to be delivered by the alternative warehouse, otherwise 0;constraints(8) means that the total cargo capacity of each distribution vehicle is less than the maximum cargo capacity of the vehicle standard; constraints (9) refers to all the warehouse to be delivered are served. The symbol description of the model is shown in Table 1.

TABLE I.
Symbol Description Table

Symbol	Description
v_j	Warehouse point set
v_i	Alternative distribution center point set
Q_j	Demand of v_j
t_{ij}	The time required for the alternative warehouse point to other demand points
Ω	Unit product price
θ	Decayed coefficient of perishable goods
T_j	Time requirement of v_j
q	The maximum capacity of the vehicle itself
α	The unit freight rate for delivering product
c_i	Construction cost ofv_i

D. Solving of Distribution Center Location Model

(1)Calculate the shortest distance from the alternate distribution point to each demand warehouse point. First find the sum of the distance of the warehouse point to be expanded to all the demand warehouse in V', $L_i = \sum_{j=1}^{m} d_{ij}(i = m+1, \ldots, m+n)$,$L = \{L_i\}$.

(2)Find $\min L_i$, mark the corresponding alternative point $v*_1$. Establish distribution center node in $v*_1$,determine when the reach of the warehouses to be delivered to the distribution center to meet the service time requirements in $V"$,remove the warehouse from V'if satisfy, mark the corresponding $x_{ij} = 1$ .If V' is non-solution, then terminate; otherwise, remove $v*_1$ from the V', go to next step.

(3)Then find the sum of the distance from each alternative warehouse point in $V'$to all demand point warehouses, mark $L_i = \sum_{j=1}^{m} d_{ij}(i = m+1, \ldots, m+n)$.Find $\min L_i$, mark the corresponding alternative point $v*_2$, and so on until all the warehouse points are met, calculate x_{ij}, y_i.

E. Model Preprocessing

First determine whether the warehouse node to be expanded can meet the distribution time requirements of the demand point. According to service time requirements of the demand point, there may be a small number of demand points cannot get any service from other alternative distribution center point. Therefore, it is necessary to preprocess the model, exclude the non-important constraints which cannot meet the delivery time requirements. The specific process is as follows: Check the delivery time $t_{ij}$of v_i to v_j and if any min { t_{ij} }> T_j for demand point v_j ,delete the constraint $\sum_{j=m+1}^{m+n} X_{ij}$,mark Q_j=0.After preprocessing, the extended alternative points service for all the remaining points that meet the conditions. Using the approximation algorithm A * to solve the results of the preprocessing: $V' = \{V_j\}(j = 1,2\ldots m)$ represents warehouseset, $V" = \{V_i\}(i = m+1, m+2, m+n)$ means the alternative distribution center set; $x_{ij} \in \{0,1\}$represents whether the alternative distribution center$v_i$serves the demand warehouse point v_j.

III. ANALYSES ON THE LOGISTICS DISTRIBUTION CENTER LOCATION MODEL OF HL COMPANY IN DAQING

A Example analysis

HL company has 8 existed warehouses, and the service radius is basically the Daqing market. The example uses model algorithms to filter out one or more as a logistics distribution center for expanding alternative location in the 8 distribution centers by using the qualitative and quantitative analytical method, to achieve the material allocation from the expand alternative point to other demand warehouse. In view of the timeliness and perishable of agricultural products and the demand for service time, the model analyzes the convenience of transportation as the main factor. Assuming the distribution vehicle models 9.6m, load 13.3 tons and distribution vehicle models 5.2m, load 2.99 tons.

TABLE II.
Model Parameter Table

Demand point	Response time（h）	Demand (Ton / week)	Speed (Km/h)	Unit product price(Million/ ton)	Freight rate (Yuan / h/ ton)	Decayed rate
Q_1	0.6	3	20	2	30	0.2
Q_2	0.85	1	20	2	30	0.2
Q_3	0.5	2	20	2	30	0.2
Q_4	1.0	1.5	20	2	30	0.2
Q_5	0.8	2	20	2	30	0.2
V_1	0.75	3	20	2	30	0.2

TABLE III.
Distance From Warehouse to be selected to Warehouse demand point (km)

	Q_1	Q_2	Q_3	Q_4	Q_5
V_1	7.75	29.70	9.71	29.59	15.08
V_2	26.68	12.86	15.04	14.18	17.30
V_3	17.46	28.92	3.27	20.23	23.75

B. Example solution

According to the model solution algorithm, results are as follows:

TABLE IV.
Results

Expand warehouse	Warehouse demand point
V_1	$Q_1Q_3Q_5V_3$
V_2	Q_2Q_4

TABLE V.
Table 5 Alternative warehouse Convert to Demand Point

	Response time（h）	Distance（km）
V_3-V_1	0.75	12.83

Expand warehouse alternative points V_1，V_2 to central distribution points,V_1 distributes for demand points Q_1，Q_2，Q_5，V_3.V_2 distributes for demand points Q_2，Q_4.

IV. HL COMPANY PATH OPTIMIZATION AND EFFECT ANALYSIS OF LOGISTICS DISTRIBUTION CENTER

A. Distribution Center Optimization

Through the distribution path optimization to avoid the circuit roundabout, reduce transportation costs. For the expansion warehouse node using mileage-saving optimization to specific routes within the city, as shown in Table 6, Table 7:

TABLE VI.
Minimum Distribution Route Distance Matrix (km)

	V_1			
Q_1	7.75	Q_1		
Q_3	9.71	15.08	Q_3	
Q_5	15.8	20.9	20.69	Q_5
V_3	12.93	17.46	3.27	23.75

TABLE VII.
Table 7 Distribution Route Savings Mileage (km)

No	Junction	Savings Mileage（km）
1	V_3-Q_3	19.3
2	V_3-Q_5	4.19
3	V_3-Q_1	3.15
4	Q_3-Q_1	2.38
5	Q_5-Q_1	1.93

The final path optimization line instruction can be got from the distribution route savings mileage sequence table, as shown in “Fig. 1.”

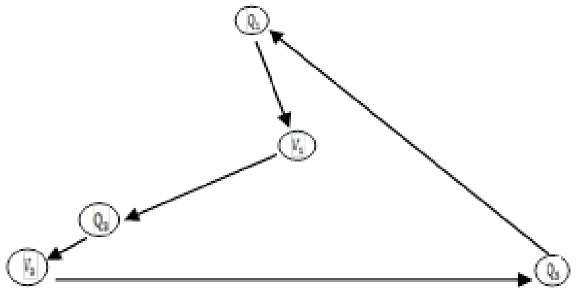

Figure 1. Final Path Optimization Line Instruction

B. Analysis of economic benefits

Path optimizing logistics distribution center can reduce transportation cost, improve the cargo turnover speed, ensure the distribution timeliness, reduce the damage cost of fresh perishable goods during the circulation process, and increase operating income in many aspects. HL company`s specific material transfer route between warehouses in Daqing City after distribution center location can be got from Figure 1.By comparison, it can be found that the transportation cost, transportation time, mileage, compared with the previous, have significant reduction, as shown in Table 8.

TABLE VIII.
Comparison Table of Optimization Results

	Before	After	Comparison
Mileage（km）	131	116	Reduce 11%
Transportation cost（Yuan）	71203	68586	Reduce 4%
Transportation time（h）	6.6	5.8	Reduce 0.8

C. Analysis of Environmental Effects

The optimization the site selected can reduce the negative impact to environment and society resulted from distribution logistics link, and improve the utilization rate of resources. Through the logistics distribution center location optimization can save about 11% mileage, reduce transportation cost about 4%.The reduction in transport cost can reduce the emissions of vehicles in transport activities, greenhouse gas emissions and the pressure on environmental damage. It not only improves the distribution of timeliness, but also takes full account of the concept of green. The emission reductions of carbon dioxide and carbon after program optimization are shown in Table 9.

TABLE IX.
Environmental Effects Analysis

Optimization Link	Mileage saving （Km/Per time）	Fuel saving（L）	Emission of carbon dioxide（KG）	Emission of carbon （KG）
Secondary network transport	15	3.1	8.1	2.0
Sum of Optimization	620	127.1	334.3	91.13

V. CONCLUSION

This paper researches the distribution center location of FMCG agricultural products with linear variable decayed rate. Based on the assumption that the decayed rate of perishable products is linear and variable linearly, the model is established with the minimum total location cost. Through case analysis, it can be proved that the distribution center location and path optimization proposed in this paper are feasible in terms of economic efficiency and green environmental protection, and provide reference for HL company's location in Daqing city and other cities.

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