Research on Optimization of Cold Chain Distribution Path of Fresh Agricultural Products Based on Big Data Technology

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Abstract. This paper takes the minimization of the cost of fresh agricultural products cold chain logistics distribution enterprises as the research goal. At the same time, we have comprehensively considered all the costs of vehicle loss, transportation, cargo damage, refrigeration, and delay that occurred during the distribution process. We use the improved ant colony algorithm to solve the model, and the validity of the model is verified by an example. Through an example, the model in the article is compared with the path optimization results of the traditional VRP model with the shortest total mileage as the objective function, so as to provide a reference for the optimization decision of the distribution path of fresh agricultural products vehicles.

Keywords: Component · Big Data Technology · Fresh Agricultural Products · Cold Chain Logistics · Distribution Path Optimization

1 Introduction

Fresh agricultural products are perishable, so they have strict requirements on time and environment in the distribution process. Cold chain logistics distribution more and more attention. Reasonable arrangement of the cold chain logistics distribution path of fresh agricultural products can not only reduce the distribution time and distribution mileage, but also reduce the loss of goods and energy consumption during the distribution process, save distribution costs, and increase the number of customers while ensuring the quality of fresh agricultural products [1]. Compared with ordinary logistics, the energy consumption of agricultural product cold chain logistics has also increased to ensure product quality and quality, thus increasing the cost of agricultural product cold chain logistics distribution. At the same time, the increase of energy consumption of cold chain logistics will directly lead to the increase of carbon emissions, which will also increase the impact on the environment, which is in contradiction with the low-carbon economy green logistics advocated today. Fresh agricultural products are often faced with difficult operations, high distribution costs, and high wastage rates during the distribution process, which seriously restrict the development of the agricultural product industry [2].

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2 Distribution Center Structure and Optimization

With different logistics distribution strategies, enterprises will adopt different structures when designing specific logistics networks [4]. The "time-cost" strategy generally uses a decentralized distribution network. Therefore, the location model of logistics distribution center is modified from the conditions of variable costs and time constraints, and a decentralized logistics distribution center location model suitable for e-commerce is established.

2.1 Relevant Conditions for Establishing the Model

The decentralized location model requires a collection of addresses at a demand point in a certain area. It is as shown in Fig. 1.

2.2 Assumptions

If a distribution center is selected, the fixed cost of establishing and operating the center is known. The specific parameters of the model are expressed as follows.

$N\{N_i\,|i = 1, 2, \ldots, N\}$ is represented as a set of logistics enterprise nodes at a series N. $M\{m_i\,|i = 1, 2, \ldots, M\}$ is represented as a set of alternative distribution center nodes at a series of M. $K\{k_i\,|i = 1, 2, \ldots, K\}$ is represented as a set of client nodes at a series K. C_{ij} represents the unit freight from logistics enterprise i to distribution center j.

2.3 Improvement of Cost in Site Selection Model

2.3.1 Fixed Fees

Fixed costs mainly include construction investment and equipment purchase costs of distribution centers, including depreciation of buildings, equipment, and machines [3].

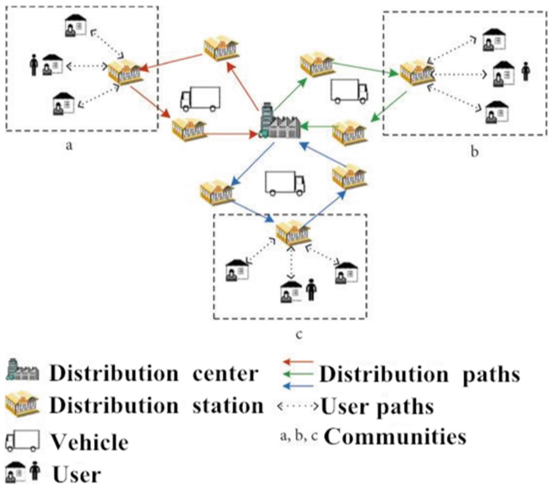

Fig. 1. Schematic diagram of site selection of decentralized logistics distribution center

Once the distribution center is established, these fixed fees are paid regardless of the operating conditions. $\sum_{j \in M} f_j Y_j$ in the decentralized distribution center location model is the fixed fee.

2.3.2 Shipping Costs

The transportation cost and the sending cost are combined into one, which is collectively referred to as the transportation cost. The $\sum_{i \in N} \sum_{j \in M} C_{ij} W_{ij} + \sum_{j \in M} \sum_{k \in K} C_{jk} W_{jk}$ in the decentralized distribution center location model is the transportation cost.

2.3.3 Variable Fees

The so-called variable cost refers to the management cost incurred by the distribution center when the product is distributed [5]. Especially in the characteristics of small and multi-batch distribution under e-commerce, the variable cost is not a linear function. Therefore, when considering the variable cost under e-commerce, an index λ is introduced, and the condition $0 < \lambda \le 1$ is satisfied, so as to conform to the actual logistics and distribution situation. Change the original variable fee $\sum_{i \in N} \sum_{j \in M} u_j W_{ij}$ to $\sum_{i \in N} \sum_{j \in M} u_j \left(W_{ij}\right)^{\lambda}$ to meet the actual situation of e-commerce.

2.4 Time Constraints in the Sitting Model

Distribution activities are activities that are close to customers and highly serviceable, and the choice of customers will inevitably lead to competition in distribution services. Therefore, the location of the distribution center should fully reflect the service competition [7]. Therefore, time must be considered heavily in the distribution center location model. In Eq. 9, W represents the amount of management cost incurred, k represents a natural constant [6].

2.5 Site Selection Model

$$\begin{aligned} Min\, Z = & \sum_{i \in N} \sum_{j \in M} C_{ij} W_{ij} + \sum_{j \in M} \sum_{k \in K} C_{jk} W_{jk} \\ & + \sum_{j \in M} f_j Y_j + \sum_{i \in N} \sum_{j \in M} u_j \left(W_{ij}\right)^{\lambda} \end{aligned} \tag{1}$$

Restrictions:

$$\sum_{j \in M} W_{ij} \le c_i, \quad i \in N \tag{2}$$

$$\sum_{j \in M} W_{jk} \ge a_k, \quad k \in K \tag{3}$$

$$\sum_{i \in N} W_{ij} \leq b_j Y_j, \quad j \in M \tag{4}$$

$$\sum_{i \in N} W_{ij} = \sum_{k \in K} W_{jk}, \quad j \in M \tag{5}$$

$$\left(t_{ij} + t_{jk}\right) \cdot Y_j \leq T_k, \quad k \in K \tag{6}$$

$$\sum_{j \in M} Y_j \leq p \tag{7}$$

$$Y_j = 0, 1 \quad j \in M \tag{8}$$

$$W_{ij} \geq 0, W_{jk} \geq 0, \quad i \in N, j \in M, k \in K \tag{9}$$

3 Distribution Route Optimization Design

The cost saving method utilizes the connection of each individual point to the origin, becomes a covered route pattern with only 1 midpoint, and then calculates the maximum cost saving value between the node and the points. Therefore, by adding constraints such as time window and temperature control, combined with the attributes of the cost-saving method, it is recommended to improve the cost method to solve the above problems [8]. The salient properties of this calculation method are as a gradual approximation method, it is easy to operate, easy to use, accurate in calculation, and comprehensively weighs various practical problems, giving full play to its advantages in the optimization of vehicle distribution routes [9]. Today, the biggest problem with the development of cold chain logistics is its high distribution cost, mainly due to the requirement of vehicle distribution time. The optimized time window saving method is used to realize the screening of the best distribution path scheme by cold chain logistics enterprises under the constraints. Therefore, adding time and temperature constraints will be more in line with the actual operation of cold chain logistics companies. Based on the route optimization model, the constraints such as time, temperature and cargo damage cost in the distribution link are integrated to minimize the total cost of the objective function. In the case of meeting the time window, vehicle load and other standards, the feasibility of the distribution route is explored, and the maximum value that can be saved between each node is explored, so as to calculate the optimal distribution path for cold chain logistics vehicles [10].

3.1 Mathematical Model

Assume that the distribution center number is 0, the customer location is numbered 1: in turn, and the customer location is called a node. To give a mathematical model of this problem the following mathematical model of the delivery routing problem with time windows is obtained:

$$\min\ z = \sum_{i=0}^{l} \sum_{j=0}^{l} c_{ij} x_{ij} \tag{10}$$

$$s.t. \begin{cases} \sum\limits_{i=0}^{l} x_{ij} = 1 \quad j = 0, 1, 2, \cdots, l \\ \sum\limits_{j=0}^{l} x_{ij} = 1 \quad i = 0, 1, 2, \cdots, l \\ X = (x_{ij}) \in S \\ S = \{(x_{ij}) | u_i - u_j + l x_{ij} \leq l - 1; 1 \leq i \neq j \leq l\} \\ x_{ij} = 0 \text{ or } 1 \end{cases} \tag{11}$$

The formula $S = \{(x_{ij}) | u_i - u_j + l x_{ij} \leq l - 1; 1 \leq i \neq j \leq l\}$ in the model is the branch elimination constraint i, and j represent 2 constants greater than 1 and less than L, the maximum value of these two numbers is less than L. The solution that constitutes the incomplete circuit is eliminated.

3.2 Solving the Problem of Distribution Route Selection Based on Genetic Algorithm

The fitness function is a function to evaluate the pros and cons of each chromosome (the pros and cons of a feasible solution), and it is the basic basis for obtaining the optimal chromosome (optimal solution). Generally, it is closely related to the objective function of the problem. Optimal value) is the optimal target of chromosome pros and cons. The fitness function value of the distribution routing problem is:

$$f = D(v_0, v_1) + \sum_{i=1}^{n-1} D(v_i, v_{i+1}) + D(v_n, v_0) \tag{12}$$

In the formula, D represents the distance between two client nodes, usually the shortest distance of dijkstra is adopted, and the straight-line distance between two points is adopted for the sake of simplification. The node coordinate information is shown in Table 1, in which 0 represents the distribution center, and the distribution customer number is 1 to 6; the distance between the two nodes adopts the straight-line distance of the rectangular coordinate plane.

The final distribution route obtained by programming operation is: 0-6-3-4-2-5-1-0. The distribution route of the solution represented by the optimal solution is shown in Fig. 2.

In Fig. 2, the abscissa represents the number of iterations, and the ordinate represents time.

Table 1. Coordinate information of distribution centers and their distribution customers

Numbering	Abscissa	Y-axis	Numbering	Abscissa	Y-axis
0	3	4	4	1	12
1	1	2	5	13	2
2	4	7	6	22	21
3	5	3			

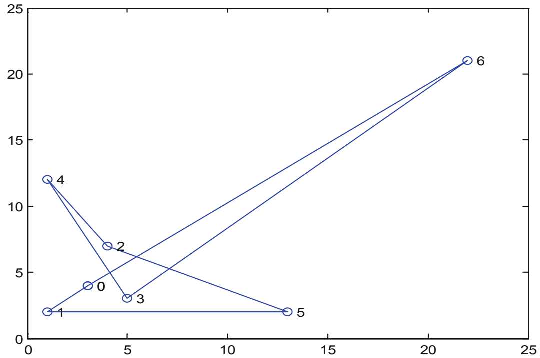

Fig. 2. Schematic diagram of optimal solution vehicle path

4 Conclusion and Suggestions for Countermeasures

Aiming at the distribution path optimization problem of agricultural product logistics, the idea of optimizing distribution path combined with automated information system is proposed, the difficult problem of distribution of agricultural products logistics is systematically studied, and the automated information system is applied in the path optimization, which solves the problem of the high cost of agricultural product logistics distribution pain points. Using operations research thinking, a target planning model with the aim of minimizing the distribution cost is constructed. The cost includes fixed cost, transportation cost, information cost and time penalty cost. Then use the improved hybrid algorithm combined with the idea of computer big data to propose various feasible path optimization schemes. The improved algorithm combines the idea of computer big data to select the population and use the algorithm to solve the calculation example. Based on the research results of the optimization of agricultural product logistics distribution path based on automated information system, some agricultural product logistics are put forward:

4.1 Promote the Development of Agricultural Products Logistics E-commerce

In this paper, by establishing a brand-new e-commerce platform that enables consumers to understand the relevant information needs of agricultural products through real-time network data. Through big data analysis, the system can provide accurate information on the demand trend of agricultural products, which can formulate reasonable logistics distribution plans for modern agricultural product logistics enterprises. The agricultural product logistics enterprises under this scheme realize real data visualization and integrated distribution management. This supporting scheme can open up online and offline sales channels, and these sales channels can solve the problem of information asymmetry in the distribution process.

4.2 Apply 5G Technology to the Logistics and Distribution of Agricultural Products

Since 5G technology can realize virtual and real big data information processing, modern agricultural product logistics enterprises can take advantage of the characteristics of 5G technology's wide coverage, high transmission, and low latency, and combine with smart devices to form an automated data system to speed up data and customer feedback and collection and analysis of information. Build a virtual scene, realize the visualization of various information, and analyze the distribution path, customer node distribution, distribution center construction and other information through the data in the virtual scene, and formulate the optimal distribution plan.

4.3 Optimize Logistics Resources and Reduce Distribution Costs

In the context of new retail, the transaction process is relatively simple, but transactions between distant regions will increase the cost of sales. At the same time, logistics distribution is also related to various factors such as e-commerce business environment, geographical environment, policy environment, etc. According to the characteristics of selling fresh agricultural products, traditional offline stores and websites should be combined to integrate the junctions and lines of the sales chain. Under the chain store, reduce the cost of sales. In addition, favorable conditions can be created to directly run the acquisition mode.

4.4 Optimize Agricultural Product Planting Bases with Big Data Platforms

The birth of the new retail industry has brought about great changes in the sales of fresh agricultural products. The new retail platform can monitor logistics information, complete the pre-sale mode in the process of using the Internet to manage and control warehousing and logistics centers, and purchase according to orders, transportation, and sales, so as to guide farmers to plant rationally.

4.5 Broaden the Transportation Channels for Agricultural Products

At present, the transportation channels of fresh agricultural products are constantly expanding, and eligible agricultural products can be imported free of charge. All localities should set up a security inspection system that automatically checks the products loaded on vehicles, so as to detect whether the vehicles meet the transportation requirements of agricultural products as soon as possible. The example in this paper is to compare and analyze the route scheme. The distribution cost before and after the optimization and improvement of the distribution route. We obtain the result that the improved route is better and can achieve the goal of optimizing the route.

5 Conclusion

Based on introducing the research status and logistics characteristics of cold chain logistics of fresh agricultural products in China and based on the optimization of the distribution path of cold chain logistics, the influence of factors such as time, temperature, and cargo damage on the total cost of fresh agricultural products in the distribution process is analyzed. A detailed analysis is carried out, and the objective function with the smallest target total cost value is established on this basis, and the optimization process is carried out in combination with the time window on the cost-saving method, in order to improve the accuracy of the algorithm. With the help of cold chain logistics distribution examples, the above model is tested, and it is concluded that the model design is scientific and meets the needs of optimal distribution path optimization. Various factors need to be considered comprehensively. In order to better meet the needs of the market, large-scale cold storage can be built in the suburbs, and fresh agricultural products can be pre-cooled, processed and stored in the original place in time to form an efficient temperature control in the entire distribution chain system to realize the standardized development of cold chain logistics. Form a cold chain logistics distribution network with local characteristics to meet cross-regional and cross-season sales and promote the sustainable development of Chinese cold chain logistics industry.

References

1. Chen Jianbiao, Lu Yuhai, Optimization of Fresh Food Logistics Distribution Mode Based on Terminal Demand. Business Economics Research, vol.6, pp.157–162, April 2021.
2. Chen Jing, Liu Juju. Research on route optimization of cold chain logistics based on ant colony algorithm. Transportation Technology and Economics, vol.23, pp.77–81, May 2021.
3. Li Dandan. Optimization of smart cold chain logistics system for fresh agricultural products. Modern Marketing: Academy Edition,vol.7, pp. 24–28,May 2020.
4. Li Juntao, Liu Mingyue, Liu Pengfei. Route optimization of cold chain logistics vehicles for multi-model fresh agricultural products. Journal of China Agricultural University, vol.26, pp. 99–104,July 2021.
5. Lin Weijun. Construction of Cold Chain Distribution Platform for Urban Fresh Products Based on Big Data Model. Rural Economy and Technology, vol.17, pp.312–315, November 2021.
6. Rao Peijun, Research on Cold Chain Logistics and Distribution of Fresh Agricultural Products. Guangdong Sericulture, vol.11, pp. 245–251, April 2020.
7. Su Hua, Research on cold chain logistics and distribution of agricultural products under the mode of agricultural-supermarket docking. Chinese Journal of Agriculture, vol.4, pp.78–82, June 2021.
8. Yang Zhenghua, Shi Junping. Time-consuming control algorithm for cold chain distribution of fresh agricultural products in e-commerce. Computer Simulation, vol.38, pp. 57–62, April 2021.

9. Yu Pengtao, Cao Xiancun. Optimization Design of Edible Fungus Logistics Distribution Route. Edible Fungi of China,vol. 39, pp.13–19,March 2020.
10. Yuan Tao, Research on Cold Chain Logistics and Distribution of Fresh Agricultural Products. Modern Marketing, vol.10, pp.112–115, August 2020.