International Journal of Global Economics and Management

ISSN: 3005-9690 (Print), ISSN: 3005-8090 (Online) | Volume 2, Number 3, Year 2024
DOI: https://doi.org/10.62051/IJGEM.v2n3.58
Journal homepage: https://wepub.org/index.php/IJGEM/index

Optimization of fresh produce delivery path based on C-W saving algorithm

Wanru Zhao *, Qi Geng

School of Economics and Management, Southwest Petroleum University, Chengdu, China
*Corresponding Author: Wanru Zhao

ABSTRACT

Because fresh agricultural products have the characteristics of difficulty in preserving freshness, short shelf life, and are perishable and fragile, so they have extremely high requirements for warehousing, distribution, and other multiple links, and their distribution costs have caused some economic pressure on Z. To reduce the distribution costs of Z's distribution centers and to maximize the satisfaction of customers' needs, it is very important to carry out reasonable planning of the distribution paths. How to scientifically and reasonably formulate the vehicle distribution plan and arrange the distribution path program, shorten the time of fresh agricultural products in transit and reduce the company's logistics and distribution costs, maximize customer satisfaction, and accurately and timely provide customers with high-quality fresh agricultural products and high-quality distribution services are of great significance. In this paper, by summarizing the existing literature on the optimization of the distribution path of fresh agricultural products cold chain logistics, the C.W saving algorithm is used to optimize the path of the distribution center of Z company.

KEYWORDS

Fresh produce; Path Optimization; C-W saving algorithm

1. INTRODUCTION

1.1. Background

With the continuous development of China's economy, the people's living consumption level gradually improved, and people paid more attention to food safety and quality. In recent years, the frequent occurrence of food safety accidents, fresh agricultural products, and other "green organic food" more favored by residents in their daily lives on the consumption of fresh food demand is also accelerating. However, due to the complexity of the market players in the fresh food industry, the variety of fresh food products, and market regulators in the management of the market is difficult to achieve complete unity, which has led to the current fresh food industry there are still some common problems. For example, the distribution efficiency of fresh food is not high, the distribution process is not standardized, and due to the high construction cost of the cold chain logistics system, some enterprises are unable to update the preservation and refrigeration technology promptly, which makes fresh food easy to deteriorate and rot in the transportation process. These problems will not only lead to an increase in the cost of fresh food wastage and increase the pressure on the survival of enterprises but also affect the quality of the products, resulting in consumers being unable to buy products that are good value for money.

1.2. Current Status And Review Of Domestic And International Research

1.2.1. Cold chain logistics for fresh produce

Although the domestic research on cold chain logistics started relatively late and the depth of research is shallow compared with that of foreign countries, with the improvement of people's quality of life and the increase of consumers' demand for fresh food, domestic scholars have carried out certain researches and put forward their viewpoints on how to better develop the cold chain logistics industry of fresh agricultural products. For the study of the development status quo of fresh agricultural products cold chain logistics, research scholars mainly start from the status quo of all aspects of cold chain logistics, analyze its development and existing problems, and put forward relevant suggestions. Yuan Xueguo (2015) and others, by analyzing the development trend of the cold chain logistics industry and the problems existing in its development, put forward suggestions for strengthening the macro management of cold chain logistics, establishing and promoting the traceability information system for agricultural products, and promoting the technological innovation of cold chain logistics [1]. Huang Xiaoxu (2022), based on comparing the practices and achievements of developed countries and analyzing the problems in the development of cold chain logistics in China, puts forward the targeted suggestions of strengthening the construction of cold chain logistics platform for agricultural products, improving the standardization system of cold chain logistics for agricultural products, and connecting with laws and regulations [2]. Luo Qianfeng (2021) Luo Qianfeng (2021) addresses the dilemma of "small, scattered and chaotic" in the cold chain logistics of fresh agricultural products, establishes a structural framework based on institutional benefits and transaction costs, and proposes countermeasures such as resource reorganization, configuration and upgrading, and industrial synergy and value-added in the cold chain logistics of fresh agricultural products [3]. It also proposes countermeasures such as resource reorganization, configuration and upgrading, and industrial synergy and value-added.

Foreign scholars Binod Kumar Sing et al. (2019) analyzed in detail the challenges faced by the fresh food cold chain industry, assessed and analyzed the gaps in cold chain logistics, and developed reasonable solutions [4]. Wetherill et al. (2019) described the opportunities and challenges of production recovery identified by the executive leadership of food banks across the United States, including regional differences in the supply of fresh produce, transport time, and lack of cold chain, and good distribution of fresh produce, proposed the establishment of an organizational partnership for the efficiency of regional sourcing and distribution [5].

1.2.2. Current status of distribution path optimization research

Wu, X., Yang, X. T. (2016) Taking the distribution of fresh produce by a fresh produce distribution center for several supermarket stores as the object, a joint optimization model of cold chain inventory transportation was constructed and solved by the branch delimitation method and the forbidden search method, and the optimal distribution scheme to reduce the logistics cost was obtained [6]. Heng Wang (2019) established a fresh produce distribution path optimization model by fully considering multi-objective factors such as time window, road conditions, and fresh produce loss, and designed an improved genetic simulated annealing algorithm to solve the optimal path [7]. The optimal path is solved by an improved genetic simulation annealing algorithm. Ji Juhai, Zhang Xuan (2019) Combined with the mode of distribution operation with pickup and delivery, a nonlinear mixed integer programming model is established, and the accuracy of the model is proved after solving with a genetic algorithm [8]. Kang, K., Han, J. (2019) A fresh produce distribution path optimization model including fixation, transportation, cargo damage, refrigeration, carbon emission, and penalty cost of distribution vehicles was established, and the solution and sensitivity analysis were carried out by an improved ant colony algorithm [9]. Sun Zongjun (2020) solved the global path optimization problem with more distribution points by applying an improved discrete particle swarm algorithm to solve the shortest paths for distribution from the starting distribution point and direct distribution from farms [10]. Zhou Tong (2020) analyzed the influence of multiple factors including vehicle waiting time, path distance, toll fee, and multiple capacity van compartment mode for fresh agricultural products, constructed an optimization model, and solved it with a genetic algorithm, which made the model closer to the reality, and provided a reference for fresh agricultural products distribution [11]. The optimization model is constructed and solved by a genetic algorithm. Ning Tao (2021) constructed a model to minimize carbon emission and total distribution cost under the influence of fresh produce distribution volume and loading/unloading time and used an improved adaptive quantum ant colony algorithm to solve the fresh produce distribution example, which reduced carbon emission and optimized the distribution path [12]. The model is used to reduce carbon emissions and optimize the distribution path.

Suraraksa, J (2019) Designed different scenarios of fresh produce transportation and distribution network in Bangkok metropolitan area based on a mathematical model using geographic information system integrating location assignment and vehicle paths, evaluated and compared the performance of all possible scenarios by considering the number of required delivery trucks, total travel time, distance, etc., and analyzed the optimal paths [13]. Wang Yong (2020), for the characteristics of community group purchasing of fresh agricultural products, established a polar pattern of routing that minimizes the fixed cost, transportation and penalty costs under the constraint of delivery time satisfaction, and optimized the delivery path by using an improved genetic algorithm to achieve a balance between the minimum total cost of the company and customer satisfaction [14].

1.2.3. Review of research

Given the characteristics of fresh agricultural products, which are easy to be corrupted and require a high distribution environment, scholars have continuously carried out relevant research on fresh agricultural products in the light of the development of cold chain logistics to promote the development of fresh agricultural products, reducing the loss of corruption and enhancing the efficiency of logistics. Foreign scholars have mainly studied the design and application of cold chain logistics technology, performance evaluation, and cold chain ecosystem, green supply chain of fresh agricultural products, distribution system planning, etc. Domestic scholars have mainly studied the risk assessment index system of cold chain logistics, the construction of quality network systems, and the problems, modes, and countermeasures of the circulation operation of fresh agricultural products cold chain logistics.

In the process of path optimization, various factors affecting the cost of fresh agricultural products cold chain logistics, and distribution are not considered comprehensively enough. Finally, the domestic and international literature on the optimization of cold chain logistics distribution path of fresh agricultural products is sorted out, and it is analyzed that it focuses more on the solution model and innovative algorithms, and then combined with the relevant arithmetic examples for validation, while combining with the company-specific cold chain logistics distribution path problem is less.

In this paper, the CW saving algorithm is used to solve the optimization scheme of the distribution center body route of Z company, which makes the enterprise finally achieve the effect of reducing the transportation cost and improving the enterprise's distribution and transportation efficiency and economic benefits.

2. COLD CHAIN LOGISTICS DISTRIBUTION PATH OPTIMIZATION MAIN CONCEPTS

2.1. Overview of Cold Chain Logistics

(1) Cold Chain Logistics

Cold chain logistics refers to ensuring food quality and reducing food loss in a refrigerated environment, based on the freezing process and using refrigeration technology as a means to carry out the logistics process of refrigerated food, the logistics process includes picking, grading and pre-cooling, packaging and processing, distribution, wholesale and retailing.

As cold chain commodities have to maintain a low-temperature state in production, storage, transportation, sales, and other links, compared with room temperature logistics, cold chain logistics requires higher coordination of various links and is more difficult to manage. Its main features include the following aspects.

Firstly, the equipment input cost is high. To reduce the loss of cold chain commodities in each link, it is necessary to rely on cold storage to maintain the low-temperature state when storing and to make use of refrigerated trucks, refrigerated ships, and other means of transportation when transporting. Secondly, the technical input cost is high. As there are more participants in the cold chain logistics system, to reduce information asymmetry, it is necessary to realize the whole process of monitoring with the help of information technology such as GPS (Global Positioning System) and to guarantee the low-temperature status of cold chain commodities in the transportation, it is necessary to carry out real-time control of temperature and humidity with the help of the cold chain logistics technology, so the cold chain logistics has high input cost in terms of technology.

Secondly, there are more types of cold chain commodities, and different cold chain commodities have different attributes and different requirements on storage temperature and humidity, transportation time, and cold storage technology. Moreover, the whole link of cold chain logistics needs to maintain a high degree of coordination, otherwise, the phenomenon of chain breakage may easily occur.

Thirdly, as cold chain commodities are intolerant to storage and have a short shelf-life, they require a high speed of circulation at all stages. Therefore, cold chain logistics must have high timeliness to ensure the quality of cold chain commodities and improve consumer satisfaction.

Cold chain logistics generally requires the use of refrigerants to achieve low temperatures throughout the process, but some refrigerants (e.g. ammonia) can explode if their concentration is too high. Therefore, staff must be clear about the operational practices when using refrigerants to ensure personal safety. Secondly, the natural attributes of fresh products require high temperature and humidity, closure, light, and ventilation in the warehouse.

2.2. Overview of Vehicle Path Problems

Vehicle path problems can be described as known customer demand and location, the distribution center according to a certain goal of reasonable organization of vehicles to each demand for customer points for distribution services, the vehicle to meet some of the conditions of the restrictions, such as the amount of customer demand, the vehicle's capacity limitations, the time window condition constraints, etc., so that the vehicle from the distribution center, the orderly passing through the various customer points and services to the customer, and finally return to the distribution center. Scientific and reasonable planning of the distribution route, and ultimately achieving the distribution cost and time at least, the shortest mileage and other optimization goals, which is conducive to achieving customer satisfaction requirements, to achieve the optimal distribution path.

2.3. Overview of the C-W Savings Algorithm

The C-W conservation algorithm is a heuristic construction method for solving the automobile routing problem proposed by Clark and Wright in 1964. The basic idea is to first connect each already owned fixed point to the origin 0 (which is the distribution center) to form a transportation route that contains all fixed points and can eventually return to the origin 0. The total cost is the cost of connecting to each fixed point at twice the distance from the origin. The total cost is the cost of connecting to each fixed point at twice the distance from the origin, and then calculating the cost "savings" of connecting points i and j to the same route:

$$S(i,\ j) = c_{0i} + c_{i0} + c_{0j} + c_{j0} - (c_{0i} + c_{ij} + c_{j0}) = c_{i} + c_{0j} - c_{ij}. \quad (1)$$

The larger S (i, j) is, the more the total distance is reduced when connecting i and j. In this formula, S(i, j) denotes the saved path distance, c0i denotes the distance from the starting point 0 to point i, c_{0j} denotes the distance from the starting point 0 to point j, and c_{ij} denotes the distance from point i to point j. The distance from the starting point 0 to point j is the distance from the starting point 0 to point j.

3. APPLICATION OF THE C-W SAVINGS ALGORITHM

3.1. Introduction To The Parameters Of Company Z's Logistics Center Point Of Demand And Distribution Center

Company Z is an enterprise engaged in the distribution of fresh agricultural products, and its distribution center is located in Jinniu District, Xitilu No. 9, Annex No. 21, and there are 10 demand points (hypermarkets) around the whole Chengdu city. This paper investigates the application of C.W algorithm to the optimization of distribution paths in the distribution center of Z company. Assuming that the basic situation of each vehicle is the same, the remaining parameters are shown in Table 1 below:

Table 1. Distribution Parameters

Related Business Name	parameterization
Refrigerated truck loading	Q=8 tons
agricultural prices	p=16,000 yuan/ton
Transportation damage factor	α=0.08%
Cargo damage factor for loading and unloading	β = 0.12%
Transportation speed	v=30km/h
Freight per unit distance	C0 = $2.5/ton-km
loading and unloading speed	V0 = 3 tons/hour
energy cost	P0 = $5/hour
fixed costs	P = $350 per session

3.2. Distribution Path Optimization Solution

(1) C.W saving algorithm views the customers as nodes, assuming there are m, and randomly selects a point to make it 1, and views this point as the base point.

(2) Connect the remaining points to the base point to form an m-1 route. The distance between the remaining points and the base point is denoted as C_{1j} (j=2, 3, ... m).

(3) Connect any two nodes (denoted by i, j) ($i \neq j \neq 1$) and calculate the savings distance value s (i, j) according to the formula: s (i, j)=$C_{1i} + C_{1j} - C_{ij}$.

(4) After connecting all the nodes in pairs, the storage distance value is calculated and all the s (i, j) are sorted from largest to smallest according to the storage value and the node with the largest storage distance value is placed on the delivery route first.

(5) Repeat the above steps until all nodes are aligned in the path.

The specific steps for applying the C.W conservation algorithm to solve the optimization of the path of the logistics center of company Z are as follows:

Step 1: Take the distribution center Q_0 as the base point and connect it to the rest of the points while calculating C_{01}, C_{02} ..., C_{10}.

Table 2. Distances between Company Z's distribution centers and each demand point and between each demand point

	Q_0	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8	Q_9	Q_{10}
Q_0	0	17	6	14	20	12	6	26	15	20	9
Q_1	17	0	12	13	27	25	20	41	32	33	22
Q_2	6	12	0	8	17	12	8	29	21	26	15
Q_3	14	13	8	0	15	14	13	31	27	34	23
Q_4	20	27	17	15	0	9	14	18	24	35	27
Q_5	12	25	12	14	9	0	6	17	16	27	20
Q_6	6	20	8	13	14	6	0	21	14	22	14
Q_7	26	41	29	31	18	17	21	0	18	30	29
Q_8	15	32	21	27	24	16	14	18	0	12	14
Q_9	20	33	26	34	35	27	22	30	12	0	12
Q_{10}	9	22	15	23	27	20	14	29	14	12	0

Step 2: Take Q_0 as the base, calculate the saving distance from 10 demand points to the distribution center according to the formula $s(i,j)=C_{0i}+C_{0j} .C_{ij}$ $(i\neq j)$ respectively, as in Table 3-3:

Table 3. Demand for Agricultural Products at Various Demand Points

Demand Point Number	Point-of-need requirements (tons)
Q1	2.3
Q2	2.5
Q3	1.7
Q4	2.3
Q5	3.5
Q6	1.6
Q7	3.3
Q8	1.9
Q9	2.7
Q10	3.4

Step 3: Take Q_0 as the base, calculate the saving distance from 10 demand points to the distribution center according to the formula $s(i, j)=C_{0i}+C_{0j} .C_{ij}$ $(i\neq j)$ respectively, as in Table 3-4:

Table 4. Saving Distances Between Demand Points

Customer Code	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Q1	-	11	18	10	4	3	2	0	4	17
Q2	11	-	12	9	6	4	3	2	3	1
Q3	18	12	-	19	12	7	9	2	0	0
Q4	10	9	19	-	23	12	28	11	5	2
Q5	4	6	12	23	-	12	21	11	5	1
Q6	3	4	7	12	12	-	11	7	4	1
Q7	2	3	9	28	21	11	-	23	16	6
Q8	0	2	2	11	11	7	23	-	23	10
Q9	4	3	0	5	5	4	16	23	-	17
Q10	17	1	0	2	1	1	6	10	17	-

Step 4: Identify the first visited demand point in the first route

Assuming that the goods are transported separately to each of the ten demand points, the transportation costs are calculated for each of the ten points to the distribution center, and the smallest demand point is the first demand point that is visited on the first route. The loading and unloading times studied in this paper consider only the unloading time used to reach the demand point and do not take into account the time used for loading and unloading produce at the distribution center.

Transportation times and distances from the 10 demand points to the distribution center are shown in Table 5. below:

Table 5. Transportation loading and unloading times and distances from distribution centers for each demand point

Demand Point Number	Distance from Q0 (kilometers)	Transportation process time (hours)	Loading and unloading time (hours)	Transportation and handling time and (hours)
Q1	17	0.57	0.77	1.34
Q2	6	0.2	0.83	1.03
Q3	14	0.47	0.57	1.04
Q4	20	0.67	0.77	1.44
Q5	12	0.4	1.17	1.57
Q6	6	0.2	0.53	0.73
Q7	26	0.87	1.10	1.97
Q8	15	0.5	0.63	1.13
Q9	20	0.67	0.90	1.57
Q10	9	0.3	1.13	1.43

Individual costing, using Q_1 as an example,total cost is $523.91.

Transportation costs for the remaining points are shown in Table 6. below:

Table 6. Transportation Costs at Remaining Points

Customer Code	Fixed costs ($)	Transportation costs ($)	Cost of cargo damage (dollars)	Energy costs ($)	Total cost ($)
Q1	350	97.75	67.56	8.6	523.91
Q2	350	37.5	66.4	7.25	461.15
Q3	350	59.5	37.91	6	453.41
Q4	350	115	70.5	9.1	544.6
Q5	350	105	135.52	10.75	601.27
Q6	350	24	28.67	5	407.67
Q7	350	214.5	141.29	12.6	718.39
Q8	350	71.25	46.81	7.25	475.31
Q9	350	135	99.14	10.1	594.24
Q10	350	76.5	124.03	10	560.53

From the above table the minimum total cost is Q_6, so Q_6 is chosen as the first demand point for delivery on the first route.

Step 5: Determine the second demand point to be delivered on the first route. Using Q_6 as the base point, the second demand point is the one that satisfies the largest of the satisfaction values $C_{6j}(j=1,2,3,4,6,7,8,9,10)$.

Distribution Center Q_0 Transportation costs for direct distribution to each point of demand are shown in Table 7.

Table 7. Costs of Distribution Center Distribution to Each Demand Point

our customers grade	Transportation time (hours)	Energy costs during transportation ($)	Cost of cargo damage during transportation ($)
Q1	0.57	2.85	16.78
Q2	0.2	1	6.40
Q3	0.47	2.35	10.23
Q4	0.67	3.35	19.72
Q5	0.4	2	17.92
Q6	0.2	1	4.10
Q7	0.87	4.35	36.75
Q8	0.5	2.5	12.16
Q9	0.67	3.35	23.16
Q10	0.3	1.5	13.06

Using Q_1 as an example, calculate the various cost savings, getting the result of saving total cost of $388.54 and saving transportation time of 6 minutes.

The cost savings for each of the remaining demand points with Q_6 are shown in Table 8. below:

Table 8. Residual Demand Points and Various Cost Savings for Q_6

Customer Code	Time saved (hours)	Mileage savings (kilometers)	Savings in fixed costs (dollars)	Savings in transportation costs ($)	Energy cost savings ($)	Savings in cargo damage costs (dollars)	Total cost savings (dollars)
Q1	0.10	3	350	17.25	3.35	17.94	388.54
Q2	0.13	4	350	25	1.35	6.23	382.58
Q3	0.23	7	350	29.75	2.2	9.25	391.2
Q4	0.40	12	350	69	2.35	12.04	433.39
Q5	0.40	12	350	105	1	4.1	460.1
Q7	0.37	11	350	90.75	3.5	25.36	469.61
Q8	0.23	7	350	33.25	2.35	10.59	396.19
Q9	0.13	4	350	27	3.7	22.65	403.35
Q10	0.03	1	350	8.5	2.35	15.71	376.56

From the above table, the highest total cost savings is Q_7, so for the second demand point on the first route we chose Q_7.

Step 6:Determine the third point of demand that is on the first route.

As in the above approach, the demand point that makes Q_7 to 8 other customers with cost savings that satisfy the maximum value of $C_{7j}(j=1,2,3,4,8,9,10)$ is the third demand point.

The cost savings for each of the remaining demand points with Q_7 are shown in Table 9.

Table 9. Residual Demand Points and Various Cost Savings for Q_7

Customer Code	Time saved (hours)	Mileage savings (kilometers)	Savings in fixed costs (dollars)	Savings in transportation costs ($)	Energy cost savings ($)	Savings in cargo damage costs (dollars)	Total cost savings (dollars)
Q1	0.07	2	350	11.5	6.85	51.57	419.92
Q2	0.1	3	350	18.75	4.85	39.95	413.55
Q3	0.3	9	350	38.25	5.2	40.45	433.9
Q4	0.93	28	350	161	3.05	28.99	543.04
Q5	0.7	21	350	183.75	2.85	23.31	559.91
Q8	0.77	23	350	109.25	3	30.26	492.51
Q9	0.53	16	350	108	5.05	41.48	504.53
Q10	0.2	6	350	51	4.85	41.11	446.96

From the above table, the highest total cost saving is Q_5, so Q_5 is selected as the third demand point on the first route. Q_5, Q_6, Q_7 The sum of the three demand points of agricultural products is 2.3+1.6+3.5=7.4 (tons), which is less than the capacity of the reefer trucks of 8 tons, so the first route according to the scheduling of the first route is Q_0 -Q_6 -Q_7 -Q_5.

Step 7: Determine the first demand point to be distributed on the second path.

It is basically the same as choosing the first demand point on the first path. When Q_0 is the base point the transportation cost to each demand point is minimized (excluding the selected Q_1, Q_6, Q_7) is Q_3, so Q_3 is the first demand point on the second path.

Step 8: Determine the second point of need for the second pathway

Using Q_3 as the base point, the customer that satisfies the cost savings, i.e., satisfies the largest value $C_{3j}(j=2,4,5,8,9,10)$, is the second path second demand point. The various savings costs for the remaining demand points with Q_3 are shown in Table10:

Table 10. Residual Demand Points and Various Cost Savings for Q_3

our customers grade	Time saved (hours)	Mileage savings (kilometers)	Savings in fixed costs (dollars)	Savings in transportation costs ($)	Energy cost savings ($)	Savings in cargo damage costs (dollars)	Total cost savings (dollars)
Q1	0.6	18	350	103.5	2.2	9.35	465.05
Q2	0.4	12	350	75	1.35	3.83	430.18
Q4	0.63	19	350	109.25	2.55	11.31	473.11
Q8	0.07	2	350	9.5	4.5	20.77	384.77
Q9	0	0	350	0	5.7	33.39	389.09
Q10	0	0	350	0	3.85	23.29	377.14

From the table above, the highest total cost savings is found at Q_4, so Q_4 is selected as the second demand point to be served on the second route.

Step 9: Determine the third point of need for the second route.

Using Q4 as the base point, the customer that satisfies the largest value $C_{4j}(j=1,2,8,9,10)$ is the third demand point of the second path.

The cost savings for each of the remaining demand points with Q_4 are shown in Table 11:

Table 11. Residual Demand Points and Various Cost Savings for Q_4

our customers grade	Time saved (hours)	Mileage savings (kilometers)	Savings in fixed costs (dollars)	Savings in transportation costs ($)	Energy cost savings ($)	Savings in cargo damage costs (dollars)	Total cost savings (dollars)
Q1	0.33	10	350	57.5	4.55	26.69	438.74
Q2	0.30	9	350	56.25	2.85	16.52	425.62
Q8	0.37	11	350	52.25	4.00	22.96	429.21
Q9	0.17	5	350	33.75	5.85	37.12	426.72
Q10	0.07	2	350	17	4.50	29.88	401.38

From the above table, the highest total cost saving is Q_1, so Q_1 is selected as the second demand point to be served on the second route.The sum of the demand of Q_3, Q_4, Q_1 is 2.3+1.7+2.3=6.3 tons, which is less than the capacity of the reefer trucks which is 8 tons and there is still a capacity of 1.7 tons, but the capacity of the remaining several demand points is greater than 1.7 tons, so it is not possible to continue the union, and it is concluded that the second route is Q_0-Q_3 -Q_4 -Q_1.

Step 10: Identify the first point of need for the third pathway.

According to the table, after excluding Q_1, Q_3, Q_4, Q_5, Q_6, Q_7 which have been selected, the remaining point with the smallest total transportation cost is Q_2, so Q_2 is selected as the first demand point of the third path.

Step 11: Identify the second point of need for the third pathway.

Using Q_2 as the base point, the customer that satisfies the largest value $C_{2j}(j=8,9,10)$ is the second demand point of the third path.

The cost savings for each of the remaining demand points with Q_2 are shown in Table 12:

Table 12. Residual Demand Points and Various Cost Savings for Q_2

our customers grade	Time saved (hours)	Mileage savings (kilometers)	Savings in fixed costs (dollars)	Savings in transportation costs ($)	Energy cost savings ($)	Savings in cargo damage costs (dollars)	Total cost savings (dollars)
Q8	0.07	2	350	9.5	3.15	16.94	379.59
Q9	0.10	3	350	20.25	3.85	26.10	400.20
Q10	0.03	1	350	8.5	2.35	18.01	378.86

From the above table, the highest total cost saving is Q_9, hence Q_9 is selected as the second demand point for the third route.

Step 12: Determine the third point of need for the third path.

The cost savings for each of the remaining demand points with Q_9 are shown in Table 13:

Table 13. Residual Demand Points and Various Cost Savings for Q_9

our customers grade	Time saved (hours)	Mileage savings (kilometers)	Savings in fixed costs (dollars)	Savings in transportation costs ($)	Energy cost savings ($)	Savings in cargo damage costs (dollars)	Total cost savings (dollars)
Q8	0.77	23	350	109.25	2.00	16.67	477.92
Q10	0.57	17	350	144.5	2.00	11.56	508.06

From the above table, the highest total cost saving is Q_{10}, because the sum of demand of Q_2, Q_9, Q_{10} is 2.5+2.7+3.4=8.6 tons, which is more than the maximum capacity of refrigerated trucks, so it gives up its Q_{10}, and chooses Q_8. The sum of demand of produce of these three demand points is 2.5+2.7+1.9=7.1 tons, which is less than 8 tons, so Q_8 can be used as the third demand point of the third route. The third distribution route is Q Q $Q_{0-2-9-8}$ Q.

Step 13: Determine the fourth distribution route. Since the above three routes already contain 9 demand points, the remaining 1 demand point Q_{10} is divided into a separate route. The fourth route is Q Q_{0-10}.

The optimal solution of C-W savings algorithm for the optimization of cold chain logistics and distribution of agricultural products in company Z is as follows:

First distribution path: Q_0 -Q_6 -Q_7 -Q_5

Second distribution path: Q_0 -Q_3 -Q_4 -Q_1

Third distribution path: Q_0 -Q_2 -Q_9 -Q_8

Fourth distribution path: Q_0 -Q_{10}

A total of 4 refrigerated trucks with a capacity of 8 tons are required.

Assuming that the rest of the factors, such as model, age, etc., are the same for each vehicle, the distribution scheme can have $4!$, a total of 24 permutations.

The distance and time for each distribution path and the cost of distribution for each path are shown in Tables 14 and15.

Table 14. Distances and Times for Each Distribution Route

trails	Transportation distance (kilometers)	Transportation time (hours)	Loading and unloading time (hours)	Vehicle load (tons)	Total time (hours)
Q0-Q6-Q7-Q5	44	1.47	2.47	7.4	3.94
Q0-Q3-Q4-Q1	56	1.86	2.1	6.3	3.96
Q0-Q2-Q9-Q8	44	1.47	2.37	7.1	3.84
Q0-Q10	9	0.3	1.13	3.4	1.43

Table 15. Distribution Costs by Path

trails	Fixed costs ($)	Transportation costs ($)	Cost of cargo damage (dollars)	Energy costs ($)	Total cost ($)
Q0-Q6-Q7-Q5	350	814	490.18	19.7	1673.88
Q0-Q3-Q4-Q1	350	882	404.01	19.8	1655.81
Q0-Q2-Q9-Q8	350	781	456.67	19.2	1606.87
Q0-Q10	350	76.5	86.82	7.15	520.47
synthesize	1400	2553.5	1437.68	65.85	5457.03

From Table15, the total cost for Company Z's distribution center to deliver to these 10 demand points at one time is $5457.03.

4. CONCLUSION

This paper analyzes the problem of distribution of Z company's logistics center, through the construction of the model and the application of algorithms to optimize the distribution path, shorten the distance of the distribution route, save the distribution cost, and reduce the cost of Z company has some significance. However, there are some shortcomings in the research of this paper, for the conditions of the argument is too idealized, in the actual distribution of the factors to be considered will be very complex, for this aspect is still to be strengthened with the research.

With the development of China's logistics and transportation traffic industry, the market competition is gradually increasing, and the trend of enterprises seeking more suitable transportation optimization routes that can reduce the cost of logistics and transportation and improve the competitiveness of the company is unstoppable. Using C-W saving algorithm we can solve the vehicle path problem and get a better distribution route. Using the improved optimized route for transportation is conducive to shortening the time and distance of logistics distribution and transportation, which can to a certain extent reduce the cost of fresh agricultural products consumed in the transportation and loss, improve the transport efficiency of the enterprise, and further improve the company's efficiency.

REFERENCES

[1] YUAN Xueguo, ZOU Ping, ZHU Jun,WU Di. Development situation, problems and countermeasures of cold chain logistics industry in China [J]. China Agricultural Science and Technology Herald, 2015, 17(01):7-14.

[2] Huang Xiaoxu. Problems and Legal Countermeasures in the Development of Cold Chain Logistics of Agricultural Products in China [J]. Grain, Oil and Food Science and Technology, 2022, 30(02):214-220.

[3] Luo Qianfeng. Theoretical interpretation and realization path of high-quality development of agricultural cold chain logistics [J]. China Circulation Economy, 2021, 35(11):3-11.

[4] Binod Kumar Sing, Saurav Negi. cold chain logistics: an impediment in the perisha ble food industryofIndia [J]. InternationalJournalof Logistics Economics and Globalisation.2019, 7(4):78-86.

[5] Wetherill, Marianna S; White, Kayla Castleberry. challenges and opportunities to increasing fruit and vegetable distribution through the US charitable feeding network: increasing food systems recovery of edible fresh produce to build healthy food access [J]. Journal of hunger & environmental nutrition. 2019, 14: 593-612.

[6] Wu Xiaoming, Yang Xinting. Joint optimization problem of inventory transportation in fresh produce distribution [J]. Computer Engineering and Design, 2016, 37(03):819-824.

[7] Wang H. Road saint optimization for fresh produce distribution based on road conditions [J]. Journal of System Simulation, 2019, 31(01);126- 135.

[8] Ji Juhai, Zhang Xuan. Optimization model and algorithm for fresh produce distribution road path considering pickup and delivery operations [J]. Journal of System Science, 2019, 27(01):130-135.

[9] KANG Kai, HAN Jie. Research on optimization of low-carbon distribution path of fresh agricultural products cold chain logistics [J]. Computer Engineering and Application, 2019, 55(02):259-265.

[10] SUN Zongjun. Fresh agricultural products distribution path design based on improved discrete particle swarm algorithm [J]. Logistics Science and Technology, 2020, 43(03):25-28.

[11] Zhou T. Research on multi-model and multi-category fresh produce distribution model considering multi-cost, Logistics Science and Technology, 2020, 43(02):28-33.

[12] NING Tao. Simulation study on cold chain logistics strategy for fresh agricultural products considering low-carbon constraints [J]. Journal of System Simulation, 2022, 34(04):797-805.

[13] Suraraksa, Juthathip, Shin, Kwang Sup. Urban Transportation Network Design for FresnFruit and Vegetables Using GIS The Case of Bangkok [J]. Applied Sciences-basel.2019, 9(23):508.

[14] Wang Yong. Optimization of the delivery route for community group-purchasing fresh products considering customer satisfaction [J]. Optimization of the delivery route for community group-purchasing fresh products considering customer satisfaction [J].