Research on Logistics Distribution Routes Optimization Based on the Saving Algorithm

Tongji Yang and Yajing Chang*

Liaoning Technical University, Huludao, China

*2877495266@qq.com

Abstract. In order to improve the distribution efficiency and reduce the distribution cost of J Express Company, this paper optimizes its distribution route based on the Saving Algorithm. The current reliance on manual experience to plan the route of J Company leads to a low vehicle loading rate and insufficient mileage utilization, resulting in a significant waste of transportation resources. By calculating the route saving values of 13 outlets and merging the high-efficiency nodes, the distribution scheme is reconstructed under the constraints of vehicle loading and one-way mileage. The results show that the optimized vehicle configuration is streamlined from 4 to 2, the total mileage is reduced by 4. 5km, and the average loading rate is increased by 27. 87%, which significantly improves the loading rate and mileage utilization rate, and provides a scientific basis for the enterprise to reduce costs and increase efficiency.

Keywords: Saving Algorithm; Route Optimization; Vehicle Routing Planning; Express Companies; Logistics Distribution.

1 Introduction

In 2024,China's express delivery volume reached 174.5 billion pieces,an increase of 21% year-on-year,the growing volume of express delivery has brought many challenges to the end of delivery process,vehicle distribution optimization has become the core of the express logistics enterprises to reduce costs and increase efficiency breakthroughs.Previous scholars in the distribution route optimization has been a certain research.1964,Clarke and Wright first proposed Saving Algorithm,through the calculation of savings between the nodes to prioritize the merger of high-efficiency routes[1].Empirical studies confirm its significant cost-reduction and efficiency gains in express delivery:①loading rate increase:such as Wang,Z.L. et al. through the regional redistribution of the loading rate by 36.46%[2],Zhang,R.Z. et al. achieve vehicle utilization rate of 95.72%[3];②mileage and cost compression:Li,B.M. successfully solves the problem of high cost in Yizhou City[4],Wang,Y.H. et al. achieve the reduction of transportation cost and route shortening of 23.08%[5];③adaptability to complex scenarios:Zhang,Y.M. combines with the clustering analysis method to enhance the applicability of the model to complex environments[6].Reconfiguring the distribution routes

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based on this algorithm can systematically increase the loading rate, shorten the mileage and reduce the logistics cost.

2 Current Overview of J Company

2.1 Status of Company J's Distribution Routes

J Express Company only distributes expresses for the J&T Express network points and the Cainiao Stations with which J&T has cooperation in the urban area of Fuxin City with a radius of no more than 5 kilometres,as shown in Fig. 1,there are 13 distribution outlets,with point P representing J Express Company,and P1 to P13 representing the distribution outlets.

J Express Company existing rated load of 400kg and 700kg express delivery vehicle each 2,in the express light weight, small volume and uniform distribution of the case,the rated load of 400kg express car can be loaded up to 500 pieces of express,rated load of 700kg express car can be loaded up to 1000 pieces of express.In order to reduce distribution costs,the company stipulates that the mileage of each vehicle for a single delivery shall not exceed 15 kilometres.

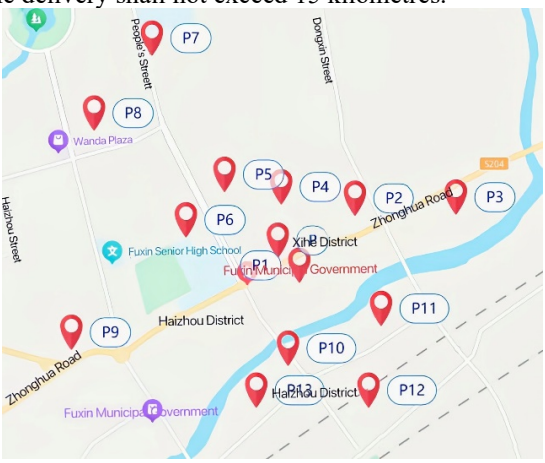

Fig. 1. Geographic location of J Company and 13 distribution outlets

Table 1. Existing distribution route programmes

Serical number	Distribution route	Total number of express deliveries/pieces	Mileage/km	Distribution vehicles/kg	Vechicle load factor
Route1	$P \rightarrow P_1 \rightarrow P_2 \rightarrow P_3 \rightarrow P$	380	5.4	400	76%
Route2	$P \rightarrow P_4 \rightarrow P_5 \rightarrow P_6 \rightarrow P$	530	3.9	700	53%
Route3	$P \rightarrow P_7 \rightarrow P_8 \rightarrow P_9 \rightarrow P$	400	10.6	400	80%
Route4	$P \rightarrow P_{10} \rightarrow P_{11} \rightarrow P_{12} \rightarrow P_{13} \rightarrow P$	585	8	700	58.5%

At present,J Express Company does not have a fixed distribution route,distributors are based on their own experience to choose the distribution route,through the field

survey,to get the 13 outlets of the most commonly used distribution route programmes such as the table 1.

2.2 Problems with Distribution Routes

J Express company distribution route there are two core problems:low vehicle loading rate(700kg car loading rate of only53%,400kg car76%)resulting in idle capacity,cost escalation;route planning is unscientific,relying on experience to choose the route,the maximum mileage of a single delivery is only 10.6km(far below the 15km limit),not combined with neighbouring outlets,resulting in frequent vehicle round-trip warehouse mileage utilization is insufficient,the waste of transport resources is serious.

3 Express Delivery Routes Optimization Based on Saving Algorithm

3.1 Study Object and Data

Thirteen express outlets located in or around residential neighbourhoods were selected for this study.These outlets have a relatively stable customer base,their average daily express handling volume fluctuates less(except during large-scale promotional activities of e-commerce),and most of the parcels are small in size and light in weight. Through field visits and surveys of outlets,the specific location of each outlet and its daily Express demand are detailed in Table 2.

Table 2. Locations and their daily express volumes

Serial number	Branch	Daily express volume/piece
P_1	Cainiao Station (Chang'an District Store)	180
P_2	J&T Express (Northern Garden Shop)	110
P_3	J&T Express(Fuxin Yipin Shop)	90
P_4	J&T Express (Furong Lane Shop)	170
P_5	Tuxi Express Supermarket (Haixin International Store)	160
P_6	Cainiao Station (Liaotong University Store)	200
P_7	J&T Neighbourhood (Greenland - Cambridge)	150
P_8	J&T Express (Rhine Town Store)	155
P_9	J&T Express (Healthy Street Shop)	95
P_{10}	J&T Express (Wuzhou Royal Garden Shop)	170
P_{11}	J&T Express (Haihe District Store)	140
P_{12}	J&T Express (Hai Tai District Station)	145
P_{13}	J&T Express (Mangrove 3rd Street Store)	130

The distance between the outlets,as well as the distance from the distribution centre of J Express Company to each outlet,are obtained through the navigation function of Gaode Map,and the relevant data are shown in Table 3.

Table 3. Distance between J Company and outlets and distance between outlets

P													
0.4	P_1												
1.2	1.3	P_2											
2.2	2.3	1.5	P_3										
0.7	1.1	1	2.4	P_4									
1.1	1.5	1.9	3.2	0.9	P_5								
1.4	1.8	2.3	3.6	1.3	0.9	P_6							
3	3.4	3.7	5.1	2.9	2.3	2.2	P_7						
3.6	4	4.4	5.7	3.4	2.9	2.3	1.8	P_8					
2.7	2.9	3.6	4.8	3.4	3.1	2.2	4.7	3.1	P_9				
1.8	1.4	2.7	3.6	2.5	2.5	2.1	4.3	3.9	3.3	P_{10}			
2.6	2.3	2.3	2.7	3.2	3.4	3	5.1	4.8	4.1	1	P_{11}		
2.8	2.5	3	3.5	3.5	3.6	3.2	5.3	5	4.3	1.1	1.1	P_{12}	
2.5	2.2	3.5	4.2	3.2	3.3	2.9	5.1	4.7	3.6	0.8	1.8	1.6	P_{13}

3.2 Delivery Routes Optimization Based on Saving Algorithm

The Saving Algorithm was introduced by Clarke and Wright in 1964,and its core idea is to combine the multiple loops present in the transportation problem so that the total distance traveled by all the vehicles is the shortest,in order to minimize the number of vehicles providing distribution services to all the outlets[1].In this study,the Saving Algorithm is used to optimize the distribution route of Company J.The core of this method is to calculate the mileage savings by combining two distribution points (M,N) into the same route compared to the original independent visits.The formula is $\delta S = S_1 - S_2 = S_{PM} + S_{pN} - S_{MN}$ .The Saving Algorithm shows significant advantages for the optimization needs of the regional express delivery of Company J.Compared with exact algorithms(e.g.,Integer Programming),its computational efficiency is higher,and it can quickly generate feasible solutions,avoiding the difficulties in solving medium-sized problems caused by the computational complexity of exact methods.Compared with meta-heuristic algorithms(e.g.,Genetic Algorithms),the principle of Saving Algorithms is simpler and more intuitive,easier to implement,faster to solve,and more relevant to the daily operation of enterprises.Therefore,for this kind of medium-sized scenarios with clear constraints,Saving Algorithms achieve a better balance of efficiency,practicality and ease of use,and are a more appropriate choice.

Using the formula the mileage savings between various outlets are calculated,the results of the calculation of mileage savings will be sorted in descending order,the same results are sorted side by side, resulting in the mileage savings table,as shown in the table 4.Based on the ranking results of the saved mileage calculated by the Saving Algorithm and constraints,the 2 assigned routes are derived as shown in table 5.

Table 4. Mileage savings sort

Serial number	Routes	Mileage saved/km	Serial number	Routes	Mileage saved/km
1	P_7—P_8	4.8	14	P_2—P_{11}, P_3—P_{12}, P_8—P_{10}	1.5
2	P_{11}—P_{12}	4.3	15	P_8—P_{11}, P_8—P_{12}, P_8—P_{13}	1.4
3	P_{12}—P_{13}	3.7	16	P_9—P_{10}, P_9—P_{11}, P_9—P_{12}	1.2
4	P_{10}—P_{12}, P_{10}—P_{13}	3.5	17	P_6—P_{10}	1.1
5	P_{10}—P_{11}	3.4	18	P_2—P_{12}, P_6—P_{11}, P_6—P_{12}, P_6—P_{13}, P_7—P_9	1
6	P_{11}—P_{13}	3.3	19	P_2—P_4, P_4—P_5, P_4—P_8	0.9
7	P_8—P_9	3.2	20	P_1—P_{10}, P_4—P_6, P_4—P_7	0.8
8	P_6—P_8	2.7	21	P_1—P_{11}, P_1—P_{12}, P_1—P_{13}, P_5—P_9	0.7
9	P_6—P_7	2.2	22	P_2—P_7, P_3—P_4, P_3—P_{13}, P_7—P_{10}, P_7—P_{11}, P_7—P_{12}	0.5
10	P_3—P_{11}	2.1	23	P_2—P_5, P_2—P_8, P_3—P_{10}, P_5—P_{10}, P_7—P_{13}	0.4
11	P_2—P_3, P_6—P_9	1.9	24	P_1—P_2, P_1—P_3, P_2—P_6, P_2—P_9, P_2—P_{10}, P_5—P_{11}, P_5—P_{12}, P_5—P_{13}	0.3
12	P_5—P_7, P_5—P_8	1.8	25	P_1-P_9, P_2—P_{13}	0.2
13	P_5—P_6, P_9—P_{13}	1.6	26	P_3—P_5, P_3—P_7, P_3—P_8, P_3—P_9, P_4—P_{11}	0.1

Table 5. Optimized distribution route solutions

Serial number	Distribution route	Total number of express deliveries/pieces	Mileage/km
Route 1	P→P_4→P_5→P_6→P_7→P_8→P_9→P	930	12.3
Route 2	P→P_1→P_2→P_3→P_{11}→P_{12}→P_{13}→P_{10}→P	965	11.2

4 Analysis of Results

Based on the comparative analysis of the data before and after the optimization,the Saving Algorithm significantly improves the distribution efficiency and resource utilization of J Express Company:the vehicle configuration is reduced from 4 to 2 vehicles,the total mileage is reduced by 4.4km,and the average loading rate is increased by 27.87%,as shown in Table 6.This optimization effectively reduces the total mileage and operating cost,and achieves efficient resource allocation by increasing the loading rate.Route consolidation and mileage reduction improve timeliness and service stability,and outlet clustering makes the service time window more focused and predictable,reducing delivery uncertainty.Reduced total elapsed time supports earlier first stop delivery or delayed last stop cutoff.Route streamlining reduces operational complexity,helping to minimize service errors and improve delivery quality,thus enhancing the overall service experience and strengthening the company's market competitiveness.

Table 6. Comparative table of vehicle loading rates for the pre- and post-optimization scenarios

	Pre-optimization	Post-optimization
400kg vehicle load factor	380/500 400/500	-
700kg vehicle load factor	530/1000 585/1000	930/1000 965/1000
Average loading rate	66.88 %	94.75%

5 Conclusion

In this study,we optimize the distribution routes of J Express Company based on the mileage-saving method,and merge the routes with high saving values under the constraints of vehicle loading and one-way mileage,and achieve a significant improvement in the operational efficiency:the vehicle configuration is reduced from 4 to 2,the total mileage is reduced from 27.9km to 23.5km,and the average loading rate is increased from 66.88% to 94.75%.This result verifies the effectiveness of the Saving Algorithm in regional express delivery scenarios.In the future,we need to incorporate dynamic traffic congestion factors and time window constraints,and enhance the practicality of the model by integrating real-time road conditions and penalty mechanisms.

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