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ARTICLE

The Optimization of Cold Chain Logistics Delivery Routes for Company B Based on Service Priority

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Abstract

In recent years, China's cold chain logistics market has developed rapidly under the strong drive of the growth of food and pharmaceutical cold chains demand, as well as the strong support of government policies. Cold chain distributiIon plays a crucial role in optimal cold chain logistics. The study focuses on company B as the research subject and aims to reduce distribution costs. Considering factors of customer timeliness requirements and vehicle types, combined with the issue of service priority, a S-TS algorithm is adopted to establish a cold chain distribution path optimal model that is in line with the actual situation of company B. Then, the optimal solution of total distribution costs is obtained through Matlab software simulation, and the optimal plan of company B's is generated, which provides a new idea and method to reduce costs and increase efficiency.

Keywords: Service priority, Cold chain logistics, Distribution path.

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1 Introduction

In recent years, driven by the strong demand growth of food and pharmaceutical cold chain, as well as the strong support of government policies, China's cold chain logistics market has entered a stage of rapid development. However, the development of the cold chain logistics industry is consistently hindered by costs and efficiency. Reducing costs and increasing efficiency is a difficult problem that needs to be overcome in the transformation and upgrading of the cold chain logistics industry [1]. Optimal distribution route is an essential aspect of costs and efficiency control in cold chain logistics [2]. Therefore, some scholars have explored the problem of distribution route optimization from different perspectives [3].

In this study, Zhao et al.[4] developed a multi-objective model by considering factors such as costs, carbon emissions, and customer satisfaction. The model adopts an improved ant colony algorithm, aiming to achieve cold chain distribution path optimization. The objective is to give logistics companies multiple options for selecting delivery routes in practical applications. A cold chain logistics transportation shortest path selection algorithm based on an improved artificial bee colony is proposed by Liu [5] to address the problems of low accuracy, long response time, and poor selection effect in current cold chain logistics transportation methods. In order to pursue the goal of low costs, Zhang et al. adopted genetic algorithm and combined with soft time window problem to explore the optimized model of cold chain logistics vehicle routing [6].

Company B have issues of cold chain distribution business: lack of planning in delivery routes, difficulty in controlling delivery timeliness, and high costs associated with delivery risks. Based on the above reality, this paper adopts the S-TS algorithm to establish a distribution route optimized model with the goal of reducing costs, while considering factors such as customer service priority and vehicle model.

2 Basic data collection

Company B, located in Quanzhou, Fujian Province, engages in the wholesale and sales of fresh and frozen food products. Company B's distribution center located in Zhenggang, Quanzhou City. The distribution center primary focus on serving 14 supermarkets and stores by providing cold chain food delivery services.

This study's data was obtained through fieldwork of Company B, and with the support of employees, department managers, and drivers. For reasons of commercial confidentiality, the data of Company B was treated in a special way in the paper. Table 1 and Table 2 presented the distances between different distribution points and Company B's ZhengGang distribution center. Table 3 presented the delivery demand statistics related to each distribution point.

Table 1. Distance between Distribution Points and ZhengGang Distribution Center.

Name of Delivery Point	No.	Distance from Zhenggang to each distribution point (km)
ZhengGang	Distribution Center	
FeiGou	1	10
TaiPing	2	28
ZhangGou	3	23
Baiping	4	65
MiCun	5	16
ChaoHua	6	16
GaoCheng	7	42
LuGou	8	16
LaoJuntang	9	21
JinLong	10	85
ZhenXin	11	23
CuiMiao	12	35
ZhaoJiazhai	13	70
SanLi	14	23

Fresh and frozen products are the main types of demand at various distribution points of Company B, with different service priorities. Table 3 provides detailed information.

The company's management department has approved

Figure 1. Geographical distribution of Distribution Center and points.

the selection of the following cold chain delivery vehicles, and their relevant information is summarized in Table 4.

3 Construction of a Cold Chain Delivery Path Optimization Model with Service Priority

In this study, the S-TS algorithm was used to construct a cold chain delivery path model for Company B, which also takes into account factors such as the incompatibility of refrigerated and frozen foods and changes in customer priority needs. There're several assumptions to make the model calculation more suitable for Company B's actual situation.

Assuming that Company B's ZhengGang distribution center has a fleet of multiple cars with M number of vehicles and needs to serve N delivery points.

Each vehicle equipped with different types and quantities of goods, the payload capacity of each vehicle is referred to as $Wm(m \in M)$, and Each type has $Lm(m \in M)$ vehicles available. To transport goods to N distribution points, the task requires using at least L (Expressed as $\sum_{m=1}^{M} Lm$) vehicles departing from the main cold chain distribution center.

In this context, the demand for a product at the distribution point i represents as $Q_i(i = 1, 2, \dots, N)$. The service priority of each product distribution point in Company B represents as $P_i(P = 0, 1, 2)$. The distance from product distribution point i to product distribution point j represents as D_{ij}, with the central warehouse denoted as 0. The variable x_{ij}^{ml} represents whether a vehicle of type m is driven from i to j, with values of 0 or 1 [7].

The demand of each product distribution point can only be fulfilled by one vehicle, and each route does not exceed the weight limit requirement of the

Table 2. Brief distance statistics between each distribution point. Unit: km

Distances	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		76	72	150	52	52	104	42	62	190	60	90	110	65
2	76	0	106	74	48	83	28	88	58	186	106	86	146	106
3	72	106	0	180	82	82	134	18	92	220	18	120	110	10
4	150	74	180	0	122	157	56	162	132	172	180	120	215	180
5	52	48	82	122	0	59	76	64	34	162	82	62	117	82
6	52	83	82	157	59	0	111	64	69	197	82	97	74	82
7	104	28	134	56	76	111	0	116	106	126	134	114	283	134
8	42	88	18	162	64	64	116	0	74	202	18	102	112	18
9	62	58	92	132	34	69	106	74	0	172	92	72	127	92
10	190	186	220	172	162	197	126	202	172	0	220	110	255	220
11	60	106	18	180	82	82	134	18	92	220	0	120	130	10
12	90	86	120	120	97	97	114	102	72	120	120	0	155	120
13	110	146	110	215	74	74	283	112	127	130	130	155	0	120
14	65	106	10	180	82	82	134	18	92	220	10	120	120	0

Note: No.1-14 represent 14 distribution points respectively, among which one refers to the distribution center.

Table 3. Demand Statistics of Distribution Points. Unit: Ton

Name of Delivery Point	Demand for chilled fresh products	Demand for frozen products	Service Priority
FeiGou	2	1	high
TaiPing	0.5	0.2	low
ZhangGou	1	0.4	low
BaiPing			-
MiCun	0.9	0.4	low
ChaoHua	0.3	1	low
GaoCheng	1.1	0.6	low
LuGou	0.7	0.1	high
LaoJuntang			-
JinLong			-
ZhenXin	0.3	0.3	low
CuiMiao			-
ZhaoJiaZhai	1.5	0	high
SanLi	2	1.2	low

vehicle. Additionally, while satisfying service priority, efforts are made to minimize the total transportation costs. Furthermore, the vehicle must return to the distribution center after completing the delivery [7].

Based on the assumptions mentioned above, the vehicle routing problem model with service priority proposed by Li et al. [7] is cited in this paper. Additionally, considering the geographical distribution and demand situation of Company B's product delivery points, appropriate adjustments are

Table 4. The Information of available cold chain delivery vehicles.

Number of Vehicles	4			
Vehicle Capacity (ton)	2	2	2	2
License plate number	4545	4537	893	763
Fuel consumption quota per 100 km (L)	11.5	11.5	11	11

made to the model, resulting in the formation of a cold chain delivery route optimized model. The formula of the model is as follows:

$$\min Z = \sum_{j=1}^{N} \sum_{l=1}^{Lm} \sum_{i=0}^{N} \sum_{j=0}^{N} c_{ij}^{m} x_{ij}^{ml} \tag{1}$$

$$\text{s.t} \sum_{j=0}^{N} \sum_{l=1}^{Lm} \sum_{m=1}^{M} x_{ij}^{ml} \leq \sum_{m=1}^{M} Lm, m \in \{1, 2, \ldots, M\} \tag{2}$$

$$\sum_{j=1}^{N} x_{0j}^{ml} = \sum_{i=1}^{N} x_{j0}^{ml} \leq 1, m \in \{1, 2, \ldots, M\}, \\ l \in \{1, 2, \ldots, Lm\} \tag{3}$$

$$\sum_{j=0}^{N} \sum_{m=1}^{M} \sum_{l=1}^{Lm} x_{ij}^{ml} = 1, i \in \{1, 2, \ldots, N\} \tag{4}$$

$$\sum_{i=0}^{N} \sum_{m=1}^{M} \sum_{l=1}^{Lm} x_{ij}^{ml} = 1, j \in \{1, 2, \ldots, N\} \tag{5}$$

$$\sum_{i=1}^{N} Qi \sum_{j=0}^{N} x_{ij}^{ml} \leq Wm, m \in \{1, 2, \ldots, M\}; \quad l \in \{1, 2, \ldots, Lm\} \tag{6}$$

$$x_{i0}^{ml} = x_{0i}^{ml} = 0, m \in \{1, 2, \ldots, M\}; \quad l \in \{1, 2, \ldots, Lm\} \tag{7}$$

$$u_i - u_j + (N+1) \sum_{l=1}^{L} x_{ijlm} \leq N, \quad i \in \{1, 2, \ldots, N\}, j \in \{1, 2, \ldots, N\} \tag{8}$$

$$P_i - P_j \geq 0, i \in \{1, 2, \ldots, N\}, j \in \{1, 2, \ldots, N\} \tag{9}$$

The equation (1) represents the objective function for minimizing the total cost, which point the transportation cost from i to j. Additionally, assuming that all vehicles must leave the destination upon arrival. The equation (2) restricts the number of vehicles dispatched from the distribution center to be less than or equal to the total number of vehicles. If a vehicle arrives and there is insufficient time to meet customer requirements, it will be discarded or rescheduled. The equation (3) ensures that the vehicles must depart from and return to the distribution center. The equations (4) and (5) constrain that each item's demand point can only be served by one vehicle. The equation (6) restricts the total of cargo carried by each vehicle to be no greater than its load capacity. In all possible scenarios, it allows one or more customers to choose their desired routes and accept any orders on those routes. The equation (7) avoids unnecessary travel of vehicles on roads between distribution centers; one or more nodes are set up on each sub-route to allocate road resources to meet customer needs. The equation (8) avoids multiple sub-loops during car operation [7]. Finally, the equation (9) ensures priority-based service for more urgent demand points along the sub-paths.

4 Model Solution and Result Analysis

After using Matlab software to simulate the model for 10 times, the result has certain randomness and is relatively accurate. The algorithm eventually converges by enforcing the precision of insertion and termination criteria on solution constraints, even though there is randomness in neighborhood operations [8].

Finally, the calculation results are analyzed in depth, and the optimal solution of company B's cold chain delivery path model is shown in Table 5.

Table 5. The results of solving the objective function.

Solve for order	Total delivery cost (RMB)	Number of Vehicle Uses
1	523.91	11
2	523.91	11
…	523.91	…
10	523.91	11
Average	523.91	11

Note: The omitted part is the same result.

Table 5 shows that the delivery costs for this scheme are 523.91 RMB and utilizes four refrigerated transport vehicles that depart and return to Zhenggang Port. Furthermore, fresh and frozen products are transported separately to the distribution points.

Under the condition of using the same input data and stopping criteria, we simulate the original cold chain distribution route of Company B, and compare the obtained results.

The result shows that the cost of the original delivery route is 831 RMB. The delivery cost optimized by S-TS algorithm is significantly better than that original scheme, saving about 32% of the cost. At the same time, the optimized solution can meet transportation requirements while significantly reducing delivery time and distance. (note: Since the original delivery route of company B is not fixed, the cost of the original delivery route mainly relied on valuation from the company's financial data. However, it also incorporated analysis and suggestions from company supervisors, making the data relatively accurate)

According to Tables 6 and 7, it can be concluded that the vehicle distribution routes meet the requirements of the constraints.

Since the priority service of the Peigou, Lugou, and Zhaojiazhai distribution points, as well as the equal importance of allocating resources to these points, routes heading towards these three distribution points are scheduled first. Zhao Jiazhai's direction is consistent with Chao Hua's direction, as observed by the geographical distribution of each delivery point. In addition, the total demand for frozen fresh products from both delivery points can be enough to fulfill the carrying capacity of the delivery vehicles. The collaborative delivery method was utilized for the first cold chain distribution. To satisfay the demand of frozen fresh products for Zhaojiazhai and Chaohua distribution points, a vehicle bearing license plate 4545 conducted the delivery.

Table 6. Optimizated Results using the S-TS Algorithm (High Priority).

Distribution path	Types of goods	Distribution plan	Vehicle License Plate
0-13-6-0	frozen fresh products	ZhengGang →ZhaoJiazhai → ChaoHua →ZhengGang	4545
0-8-11-3-0	frozen fresh products	ZhengGang→LuGou → ZhenXin →ZhangGoy →ZhengGang	893
0-1-0	frozen fresh products	ZhengGang→FeiGou → ZhengGang	763
0-8-11-3-14-0	Frozen products	ZhengGang→LuGou→ZhenXin→ZhenXin →ZhenXin→ZhengGang	4537
0-1-0	Frozen products	ZhengGang→ FeiGou →ZhengGang	763

Table 7. The optimized results using the S-TS algorithm (low priority).

Distribution path	Types of goods	Distribution plan	Vehicle License Plate
0-5-0	frozen fresh products	ZhengGang → MiCun → ZhengGang	763
0-2-7-0	frozen fresh products	ZhengGang → TaiPing → GaoCheng → ZhengGang	4537
0-5-0	frozen products	ZhengGang→ MiCun → ZhengGang	893
0-2-7-0	frozen products	ZhengGang → TaiPing →GaoCheng → ZhengGang	4545
0-14-0	frozen fresh products	ZhengGang → SanLi → ZhengGang	763
0-6-0	frozen products	ZhengGang → Chao Hua → ZhengGang	893

The second and third shipments were transported by vehicles with license plates 893 and 763, respectively. The same principle applies to the fourth shipment and the second one. For delivery points with lower service priority, the lowest delivery cost is generally regarded as the priority choice because there is no strict requirement on delivery order. It can be seen that the delivery route cheme meets the demand and effectively controls the transportation cost and time.

In summary, the application of the S-TS algorithm in the cold chain distribution routes of Company B meets the service priority of each demand point, and the delivery cost is lower under the same level of service performance. In practical applications, this method can solve complex demand problems and generate higher economic and social benefits.

5 Conclusion

Driven by the strong demand growth of food and pharmaceutical cold chain sectors, as well as robust government support, China's cold chain logistics market has transitioned from the infrastructure development stage to a phase of industry quality improvement. This shift has placed higher requirements on cost savings and quality enhancement.

First of all, this paper obtained the basic research data through fieldwork. With the consent of the management department of Company B, the data was subjected to special processing based on commercial confidentiality requirements. Then, this paper addresses the issue of company B's inability to mix refrigerated and frozen products, as well as the differences in priority level requirements from customers. The S-TS algorithm is employed to establish a delivery route optimization model, which is simulated using Matlab tools to obtain the optimal solution for delivery cost. This optimized scheme provides a new idea and method for company B's cold chain distribution business to reduce cost and increase efficiency. Furthermore, this article can also serve as a reference for optimizing cold chain distribution in similar enterprises.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

References

[1] Ji, Y., et al. (2019). Decision optimization for cold chain logistics of fresh agricultural products under the

perspective of cost-benefit. *Open Access Library Journal*, 6(02), 1. [CrossRef]

[2] Li, M., & Tang, R. (2019). Research on optimization of cold chain logistics distribution path of fresh agricultural products. In *Proceedings of the 2nd International Conference on Economy, Management and Entrepreneurship* (pp. 697–704). [CrossRef]

[3] Wicaksono, P. A., Puspitasari, D., Ariyandanu, S., & Hidayanti, R. (2020). Comparison of simulated annealing, nearest neighbour, and tabu search methods to solve vehicle routing problems. *IOP Conference Series: Earth and Environmental Science*, 426(1), 012138. [CrossRef]

[4] Zhao, B., Gui, H., Li, H., & Xue, J. (2020). Cold chain logistics path optimization via improved multi-objective ant colony algorithm. *IEEE Access*,8, 142977–142995. [CrossRef]

[5] Liu, Z. (2021). Shortest path selection algorithm for cold chain logistics transportation based on improved artificial bee colony. *Scientific Programming*, 2021, 1–10. [CrossRef]

[6] Zhang, L., Gao, Y., Sun, Y., Fei, T., & Wang, Y. (2019). Application on cold chain logistics routing optimization based on improved genetic algorithm. *Automatic Control and Computer Sciences*, 53, 169–180. [CrossRef]

[7] Li, J., Chen, Y., Wang, D., Guo, H., & Yang, J. (2014). Scanning tabu search algorithm for vehicle routing problem with service priority. *Journal of Mathematics in Practice and Theory*, 44, 169–180.

[8] Gao, W., & Wang, Y. (2023). The optimization of fresh cold chain logistics distribution route based on tabu search algorithm. *Journal of Qingdao University of Technology*, 44(5), 160–168+174.

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