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Research and Implementation of Cloud Intelligent Scheduling and Resource Optimization Algorithm for Tobacco Business Processes

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SUMMARY: *The modernization of logistics and distribution has promoted the efficiency improvement of tobacco inventory scheduling. This study provides data reference for intelligent transportation scheduling by establishing a real-time tobacco delivery model, comprehensively considering the tobacco inventory in each period, and calculating a more accurate real-time delivery demand. A single source point non-full load type time-limited distribution model is constructed, and the optimal path selection of transportation vehicles is abstracted as a vehicle total distance minimization solving problem. The C-W savings solving algorithm is introduced, combined with the soft time window cost calculation of each vehicle waiting, to correct the cost saving value and determine the optimal scheduling route. After the optimization of C-W saving solution algorithm, the shortest path between demand points can be shortened to about 35.64km, and the saving value is improved to more than 100, which can reasonably make full use of the transportation resources to complete the real-time distribution of tobacco.*

KEYWORDS: *tobacco inventory scheduling; real-time placement; time-limited distribution; C-W savings algorithm; soft time window*

1 Introduction

With the deepening of the reform of China's tobacco industry, the development of the industry has entered an important period of strategic opportunity and adjustment [1, 2]. Tobacco industry is faced with international and social pressure and challenges in many aspects, cloud-based intelligent scheduling and resource optimization for tobacco business processes is the situation requirements for the development of logistics construction work in the cigarette industry, and is also an inevitable means of building a modern logistics system for the industry [3-6].

China's tobacco industry is a relatively special industry, on the one hand, due to China's implementation of the tobacco monopoly system, the Tobacco Monopoly Bureau, China Tobacco Corporation has the nature of the government and enterprises, in the monopoly system

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to implement the “unified leadership, vertical management, monopoly management,” in a kind of administrative restriction of monopoly status [7-10]. On the other hand, the unified organization of production and deployment is the characteristics of the tobacco industry, and the production of industrial enterprises and the sales of commercial enterprises within the industry are subject to the dual influence of planning and market [11-13]. The characteristics of this monopoly franchise of the tobacco industry determines the “franchise” characteristics of the tobacco industry information technology construction, but also makes the tobacco industry information technology construction has different characteristics from other industries [14-16]. At the same time, as the tobacco industry “reorganization, integration” continues to deepen, will inevitably lead to the integration of tobacco information technology [17, 18]. Therefore, under such a development trend, the intelligent scheduling and resource optimization of tobacco enterprises' business processes in the cloud will be the demand for personalized development and rapid adjustment of enterprises, and become an effective tool for enterprises to improve their competitiveness and obtain a broad space for development [19-22].

In this study, under the premise of setting reasonable maximum and minimum tobacco stock-to-sale ratios, we construct a tobacco real-time placement model and a single-source-point non-full-load type time-limited distribution model to solve for the minimum total distance traveled and the maximum cost saving value of tobacco scheduling and distribution, and to maintain benign changes in the tobacco inventory. Select the C-W savings solving algorithm for rational planning of optimal tobacco distribution routes for multi-companies and multi-vehicles. The delayed volume interaction and time effect cost of each vehicle arriving at the same location are calculated to ensure that the optimal distribution route obtains the maximum cost saving value, improves the on-time delivery rate and avoids the ineffective waste of distribution resources.

2 Tobacco business cloud scheduling and optimal route selection

2.1 Online dispensing model for tobacco business

2.1.1 Theoretical analysis of inventory-sales ratio

Inventory-sales ratio is an important parameter in commercial and industrial cigarette delivery, which is more often used in inventory early warning and real-time delivery models. The specific meaning is: in a certain time frame or a cycle, the ratio of the inventory of the commercial company to the average daily sales. The formula is notated as:

$$\text{Stock-to-Sales Ratio} = \frac{\text{Commercial Inventory}}{\dfrac{\left(\sum_{i=1}^{m} \text{Sales Volume}_i\right)}{m}} \tag{1}$$

In the tobacco industry, the inventory and sales ratio can be divided into the highest inventory and sales ratio and the lowest inventory and sales ratio, according to the highest inventory and sales ratio can determine the maximum value of the commercial inventory of cigarettes, the industrial company is based on the highest inventory and sales ratio to the commercial company to replenish the supply of goods, the value of the setting can prevent the phenomenon of the commercial inventory backlog occurs. The minimum stock-to-sale ratio can determine the warning line of commercial inventory, to prevent the occurrence of inventory breaks. Among them, the maximum stock-to-sale ratio $R_{\max}$ is calculated by the formula:

$$R_{\max} = R_{\min} + \text{Number of days in the campaign cycle} \tag{2}$$

The minimum stock-to-sale ratio $R_{\min}$ is calculated as:

$$R_{\min} = \text{Delivery cycle} + \text{commercial"inbound to delivery"cycle} \tag{3}$$

In the actual online distribution, only a reasonable setting of the commercial maximum stock-to-sale ratio and minimum stock-to-sale ratio can ensure that the commercial inventory of cigarettes neither breaks down nor backlogs up, and normally meets the changes in market demand.

2.1.2 Business processes

Since the tobacco commercial company does not have a professional logistics and transportation department, it still belongs to the third-party transportation in the mode of cargo transportation, i.e., by signing an agreement with a third-party transportation company, letting the third-party professional logistics company complete the cloud-based intelligent scheduling of the transportation of tobacco inventory and reduce the loss of resources in the transportation process as much as possible. This benefit allows corporate personnel to focus on the company's other core business, in terms of long-term operation, can reduce the overall cost of transportation of the enterprise. Tobacco commercial companies online distribution of the main business process is: according to commercial sales data and inventory information, using the set parameters of the stock-to-sales ratio, using online distribution mode, reasonable arrangements for commercial inventory, under normal circumstances, generally using real-time distribution mechanism to supplement the sales of commercial inventory, emergency replenishment of online distribution of auxiliary methods, which belongs to the special replenishment, only when the commercial inventory appears red warning mechanism will start emergency replenishment to It is a special replenishment method, only when there is a red warning mechanism for commercial inventory will the emergency replenishment method be activated to meet the sales of commercial inventory in the fastest time. Figure 1 shows the real-time placement and distribution process of tobacco.

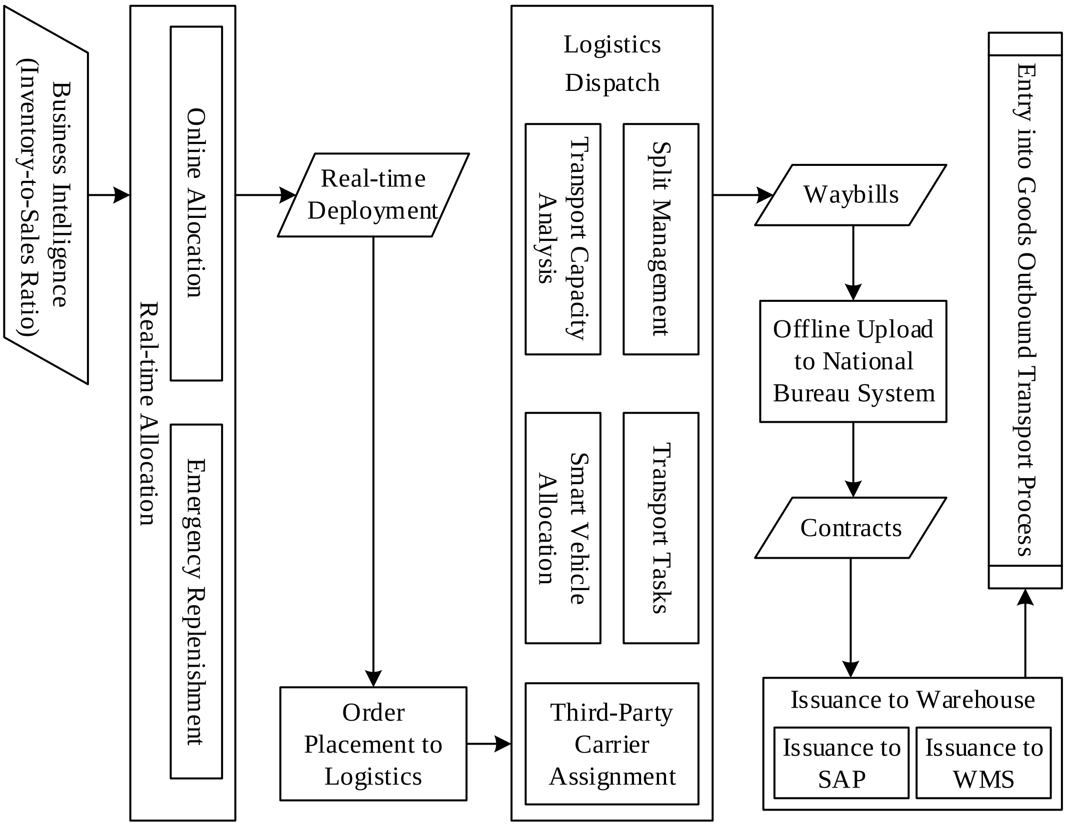


Figure 1: Real-time Tobacco Distribution Process

2.1.3 Real-time delivery model

1) Model Establishment

There are many factors to be considered for the establishment of real-time placement model, including the accuracy and timeliness of sales data, the distribution capability of the third-party transportation company, the arrival time requirements and many other aspects. Based on the above factors, in order to develop an accurate, reliable and timely production plan, the planner of an industrial company must go ahead to obtain commercial sales data. At present, there are two ways to obtain commercial data, one is the industrial sales area personnel to count the commercial company's sales data every day to fill in the report form, faxed to the business planner for manual summary. Secondly, according to the interface between the industrial and commercial systems to form a business docking, industrial companies can be timely access to commercial sales data through the marketing system. Taking into account the operational flexibility of the business, the tobacco commercial companies are currently using these two ways.

Based on the actual data and the business management style of the tobacco commercial company, a real-time placement model can be established: so that the current date is T, and the average daily sales of the commercial Q_s and the current inventory S_0 are known under the premise of calculating the commercial company's inventory after N days S_N of the model is:

$$S_N = S_0 + \sum_{i=1}^{N-1} C_i - N \times Q_s \tag{4}$$

The meaning of the above formula is that the value of the commercial company's inventory S_N can be calculated according to the known conditions after the current calculation date T is pushed back N days. That is, S_N is equal to the current inventory of the business plus the total supply in N days, and then subtract the total sales in N days. The actual replenishment after N days is determined from the formula S_N and the set maximum stock-to-sale ratio R_h, i.e., $R_h \times Q_s - S_N$.

2) Average Daily Sales Determination

The average daily sales volume is actually a forecast value, which is determined based on a comparative analysis between the historical launch dates between the commercial and industrial sectors and the base date. According to the market demand change formula $Q_{d_i} = f(P)$ analysis that, if the formula in the parameter factor did not change, the results of its calculation will basically not change. Taking the base date as the standard to push equal time intervals forward and backward respectively, the average daily sales before the base date can be calculated based on the commercial history data. Since the difference in time intervals is not very big, the average daily sales value can be recorded as the forecast average daily sales value.

In the actual calculation, we take the current time as a benchmark, and push forward four consecutive weeks as a time period, we can respectively find out the average daily sales of the period Q_i, and then weighted combination of each of its value processing, which can give a more accurate average daily sales forecast Q_s:

$$Q_s = \sum_{i=1}^{n} W_i \times Q_i \tag{5}$$

where W_i is the weighted average of the previous i weeks.

3) Beginning and ending inventory determination

Under the premise of the average daily sales are known, to calculate the industrial company to the commercial company's daily supply, but also need to determine the two inventory parameters, that is, commercial supply before the beginning of the inventory and supply after the end of the inventory. In the time period from the current time to the forecast date, if the industrial company has supplies, the shipments made during this period must be added to the calculation of the commercial's inventory for the day. In line with the reality of the tobacco commercial company's business, shipments prior to the forecast date are available in real time in the business system and can appear as a known condition. This allows the value of the commercial company's inventory for each day to be found according to the known conditions and the forecasted daily inventory Q_s:

$$S_i = S_b - i \times Q_s + C_i \tag{6}$$

The meaning is: i day's inventory is equal to the base inventory S_b minus i days' total sales plus i days' supply. Where S_b can be used as the starting inventory in the model. Considering that the forecast date and the delivery date are not the same day, we need to determine two end-of-period inventories. One is the maximum inventory after delivery where the two times coincide, and the other is the projected inventory where the two times are different.

The former inventory is calculated by the formula:

$$S_c = R_h \times Q_s \tag{7}$$

The latter inventory is calculated by the formula:

$$S_i = S_b - i \times Q_s + C_i \tag{8}$$

When $S_i < R_l \times Q_s$, (R_l denotes the minimum stock-to-sale ratio) it means that there is an early warning mechanism for the commercial inventory, and the emergency replenishment method needs to be turned on.

4) Real-time delivery volume determination

Through the relevant parameters determined above can be calculated by the following formula tobacco commercial company's supply volume:

$$\begin{aligned} S_i &= R_h \times Q_s + n \times Q_s - S_b - \sum_{i=1}^{n-1} C_i \\ &= \left(R_h + n\right) \times \sum_{i=1}^{m} W_i \times Q_i - S_b - \sum_{i=1}^{n-1} C_i \end{aligned} \tag{9}$$

Formula (9) calculates the quantity supplied for all cigarette sizes. There are two ways to trigger the formula for supply quantity calculation in online dispensing. One is the launch date is equal to the forecast date, the second is the commercial inventory forecast value reached below the minimum stock-to-sales ratio, although the two calculation of the supply quantity is the same way, but the degree of urgency of its supply is different. The latter degree of urgency is higher, this situation if you can not supply in a timely manner, the commercial company's sales warehouse will be a serious out-of-stock phenomenon. Therefore, must be in accordance with the amount of supply for timely replenishment, this replenishment we call emergency replenishment. If this phenomenon occurs frequently, it means that the commercial warehouse's maximum stock-to-sales ratio is set too low and needs to be adjusted upwards. In order to better respond to the dynamic changes in the market, tobacco commercial companies in the online distribution link at the same time in the use of normal distribution and emergency replenishment of two ways.

2.2 Cloud Intelligent Scheduling and Resource Optimization Algorithm

2.2.1 Single-source-point, non-full-load, time-limited distribution

This type of distribution business can be described as the distribution of cigarettes from a certain shipping warehouse to multiple commercial companies, with certain constraints that require rational vehicle scheduling to minimize the distribution cost. Then, this problem can be abstracted as a vehicle path selection problem from a source to multiple endpoints sequentially, and each endpoint is located in the customer can only visit once. The constraints to be satisfied by this model are shown below:

1) Each customer is served only once.

2) The distance traveled by each delivery vehicle is not less than the total distance of its formal path.

3) Carpooling can occur, i.e., multiple contracts are delivered by a single vehicle.

4) Finished cigarettes must be delivered within the time period specified by the commercial company.

Instructions for setting the basic parameters:

Assume that there is a total of K vehicle available for distribution, there are N commercial customer distribution targets, the customer point is set to be $v_1, v_2, \cdots, v_n$, the total distance traveled is S, the total distance traveled by each vehicle is D_i, the maximum load per vehicle is W_i, the longest distance traveled is L_i, Q_{ij} denotes the amount of contractual orders for vehicle i to customer j, and l_i denotes the number of customers vehicle i is responsible for transporting. $d_{i(j-1)j}$ denotes the distance between the $j-1$th customer and the jth customer visited sequentially by the traveling route of the ith vehicle and the distance between the l_ith customer in the loop corresponding to that vehicle and the source point v_0 is denoted by d_{i0}. C_i denotes the set of paths of the ith vehicle, and its set is the individual path points, which are denoted by C_{ij}, and their values are taken in $\{v_1, v_2, \cdots, v_n\}$.

Based on the above assumptions, then the following mathematical model can be established:

$$\min S = \sum_{i=1}^{K} \left[\sum_{j=1}^{l_i} d_{i(j-1)j} + d_{i0} \cdot sign(l_i) \right] \tag{10}$$

Equation (10) is the objective function, i.e., to find the minimum value of the total distance traveled by all vehicles that complete the transportation task. According to the previous business description and constraints can be obtained to find this objective function of the constraint model has:

$$N \le m \tag{11}$$

$$\sum_{j=1}^{l_i} Q_{ij} \le W_i \tag{12}$$

$$D_i \le L_i \tag{13}$$

$$1 \le l_i \le N \tag{14}$$

$$\sum_{i=1}^{K} l_i = N \tag{15}$$

$$c_i = \left\{ c_{ij} \left| c_{ij} \in \{v_1, v_2, \cdots, v_n\}, j = 1, 2, \cdots, l_i \right. \right\} \tag{16}$$

$$c_i \cap c_j = \varnothing, \forall i \ne j \tag{17}$$

$$sign(l_i) = \begin{cases} 1 & l \ge 1 \\ 0 & \text{Other} \end{cases} \tag{18}$$

Equation Description:

Equation (11) indicates that the number of vehicles is less than the number of customer points; therefore, one vehicle generally serves more than one customer point.

Equation (12) indicates that the total amount of customer demand for all orders on the vehicle's load must not exceed the vehicle's total load in order to avoid overloading the vehicle.

Equation (13) indicates that the total number of miles traveled by a vehicle must not exceed the maximum mileage for that vehicle.

Equation (14) indicates that the number of customers visited by each vehicle must neither exceed the total number of customers nor be without customers.

Equation (15) indicates that the sum of the number of customers visited by all vehicles is exactly the total number of customers, i.e., it satisfies that there are neither duplicate service customers nor default customers.

Equation (16) indicates that the loop path points of each vehicle are all customer points.

Equation (17) indicates that the loop path points of each vehicle cannot intersect, that is, it satisfies that each customer can only be served by one vehicle at the same time.

Equation (18) indicates whether a vehicle is involved in this logistics and distribution activity.

The above model meets the business requirements of vehicle non-full load distribution, conforms to the business constraints of tobacco distribution, and takes mileage as the main solution objective, and its solution method will be elaborated in the following section using the C-W savings solution algorithm.

2.2.2 Solution steps of the C-W conservation solution algorithm

1) Description of relevant parameters

From the principle of the C-W savings solving algorithm, if c_{0i}, c_{j0}, c_{ij} denote the cost of a vehicle traveling between points $0-i$, $j-0$, and $i-j$, the value of the cost savings for point i and point j connecting on a line is:

$$s(i,j)=c_{0i}+c_{j0}-c_{ij} \tag{19}$$

The soft time window problem requires the tasks to be completed within a certain time frame, and when connecting points i and j by the cost saving value $s(i,j)$, it may cause the execution of the tasks behind j to not meet the time requirement. When connecting the line where point i and point j are located, if the vehicle arrives at point j earlier than the start time of the task at point j on the original line, there is a possibility that the vehicle may have to wait at the task behind j; if the time of arriving at point j after the connection is delayed compared to the start time of the task at point j on the original line, there may be delays in executing the task behind j.

Taking EF_j to denote the amount of delay in the arrival time of the vehicle at point j after connecting the line where point i and point j are located compared to the arrival time of the vehicle at point j on the original line, EF_j can be obtained as follows:

$$EF_j = s_i + t_{ij} + T_i - s_j \tag{20}$$

where s_i represents the time when the vehicle arrives at point i; t_{ij} represents the time when the vehicle goes from point i to point j; and T_i represents the time when the task i is completed. When $EF_j < 0$, the time for the vehicle to reach the task at point j is advanced; when $EF_j = 0$, the vehicle arrival time is unchanged; and when $EF_j > 0$, the arrival time is delayed.

Therefore, according to the VRP model developed in this thesis, the savings value is calculated by the following formula:

$$s(i,j)=(C_{0k}+C_{1k}d_{0i})+(C_{0k}+C_{1k}d_{j0})-(C_{0k}+C_{1k}d_{ij}) \tag{21}$$

From the above equation:

$$s(i,j)=C_{0k}+C_{1k}\left(d_{0i}+d_{j0}-d_{ij}\right) \tag{22}$$

Since there is usually no customer complete refusal in tobacco logistics, this paper considers the soft time window problem, i.e., vehicles are allowed to wait at the task or the task is delayed to proceed, but the time effect cost is to be counted, so it is necessary to correct the above cost saving value of $s(i,j)$ to obtain the cost saving value of the soft time window VRP problem as follows:

$$s(i,j)=s(i,j)-c_1\sum D_r-c_2\sum E_r \tag{23}$$

where D_r is the waiting time of the vehicle at task r behind j when connecting the line where point i and point j are located; and E_r is the delay time for task r to start execution. D_r and E_r can be obtained from the following equations, respectively:

$$D_r=\max\left\{ET_r-\left(s_r+EF_j\right),0\right\} \tag{24}$$

$$E_r=\max\left\{\left(s_r+EF_j\right)-LT_r,0\right\} \tag{25}$$

When considering the line connecting the point i and the point j on which it is located, it is necessary to check whether the time window constraint is violated.

Δ_j^-: the maximum advance that can be made in the arrival time of point j for which the vehicle does not have to wait at any of the tasks behind point j on the line;

Δ_j^+: the maximum allowable delay in the arrival time of point j at which no task behind point j on the line violates the time window constraint.

When $EF_j<0$, if there is $|EF_j|\le\Delta_j^-$, the vehicle does not need to wait at the task behind point j, otherwise, it has to wait; when $EF_j>0$, if there is $EF_j\le\Delta_j^+$, the execution of the task behind point j will not be delayed, otherwise, it has to be delayed to proceed.

2) Implementation of the solution steps

The specific solution steps of the $C-W$ conservation solution algorithm are as follows:

Step1: Calculate the savings value $s(i,j)$ such that $M=\left\{s(i,j)\middle|s(i,j)>0\right\}$;

Step2: Arrange in M in order of $s(i,j)$ from largest to smallest;

Step3: Terminate if $M=\varnothing$, otherwise for the first item $s(i,j)$, examine the corresponding $s(i,j)$ if one of the following conditions is satisfied:

1) Neither point i nor point j is on a constituted line;

2) Point i or point j is on a line that has been constituted, but is not an interior point on the line (i.e., it is not connected to a distribution center);

3) Point i and point j are on different lines that have been constituted, neither is an

interior point, and one is the starting point and one is the ending point, then go to the next step, otherwise go to Step7;

Step4: Examine the total freight volume Q on the line after point i and point j are connected, if $Q \le q$, then go to the next step, otherwise go to Step7;

Step5: Calculate EF_j

(a) If $EF_j = 0$, go to Step6;

(b) If $EF_j < 0$, compute Δ_j^-, $\left|EF_j\right| \le \Delta_j^-$, then go to Step6, otherwise go to Step7;

(c) If $EF_j > 0$, compute Δ_j^+, $EF_j \le \Delta_j^+$, then go to Step6, otherwise go to Step7;

Step6: Connect point i and point j, calculate the new time for the vehicle to reach each task, turn to Step7;

Step7: make $M := M - s(i, j)$, turn to Step3.

3 Application of C-W savings solving algorithm in tobacco distribution path optimization

3.1 Algorithm performance comparison

3.1.1 Comparison of algorithm performance when K, N, and V parameters are varied

Since the constructed single source point non-full load type time-limited distribution model involves multiple parameters, the settings of these parameters are related to the solution performance of the C-W conservation solution algorithm, this section investigates the impact of different parameter settings on the algorithm through performance comparison experiments.

The three parameters K, N and V represent the number of distribution vehicles, the number of distribution target customers and customer points, which belong to the basic parameters and determine how many resources the third-party distribution company has to meet the inventory scheduling needs of the tobacco commercial company. We study the influence of K, N, and V on the algorithm to solve the optimal path when they become larger and larger. Set K(10~20), N(9~15), V(12~18), and the rest of the parameters are fixed. Variable Neighborhood Search Algorithm (VNS), Local Search Algorithm (LS), and Simulated Annealing Algorithm (SA) are selected as the comparison algorithms to solve the optimal paths along with the C-W frugal solver algorithm.

Fig. 2 shows the distribution resource utilization of the four algorithms as the K, N, and V parameters become larger. Under the premise that the 3 basic parameters are getting larger and more and more scheduling data, the resource utilization rate of C-W conservation solving algorithm reaches 89.485% to 97.047%, which is at a high level. Compared with other algorithms' resource utilization rate of less than 85%, the C-W conservation solving algorithm is able to consider the overall situation between each vehicle and the target customers and customer points well and reduce the resource consumption.

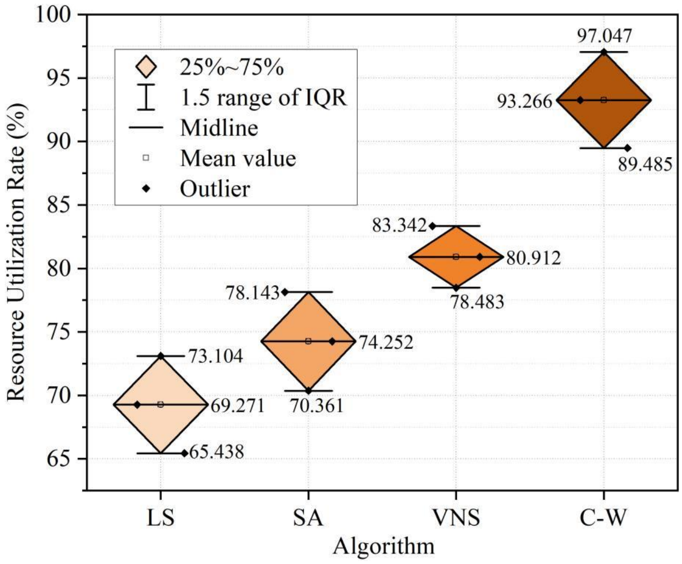


Figure 2: Resource utilization rate of the algorithm when the parameters increase

3.1.2 Comparison of algorithm performance when S, D, W, and L parameters are varied

S is the total distance traveled, D is the total distance traveled by each vehicle, W is the maximum load of each vehicle, and L is the longest distance traveled by each vehicle. Set S and D to 2000~3000km and 200~300km respectively, and W and L to 150kg~300kg and 50km~100km. the rest of the parameters are fixed. Fig. 3 shows the comparison of resource utilization of the four algorithms when S and D are varied. Figure 4 shows the comparison of resource utilization of the 4 algorithms when W and L are varied.When the distance between S and D is prolonged, the resource utilization of the C-W conservation solver algorithm is as high as 90.265% to 99.961%. And when W and D vary, the resource utilization of the results solved by the four algorithms decreases, and the highest resource utilization of the C-W conservation solving algorithm only reaches 81.452%~88.726%, and the resource utilization of the rest of the algorithms is even lower.

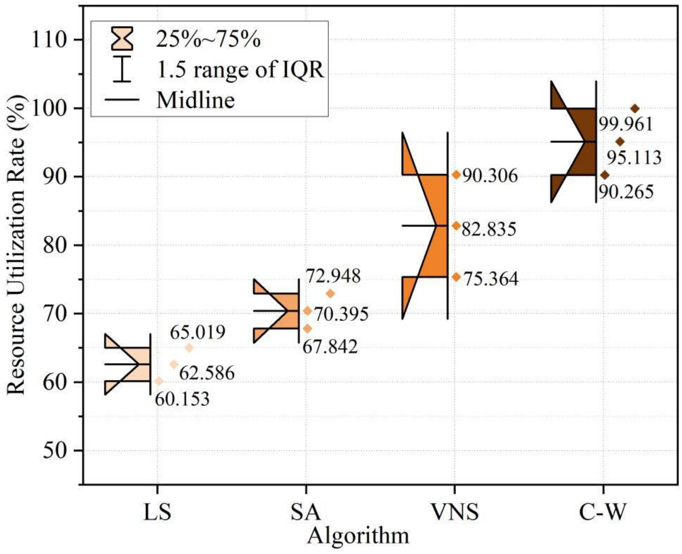


Figure 3: Resource utilization among 4 algorithms of changed S and D

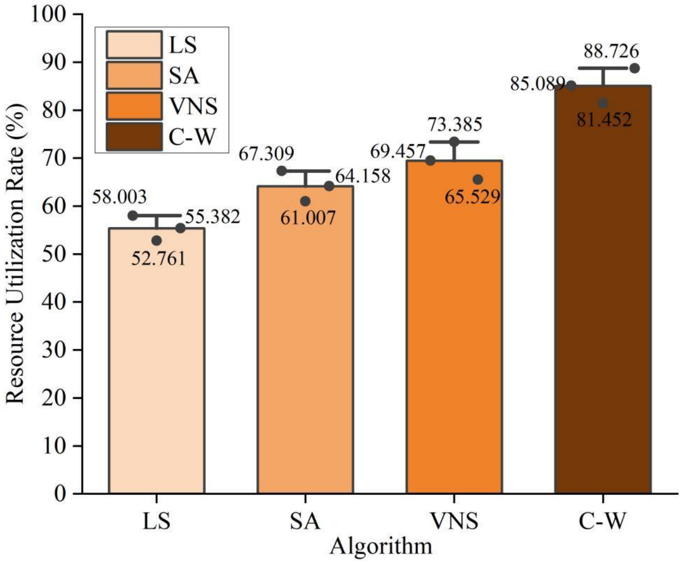
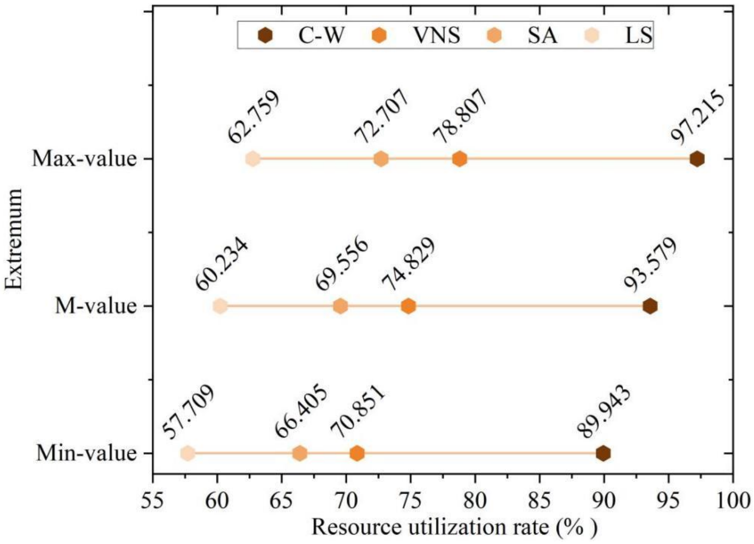


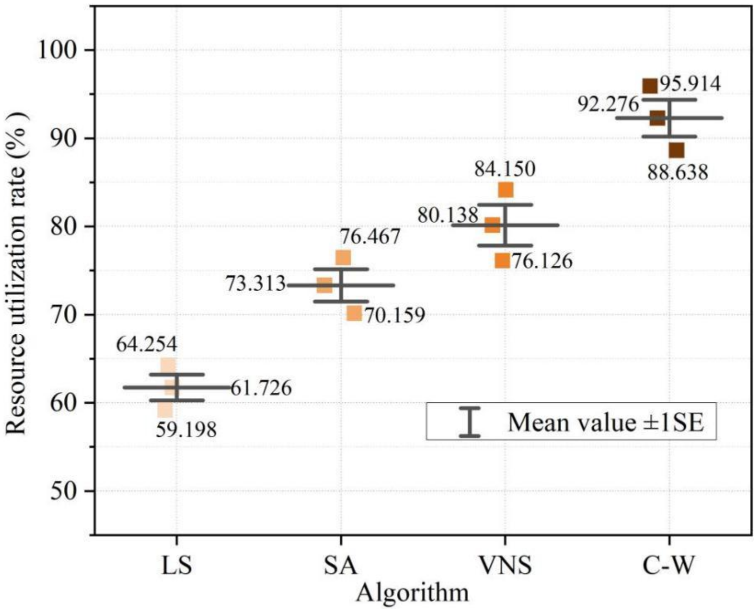
Figure 4: Resource utilization among 4 algorithms of changed W and L

3.1.3 Comparison of algorithm performance when the remaining parameters are varied

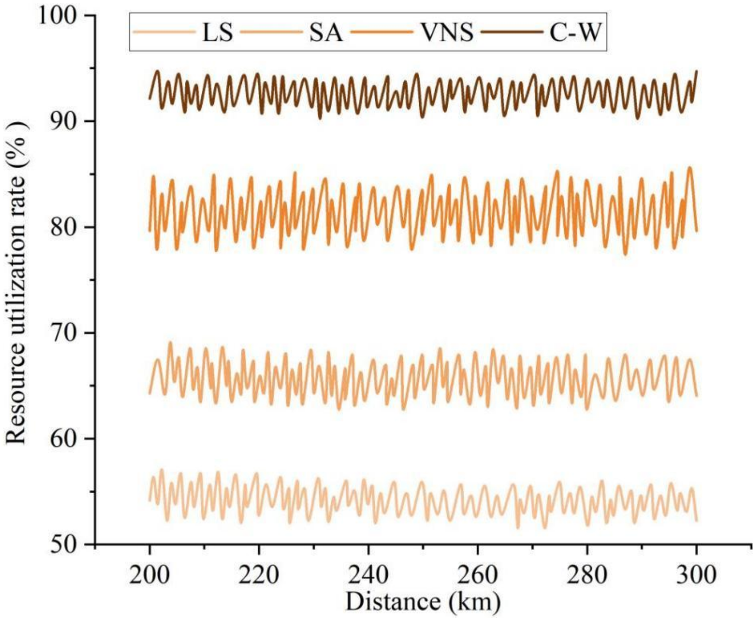
The remaining parameters, such as Q (contracted order quantity of vehicle i for customer j), l (number of customers that vehicle i is responsible for carrying), and d (distance between customer and customer, and between customer and source), are also taken to be increasing to study the resource utilization of the results of the four algorithms' solutions. Fig. 5 shows the comparison of the resource utilization of the 4 algorithms' solutions when the remaining parameters are fluctuating. When the fluctuation of the remaining three parameters increases, the resource utilization rate of the solution results of the C-W conservation solver algorithm is at a high level, the maximum reaches 97.215%, and the minimum is also 88.638%, which is significantly better than the other algorithms.



(a) Q increases



(b) l increases



(c) d increases

Figure 5: Algorithm resource utilization when other parameters change

3.2 C-W based tobacco distribution path optimization practice

3.2.1 Calculation of the shortest distance to the point of demand

The proposed scheduling and distribution method is applied to the optimization of tobacco distribution paths in Transportation Company A. The C-W savings solving algorithm is used to calculate the savings value for reducing each tobacco demand point. Figure 6 shows the shortest distances of the eight tobacco demand points before optimization.The shortest distances between the eight demand points range from 41.38 to 61.39km. The shortest distance is from demand point 6 to demand point 4 and the longest is from demand point 7 to demand point 2.

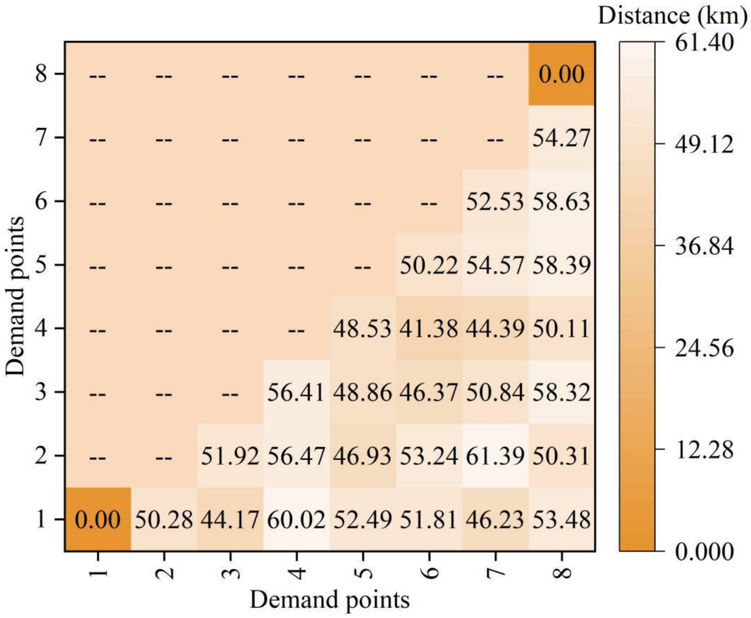


Figure 6: Shortest distance of the 8 tobacco demand points

3.2.2 Initial savings at each demand point

Based on the distance of each demand point, the initial savings value for each demand point is solved using the C-W savings solving algorithm. Figure 7 shows the initial savings value of each demand point. The initial saving value of each demand point is small, the highest is only 98.11, not more than 100, and the lowest is only 60.06, there is a large optimization space.

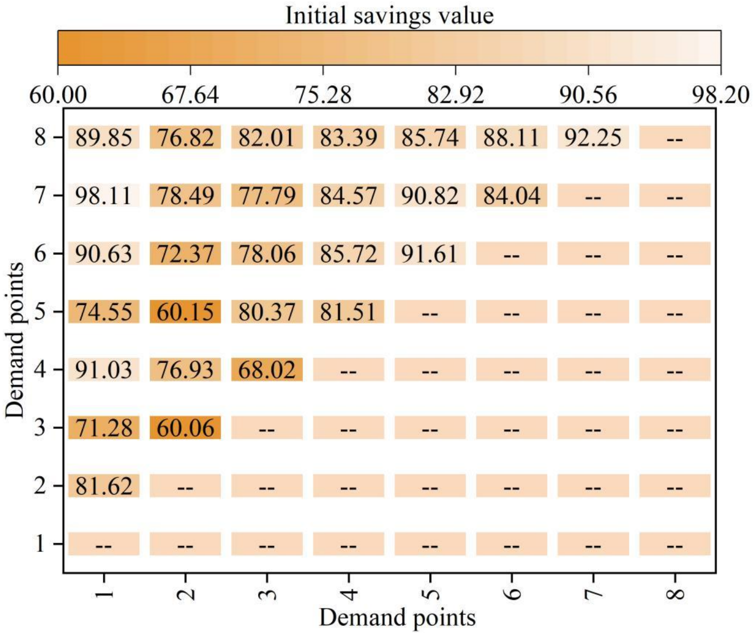


Figure 7: Initial savings at each demand point

3.2.3 Shortest path and modified demand point savings solution

Further considering the cost of time effects such as soft time windows, the C-W savings solving algorithm is utilized to find the shortest paths between the eight demand points and the modified demand point savings are calculated.

Table 1 shows the shortest paths between demand points obtained by the optimization solution. It can be seen that the distance between the demand points in the shortest path obtained by the optimized solution is reduced from the previous one. The distance between point-to-point can be shortened by less than 40km, and the shortest distance is only 35.64km (demand point 1 to demand point 7). Figure 8 shows the corrected demand point savings values. The savings value of each demand point after correction improves to more than 100 and reaches up to 126.28.

Using the C-W savings solving algorithm to comprehensively consider the waiting time between each vehicle can more reasonably complete the transportation vehicle scheduling and reduce resource consumption.

Table 1: Shortest path between optimized demand points (km)

	1	2	3	4	5	6	7	8
1	0	46.17	40.22	57.15	49.27	47.24	**35.64**	48.21
2	46.17	0	**39.36**	53.07	45.61	49.12	55.38	43.27
3	40.22	**39.36**	0	51.22	43.24	40.36	43.41	52.13
4	57.15	53.07	51.22	0	42.17	**38.27**	40.17	49.26
5	49.27	45.61	43.24	42.17	0	47.13	53.22	53.73
6	47.24	49.12	40.36	**38.27**	47.13	0	49.16	49.84
7	**35.64**	55.38	43.41	40.17	53.22	49.16	0	50.51
8	48.21	43.27	52.13	49.26	53.73	49.84	50.51	0

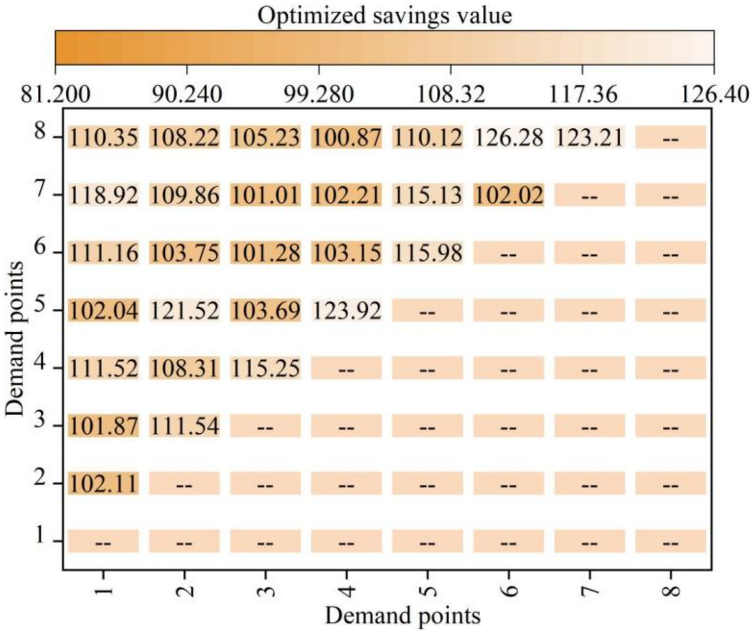


Figure 8: The savings in demand points after correction

4 Conclusion

In this paper, the C-W savings solving algorithm is used to optimize the tobacco distribution path and improve the cost savings value. When multiple parameters of the model are varied, the resource utilization rate of the algorithm's solution result is always the highest among the four compared algorithms, and can even reach 99.961%. In the actual transportation and distribution path optimization, the shortest path between demand points calculated by the C-W savings solver algorithm is only 35.64km, while the highest cost savings value can reach 126.28.

The optimization result of C-W saving solution algorithm can not only reduce the transportation cost, but also ensure the timely scheduling of tobacco inventory, quickly respond to market demand, and improve the market reputation of the company's goods.

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