

Optimization of Multi-center Joint Distribution Route for Fresh Products

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Abstract

In order to reduce the loss of fresh products in the distribution process and improve the service level, multiple distribution centers in the region are combined to distribute fresh products, and the distribution path is optimized to reduce logistics costs. Under the condition of satisfying the constraints of customer satisfaction, considering the cost factors of fresh products in the distribution process, a multi-center joint distribution vehicle routing optimization model with the goal of the lowest total cost is established, and the genetic algorithm is designed and improved for calculation. A numerical example experiment was carried out through MATLAB2017b, and the results showed that the joint multi-distribution center distribution of fresh products can not only improve the distribution efficiency and reduce the loss of fresh products, but also effectively reduce costs and increase customers compared with separate distribution and partition distribution. Satisfaction, while verifying the effectiveness of the model and algorithm.

Keywords

Fresh Products; Multiple Distribution Centers; Joint Distribution; Customer Satisfaction; Genetic Algorithm.

1. Introduction

With the advancement of science and technology and the development of refrigeration technology, many fresh products and agricultural products have changed from traditional vegetable markets to online retail, which has also been loved by many young people. Due to the large daily demand for fresh products, it is essential to expand the scale of distribution, but for fresh products, environmental requirements and time requirements are relatively high. At present, many fresh food distribution companies are unable to plan the most reasonable distribution route, which results in the prolonged time of fresh products on the road, resulting in the loss of fresh products and affecting corporate profits. In order to ensure that fresh products and agricultural products maintain their freshness during transportation, it is necessary to improve the transportation efficiency of their logistics, which also invisibly promotes the development of cold chain logistics.

As early as 1894, Albert Barrier and J.A. Ruddich[1] proposed cold chain logistics, but it was not until the 1940s that it was emphasized and developed. Considering the randomness of the perishable food distribution process, Hsu [2] et al. constructed a SVRPTW model; when Miao Xiaohong [3] et al. studied the third-party cold chain logistics and distribution problem, they considered the loss of fresh food during the distribution process and established a center The cold chain logistics distribution model of multiple demand points is solved by improving the genetic algorithm. Song [4] et al. verified the availability of refrigerated trucks in the fresh product distribution process by comparing the impact of refrigerated trucks and general types

of vehicles on consumer satisfaction when delivering fresh products. Ji Juhai and Zhang Xuan [5] considered the two-way operation mode of fresh agricultural product distribution process with taking and sending, taking the minimum total operation cost of distribution as the objective function, and establishing a nonlinear mixed integer programming model. Experiments proved that the combination of taking and sending was significantly better than the distribution mode. Pick-up and delivery separate operation mode. Zhang Jin [6] et al and Li Qian [7] et al. took into account the constraints of customer time window and built a multi-objective cold chain logistics distribution path model with the goal of lowest comprehensive cost and maximizing customer satisfaction. Dominate the sorting genetic algorithm to solve the problem. Fan Houming [8] et al took into account the requirements of fresh produce for transportation timeliness, designed the customer time window and penalty cost, and proposed a semi-open multi-distribution center joint distribution model. Experiments show that the semi-open multi-distribution center Compared with the independent distribution model of a single distribution center, the joint distribution model can quickly respond to customers' fresh demand in a timely manner. Compared with traditional room temperature logistics, cold chain logistics will generate greater energy consumption. For this reason, many scholars also consider carbon emissions while studying cold chain logistics. From the perspective of energy-saving and low-carbon, Wu Lirong [9] et al considered the impact of vehicle capacity restrictions and vehicle speed on vehicle energy consumption, established a low-carbon model with the goal of minimizing fuel consumption, and finally solved it by using the FCM-CVRP two-stage algorithm The model. When studying the problem of vehicle routing for third-party transportation services provided by a third party in a low-carbon environment, Li Jin [10] et al. proposed a calculation method for energy consumption considering vehicle volume and speed, and established a low-carbon path model under non-full-load transportation-LCRP. The problem is solved by designing a tabu search algorithm RS-TS based on path partitioning, a novel path encoding and decoding algorithm WSS is introduced, and three neighborhood search methods are used. In order to reduce the emission cost of cold chain operations, Mahla Babagolzadeh [11] et al. designed a two-stage model under the condition of uncertain demand, and used an iterative local search algorithm combined with mixed integers to solve the problem. Yang Wei [12] et al comprehensively considered the carbon emission cost of cold chain logistics inventory and distribution, and established a model with the goal of minimizing the total cost. The model was solved by improving the sparrow search algorithm, which effectively improved the convergence speed and convergence cost. Time. Zhao [13] et al. established a fresh cold chain distribution vehicle routing problem model with time windows in a time-varying road network based on the goal of distribution cost and minimized food safety value loss, while considering carbon emissions and temperature control during transportation. Based on the concept of green logistics and sharing economy, Zhu Xiaolin [14] et al discussed the integration of resources in multiple regions for joint distribution, and constructed a multi-objective optimization model that minimizes the total cost including carbon emission costs and maximizes customer satisfaction. It is solved by designing particle swarm algorithm.

Combining the characteristics of cold chain logistics, from the perspectives of environmental protection, customer service satisfaction, and economic benefits, many scholars at home and abroad have conducted more comprehensive research. However, few scholars have conducted research on short-distance transportation of cold chain logistics. Short-distance transportation will have multiple distribution centers and multiple orders at the same time, and customers are stricter on the delivery time of goods. Therefore, this article combines the characteristics of short-distance transportation of cold chain logistics, with the goal of the lowest comprehensive cost including the cost of carbon emissions, and establishes a multi-center multi-drive fresh product distribution route optimization model.

2. Problem Description and Basic Assumptions

2.1. Problem Description

In the short-distance cold chain logistics and distribution process, the temperature requirements for the storage environment of fresh products will be relatively reduced. The optimal temperature of the fresh products can be matched to the appropriate vehicles for transportation as much as possible. At the same time, multiple orders can be processed at the same time. For distribution. There are many fresh product distribution centers in the city. Since fresh products have strong timeliness, the transportation time should not be too long, otherwise it will affect their freshness. Therefore, the delivery vehicle will deliver real-time delivery according to the order situation each time, and then return to the delivery center to continue to pick up and deliver the goods after delivery. See Figure 1 for a schematic diagram of multi-distribution center joint delivery. In the delivery process, each customer has a different preferred service time. If the delivery time deviates from the customer's preferred time, a certain time deviation penalty cost will be incurred; at the same time, during the transportation process, not only transportation costs, but also transportation costs will be incurred. Produce a certain amount of carbon emissions costs.

In order to construct the model, it is assumed that: (1) The model of the refrigerated transport truck in each distribution center is the same as the load capacity; (2) The traffic jam or vehicle failure during transportation is not considered; (3) The refrigerated transport truck only needs to reach the customer point Commodities are delivered to customers, regardless of the time for customer service; (4) After completing the last delivery task, the refrigerated transport truck can choose to stop at the nearest distribution center; (5) The demand of any customer is not greater than the maximum load of the refrigerated transport truck. Weight; (6) All fresh products can be delivered at the same temperature; (7) The customer's geographic location, demand, time window and other information are known.

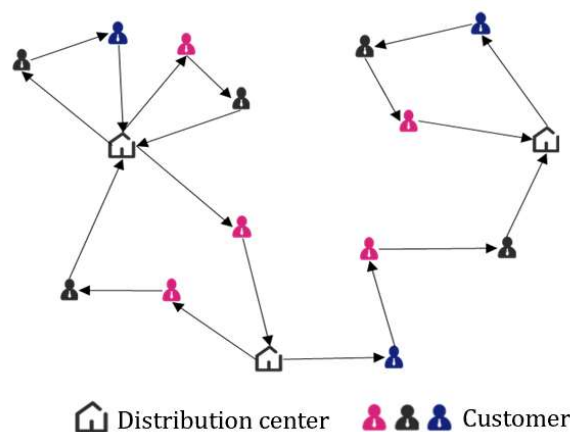


Figure 1. Schematic diagram of multi-distribution center joint distribution

2.2. Symbol Description

M: Represents a collection of distribution centers, $M = \{m | m = 1, 2, 3, \dots, m\}$.

N: Represents a collection of customers, $N = \{n | n = m + 1, m + 2, m + 3, \dots, m + n\}$.

K: Represents the collection of refrigerated transport vehicles, $K = \{k | k = 1, 2, 3, \dots, k\}$.

v_1 : indicates the average driving speed of refrigerated transport vehicle.

Q: Indicates the maximum load capacity of the refrigerated transport vehicle.

q_i : Indicates the demand of customer i .

q_{ij} : Indicates the load capacity of the refrigerated transport truck from customer i to j .

d_{ij} : indicates the customer i To customers j Unit distance of.

$[ET_i, LT_i]$: indicates the customer i Preferred service time.

C_1 : indicates the fixed cost of refrigerated transport vehicles.

C_2 : indicates the transportation cost per unit distance.

C_3 : represents the unit loss cost that arrives earlier than the customer preferred service time.

C_4 : represents the unit loss cost that arrives later than the customer preferred service time.

T_0 : indicates the departure time of refrigerated transport vehicles from the distribution center.

T_{ij} : indicates the slave node of refrigerated transport vehicle i To node j Transportation time.

T_{ik} : indicates refrigerated transport vehicle k Arrive at customer point i Moment of.

C_5 : indicates the carbon trading price.

λ_0 : indicates the unit fuel consumption of the empty vehicle.

λ' : indicates the unit fuel consumption when driving at full load.

e_0 : indicates the carbon emission factor.

$x_{ijk} = \begin{cases} 1, & \text{Refrigerated transport truck } k \text{ from customer } i \text{ to customer } j \\ 0, & \text{The refrigerated transport vehicle } k \text{ does not pass through customer } i \text{ to customer } j \end{cases}$

$y_{ik} = \begin{cases} 1, & \text{Refrigerated transport truck } k \text{ serves customers } i \\ 0, & \text{Refrigerated transport truck } k \text{ does not serve customers } i \end{cases}$

Optimal Model of Joint Distribution Route for Multi-distribution Center.

2.3. Customer Satisfaction Analysis

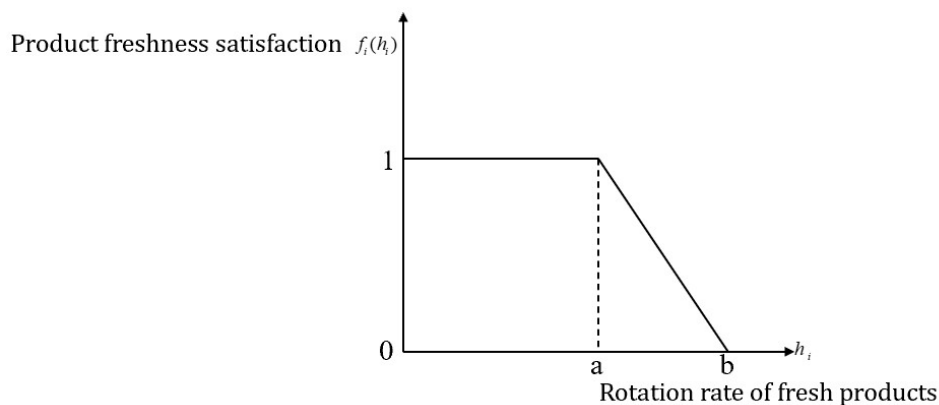


Figure 2. customer satisfaction function of fresh products

In the distribution process of fresh products, there are often extrusion caused by improper transportation, or decay caused by long transportation time, which will reduce the freshness of fresh products to a great extent and affect customer satisfaction. Customer satisfaction consists of the freshness of fresh products, θ Indicates the decay coefficient per unit time of fresh products, and the value range of customer satisfaction is $[0, 1]$. During the distribution of fresh

products, customer satisfaction decreases with the increase of decay rate of fresh products, as shown in Figure 2 below, when the freshness of fresh products is within the range acceptable to customers $[0, a]$ Within, customer satisfaction is 100%; When the freshness of fresh products is within the range acceptable to customers $[a, b]$ Customer satisfaction will decrease with the increase of decay rate of fresh products; When the decay rate of fresh products is in the range $[b, +\infty]$ During the period, the customer satisfaction is the lowest, and there may be returns or bad comments, that is, the customer satisfaction is 0.

The expression of customer fresh product freshness satisfaction function is as follows:

$$f_i(h_i) = \begin{cases} 1 & , 0 \leq h_i \leq a \\ \frac{b-h_i}{b-a} & , a < h_i < b \\ 0 & , h_i \geq b \end{cases} \quad (1)$$

Decay rate of fresh products h_i Calculation expression for:

$$h_i = \theta T_{ik} \quad (2)$$

For long-term and stable development, fresh e-commerce will ensure that the distribution services provided to customers must meet certain standards, and the satisfaction of each customer is no less than σ , therefore:

$$f_i(T_{ik}) \geq \sigma \quad (3)$$

2.4. Mathematical Model

Under the condition of meeting the constraints of customer satisfaction, a refrigerated transportation vehicle routing optimization model with minimum distribution cost is established:

Objective function:

$$\min F = F_1 + F_2 + F_3 + F_4 \quad (4)$$

Among them, F_1 : indicates the fixed use cost of the vehicle:

$$F_1 = C_1 K \quad (5)$$

F_2 : indicates vehicle transportation cost:

$$F_2 = C_2 \sum_{i \in M \cup N} \sum_{j \in M \cup N} \sum_{k \in K} d_{ij} \cdot x_{ijk} \quad (6)$$

F_3 : indicates time penalty cost:

$$F_3 = C_3 \sum_{i \in M \cup N} \sum_{j \in M \cup N} \sum_{k \in K} x_{ijk} \cdot \max(ET_i - T_{ik}, 0) + C_4 \sum_{i \in M \cup N} \sum_{j \in M \cup N} \sum_{k \in K} x_{ijk} \cdot \max(T_{ik} - LT_i, 0) \quad (7)$$

F_4 : indicates the cost of carbon emissions.

The carbon emission cost mainly comes from the fuel consumption generated by the refrigerated transport vehicle during driving, and is also affected by the load capacity of the vehicle.

$$F_4 = C_5 [e_0 \sum_{i \in M \cup N} \sum_{j \in M \cup N} \sum_{k \in K} x_{ijk} \cdot d_{ij} \cdot (\lambda_0 + \frac{\lambda' - \lambda_0}{Q} q_{ij})] \quad (8)$$

Constraints:

$$\sum_{i \in M \cup N} \sum_{k \in K} x_{ij}^k = \sum_{j \in M \cup N} \sum_{k \in K} x_{ij}^k = 1 \quad (9)$$

$$\sum_{i \in M \cup N} \sum_{k \in K} y_{ik} \leq K \quad (10)$$

$$\sum_{i \in M \cup N} \sum_{k \in K} y_{ik} \cdot q_i \leq Q \quad (11)$$

$$T_{ij} = \frac{d_{ij}}{v_1} \quad (12)$$

$$\sum_{i \in M \cup N} \sum_{k \in K} \sum_{m \in M} x_{ijkm} = \sum_{j \in M \cup N} \sum_{k \in K} \sum_{m \in M} x_{jikm} \leq 1, i = 0 \quad (13)$$

$$f_i(T_{ik}) \geq \sigma \quad (14)$$

Among them, constraint (9) means that all customers can only be served by one car once; constraint (10) means that the number of vehicles in the area cannot be greater than the total number of vehicles; constraint (11) means that the maximum demand of a single customer cannot exceed The maximum load capacity of the refrigerated transport truck; the constraint condition (12) indicates the calculation formula of time and distance; the constraint condition (13) indicates that the refrigerated transport truck starts from the distribution center and can return to any distribution center after serving all customers; the constraint condition (14) It means that the delivery service of fresh products must meet the minimum customer satisfaction σ .

3. Model Solving based on Genetic Algorithm

3.1. Genetic Algorithm

Genetic Algorithm (Genetic Algorithm, abbreviated as GA) is evolved according to natural selection and genetic mechanism of natural organisms in the process of evolution. It is a heuristic algorithm of global probability search that imitates the process of natural evolution

to search for the optimal solution. , Can simultaneously evaluate the practicability of multiple feasible solutions, use its own organizational structure to make the survival rate of individuals with greater fitness higher, and guide the search direction of the optimal solution.

The multi-distribution center joint distribution route optimization problem is more complicated than the traditional vehicle route optimization problem, and the genetic algorithm has strong robustness and global search capabilities, and has certain advantages in terms of solution speed and solution effect. It is suitable for solving large-scale, Complex vehicle routing problems. Based on this, this paper chooses genetic algorithm to solve the multi-distribution center joint distribution vehicle routing optimization model. The flow chart of genetic algorithm is shown in Figure 3 below:

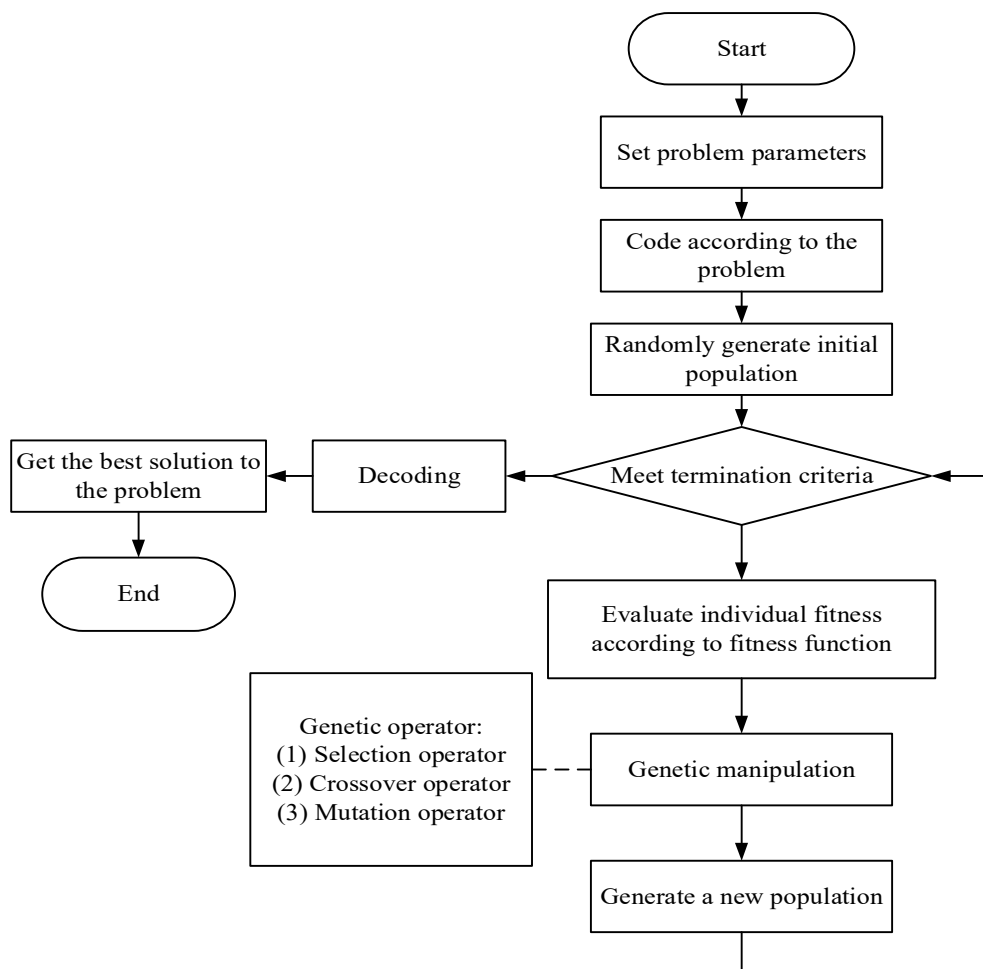


Figure 3. flow chart of genetic algorithm

3.2. Algorithm Design

3.2.1. Coding Operation

In this paper, chromosomes are coded with real numbers. First, all nodes are sorted with real numbers. $M=\{-3,-2,-1\}$ indicates the distribution center, 0 indicates the virtual distribution center, and $N=\{1,...,n\}$ indicates the customer. For example, the code number "3,4,2,1,6,5" inserts "0" in accordance with the vehicle load constraint, and becomes "0,3,4,2,0,1,6,5,0", indicating the need Use two vehicles for service. Then according to the customer points around 0, namely 3, 2 and 1, select the closest distribution center to replace 0, which becomes "-1,3,4,2,-2,-1,1,6,5,-3" It means that two vehicles are needed to provide services to six customers through three distribution centers. The detailed routes are D1-3-4-2-D2 and D1-1-6-5-D3.

3.2.2. Population Initialization

The length of each chromosome in GA is the number of visited nodes. Randomly arrange the number to generate a chromosome. The arrangement of chromosomes only represents the order in which the delivery vehicle visits the nodes. After encoding, the initial path gene sequence is generated to form the initial individual. According to this method, popsize individuals are generated to form the initial population $\text{pop}(h)$, the number of initialization iterations $h=0$, T_0 is the initial temperature, and Max is the maximum number of initialization iterations. If the initial temperature T_0 is too large, the probability of receiving an infeasible solution is greater, the algorithm iteration time is longer, and it is not easy to converge; if it is too small, the probability of receiving an infeasible solution is small, and it is easy to fall into a local optimum.

3.2.3. Fitness Calculation

The fitness of the individual determines the quality of the individual, and the fitness in the GA determines whether the individual is retained in the iterative process. According to the individual path gene sequence, arrange the distribution tasks and calculate the fitness. The specific process is as follows:

Step 1: Decode each individual in $\text{pop}(h)$. The decoding process is to convert the chromosome code into customer point and distribution center point codes according to all constraints, and insert 0 into the code (0 stands for virtual distribution center), and then convert 0 into an actual distribution center to form a specific vehicle distribution route. The specific steps are as follows.

1) Initialize the departure time of the delivery vehicle according to the opening time of the delivery center. For an individual, first insert 0 in the first position of the chromosome code, arrange all customer points in the order of time window, add customer points according to the load of the vehicle, if it cannot be added, go to step 2);

2): Determine whether all customer points have been allocated, if there are still customer points that need to be allocated, return to step 1, if there are no customer points that need to be distributed, go to step 3);

3): After the task assignment is completed, judge whether the last bit of the code is 0, if it is not 0, add 0 to the last position. The virtual distribution center 0 is transformed into a real distribution center. If there are customer points around 0, the distribution center closest to the corresponding customer point is selected. For example, suppose the path number of the i -th individual in the group is $[0,4,7,3,0,1,5,2,6,0]$, and the distribution centers closest to 4,3,1,6 are -3,-3,-2,-1, after converting 0 to a negative number, it becomes $[-3,4,7,3,-3,-2,1,5,2,6,-1]$. According to the above task assignment, the assigned tasks are:

(1) The route of the first car is D3-4-7-3-D3.

(2) The route of the second car is D2-1-5-2-6-D1.

Step 2: Calculate the total cost and customer satisfaction of each individual according to the decoded population, and then calculate the objective function value of each individual according to formula (6), that is, the fitness value.

3.2.4. Individual Selection

Step 3: According to the fitness value calculated in step 2, arrange the individuals of the population in descending order, and mark the individual with the largest objective function value as $T_{\max}$, and the individual does not perform crossover and mutation operations; then The remaining individuals are subjected to crossover and simulated annealing mutation operations according to their relative fitness. The proportional selection method is adopted to select individuals to form a new population $\text{Newpop}(h+1)$.

3.2.5. Crossover

Step 4: According to the partial crossover method for Newpop(h+1), crossover with the crossover probability P_c to obtain the new population Cpop(h+1). This means that individuals participating in the crossover operation will have the probability that P_c crosses their gene sequences through the partially mapped crossover operator to generate new individuals with new gene sequences.

3.2.6. Mutation Operation

Step 5: Imitate the phenomenon of gene mutations in nature, and change the gene chain of chromosomes according to a certain probability of mutation, and tap the diversity of gene combinations in individual chromosomes. The possibility of species mutation is relatively small, so mutation operations mainly play a role in assisting evolution in genetic algorithms.

4. Case Analysis

4.1. Example Data

There are three fresh product distribution centers in area B. Each distribution center provides fresh product distribution services based on customer order requirements and geographic location. Now 24 customer points are randomly selected as distribution nodes. The relevant information of the distribution nodes and the distribution center is as follows Table 1 and Table 2 show:

Table 1. relevant information of each customer point

Serial number	X coordinate (km)	Y coordinate (km)	Demand (kg)	Customer's preferred service start time	Customer's preferred service end time
1	-34	70	1.8	3.5	15
2	-30	5	1.2	7.5	20
3	-10	60	0.5	4.5	15
4	-67	68	1.2	9	18.5
5	-50	78	2.2	8.5	15.5
6	-2	-2	3.2	2.5	10
7	27	10	1.8	9.5	16.5
8	-40	-20	0.8	10.5	19.5
9	-78	100	1.1	7.5	15.5
10	20	55	1.5	12.5	20.5
11	40	50	2.5	7.5	16.5
12	-60	30	1.4	2.5	10.5
13	18	96	1.2	8.5	15.5
14	-37	-30	0.5	8.5	18
15	-43	21	1.4	8.5	16.5
16	-35	24	2	10.5	19.5
17	55	15	1.4	14.5	24.5
18	49	30	0.8	10.5	22.5
19	22	56	0.9	16.5	30
20	39	3	1.3	6.5	12
21	-16	20	1	2.5	19.5
22	18	23	2.4	2.5	16.5
23	11	17	0.4	2.5	16.5
24	42	-3	1	2.5	16.5

Table 2. location information of distribution center

Distribution Centre	position
D1	(-49,68)
D2	(-29,3)
D3	(31,32)

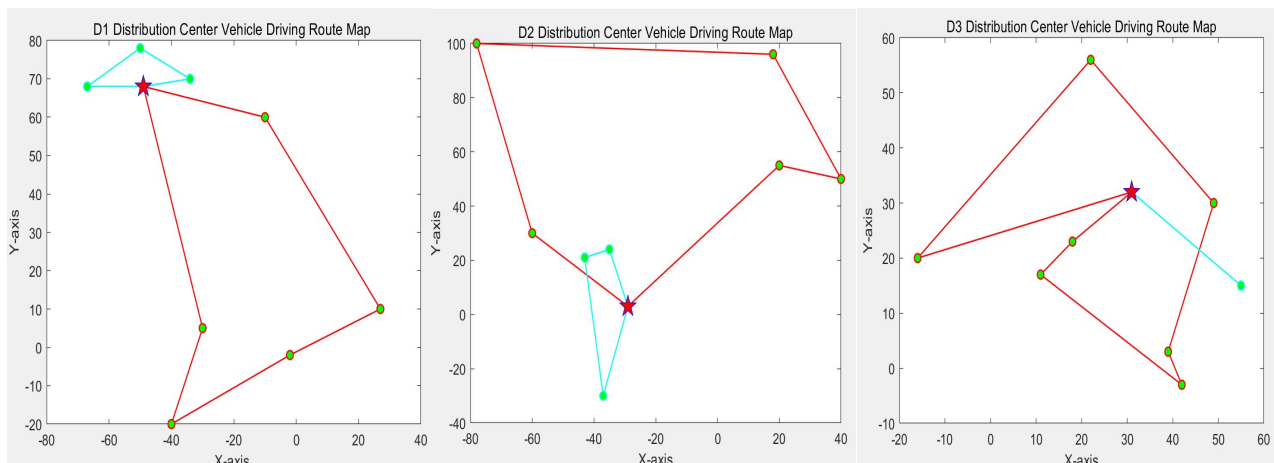
4.2. Relevant Parameters

The relevant parameters in the joint distribution path optimization model of multiple distribution centers for fresh products are set as shown in Table 3 below, in which the range of decay rate of fresh products acceptable to customers is $[0,0.2\%]$, the range of decay rate of fresh products that customers can tolerate is $[0.2,1\%]$.

Table 3. setting of relevant parameters

Symbol	explain	Parameter value	Company
M	Number of distribution centers	3	individual
N	Number of customer points	24	individual
Q	Maximum load capacity of refrigerated transport vehicles	8	kg
C_1	Fixed usage fee per refrigerated transport vehicle	300	Yuan / vehicle
C_2	Transportation cost per unit distance	10	Yuan / km
C_3	On transaction price	53	Yuan / ton
v_1	Average speed of refrigerated transport vehicle	60	km/h
λ_0	Unit fuel consumption when empty	0.165	Kg/km
λ'	Unit fuel consumption at full load	0.380	Kg/km
e_0	Carbon emission coefficient	1.23	kg/kg
θ	Decay coefficient per unit time of fresh products	0.02	
σ	Minimum customer satisfaction	0.6	

4.3. Result Analysis

**Figure 4.** driving route of vehicles separately distributed by the distribution center

(1) Arrange distribution center distribution according to customer order requirements

Twenty-four customers ordered fresh products with different demands at the three distribution centers. Among them, 1-8 are customer orders of D1 distribution center; 9-18 are customer orders of D2 distribution center; 19-24 are customer orders of D3 distribution center. Each distribution center provides delivery services according to customer orders and preferred service time. Through the simulation calculation of MATLAB2017b, the total cost of D1 distribution center is 7964 yuan; the total cost of D2 distribution center is 8891 yuan; the total cost of D3 distribution center is 6962 yuan. The driving route map of the three distribution centers D1, D2 and D3 is shown in Figure 4 below.

Table 4. driving route of vehicles separately distributed by the distribution center

Distribution Centre	Vehicle route	customer satisfaction
D1	D1-4-5-1-D1	40%
	D1-2-8-6-7-3-D1	60%
D2	D2-10-11-13-9-12-D2	36%
	D2-14-15-16-D2	72%
D3	D3-18-19-20-24-21-23-22-D3	29%
	D3-17-D3	82%

(2) Each distribution center carries out regional distribution

First, the 24 customer points are divided into regions according to their coordinate positions through spss. See the table below for details. Then, each distribution center separately optimizes the driving route of the vehicles in the area. Through the simulation calculation of MATLAB2017b, the total cost of distribution in the D1 distribution center area is 4987 yuan; the total cost of distribution in the D2 distribution center area is 6248 yuan; the total cost of distribution in the D3 distribution center area is 11463 yuan. After the implementation of zoning distribution, the vehicle driving route map of the three distribution centers D1, D2, and D3 is shown in Figure 5 below:

Table 5. customer area division

Distribution Centre	Customer service point
D1	1, 3, 4, 5, 9, 12
D2	2, 6, 8, 14, 15, 16, 21
D3	7, 10, 11, 13, 17, 18, 19, 20, 22, 23, 24

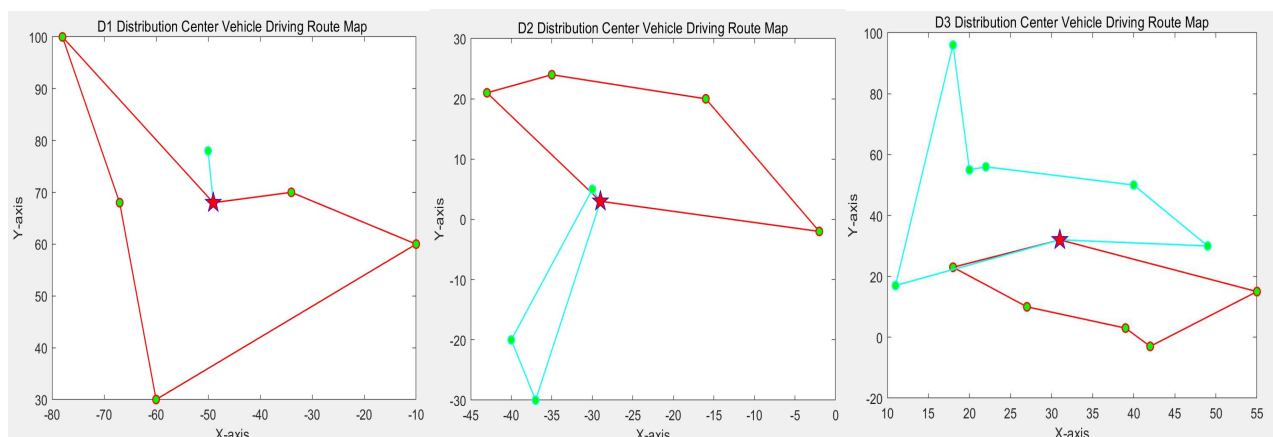


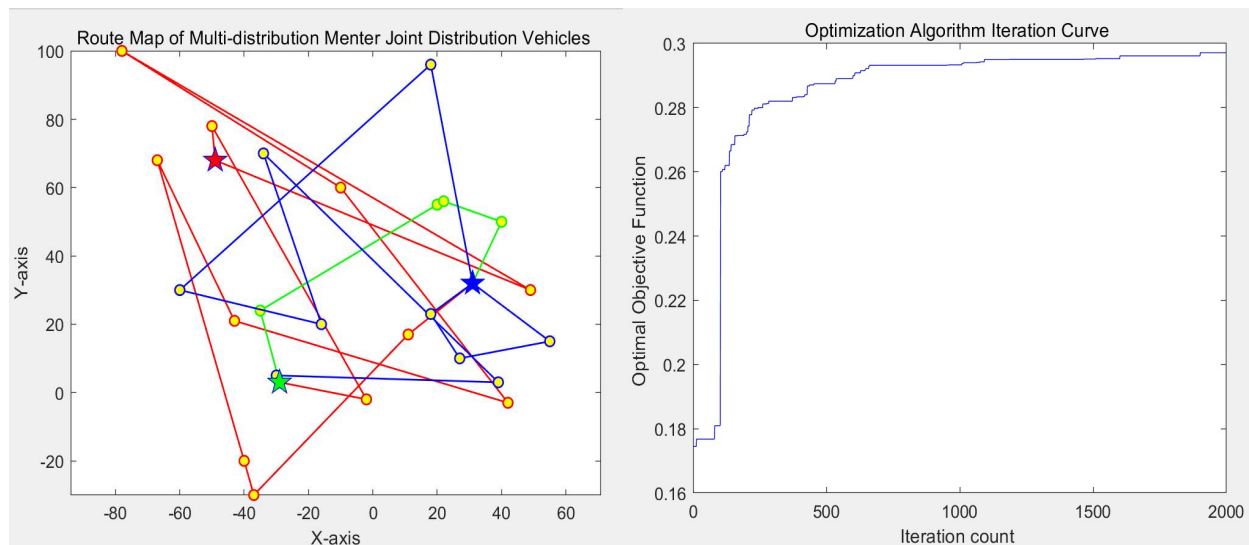
Figure 5. driving route of divisional distribution vehicles

Table 6. driving route of divisional distribution vehicles

Distribution Centre	Vehicle route	customer satisfaction
D1	D1-3-9-4-6-12-D1	39%
	D1-5-D1	82%
D2	D2-6-21-16-15-D2	53%
	D2-14-8-2-D2	68%
D3	D3-17-24-20-7-22-D3	76%
	D3-23-13-10-19-11-18-D3	58%

(3) All distribution centers carry out joint distribution

Under the situation that the customer resources and material resources of each distribution center are shared, the three distribution centers implement joint distribution, and vehicles from different distribution centers can be parked at any joint distribution center, which increases the transportation batch and shortens the transportation cycle, which can be effective. Meet the requirements for distribution of fresh products in small batches, multiple batches and scattered demand points. Through MATLAB2017b for simulation calculation, after the implementation of multi-distribution center joint distribution, the total distribution cost is 21658 yuan, and the vehicle driving route map is shown in Figure 6 below:

**Figure 6.** driving route of vehicles jointly distributed by multiple distribution centers**Table 7.** driving route of joint distribution vehicles in multiple distribution centers

Vehicle number	Vehicle route	customer satisfaction
1	D1-24-9-3-20-4-2-8-14-23-D3	82%
2	D2-6-22-D3	66%
3	D2-11-13-10-19-18-D3	72%
4	D3-5-12-21-1-D1	66%
5	D3-7-17-16-15-D2	78%

(4) A comparative analysis of the data results in the three situations shows that when the distribution center directly arranges refrigerated transport vehicles for distribution according

to their customers' demand for fresh products, the maximum total distribution cost is 23358 yuan, and the vehicle driving route is complicated. The fuel consumption is high, and the carbon emissions are also the largest. When the customer sites are divided into regions and then the distribution center vehicles are arranged for delivery, the total distribution cost is reduced, and the satisfaction of each customer site is improved, and the service efficiency is increased ; When multiple distribution centers adopt joint distribution, the total distribution cost is at least 21658 yuan, which reduces the number of vehicles used compared to the previous two cases.

5. Conclusion

Under the circumstance of meeting the constraints of customer satisfaction, with the lowest total cost as the goal, a mathematical model is established to study the joint distribution of fresh products with multiple distribution centers, and multiple simulation solutions are carried out through calculation examples. Finally, it is independently distributed with the distribution center. A comparative analysis of the two schemes of sub-regional distribution has verified that joint distribution has a relatively large degree of advantages in terms of economic benefits and customer satisfaction. At the same time, in response to the national energy saving and emission reduction policy, the carbon emission cost of refrigerated transport vehicles is also considered accordingly. However, this article only considers that all fresh products are delivered at the same temperature, and does not take into account the transportation of special fresh products. The storage temperature is different, and the path optimization problem of multi-temperature co-matching vehicles can be further studied in the future.

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