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Research on Urban End-Delivery Paths Considering the Consumer's Delivery Time Demand

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Abstract: Delivery time is an increasingly important consideration in consumer behavior, and there are still some problems in the urban logistics and delivery industry in considering matching consumer demand and improving logistics and delivery efficiency to control enterprise costs. In this paper, we will construct an end delivery path model based on consumers' delivery time preference, use ALNS algorithm to analyse the distribution routes of five real communities, and conclude that the total distribution cost increases and then decreases with the increase of the number of consumers who choose value-added services. In this paper, we use scientific methods to calculate and design distribution routes to reduce distribution costs and further satisfy consumer preferences. At the same time, from the perspective of the industry management department, delivery enterprises and the consumers, three main bodies, the next development direction is proposed for different main bodies to promote the high-quality development of urban logistics and delivery market.

Keywords: ALNS algorithm; cost reduction and efficiency; logistics and delivery; market demand; transportation

1 INTRODUCTION

The industry management, delivery enterprises and the actual consumer are important participants in the transportation market, and their collaborative development has an important impact on urban end delivery. The three complement each other and can promote the high-quality development of urban logistics and delivery market. At present, the scale of logistics and delivery market of China is expanding, the efficiency of each link is gradually improved, and the urban logistics and delivery industry as a whole shows a stable development trend, however, there are still some problems in matching the demands of the consumer and improving the efficiency of logistics and delivery to control the cost of enterprises.

First, the time of logistics delivery and the actual needs of the consumer do not match. In urban logistics end delivery, sometimes the delivery service cannot meet the consumer's demand for delivery time, location or mode, such as the arrival of goods at a time not agreed upon by both parties, or even if they arrive at the agreed time, due to the lack of accuracy of the agreed time in some cases, there is also the case that the consumer does not appear at the agreed time at the agreed location. For the delivered goods, some consumers need to unpack and check in person, which also requires the delivery personnel to set aside time.

Second, the delivery path selection is more random leading to the existence of randomness in delivery time. The current urban logistics end delivery selection exists randomly, relying on the judgment of the delivery personnel themselves, as well as the communication and coordination between the delivery personnel and consumers to arrive at the results, which will lead to greater uncertainty in the efficiency of logistics delivery. This randomness for the determination of specific delivery time and the transport route has negative influence.

Third, the contradiction between the consumer's demand for time and the enterprise's demand for cost reduction. When implementing end delivery, due to the different communication and coordination methods of consumers and couriers, different delivery preferences, the resulting degree of risk of delayed goods due to the inability to scientifically and rationally select the delivery path will also be different, and if the delivery personnel do not communicate well with consumers on matters such as delivery time, location and mode, it will lead to complaints. When there is a temporary change of the agreed time and place, if there is no scientific and effective means of response, the duplication and repetition of routes will lead to an increase in delivery costs.

Since the purpose of all business operations is profitability, companies will not provide unlimited precise time to meet consumer demand. Therefore, in order to further promote the high-quality development of the urban delivery market, this paper considers a new convenience-enhancing service for consumers while continuing to provide traditional delivery services: time-based delivery. Based on the summary of domestic and foreign scholars' research on consumers' preference for time and the research on end-delivery path optimization problem, this paper establishes a delivery path optimization model based on consumers' delivery time to optimize the driving path of end-delivery vehicles, and also designs the solution algorithm. Therefore, in order to provide better services to the consumer and considering the personalized demand for time, this paper proposes a convenience-enhanced delivery service with more accurate delivery time to meet different consumer needs. And since the delivery cost brought by the enhanced time accuracy will increase, it is set that the consumer will have to pay extra courier cost if he needs to use the service.

2 LITERATURE REVIEW

The "last mile" end delivery time of goods will vary according to the needs of the consumer. The consumer may request that the goods be delivered at a specified time, or may pick up the goods at any time without request. The logistics end delivery method will influence the time preference of consumers, and the consumer will try to adapt to the receipt time of each suitable delivery method.

At present, domestic and foreign scholars have conducted more studies based on the time window theory, among which Campbell, Bent [1-4] and others were the first to explore the theory. In the process of end delivery, each consumer has its own unique time window for distribution service, and the end delivery work of logistics needs to complete the delivery of goods within the specific time window of the consumer. According to the difference in penalty cost, time windows can be divided into hard and soft time windows; in the hard time window scenario, there is no penalty if the goods are delivered to the consumer on time, and vice versa, there is a huge penalty; in the soft time window scenario, the penalty cost is proportional to the delay time of delivery, and the longer the delay time the larger the penalty cost [5]. Rai et al. [6] found through their study that in general after a consumer chooses to place an order for an item at normal time, the goods are usually delivered the next day. Agatz et al. [7] developed a time window planning problem model to analyze the distribution of end goods considering the time gap of end goods distribution. Klapp et al. [8] and Klein et al. [9] constructed integer programming models in order to effectively solve the problem of distributing goods with different time slots for the consumer. Qiu Hanguang et al. [10] constructed a decision framework for dynamic orders for end-of-line delivery based on a time window scenario. Huai-Li Chen et al. [11] refer to the Logit time slot selection probability formula and combine two hierarchical indicators of delivery price and delivery time slot to construct a multi-time slot pricing model considering the goods delivery period constraint and equilibrium delivery capacity. Huaiqi Zhu et al. [12] proposed that waiting time and service level are the two aspects that consumers are most concerned about on the basis of studying the relationship between delivery mode, service mode and delivery time slot. Li Xin [13] stated that consistently on-time and high level of service for goods delivery will make the consumer more dependent on this delivery service method and will prefer it in the future when they encounter the same type of service; conversely, this consumer will be lost and lead to the choice of other delivery methods.

The ALNS algorithm searches the "neighborhood" solutions of the current solution through countless iterations and compares and analyzes them to find a better solution. The larger the neighborhood is, the better the solution is. Li [14] introduced ALNS into the large-neighborhood search algorithm to optimize the performance of the algorithm by merging the attributes of the best service sequence, and tested its superiority in the delivery path problem. Rohmer [15] et al. improved the adaptive large-neighborhood search metaheuristic algorithm and verified its effectiveness. Breunig et al. [16] combined the large-neighborhood search algorithm with a programming algorithm to provide an optimal or near-optimal solution for path optimization in order to better solve multi-layer logistics route planning.

By combing the research status of domestic and foreign scholars, it can be seen that the research on the consumer's preference for time is mainly focused on the matching of delivery to the consumer's time window, and since different consumers have different needs for time window matching, delivery companies cannot fully satisfy all consumers' needs at the first time, so some studies rank different consumers' time window needs in order to obtain the highest consumer satisfaction rate by means of product characteristics and delivery prices. For the research of end-delivery path optimization problem, ALNS algorithm is widely used by domestic and foreign scholars in the field of end-delivery research because of its advantages for the research of differentiation problem, so it is more adaptable for the research of different user needs in the field of distribution, and in the application process.

3 MODEL CONSTRUCTION AND VALIDATION

At present, the focus of China's logistics supply chain development is shifting from the front-end and middle-end to the end, and improving the efficiency of urban end-delivery has become an important foundation for creating a complete, smooth and efficient logistics supply chain. The urban logistics end delivery studied in this paper focuses on the "last mile" of the logistics supply chain, where the goods are transported and delivered from the distribution site to the agreed location of the user by the distribution enterprises after the goods are transferred to each distribution site in the city. The delivery path problem refers to the method of seeking the goods to be delivered from the delivery center to the users under the constraints of multiple factors such as the number of goods, the number of delivery vehicles, the address of the delivery center, the address of the passenger and cargo receiving address, etc. By analyzing and planning a reasonable delivery route, the whole delivery process can achieve the least delivery time, the shortest travel distance and the lowest delivery cost. In this paper, we will construct an end delivery path model based on the consumer's delivery time preference, and use scientific methods to calculate and design the delivery path to reduce the delivery cost, so as to further meet the consumer preference demand.

3.1 Model Construction

This paper studies Vehicle Routing Problems with Time Windows Capacicated Problem, VRPTW-CP. In order to improve the consumer experience, e-commerce platforms will provide value-added services in addition to basic services.

Table 1 Explanation table of the symbols

Symbols	Explanation
0	Delivery points
C	The consumer collection, $C = \{1, 2, 3, ..., m\}$
P	Points collection, where $P = CU\ \{0\}$
V	Vehicle collection, $V = \{1, 2, ..., v\}$
$t_{i,j}$	Running time between arcs (i, j)
S_i	Service hours for consumer i
q_i	Demand of consumer i
E_i, L_i	Time window for consumer point i
Q_v	Vehicle capacity
x_{ijv}	1 if vehicle v passes through arc (i, j); 0 otherwise
y_{iv}	1 if consumer i is served by vehicle v; 0 otherwise
Z_t	0 if the delivery method is consistent with consumer i 's preference, 1 otherwise
r_{iv}, r_{jv}	The moment vehicle v starts serving consumer point i
H	Total profit of goods obtained by e-commerce platform
w	Service costs arising from value-added services
u_i	0 - 1 variable, $u_i = 1$ when consumer i chooses value-added services, otherwise, $u_i = 0$

Consumers are free to choose whether they need the service or not, and the platform will charge a fee for the service. In this paper, we assume that the total profit of existing consumers purchasing goods is H, when consumers tick the value-added services, they will pay a fixed service fee w, and the e-commerce platform will definitely deliver according to consumers' preferences and will not allow violating the time window.

Assuming u_i is a 0 - 1 variable, when the consumer i chooses the value-added service， u_i = 1, otherwise， u_i = 0. The original delivery cost is denoted as f_{trans}. The profit obtained by the e-commerce platform f_{prof} can be expressed as $H+,\sum_{i\in P} u_i$. Therefore, the net profit obtained is $f_{netp} = f_{prof} - f_{trans}$.

Modeled as follows:

$$\max f_{netp} \tag{1}$$

$$\sum_{v\in V}\sum_{j\in C} x_{0jv} \le V \tag{2}$$

$$\sum_{i\in P} x_{ijv} = v_{jv} \quad \forall j\in C,\, v\in V \tag{3}$$

$$\sum_{v\in V}\sum_{j\in C} x_{ijv} = 1 \ \ \forall i \in c \tag{4}$$

$$\sum_{i\in P} x_{ijv} = \sum_{i\in P} x_{ijv} \quad \forall j\in C,\, v\in V \tag{5}$$

$$\sum_{i\in C} y_{iv} q_i \in Q_v = \quad \forall v\in V \tag{6}$$

$$r_{iv} + s_i + t_{ij} - r_{jv} \le M\left(1 - x_{ijv}\right) \quad \forall i\in P, j\in P,\, v\in V \tag{7}$$

$$r_{0v} = 0 \tag{8}$$

$$s_0 = 0 \tag{9}$$

$$x_{ijv} = \{0, 1\} \quad \forall i\in P, j\in P,\, v\in K \tag{10}$$

$$y_{iv} = \{0, 1\} \quad \forall i\in C,\, v\in V \tag{11}$$

$$z_i \in \{0, 1\} \quad \forall i\in C \tag{12}$$

$$z_i + u_i \le 1 \quad \forall i\in P \tag{13}$$

Eq. (1) indicates maximization of net profit f_{netp}. Eq. (2) limits the number of vehicles used. Eq. (3) expresses the relationship between x_{ijv} and y_{iv}. Eq. (4) guarantees that each consumer can be served only once. Eq. (5) expresses the flow balance. Eq. (6) expresses that the total demand of consumer points delivered by a delivery vehicle cannot exceed the capacity of that vehicle. Eq. (7) expresses the relationship between the starting service moments of two neighboring consumer points visited by vehicle v. Eq. (8) and Eq. (9) are the initial values when the vehicle stops at the delivery station. Eq. (10) and Eq. (12) are the definition domains of the decision variables. Eq. (13) indicates that once consumer i selects the value-added service, the delivery method for that consumer cannot be changed.

3.2 ALNS Algorithm Design

(1) Initial settings:

Since the objective function is profit maximization, we need to process the objective function first. Since $\max f_{netp} = min-(f_{nept}.)$, we let the cost O(S) = $-f_{nept}$ of any feasible solution S. So the temperature function expression corresponding to the initial solution S^0 is:

$$T = O\left(S^0\right) \times P_{init} \tag{14}$$

(2) Neighboring structure:

Since the delivery method of consumers who have checked the value-added service will no longer change, we add new removal and insertion strategies to the original removal and insertion strategies to improve the feasibility of the path. For the sake of description, we refer to the consumers who have checked the value-added service as value consumers. The basic idea of these two strategies is that the higher the proportion of value consumers included in a path, the lower the number of solutions generated by adjusting the consumer delivery method for that path, and the less favorable it is to generate feasible solutions in the early stage of the algorithm. Therefore, these two strategies operate mainly on such paths to ensure the convergence speed of the algorithm.

(3) Route removal strategy:

Step1: Count the proportion of each path in a solution that contains value consumers, and then sort them in descending order.

Step2: Remove the paths until the number of removed is n_r.

(4) Time window factor insertion strategy:

The time window factor insertion strategy focuses on determining whether a consumer point is allowed to be inserted based on the time window.

Step1: Calculate the time window correlation between the arc and the consumer point to be inserted.

Suppose arc (i, j) is an arc on path p, v is a target insertion point, and consumer point $E_i \le E_v \le E_j$. The time window association between arc (i, j) and consumer point v is calculated as:

$$\sigma_{iv} = \begin{cases} \max\{L_i - E_v,\, 0\}\, E_i \le E_v \\ \min\{L_i, L_v\} - E_i E_v < E_i < L_v \\ \max\{L_i - E_i,\, 0\}\, E_i > L_v \end{cases} \tag{15}$$

$$\sigma_{vj} = \begin{cases} \max\{L_v - E_j,\, 0\}\, E_v \le E_j \\ \min\{L_v, L_j\} - E_v E_j < E_v < L_j \\ \max\{L_j - E_v,\, 0\}\, E_v > L_j \end{cases} \tag{16}$$

$$\sigma_{ij} = \sigma_{iv} + \sigma_{vj} \tag{17}$$

Step2: Insert the consumer point v into the arc (i, j) with the highest correlation according to the time window correlation.

The time window correlation here is different from the previous one, mainly because in the middle and later stages of the algorithm, due to the existence of value consumers, the basic constraints such as vehicle capacity are easy to satisfy, but satisfying the time window constraint is more difficult, and the penalty cost incurred by it is larger and needs to be handled specifically for the time window. In contrast, the increased cost of considering arc (i, j) to insert consumer point v does not need much consideration. Therefore, the correlation needs to be recalculated.

4 EXAMPLE ANALYSIS

In this paper, we set up consumer alternative times, and the information of consumer's alternative times is obtained from the questionnaire survey. Each consumer can provide up to five times according to his or her wish, and the times are ranked according to the consumer's preference level. The first time is the consumer's preferred time, for which the consumer is most satisfied, and the fifth time is the time with the lowest consumer satisfaction. The five times of satisfaction are 100%, 80%, 60%, 40% and 20%.

4.1 Route Analysis

In conducting the empirical analysis, in terms of example selection, it is proposed to select different construction year neighborhoods to enhance representativeness because of the different construction years and the large differences in management modes, such as allowing home delivery or not allowing home delivery. Therefore, this paper selects Gangyan Community (built in 1954), Jiaoda Jiayuan (built in 2002), Mingguangcun District (built in 1976), Tianzhao Jiayuan (built in 2002), and Changhewan Distric (built in 2005) as research examples, covering different construction years and different management modes.Tab. 2 shows the results of the route analysis. When there is a consumer-paid service for time accuracy, the driving path of the delivery vehicle will appear as a detour. In this paper, we mainly analyze the detour routes and dig the characteristics of the vehicle driving routes.

Let Jiaoda Jiayuan be A, Gangyan Community be B, Changhewan District be C, Tianzhao Jiayuan be D, and Mingguangcun District be E. As mentioned before, the consumer's delivery points in each district are simplified to 5.

(1) Route 2 and Route 3.

As in Fig. 1, the driving path of route 2 is E1-E2-E3-E2-E1-E3-E5-D2-D1-D5-A5-A4-A3-A2-A1-C1-C2-C3, and a rather unusual detour occurs. The detour route is: E1-E2-E3-E2-E1-E3. After E1, E2 and E3, the vehicle repeats to E2, E1 and E3. Analysis of consumer characteristics reveals that since consumers 21, 264, 390 and 337, who are present at E1 and E2 for the second time, have chosen value-added services, the vehicle would have been at E3, and to meet their time window, the vehicle would re return to E1 and E2 to deliver to them and then return to E3, thus appearing as a detour.

Table 2 Route Result

No.	Route
1	[0, 50, 115, 293, 424, 427, 142, 246, 287, 315, 347, 349, 2, 8, 44, 87, 102, 110, 114, 120, 141, 166, 169, 207, 209, 247, 283, 308, 325, 385, 421, 46, 194, 274, 327, 391, 184, 201, 222, 244, 330, 99, 299, 155, 223, 379, 98, 180, 314, 116, 0]
2	[0, 403, 30, 82, 152, 224, 228, 268, 9, 136, 149, 162, 230, 270, 21, 264, 390, 337, 426, 346, 168, 226, 255, 316, 321, 350, 400, 62, 368, 404, 23, 101, 372, 432, 189, 192, 205, 183, 417, 103, 109, 143, 164, 277, 284, 326, 419, 153, 361, 364, 19, 63, 130, 170, 212, 344, 11, 18, 81, 187, 231, 125, 94, 119, 135, 45, 0]
3	[0, 304, 402, 15, 129, 131, 206, 213, 285, 289, 324, 331, 431, 178, 259, 436, 83, 338, 397, 429, 225, 328, 124, 92, 150, 197, 273, 352, 411, 39, 48, 61, 250, 128, 305, 334, 383, 126, 343, 40, 281, 173, 172, 280, 84, 186, 243, 282, 4, 36, 204, 332, 275, 106, 354, 47, 227, 118, 236, 151, 394, 405, 16, 105, 147, 245, 249, 252, 254, 336, 340, 107, 80, 0]
4	[0, 309, 428, 279, 199, 307, 359, 20, 145, 157, 176, 251, 258, 271, 317, 323, 73, 341, 134, 202, 369, 377, 395, 415, 430, 42, 57, 74, 112, 272, 298, 387, 396, 10, 58, 77, 122, 154, 182, 96, 358, 290, 1, 265, 51, 214, 348, 399, 433, 435, 167, 216, 266, 292, 375, 165, 418, 137, 146, 335, 72, 177, 398, 210, 253, 310, 408, 55, 13, 376, 362, 322, 22, 412, 26, 0]
5	[0, 71, 195, 37, 89, 27, 93, 75, 215, 393, 288, 370, 41, 132, 237, 261, 345, 353, 181, 3, 14, 229, 28, 160, 218, 161, 238, 179, 52, 355, 200, 300, 410, 6, 108, 220, 33, 59, 70, 85, 35, 193, 221, 240, 296, 263, 294, 79, 381, 34, 65, 90, 239, 311, 342, 374, 367, 392, 401, 416, 356, 49, 329, 382, 67, 127, 144, 148, 0]
6	[0, 232, 260, 320, 156, 256, 286, 303, 371, 384, 388, 378, 235, 413, 423, 425, 97, 86, 56, 111, 121, 185, 139, 163, 211, 366, 409, 123, 363, 12, 17, 88, 188, 269, 91, 100, 76, 69, 60, 5, 234, 203, 217, 278, 297, 301, 357, 360, 386, 434, 422, 373, 208, 66, 68, 25, 407, 319, 262, 0]
7	[0, 140, 380, 389, 159, 24, 38, 267, 318, 414, 420, 133, 171, 174, 198, 31, 78, 104, 196, 333, 53, 233, 117, 276, 175, 306, 219, 113, 313, 0]
8	[0, 351, 339, 7, 43, 64, 95, 190, 242, 406, 365, 295, 312, 158, 291, 241, 302, 248, 138, 257, 54, 29, 32, 191, 0]

Figure1 The User Delivery and the Path of Route 2

As in Fig. 2, the driving path of route 3 is E2-E3-E1-E2-E3-E5-D2-D1-D4-D5-A5-A4-A3-A2-A1-C1-C3-C4-C5-B5-B4-B3. The detour route is E2-E3-E1-E2-E3-E5. After E2, E3 and E1, the vehicle repeats its journey to E2 and E3. Analysis of consumer characteristics revealed that the detour occurred because consumers 259, 436, and 83, who were present at E1 and E2, chose value-added services, and originally the vehicle was at E3. In order to meet their time window, the vehicle would first go to E1 and E2 to deliver to them, and then return to E3.

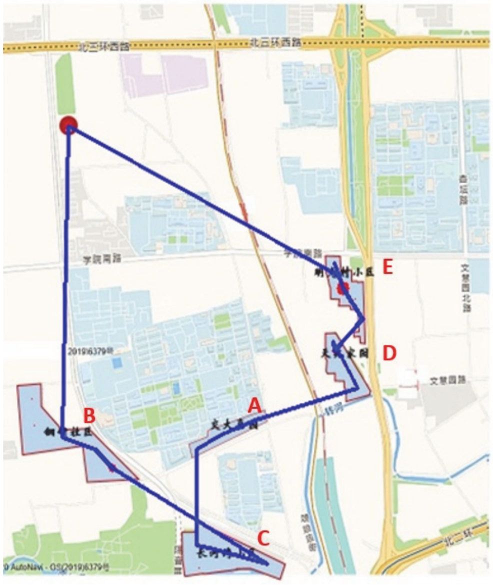

Figure 1 The User Delivery and the Path of Route 3

(2) Route 4 and Route 5.

As shown in Fig. 3, the driving path of route 4 is E1-E3-E5-D2-D1-D4-D5-D2-A5-A4-A3-A2-A1- C1-C2-C3-C4-C5-B5. The detour route occurs at: D2-D1-D4-D5-D2-A5. Due to the late time window of 96, 358, and 290 for the second trip to D2 and the selection of the value-added service, it was not possible to match with the previous consumers to implement co-delivery, so the situation of delivering D2 twice occurred.

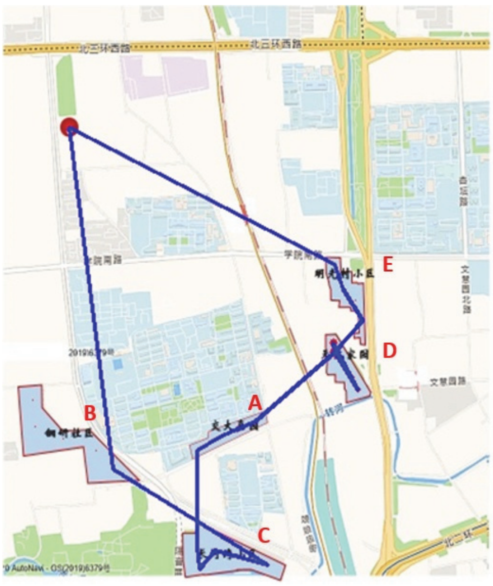

Figure 2 The User Delivery and the Path of Route 4

As shown in Fig. 4, route 5 travels as follows: E3-D2-D4-D5-A5-A4-A3-A2-A1-C1-C2-C3-C4-C5 -C2-C5-C3-C1-B5-B4-B5-B4-B4-B3-B2-B1 two detour routes occur. The first one appears at C1-C2-C3-C4-C5-C2-C5-C3-C1. The second time the four consumers at C2, C3 and C1 have a later time window after 16:00 and therefore will delay the delivery. Since there are more consumers at C5 for the first time, if the consumers at C5 are delivered before delivering to the consumers at C2 it will result in a delayed C2 situation, so there is a situation where delivery is made to C2 first and then returned to C5.

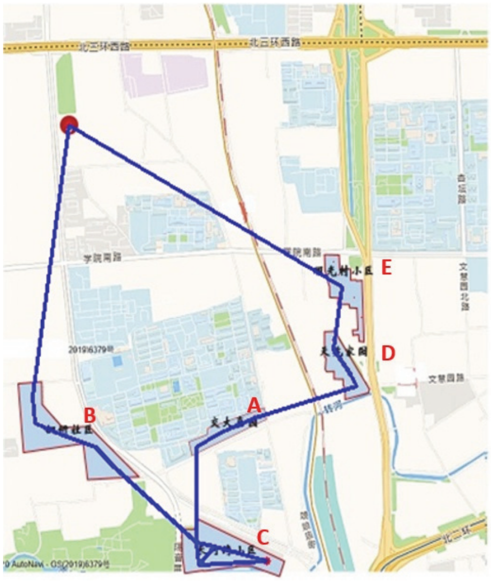

Figure 3 TheUser Delivery and the Path of Route 5

(3) Route 6.

As in Fig. 5, the driving route of route 6 is A3-A2-A1-C1-C3-C4-C5-C4-C3-A1-B5-B4-B3-B2. Route 6 has more detours, and even has a cross-cell detour. The vehicle travels to Changhewan district after delivery from Jiaoda Jiayuan, and then returns to Jiaoda Jiayuan from Changhewan district. The reason is that 76 consumers at A1 chose the value-added service, but the time window is late, so they need to be delivered separately.

Figure 4 The User Delivery and the Path of Route 6

4.2 Cost Trade-Offs

In this paper, we will analyze the changes in costs and revenues of delivery companies after providing value-added services with time accuracy. In the base model without considering value-added services, the delivery cost of vehicles is 184.75, and after considering value-added services, the total delivery cost of vehicles is 222. By comparison, it can be found that the path cost increases by 37.25 or 20.2% because of the detour of the path after providing value-added services in order to meet the time window constraint of consumers. However, the value-added service brings additional revenue to the delivery company with a revenue increase of 60. In terms of total profit, the revenue brought by the value-added service to the delivery company will be higher than the increased cost of the delivery path. The cost of value-added services assumed in this model is 2, but it is clear from the data that the implementation of value-added services is beneficial to the delivery companies as long as the cost of value-added services is higher than 0.92. Fig. 6 compares the paths of the two models, and it can be seen from the figure that, in contrast to the previous model, although some consumers choose value-added services, the difference in routes is not significant, and some consumers who choose value-added services do not need to pay much to satisfy their demand because their time windows can be satisfied by adjusting the routes appropriately.

Figure 5 Comparison of Old and New Routes

4.3 Sensitivity Analysis

This paper focuses on the impact of the number of consumers who choose value-added services on costs.

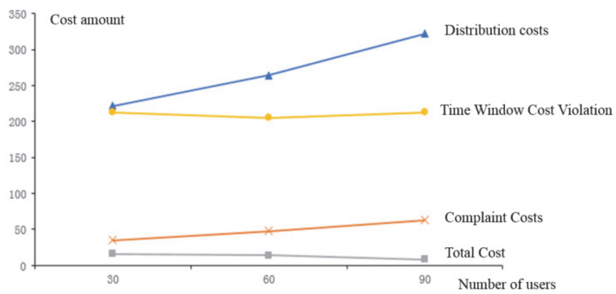

Figure 6 The Impact of the Number of Users Choosing Value-added Services on Costs

As shown in Fig. 7, the delivery cost increases exponentially. Because the number of consumers who choose value-added services increases and the number of consumers who do not choose value-added services decreases, the opportunity to satisfy value-added service consumers by regulating the time of consumers who do not choose value-added services further decreases.

The above all analysis shows that, in terms of delivery costs, the greater the number of consumers who choose value-added services, the greater the delivery costs, which is in line with reality. In order to meet the time window demand of value-added service consumers, more detours occur for vehicles, so the delivery routes become longer and the delivery cost increases. In addition, the delivery cost curve is a convex increasing function, implying that the delivery cost increases more as the number of consumers who choose value-added services increases. From the perspective of time window violation cost, intuitively, as more consumers choose value-added services, more consumers' time windows are satisfied, so the time window violation cost should be reduced. However, the results of this paper find that the time window breach cost increases as the number of consumers choosing value-added services increases. The reason is that as the number of consumers who choose value-added services increases, the number of consumers who satisfy their time windows increases, but in order to satisfy the time windows of this group of consumers, more time windows of other consumers are violated, so the time window violation cost increases. Complaint cost decreases as the number of consumers who choose value-added services increases. Since the time precision requires the delivery person to deliver at home, more consumers can enjoy the home delivery service, and the cost of complaints caused by not satisfying the home delivery further decreases.

5 MODEL CONCLUSION AND SUGGESTIONS

In this paper, a delivery route optimization model based on consumer delivery time is established to optimize the driving path of end delivery vehicles and the delivery method, and the solution algorithm is also designed. Based on the improved algorithm and the construction method of consumer portrait, this paper establishes the solution scenario and plans the delivery route and delivery method based on the data of five real communities. The total cost increases and then decreases with the increase of the number of consumers who choose value-added services. When the number of consumers choosing value-added services is small, the benefits of value-added services are greater than the costs because the delivery company does not need to adjust too many routes to meet the time windows of consumers. However, as the number of consumers choosing value-added services becomes larger, the total cost of delivery increases sharply to meet the time window requirements of more people, and the increased cost exceeds the benefit, so the total cost of delivery increases further.

Since the purpose of all company operations is profitability, companies will not meet consumer demand for unlimited precise time, and the synergistic development of industry management, distribution companies and actual consumers has an important impact on urban end distribution, and the three complement each other. In this paper, from the perspective of the industry management, delivery enterprises and the actual consumer three subjects, for different subjects to make recommendations for the next specific development direction of each subject to promote the development of high-quality market.

Firstly, from the perspective of the industry, we should take policies and regulations, standards and norms as a grip to guide enterprises to establish a scientific and efficient "last mile" urban logistics end delivery system, and increase the support of national policies on logistics delivery paths. It is suggested that for urban logistics end delivery, further strengthen the policy guidance, to policy as a guide, from the industry's perspective, from the perspective of tax and fee reduction, strengthen land supply, etc. to guide the localities to increase support for urban logistics end delivery path optimization, to achieve the end delivery path layout design of scientific rationalization.

Second, enterprises focus on improving the quality of end delivery services. Combine the calculation results and conclusions of the aforementioned model, make reasonable analysis of consumer delivery time, location and delivery mode and implement optimization of the delivery path. Increase the investment in research and development of delivery path analysis system to ensure the consistency of path selection standards, the rationality of methods and the scientific nature of means. Make full use of the logistics and delivery information service platform, regularly collect and analyze customer preference information, and establish a dynamic delivery path analysis system. In order to improve consumer satisfaction, the information related to consumer delivery time, delivery location and delivery method can be considered to be collected regularly in the path optimization analysis system and updated in real time to improve the accuracy of the system.

Third, consumers as the audience group of logistics and delivery services need to further play the function of social supervision, to assist the management of delivery enterprises to do a good job of monitoring the quality of service, timely feedback on related issues, to help logistics enterprises actively optimize the way of service. Further strengthen the implementation of consumer evaluation linked to the performance of delivery personnel, to provide high-quality services as the guide, and focus on improving the quality of logistics and delivery personnel, firmly establish the idea of service for the purpose. Enrich the evaluation channels of social groups to logistics enterprises, strengthen the collection and collation of consumer reactions through telephone, network platforms, social media and other channels, and provide timely feedback and rectification to the problems raised by consumers.

6 REFERENCES

[1] Campbell, A. M. & Savelsbergh, M. W. P. (2005). Decision support for consumer direct grocery initiatives. *Transportation Science*, *39*(3), 313-327. https://doi.org/10.1287/trsc.1040.0105

[2] Bent, R. W. & Hentenryck, P. V. (2004). Scenario-based planning for partially dynamic vehicle routing with stochastic customers. *Operations Research*, *52*(6), 977-987. https://doi.org/10.1287/opre.1040.0124

[3] Fhmke, J. F. & Campbell, A. M. (2014). Customer acceptance mechanisms for home deliveries in metropolitan areas. *European Journal of Operational Research*, *233*(1), 193-207. https://doi.org/10.1016/j.ejor.2013.08.028

[4] Campbell, A. M. & Savelsbergh, M. (2006). Incentive schemes for attended home delivery services. *Transportation Science*, *40*(3), 327-341. https://doi.org/10.1287/trsc.1050.0136

[5] Wang, J., Wang, S., & Fan, S. (2017). Optimal design of logistics distribution of Baidu takeaway in Yuzhong District, Chongqing. *China Market*, (24), 118-119.

[6] Rai, H. B., Verlinde, S., & Macharis, C. (2019). The "next day, free delivery" myth unravelled Possibilities for sustainable last mile transport in an omnichannel environment. *International Journal of Retail & Distribution Management*, *47*(1), 39-54. https://doi.org/10.1108/ijrdm-06-2018-0104

[7] Niels, A., Ann, C., Moritz, F., Martin, S. (2011). Time slot management in attended home delivery. *Transportation Science*, *45*(3), 435-449. https://doi.org/10.1287/trsc.1100.0346

[8] Klapp, M. A.,Erera, A. L., & Toriello, A. (2018). The Dynamic Dispatch Waves Problem for same-day delivery. *European Journal of Operational Research*, *271*(2), 519-534. https://doi.org/10.1016/j.ejor.2018.05.032

[9] Robert, K., Michael, N., Dimitri, R., Claudius, S. (2009). Differentiated time slot pricing under routing considerations in attended home delivery. *Transportation Science*, *53*(1), 236-255. https://doi.org/10.1287/trsc.2017.0738

[10] Qiu, H., Zhou, J., & Long, Y. (2020). Optimization of dynamic order acceptance for urban distribution with customer selectable end delivery methods and time windows. *China Management Science*, *28*(8), 114-126.

[11] Chen, H. L., Wei, Y., & Li, J. Y. (2016). Multi-time slot option pricing for e-tailing delivery under delivery period constraints. *Journal of Systems Engineering*, *31*(4), 515-525.

[12] Zhu, H., Qiu, Y., Jiang, T., & Hu, M. (2020). Joint selection of "last-mile" delivery mode, service mode and delivery time slot for consumers.*Computer Integrated Manufacturing Systems*, *26*(07), 1998-2006.

[13] Li, X. (2018). *Study on the method and application of "last-mile" logistics delivery mode selection*. Northeastern University.

[14] Li, W., Wu, Y., Ram Kumar, P. N., Kumpeng, L. (2020). Multi-trip vehicle routing problem with order release time. *Engineering Optimization*, *52*(8),1279-1294. https://doi.org/10.1080/0305215x.2019.1642880

[15] Rohmer, S. U. K, Claassen, G. D. H., & Laporte, G. (2019). A two-echelon inventory routing problem for perishable products. *Computers & Operations Research*, *107*, 156-172. https://doi.org/10.1016/j.cor.2019.03.015

[16] Breunig, U., Baldacci, R., Hartl, R. F., & Vidal, T. (2019). The electric two-echelon vehicle routing problem. *Computers & Operations Research*, *103*, 198-210. https://doi.org/10.1016/j.cor.2018.11.005

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