Research on the Location of Community Group Purchase Pick-Up Points Based on Improved Sparrow Search Algorithm

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Abstract. In order to develop in the long run and improve the overall revenue, community group buying enterprises should further improve the end of the self-pickup point. Community group buying self-pickup points are characterized by direct communication between the head of the group and the customer, therefore, customer satisfaction with the self-pickup points is not only affected by the pickup distance, but also deeply affected by the trust of the head of the group. Therefore, this paper constructs a site selection model with the goal of maximizing the revenue of self-pickup points and solves it by using the improved sparrow search algorithm. Finally, the results show that customer satisfaction has an important influence on the location selection result of the pickup point, and it is necessary for enterprises to consider more when reviewing the application of the head of the company.

Keywords: Community group buying · Pick-up point location · Headmaster trust · Customer satisfaction · Improved sparrow search algorithm

1 Introduction

In these years of community group buying exploration and development, many companies are unable to make profits or even keep losing money because of poor operation, and eventually go bankrupt and close down. Including the earlier hot with the life, ten aloe network, and even in March 2022, even backed by the drop of the big factory of orange heart of preferential selection also shut down. Of course, community group buying companies have been exploring innovative modes of operation to find a farther way out, including the Orange Heart Yousei's tried and true warehouse-store integration model of self-operated stores. After years of continuous exploration, nowadays the most common basic operation mode of community group purchase has been established: customers place orders on the platform the day before, or the group purchase solitaire is initiated by the head of the group in the WeChat group, and the head of the group places orders on behalf of the head of the group, the enterprise feeds the order to the supplier, the supplier sends the goods to the city center warehouse, and then the center warehouse sends them to each grid warehouse, and the grid warehouse arranges the distribution team to distribute the goods to each Self-pickup point, generally delivered before 4:00 pm the next day, after the goods arrive at the self-pickup point, the head of the group will organize the goods and notify customers to pick up.

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With the development of community group buying, the drawbacks existing in its self-pickup points have become increasingly obvious. The current community group buying pick-up points are dense, community group buying enterprises lack of reasonable planning of pick-up points, community group buying head application is relatively easy, the head of the general only need to have a fixed location and refrigeration equipment can be, for many head, especially at home mothers or small store owners, as long as there are group orders, then there is revenue, which causes the same community group buying enterprises in the same community within the scope of the existence of multiple This will not only make it difficult for many customers to choose when placing orders, but also increase the workload of head management and background processing for enterprises. In addition, a large number of dense self-pickup points will also cause the coverage of self-pickup points and excessive overlap of distribution routes, leading to a waste of resources, which is also not conducive to the development of the national low-carbon economy.

Compared with the general site selection problem, the difference of the community group purchase from the site selection problem is mainly reflected in the choice of the head of the group. In the whole supply chain of community group purchase, the head of the group plays the role of "the last mile" and plays a crucial role, the head of the group is the most direct contact with customers and goods in the whole supply chain, connecting customers and the platform. The head of the group is responsible for various group purchase matters of community customers, including promotion of the platform; release of marketing products in WeChat group; feedback on the set list; post-arrival goods management and temporary storage of goods; notification of customers to pick up goods, help customers to pick up goods or home delivery and other after-sales services. However, too dense self-pickup points, resulting in more and more vicious competition among the chiefs, in order to pull more customers to get higher personal income, the chiefs focus on scrambling traffic, fission community, while ignoring the quality of the products, can not concentrate on the docking of customers and goods, in the long run, the low quality of goods will reduce customer expectations of the platform, leading to a reduction in customer demand.

Any kind of commercial consumption activity is based on the trust between customers and operators, for community group buying in addition to building trust between customers and the platform, the trust of customers for the head of the group is also a part that can not be ignored. In addition to the price and quality of the products, the pickup environment, the waiting time in the queue when picking up the products, the service level of the leader, and the recommendation of the leader's products also affect the satisfaction of the customers. Therefore, this paper takes the trust degree of the headmaster into consideration when measuring customer satisfaction, which helps community group buying enterprises to allocate their resources reasonably.

Qian Yang [1] constructs a multi-objective site selection model with the objective of maximizing the utility of self-service points and minimizing the total construction cost under the influence of existing self-service points. Lu Huang [2] established a multi-objective optimization model based on the scale constraint of parcel handling volume, and found that there is a "marginal decreasing" law between the self-pickup volume and cost. Ling Liu et al. [3] studied the spatial distribution characteristics and influencing factors of express pick-up points. Xiang Zhou et al. [4] studied the integrated optimization of pick-up point location and path planning based on mixed addresses of customer points in e-tailing distribution. Gang Li et al. [5] studied the organization form, location selection, spatial pattern and clustering pattern of self-service points. Xun Han et al. [6] studied the problem of pick-up point location under the influence of joint coverage on customer choice and the location problem considering the capacity of pick-up points [7]. In this paper, we take the self-pickup point of community group purchase as the research object, consider several factors affecting the self-pickup point such as the trust degree of headman and customer satisfaction, construct a self-pickup point location model with the goal of maximizing the self-pickup point revenue, and design an improved sparrow search algorithm to solve it, so as to provide reference for the decision of self-pickup point cooperation of community group purchase enterprises.

2 Site Selection Model

2.1 Problem Description

With the development of community group purchasing, its pickup points need to be gradually standardized, and the appropriate pickup point location is mainly to improve the revenue and customer satisfaction. Therefore, the location model of pick-up points in this paper is described as follows: in a given network G(V, A), the set number of pick-up points n, the set of pick-up points is selected from the set of alternative points J, so that the pick-up point revenue is maximized, the main revenue of community group purchase pick-up points comes from commission, so the larger the number of pick-up points covering customer pick-ups, the larger the pick-up point revenue.

2.2 Model Assumptions

The main model assumptions of this paper are:

(1) Customer locations and alternative locations for pick-up points are known.
(2) The distance between the customer location and the alternative location of the pick-up point is known.
(3) Each customer will only choose one pick-up point.
(4) All customers are equally important.
(5) The commission is the same for each item.
(6) The capacity limit of the pick-up point is not considered.
(7) Construction costs are not considered.
(8) Does not consider incompatibility constraints of different products.

2.3 Model Parameters

The parameters involved in this paper and their meanings are as follows:

I denotes the set of locations of the client.

J denotes the set of alternative points for self-pickup.

dij denotes the pickup distance from customer i to pickup point j.

R denotes the maximum coverage radius of the pick-up point.
R denotes the minimum coverage radius of the pick-up point.
n indicates the number of pick-up points for the head of the application.
mi indicates the number of items picked up by customer i.
v indicates the commission for a single item.
Fij denotes customer i's satisfaction with pick-up point j.
εj denotes the credit of the head of the self-pickup point j.
θi denotes the distance sensitivity coefficient of client i.
D(rij)denotes the distance attraction function of the self-pickup point j to customer i.

xij takes the variable 0–1, a value of 1 indicates that customer i chooses pickup point j, otherwise it takes the value 0.

yj takes 0–1 variables, a value of 1 indicates the establishment of a self-pickup point at alternative point j, otherwise it takes the value of 0.

2.4 Model Building

Whether a customer chooses that pickup point or not is determined by a variety of factors. The main influencing factor of the general pickup point is distance, but the special nature of community group buying determines that the trustworthiness of the head of the group is also an important factor. When the trustworthiness of the head is large, it can largely reduce the impact of pickup distance on customers. Drezner et al. [8] proposed to express customer satisfaction using a gradual coverage model. This paper inscribes a distance attraction function based on this as Eq. (1):

$$D(r_{ij}) = \begin{cases} 1 & d_{ij} \le r \\ 1 - \left(\frac{d_{ij}-r}{R-r}\right)^{\theta_i} & r < d_{ij} < R \\ 0 & d_{ij} \ge R \end{cases} \tag{1}$$

The customer satisfaction function is given in Eq. (2).

$$F_{ij} = \varepsilon j \cdot D\big(r_{ij}\big) \tag{2}$$

In the given network G(V,A), a model for the location of the pick-up point considering the trust of the head and customer satisfaction is developed, with the following model and constraints.

$$\max Z = \sum_{i \in I} \sum_{j \in J} F_{ij} m_i v x_{ij} \tag{3}$$

$$\sum_{j \in J} y_j = n \tag{4}$$

$$\sum_{i \in I} x_{ij} = 1 \tag{5}$$

$$x_{ij} \le y_j \tag{6}$$

$$x_{ij} = 0, 1 \tag{7}$$

$$y_j = 0, 1 \tag{8}$$

The objective function Eq. (3) indicates that the self-pickup point revenue is maximized; constraint (4) is to ensure that the number of self-pickup points is n; constraint (5) ensures that each customer can only choose one self-pickup point applied by the head of the community group purchase; constraint (6) indicates that a customer can only place an order to a self-pickup point after the head of the community group purchase has applied to establish a self-pickup point; constraints (7) and (8) indicate 0–1 integers of the decision variables planning constraints.

3 Algorithm Design

The SSA algorithm is a new group intelligence optimization algorithm that simulates the foraging and anti-predatory behavior of sparrows in biology. In this algorithm, sparrows are divided into discoverers and predators, and some of them act as perceivers by adding a model of reconnaissance and early warning to the algorithm. The discoverer itself has a high degree of adaptation and a wide search range, and can provide foraging direction and area for all predators. In the foraging process, predators are always able to search for the finder that provides the best food, and then get food from the best food or forage around the finder. At the same time, some predators in order to increase their predation rate may constantly monitor the dynamics of the finder and then to compete for food resources. When aware of danger, sparrows at the edge of the group will quickly move to a safe area to get a better position, while sparrows in the middle of the population will move randomly to get closer to other sparrows. The specific formula is as follows.

$$X_{ij}^{a+1} = \begin{cases} X_{ij}^{a} \cdot \exp\left(\frac{-i}{\beta \cdot iter\max}\right) & R2 < ST \\ X_{ij}^{a} + Q \cdot H & R2 \geq ST \end{cases} \tag{9}$$

$$X_{ij}^{a+1} = \begin{cases} Q \cdot \exp\left(\frac{X_{worst}^{a} - X_{ij}^{a}}{i^2}\right) & i > \frac{M}{2} \\ X_{p}^{a+1} + \left|X_{ij}^{a} - X_{p}^{a+1}\right| \cdot A^{+} \cdot \mathrm{H} & i \leq \frac{M}{2} \end{cases} \tag{10}$$

$$X_{ij}^{a+1} = \begin{cases} X_{best}^{a} + \partial \cdot \left|X_{ij}^{a} - X_{best}^{a}\right| & fi > fg \\ X_{ij}^{a} + c \cdot \frac{\left|X_{ij}^{a} - X_{worst}^{a}\right|}{fi - fw + \mu} & fi = fg \end{cases} \tag{11}$$

where Eq. (9) is the updated position equation for the discoverer, Eq. (10) is the updated position equation for the predator, and Eq. (11) is the updated position equation for the perceiver.

The traditional sparrow algorithm is prone to fall into local extremes and lose the overall diversity in the late stage of foraging, resulting in inaccurate final results. Therefore, in the initial foraging stage, in order to improve the population diversity of the sparrow population, a reflexive learning mechanism and an elite strategy are introduced in the initialization process of the leader. Its elite reversal solution is Eq. (12).

$$xij(a)' = \phi\left[uij(a) + vij(a)\right] - xij(a) \tag{12}$$

where: ϕ is the elite inverse coefficient, taken as a random number between 0 and 1. Uij(a) and vij(a) are the minimum and maximum values of xij(a)' in the ϕth dimension, respectively. [uij,vij] is the interval constructed by the elite group.

In order to improve the global merit-seeking ability and make the predator jump out of the local extremes, the Corsi variation strategy is introduced with the following equation.

$$\begin{aligned} &W_{best}^{t} \\ &= x_{best}^{t}\left[1 + \omega 1 \cdot cauchy(0, \sigma^2) + \omega 2 \cdot Gauss(0, \sigma^2)\right] \end{aligned} \tag{13}$$

$$\sigma = \begin{cases} 1 & f(Xbest) < f(Xi) \\ \exp\left(\frac{f(Xbest) - f(Xi)}{|f(Xbest)|}\right) & f(Xbest) \geq f(Xi) \end{cases} \tag{14}$$

Where: W_{best}^{t} denotes the position of the optimal individual after variation;σ2 denotes the standard deviation of the Coase-Gaussian variation strategy cauthy(0,σ2),is a random variable satisfying the Coassian distribution; Gauss(0,σ2) is a random variable satisfying the Gaussian distribution

Random variables; ω1 and ω2 are dynamic parameters that adjust adaptively with the number of iterations.

The specific steps are as follows.

(1) Initialization of sparrow populations by refractive inverse learning; setting relevant parameters.
(2) Calculate the fitness value of each sparrow and rank them to determine the current best and worst adapted individuals.
(3) Update the position of the lead bird.
(4) Introducing the Corsi variation strategy to update the position of followers.
(5) Position updates for scouts.
(6) Judge whether the stopping condition is satisfied: if it is satisfied, exit the loop and output the optimal siting and capacity fixing scheme; otherwise, return to step (3).

4 Example Analysis

In this paper, we assume that the number of customers in a network I = 5000 and the number of alternative pickup points J = 50 are distributed as shown in Fig. 1, where black represents the distribution of customer locations and red points correspond to the distribution of alternative pickup point locations. The pickup volume of customers in the range of [5, 200] obeys the normal distribution N(150, 102), the distance sensitivity coefficient of customer i θi the uniform distribution U(0.5,1.5), and the remaining parameters are set as shown in Table1.

The convergence of the improved sparrow search algorithm for solving the community group purchase pick-up point location model is shown in Fig. 2. From the figure,

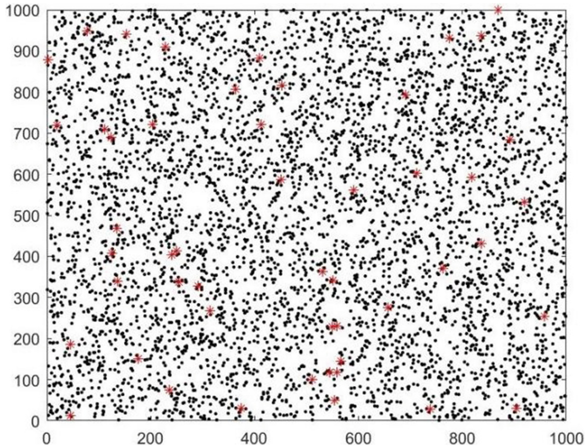

Fig. 1. Distribution of customers and alternative points

Table 1 Parameter settings

Parameters	Numerical value
n	4
v	1
R	14
r	10
εj	1
Race Size	30
Number of iterations	1000
ST	0.8
PD	0.8
SD	0.2
ub	100
lb	−100
dim	30

it can be seen that the improved sparrow search algorithm (ISSA) is used to solve the community group purchase pick-up point location model to obtain the optimal solution faster than the traditional sparrow search algorithm (SSA), reflecting the efficiency of the improved sparrow search algorithm. When the satisfaction function Fij indicates that the site selection model does not consider customer satisfaction. The pick-up points established by the site-selection model considering customer satisfaction are [8, 27, 35, 41], while the pick-up points established by the site-selection model not considering customer satisfaction are [3, 18, 27, 38], reflecting the influence of customer satisfaction on the selection of pick-up points for community group purchases.

From Eq. (1), it can be seen that customer satisfaction is mainly influenced by the trust degree of the headman and the pickup distance of customers. Among them, the

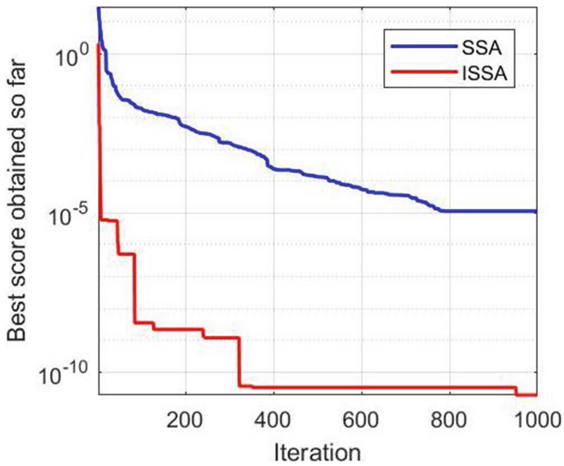

Fig. 2 Convergence curve

Table 2 Influence of ε on the results of pick-up point location

ε	Site Selection Results	Self-pickup point revenue ($\times 10^3$)
0.5	[8, 27, 35, 21]	758.32
1.0	[8, 27, 35, 21]	1359.41
1.5	[8, 27, 35, 21]	1825.36

trust degree of headman has the greatest influence, so this paper discusses the influence of headman trust degree on the location of pick-up point, and sets the trust degree of headman as 0.5, 1, 1.5, as shown in Table 2. As seen from the table, when other factors remain unchanged, as the trust degree of headman increases, the earnings of self-service point increases, but the change of site selection result is small. Therefore, if the self-pickup point wants to improve the revenue, it must improve the trust degree of the headmaster.

5 Conclusion

With the development and popularity of community group purchasing, a scientific and reasonable pick-up point location is of great practical significance to improve customer satisfaction and pick-up point revenue. In this paper, we construct a pick-up point location model with the goal of maximizing pick-up points and solve it by using the Improved Sparrow Optimization Algorithm (ISSA). Finally, the results show that customer satisfaction has an important influence on the location selection result of community group purchase pick-up points and the final revenue of pick-up points, and the creditworthiness of the head of the group is an important factor affecting customer satisfaction. Therefore, community group purchase enterprises should consider multiple factors when approving the applications of the head of the group to protect the rights and interests of customers and improve customer satisfaction, so as to improve the revenue of pick-up points.

References

1. Qian Yang. A study on multi-objective siting of self-service points considering the influence of established self-service points[J]. Modern Computer,2022,28(10):102-106.
2. Lu Huang, Yanguang Ji. Multi-objective planning research on the siting of self-pickup points considering processing capacity optimization[J]. Journal of Wuhan University of Technology (Information and Management Engineering Edition),2020,42(04):326-331.
3. Ling Liu, Gang Li, Lan Yang, Shuyan Xue. Spatial distribution characteristics and influencing factors of express pick-up points in Shenzhen[J]. Journal of Geoinformation Science,2019,21(08):1240-1253.
4.]Xiang Zhou, Maozeng Xu, Qiguang Lv, Dan Li. Self-pickup point location-path optimization based on customer point administrative address[J]. Computer Integrated Manufacturing Systems,2019,25(08):2069–2078.
5. Gang Li, Weiyu Chen, Lan Yang, Qian Liu, Xiliang Chen. Study on the spatial pattern and agglomeration mode of express pick-up points in Wuhan[J]. Advances in Geographical Sciences,2019,38(03):407-416.
6. Xun Han, Jin Zhang, Qian Zeng. Siting problem of multi-level self-service points considering cooperative coverage[J]. Transportation System Engineering and Information,2019,19(01):165-171.
7. Xun Han, Jin Zhang, Xiaolai Ma. A study on capacity optimization of self-pickup points considering customer congestion cost[J]. Industrial Engineering and Management,2019,24(01):31-36.
8. Zvi Drezner,George O. Wesolowsky,Tammy Drezner. The gradual covering problem[J]. Naval Research Logistics (NRL),2004,51(6).