Research on double-layer model of cold chain Network based on Genetic Algorithm

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Abstract. Based on the self-run cold chain logistics model dominated by large chain supermarkets, this paper establishes a double-layer programming model of fresh agricultural products cold chain logistics network optimization model of large chain supermarkets. The upper model is the total cost optimization model of cold chain logistics network, which solves the location problem of distribution points and the optimization problem of vehicle path. The lower level model is the optimized model of customer time satisfaction, which solves the problem of supermarket flow distribution. Finally, an example is given and an improved genetic algorithm is used to solve the two-layer programming model, which proved the double-layer model has certain theoretical and practical significance.

Keywords: Double-layer model, Cold chain network, Covering site selection, Vehicle path optimization, Genetic algorithm.

1. Introduction

In recent years, China's logistics industry has entered a golden age of rapid development. With the continuous improvement of national economic level, consumers' demand for fresh agricultural products has been increasing, and meanwhile, higher requirements have been put forward for cold chain logistics [1].

According to statistics, about 400 million tons of agricultural products enter the circulation field in China every year, but the proportion of fresh agricultural products distributed by cold chain is very low, accounting for about 5% of fruits and vegetables, 15% of meat and 23% of aquatic products. This causes the damage of 20% ~ 30% of fruits and vegetables, 12% of meat and 15% of aquatic products in circulation [2]. Every year, the country loses more than 100 billion yuan due to fruit and vegetable rot alone. In contrast, the United States, Japan, South Korea, Canada, the United Kingdom and other developed countries, 95% of fresh agricultural products can be transported in the cold chain, the rate of decay maintained at less than 5% [3].

At present, some agricultural products operating enterprises and third-party logistics companies have initially established their own cold chain logistics network, but most of them have unreasonable network layout and low efficiency, resulting in a large amount of waste of resources and economic losses [4]. Therefore, scientific planning of fresh agricultural products logistics node layout and site selection and optimization of cold chain logistics distribution routes are not only conducive to promoting the...
improvement of cold chain logistics network, but also conducive to ensuring the quality and safety of cold chain food.

In this paper, based on the summary of domestic and foreign research, a large chain supermarket cold chain logistics network optimization model of fresh agricultural products based on two-layer programming was built, and an improved genetic algorithm was designed. Finally, the solution was carried out with an example, which verified the scientific nature and feasibility of the model.

2. Network optimization model design

2.1. The elements of network

The operation process of the cold chain logistics model of fresh agricultural products in large chain supermarkets is shown in Figure 1.

It can be seen from Figure 1 that the elements of cold chain logistics network are mainly composed of logistics nodes and distribution routes.

(1) Logistics node

It mainly includes four main types: supplier node, cold chain logistics center node built by large chain enterprises, supermarket chain node and customer demand node.

(2) Delivery routes

Since this paper does not consider the supplier's optimized route to the distribution center, the distribution route includes two types of routes: distribution center -- supermarket and customer-supermarket.

To sum up, the schematic diagram of cold chain logistics network studied in this paper is shown in Figure 2.
2.2. Problem description
In a certain region, a large supermarket chain needs to establish a number of supermarkets among m candidate points, which are required to cover the needs of all customers and provide all customers with the greatest time satisfaction. After figuring out the number, location and demand of supermarkets to be established, vehicle distribution routes from distribution centers to these supermarkets should be established to minimize the total network cost established by enterprises. It is known that the enterprise has a distribution center in this region, and the location is known. There are k cars in the distribution center. In this region, there are M candidate service stations whose locations are known, and the demands and locations of N customer demand points are known.

2.3. Basic assumptions
(1) Distribution centers, alternative locations of supermarkets, and customers' geographical locations are known;
(2) The number of distribution centers is one, the number of supermarkets is unknown, and the number of customers is known.
(3) The demand of each customer is a constant, which remains stable within a certain period of time, and the demand of a single customer does not exceed the maximum service capacity of the supermarket.
(4) In this paper, fresh agricultural products of a single category are taken as the research object, and the vehicle specifications and models are unified.
(5) Each vehicle starts from the distribution center, completes the distribution route and returns to the distribution center;
(6) The distribution center's distribution capacity meets the needs of all supermarkets, and the maximum service capacity of each chain supermarket is fixed;
(7) The vehicle runs at a fixed speed and the loading and unloading speed remains unchanged.
(8) The quality loss of fresh agricultural products in the process of transportation and loading and unloading is only related to the delivery time and temperature, and meets the total deterioration rate of products.
(9) Customer satisfaction is expressed as a linear time satisfaction function.
(10) Distribution center distribution time is night distribution.

2.4. Network optimization goal

The establishment of the cold chain logistics network optimization model for fresh agricultural products in large chain supermarkets adopts the idea of two-layer programming model and the optimization problem of the total network cost in the upper model with the goal of minimizing the total network cost. The lower level model is based on the supermarket flow allocation problem of customer time satisfaction, and the objective function is the maximum of customer total time satisfaction.

2.4.1. Upper-layer model objective analysis

The upper-layer model aims to minimize the total cost of the network. The total network cost $F$ mainly includes the construction cost $F_1$ of the supermarket in the early stage, the operation cost $F_2$ of the supermarket in the later stage and the distribution cost $F_3$ of the delivery to the supermarket by the distribution center. Among them, the distribution cost includes transportation cost, goods loss cost and energy consumption cost. The longer the distribution time, the greater the goods loss. Each cost in the total cost of the network is assigned a weight, which is denoted as $\lambda_1, \lambda_2, \lambda_3$. The mathematical model with the minimum total cost of the upper model is:

$$
\begin{align*}
\text{Min} F &= \text{Min} \left( \lambda_1 F_1 + \lambda_2 F_2 + \lambda_3 F_3 \right) \\
&= \text{Min} \left( \lambda_1 F_1 + \lambda_2 L F_2 + \lambda_3 LF_3 \right) \\
&= \text{Min} \left\{ \lambda_1 \sum_{j \in J} S_j Z_j + \lambda_2 L \sum_{j \in J} R_j Z_j + \right. \\
&\left. \sum_{k \in K} C_k X_k + \sum_{k \in K} \sum_{a \in J \cup P} \sum_{b \in J \cup P} C_{ab} d_{ab} X^k_{ab} + \right. \\
&\left. \lambda_3 L \alpha \sum_{j \in J} W^k_j \left[ (1-e^{-\delta t_1}) \times 100\% \times M_j (t_1) + (1-e^{-\delta t_2}) \times 100\% \times M_j (t_2) \right] + \\
&\beta \sum_{k \in K} X^k \left( \sum_{a \in J \cup P} \sum_{b \in J \cup P} \frac{d_{ab} X^k_{ab}}{v_1} + \sum_{j \in J} \frac{d_{j} W^k_j}{v_2} \right) \right\} \\
\end{align*}
$$

In the above formula:
$F_1$ —— The enterprise plans the annual operating cost of the supermarket;
$F_2$ —— The enterprise plans the annual vehicle distribution cost;
$F_3$ —— The enterprise plans the annual vehicle distribution cost;
Customer demand spot $I = \{i \mid i=1,2,L,n\}$;
supermarket candidate spot $J = \{j \mid j=1,2,L,m\}$;
Vehicle collection $K = \{k \mid k=1,2,L,k\}$;
$S_j$: the fixed construction costs of $j$;  
$L$: Operating time correction factor of enterprise; 
$R_j$: fixed operating expenses of $j$;
$C_k$: The fixed cost of vehicle $K$;
$C_{ab}$: The transportation cost per unit distance from node A to node B;
$d_{ab}$: Distance from node A to node B ($a,b \in J \cup P \land a \neq b$);
$d_j$: The demand for $j$ in the supermarket;

$K_{max}$: Represents a temperature independent constant of the reaction rate ($s^{-1}$);

$E_a$: The activation energy ($Jmol^{-1}$);

$R$: Gas constant $8.314 (Jmol^{-1}K^{-1})$;

$T$: Thermodynamic temperature ($K$);

$t$: time (s);

$$\delta = -K_{max} \exp\left(-\frac{E_a}{RT_j}\right), \quad \forall \delta > 0;$$

$Z_j$: $Z_j = \begin{cases} 1 & \text{Set up a supermarket at candidate point } j \\ 0 & \text{else} \end{cases}$

$X_k$: $X_k = \begin{cases} 1 & \text{Vehicle } K \text{ is occupied} \\ 0 & \text{else} \end{cases}$

$X_{ab}^k$: $X_{ab}^k = \begin{cases} 1 & \text{Vehicle } K \text{ is on route } (a, b) \\ 0 & \text{else} \end{cases}$

$W_j$: $W_j = \begin{cases} 1 & \text{Supermarket } j \text{ is distributed by the vehicle } K \\ 0 & \text{else} \end{cases}$

$\alpha$: The cost of goods lost per unit amount of goods lost;

$\beta$: The energy cost per unit of time of the vehicle;

$v_1$: The speed of a vehicle in transit;

$v_2$: The speed of loading and unloading of goods in a supermarket;

2.4.2. Lower-layer model objective analysis

The target of the lower-layer model is the maximum time satisfaction of the customer $G$, and the target function is:

$$\text{Max}G = \text{Max} \sum_{i \in I} \sum_{j \in J} h_i F(t_{ij}) Y_{ij} \quad (4)$$

In above formula

$h_i$: The quantity demand of point $i$;

$t_{ij}$: The shortest distance for demand point $i$ to accept the service of supermarket $j$;

$F(t_{ij})$: The customer satisfaction of demand point $i$ on the response time of supermarket $j$ satisfies the linear time satisfaction;

$Y_{ij}$: $Y_{ij} = \begin{cases} 1 & \text{Customers i receive service of the j supermarket} \\ 0 & \text{else} \end{cases}$
2.5. Model building

2.5.1. Upper-layer model

\[
\begin{align*}
\text{Min} F &= \text{Min} \left( \lambda_1 F_1 + \lambda_2 F_2 + \lambda_3 F_3 \right) \\
\text{s.t.} \quad \sum_{j \in J} S_j Z_j &\leq U \\
\sum_{j \in J} Z_j E_j &\geq \sum_{i \in I} h_i \\
\sum_{i \in I} \sum_{j \in J} h_i F(t_{ij}) Y_{ij} &\geq \eta \\
&= \sum_{i \in I} Y_{ij} h_i \quad \forall j \in J \\
\sum_{j \in J} d_j W^k_j &\leq Q_k \quad \forall k \in K \\
\sum_{k \in K} W^k_j &= 1 \\
\sum_{a \in J \cup P} \sum_{b \in J \cup P} X^{ab}_k &\leq 1 \quad \forall k \in K \\
\sum_{a \in J \cup P} X^{ar}_k - \sum_{b \in J \cup P} X^{rb}_k = 0 &\quad (r \in J \cup P) \quad \forall k \in K
\end{align*}
\]

\[Z_j = \begin{cases} 
1 & \text{Set up supermarket at candidate point } j, \quad \forall i \in I \\
0 & \text{else}
\end{cases}
\]

\[Y_{ij} = \begin{cases} 
1 & \text{Customers } i \text{ receive service of the } j \text{ supermarket } \quad \forall i \in I, \quad \forall j \in J \\
0 & \text{else}
\end{cases}
\]

\[X^{ab}_k = \begin{cases} 
1 & \text{Vehicle } K \text{ is on route } (a, b) \\
0 & \text{else}
\end{cases}
\]

\[W^k_j = \begin{cases} 
1 & \text{Supermarket } J \text{ is distributed by the vehicle } K \\
0 & \text{else}
\end{cases}
\]

\[X_k = \begin{cases} 
1 & \text{Vehicle } K \text{ is occupied} \\
0 & \text{else}
\end{cases}
\]

In above formula, \( E_j \): maximum service capacity of \( j \);
\( Q_k \): Maximum carrying capacity of vehicle \( k \);

Equation (5) represents the minimum total network cost; Equation (6) indicates that the total construction cost of the supermarket should not be greater than the initial investment; Equation (7) indicates that the sum of the maximum service capacity of all supermarkets under construction is greater than the sum of the demands of all customers. Equation (8) indicates that the customer’s total time satisfaction level is greater than \( \eta \); Formula (9) indicates that the demand of supermarket \( J \) is equal to the demand of all customers covered by the supermarket; Formula (10) indicates that the distribution quantity on each path will not exceed the maximum carrying capacity of each vehicle; Formula (11) indicates that each supermarket must and can only be delivered by one car; Formula (12) indicates that each vehicle can only be served once at most; Formula (13) indicates that the vehicle arrives at a
supermarket and then starts from that supermarket. Equations (14), (15), (16), (17) and (18) are 0-1 constraints.

2.5.2. Lower-layer model

\[
\text{Max} \sum_{i \in I} \sum_{j \in J} h_i F(t_{ij}) Y_{ij} \tag{19}
\]

\[\text{S.t.} \quad \sum_{j \in J} Y_{ij} = 1 \quad \forall i \in I \tag{20}\]

\[Y_{ij} \leq Z_j \quad \forall i \in I, \quad \forall j \in J \tag{21}\]

\[\sum_{i \in I} Y_{ij} E_{ij} \leq Z_j \quad \forall j \in J \tag{22}\]

\[F(t_{ij}) = \begin{cases} 
1 & t_{ij} \leq L_i \\
\frac{U_i - t_{ij}}{U_i - L_i} & L_i < t_{ij} \leq U_i \\
0 & t_{ij} > U_i 
\end{cases} \quad \forall i \in I, \quad \forall j \in J \tag{23}\]

\[Z_i = \begin{cases} 
1 & \text{Set up supermarket at candidate point } j \quad \forall i \in I \\
0 & \text{else} 
\end{cases} \tag{24}\]

\[Y_{ij} = \begin{cases} 
1 & \text{Customers } i \text{ receive service of the } j \text{ supermarket} \quad \forall i \in I, \quad \forall j \in J \\
0 & \text{else} 
\end{cases} \tag{25}\]

Equation (4.19) indicates that the customer's total time satisfaction is the highest; Equation (20) indicates that each customer must and can only get the service of one supermarket; Equation (21) indicates that the premise for customers to accept the service of a supermarket is that there is a supermarket at that point; Formula (22) indicates that the total demand of all customers covered by each supermarket does not exceed the maximum service capacity of the supermarket; Equation (23) is the time satisfaction function of customers; Equations (24) and (25) are 0-1 constraints.

The cold chain logistics network of fresh agricultural products was optimized by establishing a two-layer programming model, so as to reduce the total cost of the cold chain logistics network and maximize the total time satisfaction of customers. Therefore, the model can realize the purpose of optimizing the cold chain logistics network of fresh agricultural products in large chain supermarkets.
3. Improved genetic algorithm design
The basic flow chart of improved genetic algorithm designed in this paper is shown in Figure 3.

![Image of flow chart]

**Fig.3 Improved genetic algorithm basic flow chart**

3.1. Coding
The location 0-1 variable, traffic allocation variable and distribution path variable were coded on three chromosomes $A_1$, $A_2$ and $A_3$ respectively. The final solution of the model consists of these three chromosomes.

(1) In the location selection problem of supermarket layout, the decision variable $Z_j$ uses the binary 0-1 encoding form. The length of encoding chromosome of $Z_j$ is the number of supermarket candidate points, equals $m$, and the sequence of encoding genes corresponds to the sequence number of supermarket position. The supermarket layout location coding scheme is shown in Figure 4.
In the distribution of supermarket demand attraction, the form of natural number coding is adopted. After obtaining the number of supermarket construction \( m^* \) according to the supermarket layout code, the supermarket flow distribution problem needs to determine the number of customers served by each supermarket and the corresponding relationship between the supermarket and customers. The supermarket traffic distribution coding scheme is shown in Figure 5.

![Fig.5 Supermarket traffic allocation coding scheme](image)

(3) The vehicle path optimization problem takes the form of natural number coding. According to the supermarket flow distribution scheme, the demand of each supermarket can be obtained \( d_j \), and the problem of supermarket flow distribution needs to determine the number of customers served by each supermarket and the corresponding relationship between the supermarket and customers. The vehicle routing optimization coding scheme of distribution center is shown in Figure 6.

![Fig.6 Vehicle path optimization coding scheme](image)

3.2. Initial population

\( A_1 \) chromosomes initialization is relatively simple, randomly given 0 or 1. For \( A_2 \) and \( A_3 \) chromosomes, in addition to random generation of the initial population, constraint conditions should be determined for each individual to improve the quality of the initial population.
3.3. Fitness function

The fitness function of upper-layer model $F'$ is:

$$F' = \frac{1}{F}$$

The fitness function of lower-layer model $G'$ is:

$$G' = G$$

The constraints of the upper-layer and lower-layer models are treated, added together, and multiplied by a sufficiently large positive number as a penalty function. The constraint conditions of the upper model are treated as follows:

- Formula (4.6) is converted to
  $$P_1(X) = \sum_{j \in J} (U - S_j Z_j)$$

- Formula (4.7) is converted to
  $$P_2(X) = \sum_{i \in I} \sum_{j \in J} (Z_j E_j - h_i)$$

- Formula (4.8) is converted to
  $$P_3(X) = \sum_{i \in I} \sum_{j \in J} (h_i F(t_j) Y_j - \eta)$$

- Formula (4.9) is converted to
  $$P_4(X) = \sum_{i \in I} \sum_{j \in J} (Y_j h_i - d_j)$$

- Formula (4.10) is converted to
  $$P_5(X) = \sum_{k \in K} \left( Q_k - \sum_{j \in J} d_j W_j^k \right)$$

- Formula (4.11) is converted to
  $$P_6(X) = \sum_{k \in K} (W_j^k - 1)$$

- Formula (4.12) is converted to
  $$P_7(X) = \sum_{a \in J \cup P} \sum_{b \in J \cup P} (1 - X_{ab})$$

- Formula (4.13) is converted to
  $$P_8(X) = \sum_{a \in J \cup P} \sum_{b \in J \cup P} \sum_{r \in J \cup P} (X_{rb}^k - X_{ar}^k)$$

Therefore, new fitness function of upper-layer, $f'$, is:

$$f' = \frac{1}{F'} + M \sum_{i=1}^{8} P_i(X)$$

In the same way, new fitness function of upper-layer, $g'$, is:

$$g' = G + M \sum_{i=9}^{11} P_i(X)$$

3.4. Select operator

A roulette wheel is used to select operators inherited from the next generation.

Suppose the population size of the upper model is $N$ and the fitness of individual $i$ is $f'_i$, then the probability of individual $i$ being selected is $P_i^i$.

$$P_i^i = \frac{f'_i}{\sum_{i=1}^{N} f'_i}$$
Suppose the population size of the lower model is $M$ and the fitness of individual $j$ is $f_j$, then the probability of individual $j$ being selected is $P_j^2$

$$P_j^2 = \frac{g_j}{\sum_{j=1}^{M} g_j}$$

### 3.5. Crossover operator

(1) Crossover operator of supermarket layout site selection

Chromosomes $A_1$ were reprogrammed by means of single point crossing.

(2) Supermarket flow allocation crossover operator

The first chromosome of $A_2$ adopts cross preposition, and the second chromosome adopts single point crossing.

(3) Vehicle path optimization crossover operator

The first chromosome of the $A_3$ adopts cross preposition, and the second chromosome adopts single point crossing.

### 3.6. Mutation operator

(1) Supermarket layout site selection mutation operator

The method of uniform variation was used for chromosome $A_1$.

(2) Supermarket flow allocation mutation operator

The first chromosome of $A_2$ adopts the method of inversion variation, while the second chromosome adopts the method of uniform variation, with the variation range not exceeding the number of supermarkets under construction $m^*$.

(3) Vehicle path optimization mutation operator

The first chromosome of $A_3$ adopts inversion variation, while the second chromosome adopts uniform variation. The variation range does not exceed the quantity $k^*$ of refrigerated trucks.

In this paper, the linear variation probability formula is used to determine the variation probability, and the formula of $P_m$ is:

$$P_m = 0.005 + 0.005 \times \frac{\text{current generation}}{\text{Total generation of evolution}}$$

### 4. Computational experiments

Founded in 1998, Y Group has grown to more than 300 supermarket chains, mainly dealing in fresh products such as fruits, vegetables and meat. Y Group also has its own logistics team, which makes use of its own logistics center to deliver goods to supermarket chains.

### 4.1. Parameter setting

The location map of Distribution center P and supermarket candidate points (A1 to A10) planned by Y Group in Hohhot distribution supermarket is shown in Figure 7. The locations of customer demand points (B1 through B20) are shown in Figure 8. Distribution center and each supermarket candidate points, the distance between each supermarket candidate points and the distance between the supermarket candidate points and customers using the map.
According to the survey data of Y Group, the demand of each customer for fresh agricultural products is shown in Table 1.
Table 1 Demand for fresh Agricultural products per customer (unit: ton)

| Customers | Demand of customers |
|-----------|---------------------|
| B1        | 0.6                 |
| B2        | 0.54                |
| B3        | 0.81                |
| B4        | 0.96                |
| B5        | 0.45                |
| B6        | 0.66                |
| B7        | 0.9                 |
| B8        | 0.78                |
| B9        | 1.11                |
| B10       | 1.05                |
| B11       | 0.75                |
| B12       | 1.2                 |
| B13       | 0.36                |
| B14       | 0.69                |
| B15       | 0.99                |
| B16       | 0.87                |
| B17       | 0.54                |
| B18       | 0.96                |
| B19       | 0.51                |
| B20       | 1.02                |

This example assumes that the construction cost of each supermarket is fixed at 1 million yuan. The maximum coverage radius of the supermarket is 3 kilometers, the maximum service capacity of the supermarket is 3 tons, the supermarket is within 1 kilometer from the customer, the customer satisfaction is 1, more than 1 kilometer, the customer satisfaction gradually declines, the maximum carrying capacity of the vehicle is 8 tons, the fixed cost of the vehicle is 350 yuan/time. The unit cost of fresh agricultural products is 20,000 yuan/ton, the transportation cost of refrigerated vehicles is 2.5 yuan/kilometer per unit mileage, and the driving speed is 30 kilometers/hour. The shelf life of fresh agricultural products at room temperature is 60 hours. In the loading and unloading process, the loading and unloading rate per unit time is 1.4 tons/hour, the energy cost is 4 yuan/hour, and the damage coefficient is 0.0019.

4.2. Results output
By using the improved genetic algorithm and substituting parameters, the population reached the optimal value when the iteration was about 100 times. The optimal value of the total network cost is RMB 45025168, and the total customer satisfaction level is 10.293, accounting for 65.15% of the total customer demand of 15.8, which meets the purpose of network optimization. The supermarket construction plan is shown in Table 2, the traffic distribution is shown in Table 3, and the vehicle path optimization plan is shown in Table 4.

Table 2 Supermarket Construction scheme

| supermarket | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 |
|-------------|----|----|----|----|----|----|----|----|----|-----|
| Z_j         | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 1  | 1  | 1   |
Table.3 The optimal distribution scheme of supermarket demand attraction

|     | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 |
|-----|----|----|----|----|----|----|----|----|----|-----|
| B1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B2  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B3  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B4  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B5  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B6  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B7  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B8  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B9  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B10 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0   |
| B11 | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B12 | 0  | 0  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0   |
| B13 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0   |
| B14 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0   |
| B15 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   |
| B16 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1   |
| B17 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0   |
| B18 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0   |
| B19 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1   |
| B20 | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1   |

Table.4 Vehicle path optimization scheme

| The vehicle number | Order of paths   |
|--------------------|-----------------|
| Vehicle 1          | 0-3-2-1-0       |
| Vehicle 2          | 0-8-10-9-0      |

The simulation results of the example obtained the minimum total cost of the cold chain logistics network of Y supermarket, and on the basis of the minimum total cost, the total customer satisfaction was maximized, so as to achieve the purpose of optimizing the cold chain logistics network of fresh agricultural products in large chain supermarkets.

5. Conclusion
This paper is based on dominated by large chain supermarket of self-supporting cold-chain logistics mode, through the analysis of cold chain logistics and related theory foundation, model design of large supermarket chain of fresh agricultural products cold chain logistics network optimization, namely the enterprise location and distribution center, a supermarket chain putting vehicle distribution routing optimization, in order to decrease the total network cost and raise the level of customer satisfaction, reduce the loss of fresh agricultural products, to meet consumer demand, improve the service level of the cold chain logistics industry in our country. Finally, the improved genetic algorithm is designed to solve the bilevel programming model and an example is given to verify the feasibility of the algorithm.

This paper still has some shortcomings and needs to be improved, mainly in the following aspects:
(1) In the supermarket traffic distribution problem, customer satisfaction is solved by using a fixed time satisfaction function. However, in real life, customer satisfaction is not only related to time, but also related to service level, customer experience and other factors, which need to be comprehensively considered in future studies.
(2) In the basic assumption of vehicle path optimization, it is assumed that the vehicle speed is a fixed value. However, in real life, the vehicle speed will change with the surrounding conditions at any time.
(3) Only the improved genetic algorithm is used to solve the problem, and no comparison is made with other algorithms. Therefore, other heuristic algorithms can be used to solve the model in future research, so as to compare the advantages and disadvantages of each algorithm.

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