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Distribution Path Optimization of Cold Chain Logistics Based On Multi-Layer Dynamics Method

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ABSTRACT

Urban residents tend to buy fresh agricultural products in large supermarkets. This is not only an opportunity but also a challenge for large supermarkets. The key to ensure the quality of fresh agricultural products lies in the distribution of the last kilometer. In this paper, Jinwei supermarket has been choose as a cold chain distribution case. To optimize the distribution route of Jinwei supermarket, three layers dynamics method are designed to reduce the transportation mileage. According to the above algorithm, the three paths are all the optimal paths after considering the transportation cost, energy consumption cost; goods damage cost and penalty cost. In this way, the transportation time could be reduce, the operation efficiency could be improve, the transportation cost can be reduced, and the goal of improving the quality of fresh agricultural products could finally be achieved.

Keywords: : Cold Chain Logistics, Distribution Path, Multi-Layer Optimization

INTRODUCTION

Agricultural development still has a strong driving force for the development of national economy. Therefore, agriculture has been the focus of the state. In particular, the circulation of agricultural products needs special attention. In recent years, with the rapid development of China's logistics industry, cold chain logistics, as an indispensable part of the logistics industry, is also developing rapidly[1]. With the development of national economy, consumers' demand for fresh agricultural products is expanding. This change also puts forward higher requirements for cold chain logistics. In recent years, the development of cold chain logistics in China has been showing a growing trend, with a compound growth rate of more than 22%[2]. In 2015, the total amount of cold chain logistics in China reached 4320 billion yuan, and the market scale of cold chain logistics was more than 100 million tons[3-4]. According to the data of the National Bureau of statistics, in 2017, China's fresh market (meat, aquatic products, poultry, eggs, milk, vegetables, and fruits) exceeded 1.3 billion tons, and the proportion of fresh food ingredients in the consumer consumption list increased, which benefited from the development of cold chain logistics and the improvement of living standards. In the latest report released by China Federation of logistics and purchasing in 2017, it shows that China's cold chain logistics demand continues to maintain a medium and high-speed development[5]. In the next five years of development, the cold chain logistics market will maintain a growth rate of more than 20%, and the total cold chain logistics will exceed 4700 billion yuan by 2020[6-8].

With the support of the state, although China's cold chain logistics started late, it cannot limit its continuous progress. However, the overall level of China's cold chain logistics is still in the primary stage of development. Compared with Europe and the United States and other countries, there are shortcomings, not only in terms of logistics cost, but also in terms of operational capacity. In the process of cold chain logistics transportation, the quality control ability of agricultural products is poor, and the economic loss due to the rotten deterioration in the circulation process is up to more than 100 billion yuan every year[9]. After realizing the gap with other countries, the most important thing is to improve the existing technology. From the original basis to the developed countries, starting from the foundation, it involves a wide range and deep points. In particular, there are big problems in distribution. First of all, we need to improve the efficiency of cold chain logistics distribution.

2. CHARACTERISTICS OF COLD CHAIN DISTRIBUTION

2.1 Large Amount of Investment Capital and High Cost

Cold chain logistics is different from traditional logistics, which requires a special cold chain logistics system. From the production and processing of products to the distribution of each link need to be equipped with professional cold chain equipment, especially the construction of cold storage and the purchase of cold trucks need more funds. Moreover, in order to improve the efficient operation of the whole cold chain logistics system, it is necessary to equip the corresponding information system and professional personnel, which will lead to high cost.

2.2 High Requirements for Time and Temperature

The products delivered by cold chain logistics generally have a short shelf life, which will put forward higher requirements for the temperature of transportation environment. It is necessary to deliver the product to the terminal object in time under the specified time and stable distribution temperature, so as not to reduce the quality and freshness of the distribution product.

2.3 High Coordination

Due to the perishable characteristics of the distribution object, the storage and transportation time should not be too long, so the coordination of each link is put forward high requirements. If each link cannot be connected in time, it will affect the quality of the transportation object, which will reduce its economic value. A high rate of goods damage is not conducive to the improvement of the competitiveness of enterprises. Therefore, the characteristics of cold chain lead to the overall coordination of its logistics system.

2.4 High Requirements for Information Technology and Facilities and Equipment

In order to ensure the quality of cold chain goods in the whole cold chain transportation process, it is required that all links in the cold chain logistics system maintain good communication and information transmission. In order to achieve this goal, we must rely on the modern logistics information system. There are many participants in cold chain logistics system. Only by sharing information, can we respond to all kinds of unexpected problems quickly. The equipment of cold chain transportation is required to be highly professional, which can ensure that the required temperature of cold chain goods can be reached, and the facilities and equipment of each link should be relatively high.

3. AN EXAMPLE OF COLD CHAIN DISTRIBUTION

Jinwei supermarket is located in Shangdang basin, Changzhi. Jinwei supermarket mainly provides prepackaged food (including health food), bulk food (including direct import bulk food and indirect import bulk food), frozen (Tibetan) food, bread processing, staple food, stir fry, cold dishes (the above items are subject to the scope and term of the license) and general merchandise And so on. Jinwei Supermarket Co., Ltd. has 10 stores all over Changzhi and surrounding

3.1 cold chain distributions in j supermarket

3.1.1 Detour and No-Load Problems

This paper mainly studies the distribution situation of distribution center 1. The number of distribution stores is 8. The demand of each store is shown in Fig. 1. E-F represents 8 stores.

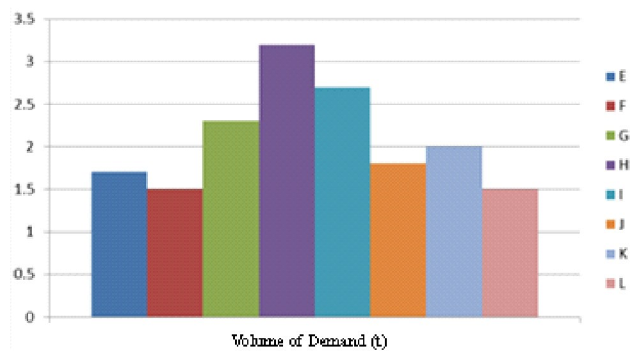

Fig.1 Store volume of demand (E-F represents 8 stores.)

In the initial stage of establishing the self-supporting logistics distribution system, the refrigerated vehicle owned by the enterprise has a small capacity, and the transportation volume only meets the needs of one store. Therefore, the phenomenon of detour and no-load appears in the transportation of vehicles, which causes the waste of transportation resources and costs a lot. The existing distribution path is that the vehicle starts from distribution center s, serves a distribution store and returns to distribution center s. Each distribution vehicle serves two stores, and the distribution order of vehicle 1 is s-e-s, s-f-s. The distribution order of vehicle 2 is s-h-s, s-g-s. The distribution order of vehicle 3 is S-I-S, s-k-s; the distribution order of vehicle 4 is s-j-s, s-l-s. There is a circuitous phenomenon in the existing distribution mode, so it is necessary to improve the distribution path to form a closed loop. Fig. 2 shows the existing distribution mode of Jinwei supermarket cold chain distribution, each path only serves one store. Therefore, the phenomenon of detour and no-load appears in the transportation of vehicles, which causes the waste of transportation resources and costs a lot.

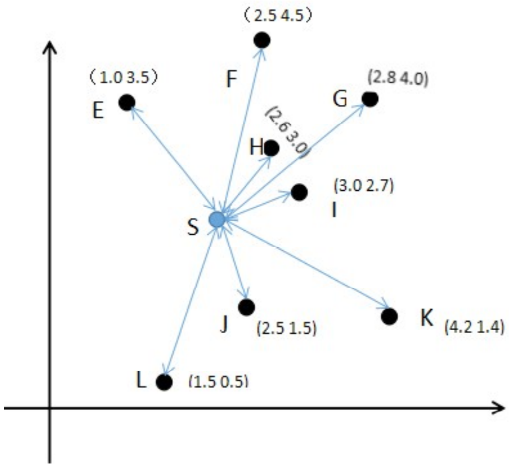

Fig.2 Existing Distribution Mode

3.1.2 Poor Punctuality

As shown in Fig. 3, the fresh agricultural products transported are vegetables, and the purchase time of vegetables is mostly in the morning, which requires high punctuality of transportation. At present, the enterprise's transport vehicles often go to and from the distribution center, which will cause the problem of untimely distribution.

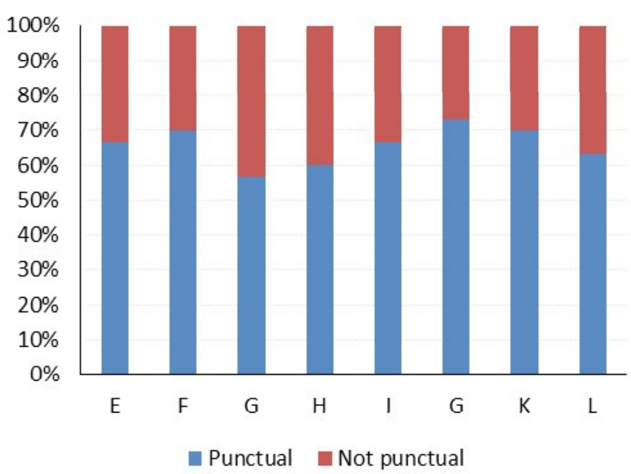

Fig. 3 Punctuality Rate of Each Store

3.1.3 No Fixed Line

Enterprises choose their own vehicles for distribution, distribution system is not perfect, often loading at will, there is no fixed route. In the selection of distribution path, usually, the driver of distribution products will not specify the driving route in advance, but will distribute the products according to their own driving habits. Although this operation mode is simple, fast and convenient, but due to the lack of reasonable calculation and consideration of the particularity of cold chain distribution, there are problems in this mode.

3.1.4 High Corrosion Rate

Enterprises do not consider the different demand of different stores when delivering. The freshness of the product is the largest when loading. With the continuous opening of the refrigerated car during the transportation, the freshness of the product will be reduced. The longer the door is opened, the longer the agricultural products are exposed to normal temperature, and the lower the freshness. Therefore, during transportation, the demand of different stores on the same distribution route should be considered, that is, the unloading volume of transportation vehicles. The corrosion rates are shown in Fig.4.

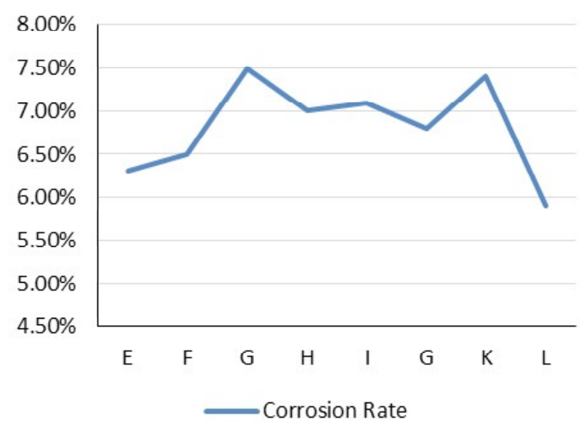

Fig. 4 corrosion rates of each store

3.2 Causes of Distribution Problems

3.2.1 Backward Equipment

The basic equipment is backward. Although Jinwei supermarket has 6 refrigerated vehicles, the performance of the transportation equipment is aging and cannot be updated in time. The vehicles are only simple refrigerated vehicles and lack of advanced monitoring equipment. Moreover, the vehicle is not equipped with a positioning system, which cannot manage the refrigerated vehicle in time, so it will affect the quality of fresh agricultural products in cold chain transportation. Moreover, the technology of fresh-keeping, packaging and processing in the process of distribution is relatively backward, which makes the rate of agricultural products corruption higher.

3.2.2 Lack of Professional Talents

Jinwei supermarket's cold chain logistics system has not been established for a long time. Compared with traditional logistics, cold chain logistics has higher requirements for talents. In the early days of Jinwei supermarket, there were no professional logistics management personnel, only the transport fleet, and the staff's cultural and educational level was not high. With the development of recent years, the existing staff quality has not been able to meet the needs of enterprise development, coupled with the lack of training for logistics professionals in higher education institutions in this region, making enterprises unable to recruit suitable professional logistics personnel. The lack of professional and high-quality talents makes the staff unable to guarantee the efficient operation of cold chain logistics system in the actual operation process, which will affect the quality of agricultural products transportation.

3.2.3 Unreasonable Distribution Path

The original vehicle transport route is to provide only one delivery point to the distribution vehicle and then return to the distribution center. There is no reasonable planning for the distribution route, only relying on the driver's driving experience. In this way, due to the long distance of distribution, the corresponding transportation cost will increase, and there will be a waste of resources due to the "empty" situation of vehicles. In the process of transportation, there are many problems such as backflow and detour, which will seriously affect the quality of fresh agricultural products. Therefore, the focus of this paper is to use the mileage saving method and consider the cost to build an optimization model, combined with the actual consideration to build a new distribution path.

4. COLD CHAIN DISTRIBUTION OPTIMIZATION

4.1 Initial Model

It is a point-to-point distribution process to distribute vegetables from distribution center 1 to specific stores. If we can't make full use of the line, we will waste time and distance. Therefore, this section will adopt the thought of saving method to solve the problem. Design a good transportation route, form a closed loop to improve the transportation efficiency and improve the quality of fresh agricultural products.

4.1 determine the location of stores and the shortest distance between stores

Fig.5 location of each store

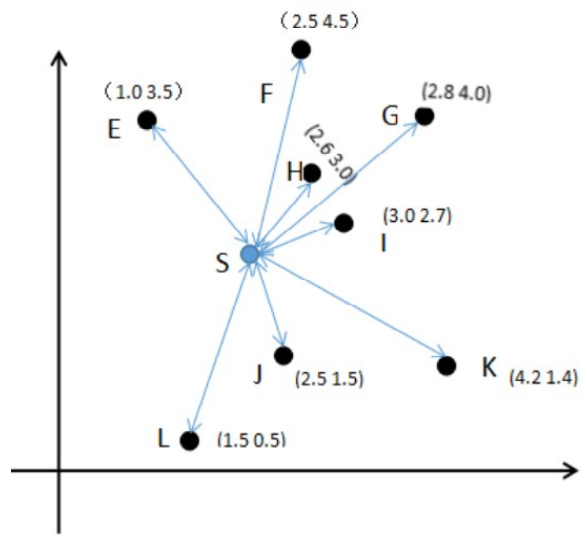

Fig.6 geographical coordinates of each store location

The numbers 1, 2, 3, 4, 5, 8, 9 and 10 in Fig. 5 respectively represent stores g, e, K, l, h, J, F and I. The red circle represents distribution center 1.

In order to facilitate the calculation, the map is simplified as a point line relationship, and the geographical location of each store is roughly determined. See the Fig. 6 for details. E-L represents the store of Jinwei supermarket, s represents the distribution center 1, and the scale of the picture is 1cm: 1km.

4. 2 Calculate the Shortest Distance from the Distribution Center To Each Store

The shortest distance not only considers the actual distance, but also considers the road conditions and the number of traffic lights (calculate the waiting time). After comprehensive consideration, the shortest distance from the distribution center to each store is obtained.

Tab. 1 shortest distance between distribution center and supermarket stores

Demands (t)	S								
1.7	3.7	E							
1.5	4.2	2.9	F						
2.3	3.4	3.8	2	G					
3.2	1.9	2.9	2.7	3	H				
2.7	2.2	3.9	4.1	2.2	1.6	I			
1.8	4.1	4.6	6.6	4.7	4.1	3	J		
2	4	7.7	7.1	5.2	4.5	3.5	2.5	K	
1.5	3.9	7.6	8.1	7.3	5.8	4.5	2.2	4.7	L

(S is the distribution center 1. E-L is supermarket stores.)

(1) Calculate the mileage saved between stores. Di represents the distance from distribution center 1 to store i, d_j represents the distance from distribution center 1 to storej, and D_{ij} represents the distance between store i and store j.

(2) According to the formula, the data in the above table can be calculated to calculate the mileage saving of the improved logistics distribution route.

Tab. 2 mileage savings of distribution (km)

E							
5	F						
3.3	5.6	G					
2.7	3.4	2.3	H				
2	2.3	3.4	2.5	I			
3.2	1.7	2.8	1.9	3.3	J		
0	1.1	2.2	1.4	2.7	5.6	K	
0	0	0	0	1.6	5.8	3.2	L

4. 3 the Supermarket Stores Are Arranged From Large To Small According to the Saved Mileage

Tab. 3 ranking of saving mileage of supermarket stores

No.	Connection point	Mileage saved (km)
1	J-L	5.8
2	J-K	5.6
3	F-G	5.6
4	E-F	5
5	F-H	3.4
6	G-I	3.4
7	E-G	3.3
8	I-J	3.3
9	E-J	3.2
10	K-L	3.2
11	G-J	2.8
12	E-H	2.7
13	I-K	2.7
14	H-I	2.5
15	G-H	2.3
16	F-I	2.3
17	G-K	2.2
18	E-I	2
19	H-I	1.9
20	F-J	1.7
21	I-L	1.6
22	H-K	1.4
23	F-K	1.1

Contd...

4.4 Each Supermarket Store Uses Mileage Saving to Form a New Itinerary

4.4.1 Initial Solution

From the distribution center s, one refrigerated vehicle will be sent to each store for distribution. There are 8 distribution routes, 8 refrigerated vehicles with a total mileage of 46.6km, which need to be loaded with 3 tons. As shown in Fig. 7.

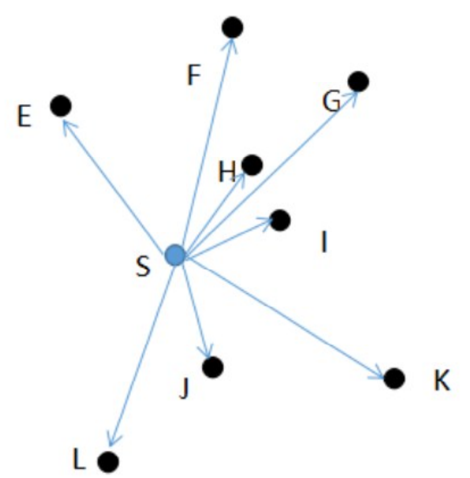

Fig. 7 initial solution

4.4.2 Quadratic Solution

According to saving mileage sequence Tab. 3, connect L-J and J-K in order of saving mileage to form distribution loop '$: s-k-j-l, cancel S-J route at the same time, and get secondary solution. The demand of K, J and l supermarkets is 2T, 1.9t and 1.7t respectively, with a total of 5.6t. A refrigerated vehicle with a capacity of 6T needs to be dispatched for distribution. The total running distance is: 4.5 + 2.5 + 2.2 + 3.9 = 12.6km. As shown in Fig. 8.

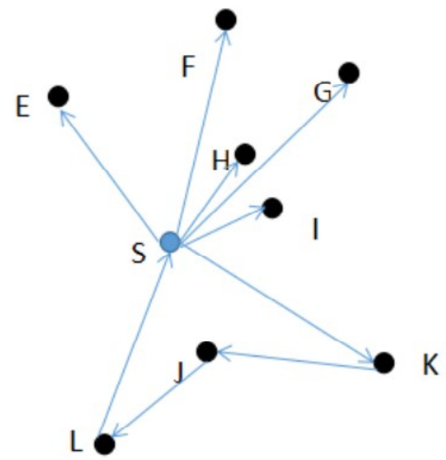

Fig. 8 quadratic solution

4.4.3 Cubic Solution

According to saving mileage sequence Tab. 3, connect F-G and E-F in order of saving mileage to form distribution circuit a$: s-e-f-g, cancel s-f route at the same time, and get three solutions. The demand of F, F and G supermarkets is 1.7t, 1.5T and 2.3t respectively, with a total of 5.5t. A refrigerated vehicle with a capacity of 6T needs to be dispatched for distribution. The total running distance is: 3.7 + 2.9 + 2 + 3.4 = 12km. As shown in Fig. 9.

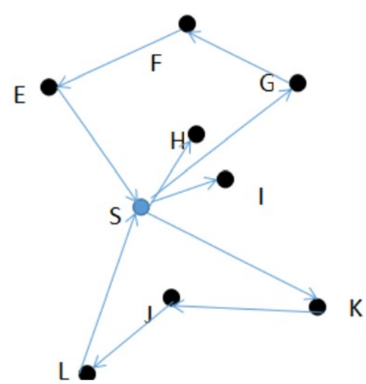

Fig. 9 cubic solution

4.4.4 Final Solution

According to the sequence table of saving mileage in Tab. 3, H-I is connected in order of saving mileage to form distribution circuit b$: s-h-i, and three solutions are obtained. The demand of H and I supermarkets is 3.2T and 2.7t respectively, with a total of 5.9t. A refrigerated vehicle with a capacity of 6T needs to be dispatched for distribution. The total running distance is: 1.9 + 1.6 + 2.2 = 5.7. Km. As shown in Fig. 10.

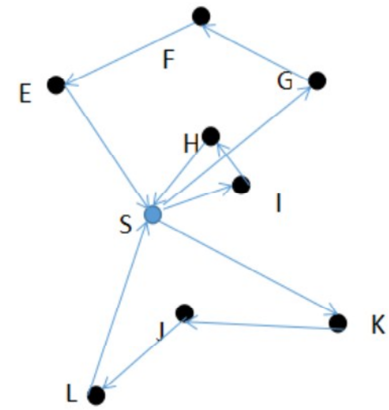

Fig. 10 final solution

The total distribution route of the three supermarket stores is 12.6 + 12 + 5.7 = 30.3km, saving 13.3km. The three distribution routes are as follows:

Route 1, i.e. s-k-j-l-s requires a refrigerated vehicle with a load of 6T;

Route 2, i.e. s-g-f-e-s requires a refrigerated vehicle with a load of 6T;

Route 3, i.e. s-i-h-s, requires a 6-T refrigerator car.

5. IMPROVEMENT OF PATH OPTIMIZATION ALGORITHM

The simple mileage saving method only considers the transportation distance, not the time window and cost of the store. Therefore, it optimizes the mileage saving method, considering the distribution time, the cost of goods damage and the cost of transportation on the original basis, and improves the algorithm.

5.1 Constraint Condition

1) The distribution center meets the store's requirements for product quantity, quality and type,
2) Complete delivery within the time window specified by the store
3) The actual load capacity of the cold chain vehicle shall be lower than the maximum load capacity of the vehicle, and the load capacity of each vehicle shall be certain
4) Cold chain vehicles shall be distributed at the same speed and run at a uniform speed
5) The starting point of each cold chain car is

distribution center 1, and finally return to the distribution center

6) The research object of this section is a single distribution center and multiple demand points
7) The distribution task of each store is only completed by one vehicle, and the vehicle transportation process is better than any other assignment

5.2 Determine Objective Function

1) Transportation cost

This section considers the transportation cost of distribution vehicles, which increases with the increase of transportation distance. The expression of transportation cost is:

$$C_y = \sum_{i=o}^{n} \sum_{j=0}^{n} \sum_{k=1}^{n} c d_{ij} q_{ij} x_{ijk} \quad (1)$$

Where C represents the transportation cost per mileage; dij represents the distance between store i and store j, and dij = dji; qij represents the transportation volume from store I to store J; xijk is the variable 0, 1, if the vehicle K passes through (Pi Pj), then xijk is 1, otherwise it is 0.

2) Energy consumption cost of refrigeration

In the process of transportation, due to the temperature difference between the external temperature and the internal temperature of the cold chain car, in order to keep the agricultural products in the proper temperature during the distribution process, a lot of energy is needed. The relevant factors are the distance of transportation and the time of loading and unloading products. Because the door of cold chain is opened many times, the temperature in the car will be affected, thus the quality of fresh agricultural products will be affected. Therefore, the energy cost in the cold chain distribution process will affect the rationality of transportation path arrangement. In the expression, $è_1$ represents the vehicle cooling energy consumption coefficient in the transportation process, $è_2$ represents the energy consumption of each ton of cargo in the loading and unloading process, and qj represents the demand of j store[10].

$$C_n = \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{n} \left[\left(\theta_1 d_{ij} / v \right) + \theta_2 q_{ij} \right] + x_{ijk} \quad (2)$$

3) Cost of goods damage

It is assumed that the damage coefficient of the damage cost is $è_3$ and the unit value of each ton of product is p. This paper introduces the cost of goods damage. The expression of the loss cost of fresh agricultural products in the distribution process of the supermarket is:

$$C_h = \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{n} p q_{ij} \left(1 - e^{\theta 3 dij / v} \right) x_{ijk} \quad (3)$$

4) Penalty cost

The delivery time specified for each supermarket store is set in advance to be within [M N], or within [m n]. In case of early arrival, the damage coefficient to be borne is $è_3$; in case of exceeding the required time, the penalty cost to be borne is + “; in case of delivery within [M n], the penalty cost to be borne is 0. In this paper, penalty cost is introduced. The expression of penalty cost is:

$$C_f = \begin{cases} \theta_3 p q_{ij} \left(M_j - X_j \right), X_j < M \\ 0, M_j \le X_j \le N_j \\ +\infty, X_j > N_j \end{cases} \quad (4)$$

5.3 Establish Distribution Path Optimization Model

To sum up, the model of cold chain distribution path optimization constructed in this section is:

$$\min \varphi = \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{n} c d_{ij} q_{ijk} + \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{n} \left[\left(\theta_1 d_{ij} / v \right) + \theta_2 q_j \right] + \sum_{i=0}^{n} \sum_{j=0}^{n} \sum_{k=1}^{n} p q_{ij} \left(1 - e^{\theta 3 dij / v} \right) x_{ijk} + C_f \quad (5)$$

$$\sum_{j=1}^{n} \sum_{k=1}^{m} x_{ij} \le m, i = 0 \quad (6)$$

$$\sum_{j-1}^{n} x_{ijk} = \sum_{j-1}^{n} x_{jik} \le 1, i = 0, k = 1,2,\ldots,m \quad (7)$$

$$\sum_{i=0}^{n} \sum_{k=1}^{m} x_{ijk} = 1, i = 1,2,\ldots,n, i \ne j \quad (8)$$

$$\sum_{j=0}^{n} \sum_{k=1}^{m} x_{ijk} = 1, j = 1,2,\ldots,n, i \ne j \quad (9)$$

$$\sum_{i=1}^{n} Q_i \sum_{j=0}^{n} x_{ijk} \le Q, i \ne j, k = 1,2,\ldots,m \quad (10)$$

$$Mj \le Xj \le Nj \quad (11)$$

Among them, Function (6) means that the number of routes should be less than or equal to the number of vehicles, Function (7) means that distribution center 1 is the starting and ending point of the cold chain car, Function (8) and Function (9) mean that each store will only be distributed by one cold chain car, Function (10) means that the maximum load of the vehicles dispatched on each transportation route should be greater than the demand of the stores passing by, Function (11) means that the delivery time of the products must be when required Within the interval.

5.4 Algorithm Design

In the arrangement of routes, the first consideration is the time window of supermarket stores, and the stores with the priority of delivery time window are in the front order. The second is the cost saving. The model Function (5) is the expression of the minimum total cost. On this basis, it is transformed to obtain the cost saving model, and the cost saving model is introduced.

$$\min \varphi = \max \sum_{i=0}^{n}\sum_{j=0}^{n}\sum_{k=1}^{3}\left[(c+\theta_1/v)s_{ij} + pq_i e^{-\theta 3dij/v}\left(1-e^{-\theta 3sij/v}\right)\right]x_{ijk} - \sum_{j=0}^{n} C_f \quad (12)$$

On the basis of calculating the saved mileage by using the mileage saving method, the steps of optimizing the distribution path are carried out:

1) List the time windows of each store, and sort the time windows of all stores.
2) Calculate the saved distribution mileage Sij.
3) Take distribution center 1 as the starting point, first consider the store with the first time window sorting as the first distribution object of the first line, find out the store with Sij not 0 in the table of mileage saving, and calculate the cost saving, the next distribution object of the line with the largest cost saving. And so on until the driving line reaches the limit of time window or flow.
4) Delete the stores involved in the first path and repeat step 3) until all stores are discharged into the route.

5.5 Relevant Data Required

1) The relevant data are shown in Tab. 4. Energy consumption is mainly related to fuel oil. Therefore, the energy consumption coefficient is mainly related to fuel oil consumed in vehicle transportation. The cargo loss coefficient is the percentage of the corruption degree of fresh agricultural products converted into cost loss.

Tab. 4 Relevant data

Related business	quantity	unit
Price of fresh agricultural products	P=10000	yuan / t
Energy consumption in transportation process	θ_1=50	yuan / h
Energy consumption during loading and unloading	θ_2=2.5	yuan / t
Cargo damage coefficient	θ_3=0.6%	
Unit transportation cost	C=2.8	yuan / t.km
Transportation speed	S1=30	km / h
Cold chain vehicle weight	Q=6	t
Unloading speed	S2=10	t / h

2) supplement the complete distribution center and distribution distance table between stores:

Tab. 5 distribution distance of distribution center and stores (unit: km)

	S	E	F	G	H	I	J	K	L
S	0	3.7	4.2	3.4	1.9	2.2	4.1	4	3.9
E	3.7	0	2.9	3.8	2.9	3.9	4.6	7.7	7.6
F	4.2	2.9	0	2	2.7	4.1	6.6	7.1	8.1
G	3.4	3.8	2	0	3	2.2	4.7	5.2	7.3
H	1.9	2.9	2.7	3	0	1.6	4.1	4.5	5.8
I	2.2	3.9	4.1	2.2	1.6	0	3	3.5	4.5
J	4.1	4.6	6.6	4.7	4.1	3	0	2.5	2.2
K	4	7.7	7.1	5.2	4.5	3.5	2.5	0	4.7
L	3.9	7.6	8.1	7.3	5.8	4.5	2.2	4.7	0

3) the time window and demand of each store are shown in Tab. 6 below:

Tab. 6 Demand of each store and demand schedule

Customer	E	F	G	H
Requirement	1.7	1.5	2.3	3.2
Customer request time window	7:35-8:05	7:55-8:25	8:15-8:45	7:35-8:05
Customer acceptable time window	7:05-8:35	7:25-8:55	7:25-9:15	7:05-8:35
Customer	I	J	K	L
Requirement	2.7	1.8	2	1.5
Customer request time window	8:00-8:30	7:55-8:25	8:10-8:40	7:30-8:00
Customer acceptable time window	7:20-9:00	7:25-8:55	7:40-9:10	7:00-8:30

4) Supplement the table of saving transportation

distance between stores after completion:

Tab. 7 Saving transportation distances between stores

	E	F	G	H	I	J	K	L
E	0	5	3.3	2.7	2	3.2	0	0
F	5	0	5.6	3.4	2.3	1.7	1.1	0
G	3.3	5.6	0	2.3	3.4	2.8	2.2	0
H	2.7	3.4	2.3	0	2.5	1.9	1.4	0
I	2	2.3	3.4	2.5	0	3.3	2.7	1.6
J	3.2	1.7	2.8	1.9	3.3	0	5.6	5.8
K	0	1.1	2.2	1.4	2.7	5.6	0	3.2
L	0	0	0	0	1.6	5.8	3.2	0

5.6 Calculation of Algorithm

1) Calculate the first path, and use L as the first distribution object of the first distribution path according to the data in Tab. 6. According to Tab. 7, find out the relevant stores with Sij not 0, and calculate the cost savings of the stores. As shown in Tab. 8, the cost savings of J are the largest, so J store is taken as the second distribution object of the first line, and the sum of the demand of L store and J store does not exceed the load capacity of the cold chain car. Repeat this step to calculate the third distribution object, and the relevant calculation data is shown in the table below:

Tab. 8 the second store of the first line

Customer	demand	mileage saved	transportation cost saved	goods damage cost saved	energy cost saved	penalty cost	total cost saved	whether to choose
I	2.7	1.6	12.1	4.79	2.67	“	-”	n
J	1.8	5.8	29.23	17.38	9.67	0	56.28	y
K	2	3.2	17.92	9.59	5.33	0	32.84	n

Tab. 9 the third store of the first line

Customer	demand	mileage saved	transportation cost saved	goods damage cost saved	energy cost saved	penalty cost	total cost saved	whether to choose
E	1.7	3.2	15.23	11.5	5.33	“	-”	n
F	1.5	1.7	7.14	6.11	2.83	“	-”	n
G	2.3	2.8	18.03	10.07	4.67	0	32.77	n
H	3.2	1.9	17.02	6.83	3.17	“	-”	n
I	2.7	3.3	24.95	11.87	5.5	“	-”	n
K	2	5.6	31.36	20.13	9.33	0	60.82	y

2) According to Tab. 9, the third distribution store is store K. since the demand of the three stores reaches 5.6t, nearly 6T, and other stores cannot be added. Therefore, the first distribution route is s-l-j-k-s, the total transportation mileage is 12.6km, the cost savings of distribution route is 117.1 yuan, and the transportation mileage savings are 11.4km. In the same way, other distribution routes can be calculated according to the above methods:

Tab. 10 the second store of the second line

Customer	demand	mileage saved	transportation cost saved	goods damage cost saved	energy cost saved	penalty cost	total cost saved	whether to choose
F	1.5	5	21	16.98	8.33	0	46.31	y
G	2.3	3.3	21.25	11.21	5.5	0	37.96	n
H	3.2	2.7	24.19	9.17	4.5	“	-”	n
I	2.7	2	15.12	6.79	3.33	“	-”	n

Tab. 11 the third store of the second line

Customer	demand	mileage saved	transportation cost saved	goods damage cost saved	energy cost saved	penalty cost	total cost saved	whether to choose
G	2.3	5.6	36.06	16.78	9.33	0	56.17	y
H	3.2	3.4	30.46	10.19	5.67	“	-”	n
I	2.7	2.3	17.39	6.89	3.83	“	-”	n

3) The second distribution route is s-e-f-g-s. the total transportation distance is 12 kilometers, the saved transportation mileage is 11.6 kilometers, and the saved cost is 102.48 yuan.

4) In the end, only store h and store I are still in the priority of distribution in the order of time window. Store h is the first store of the third distribution route, so the distribution route is s-h-i-s, and the total transportation mileage is 5.7KM. Finally, all customers are included in the distribution route. The total transportation distance

is 30.3km, the mileage saved is 13.3km, and the cost saved is 219.58 yuan.

The final distribution results are shown in Fig. 11:

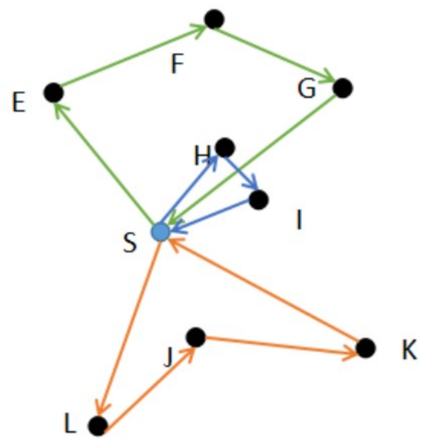

Fig. 11 Optimized path

5. CONCLUSION

Urban residents tend to buy fresh agricultural products in large supermarkets. This is not only an opportunity but also a challenge for large supermarkets. The key to ensure the quality of fresh agricultural products lies in the distribution of the last kilometer. Then arranging the route of distribution vehicles becomes the key point to solve the problem. In this paper, Jinwei supermarket has been choose as a cold chain distribution case. To optimize the distribution route of Jinwei supermarket, three closed routes are designed to reduce the transportation mileage. According to the above algorithm, the three paths are all the optimal paths after considering the transportation cost, energy consumption cost; goods damage cost and penalty cost. Compared with the basic mileage saving method, the optimized algorithm considers the time window problem of the distribution object, so as to determine the order of distribution in the distribution path and the goods damage in the distribution process the problem. As the cold chain transportation is different from the traditional transportation, the quality of fresh products will have a great impact on their sales, so we should try to reduce the rate of goods damage and energy consumption cost of fresh products. The original mileage saving method determines the stores involved in the three distribution paths, and does not give a reasonable distribution order. Therefore, the optimization of cold chain logistics distribution path of fresh agricultural products needs to be considered in combination with the characteristics of cold chain. In this way, the transportation time could be reduce, the operation efficiency could be improve, the transportation cost can be reduced, and the goal of improving the quality of fresh agricultural products could finally be achieved.

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[1] market status and development prospect of China's cold chain logistics industry in 2016 [EB/OL].http://chinaidr.com/tradenews/2016-09/102989.html, 2019-02-26.

[2] Zhao Yingxia. (2010). Discussion on the development of cold chain logistics of agricultural products in China [J]. Journal of Harbin Business University (SOCIAL SCIENCES), (02):44-48.

[3] Hu Jianmiao. (2017). Problems and Countermeasures in the development of cold chain logistics of fresh agricultural products in China [J]. Reform and strategy. (05):82-84.

[4] Zhang Misha. (2018). Research on the current situation and strategy of cold chain logistics of agricultural products in China [J]. Chinese market, (30):171-172.

[5] Liu K. (2019). Cold chain logistics of agricultural products has become a "new battlefield" [J]. Logistics technology and Application, (01):20-22.

[6] Sobhi Mejjaouliÿ Radu F. (2018). Babiceanu.Cold supply chain logistics: System optimization for real-time rerouting transportation solutions[J].Computers in Industry, (95):68-80.

[7] S.J. James, C. James. (2010).The food cold-chain and climate change[J].Food Research International, 43(07):1944-1956.

[8] Amalia UtamimaÿK. Renny PradinaÿNisa Setya DiniÿHudan Studiawan. (2015). Distribution Route Optimization of Gallon Water Using Genetic Algorithm and Tabu Search.[J].Procedia Computer Science, (72):503-510.

[9] Xuping WangÿMeng WangÿJunhu RuanÿHongxin Zhan. (2016). The Multi-objective Optimization for Perishable Food Distribution Route Considering Temporal-spatial Distance[J].Procedia Computer Science, (96):1211-1220.

[10] Shen Junyu. (2018). Research on location and distribution path optimization of regional cold chain logistics distribution center [D]. Sichuan: Logistics Engineering of Southwest Jiaotong University.