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The Relationship of Delivery Frequency with the Cost and Resource Operational Efficiency: A Case Study of Jingdong Logistics

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Abstract: Under drastic competition, major express companies have increased their daily delivery frequency to improve customer satisfaction and market share. The inverse relationship of frequency with cost and operational efficiency becomes the key to the decision of delivery frequency. This paper uses JD Logistics as an example to quantitatively analyze the relationship mentioned above. The results show that: (1) The cost and resources operational efficiency are closely related to the order splitting ratio under the same delivery frequency; (2) The delivery frequency has different effects on the operational efficiency of the resources in different links. (3) Through the proper splitting and loading of orders, staff scheduling, and area adjustment of delivery station, the optimal delivery frequency can be achieved under the balance of cost and resource operational efficiency. In order to reduce the operating costs of logistics enterprises on the basis of ensuring service levels, one should first properly allocate the amount of orders and splitting ratios to achieve an economic increase in the delivery frequency. In addition, it is important for the logistics enterprises to consider the constraints such as delivery resources and consumer satisfaction to achieve the appropriate decision of delivery frequency. What's more, it is also crucial to reasonably arrange vehicle loading, staff scheduling and distribution station leasing for the logistics enterprises.

Keywords: Delivery Frequency, Delivery Cost, Delivery Resource Operational Efficiency, System Dynamics

1. Introduction

As the volume of orders and consumers' demand of rapid delivery services increasing, express companies are required to increase the daily delivery frequency to cope with the pressure of delivery during peak period and meet the consumers' needs effectively. However, the increasing in delivery frequency will lead to changes in the workload of different resources (distributors, facilities, equipment, etc.) at various stages in the delivery system, which will more likely to result in uneconomical performance. At present, most express companies are operating different delivery frequencies in different regions. The order volume, the orders' splitting ratio, the operational efficiency of delivery resource and the delivery costs will affect the delivery frequency. Therefore, it is necessary to analyze the quantitative relationship among the above-mentioned factors to ensure that the express company can achieve high delivery economy while realizing multi-frequency and fast delivery to improve the customer satisfaction.

2. Literature Review

The transportation system is a very complex system with many different feedbacks and lagged responses between policy makers. System dynamics models not only offer a different perspective while whole system approach to transport planning, but also demonstrate to policy makers the importance of these feedbacks and lagged responses [1]. There are various of applications of system dynamics in the area of transportation [2, 3]. At present, the researches on delivery frequency, resource operation efficiency and cost utilization were mainly focusing on the following two aspects: (1) Delivery efficiency improvement through the choice of delivery model, And (2) Delivery link optimization.

Fan Xuemei et al. [4] discussed the delivery efficiency problem under e-commerce model from input and output perspectives. That research explored three scenarios, which are joint delivery, autonomous delivery, and third-party delivery, which also pointed out that, in order to improve delivery efficiency, enterprises should adequately consider relevant factors such as own resources, competitors' delivery strategies, and urban transport policies before determining delivery methods. Jesus et al. [5] pointed out that joint delivery can effectively improve the efficiency of urban delivery. It proposed an assessment framework for joint delivery. That research took Lyon in France as an example with the using of radar map to visually show CO2 emissions, risk values, delivery costs, traffic impact and delivery time of joint delivery under different scenarios. Some other researches tried to improve the delivery efficiency and reduce the delivery cost through delivery center location optimization [6-8], delivery vehicle route optimization and scheduling [9-12], and delivery resource integration [13-15].

The system dynamics has a good applicability in analyzing the delivery efficiency, and some researches have achieved a series of results. Tang Mingyu [16] took the Beijing delivery system as research object, and measured urban delivery efficiency from three aspects including economy, technology and environment. After that, that research built a dynamic model of the urban delivery system, and simulated the impact of Beijing's pilot logistics policy on delivery efficiency. Wang Wei [17] analyzed the advantages and disadvantages of self-operated, outsourced, and federated modes in e-commerce delivery model, and constructed a system dynamics model for the combination selection of delivery modes by selecting six core factors, which can provide decision-making advice for managers to improve the delivery efficiency. Barla [18] used system dynamics to simulate the links of orders, production, and inventory for apparel delivery companies, and considered how to adjust inventory levels to increase the delivery systems' efficiency and economy when demand fluctuates significantly. Hongtao Yang and Jianbang Du [19-21] uses system dynamics to analyze the problems of supply chain and delivery efficiency from the perspectives of transportation routes, drivers and cooperation agreements, and its sensitivity analysis provides some reference to this paper for the corporate in this case to improve the delivery efficiency. Lin Wanting [22] considers the phenomenon of unfilled orders, information leakage, and product damage which exists in crowdsourcing delivery, then built system dynamics model from five dimensions of reliability, responsiveness, assurance, empathy and security, which provide decision-making advice for enterprise delivery efficiency management.

This paper uses Jingdong Logistics (JDL for short) as research objects. First, it analyzes the boundary and causality of its delivery system. Then, it establishes a simulation model for the operation of the delivery system on the base of system dynamics. Next, it uses the simulation model to study the effect of changes in delivery frequency on delivery costs and resource operation efficiency under different quantity of delivery orders. It provides reference for express companies to determine the delivery frequency.

3. JDL Delivery System Model Construction

As the first step, this paper defines the research boundary of JDL delivery system. Secondly, it constructs subsystems of cost and resource operation efficiency for the delivery activities in the boundary. Next, it analyzes the interaction between delivery frequency, cost, and resource efficiency, and builds dynamics simulation model to get the equilibrium of cost and resource operation efficiency under different delivery frequency.

3.1. JDL Delivery Process

Based on field surveys of JDL delivery systems and interviews with operational personnel, on a route daily business JDL delivers orders within the region based on a fixed frequency. Each delivery operation mainly includes: storage, ferry, sorting, transportation and terminal delivery. The relationship of the workflows in the delivery system is shown in Figure 1.

As shown in Figure 1, JDL delivery process nodes in the area include: warehouses, three sorting centers and two delivery stations; resources include: storage facilities, sorting facilities, various transport vehicles and delivery workers.

Based on the details of research object, this paper constructs two subsystems: delivery cost subsystem and delivery resource subsystem. According to investigation results, the cost of storage and ferry in JDL only accounted for about 8% of the average cost in daily delivery. Therefore, the storage and ferry crossings are negligible in this paper., Only the section within the dotted line in Figure 1 is considered in this paper.

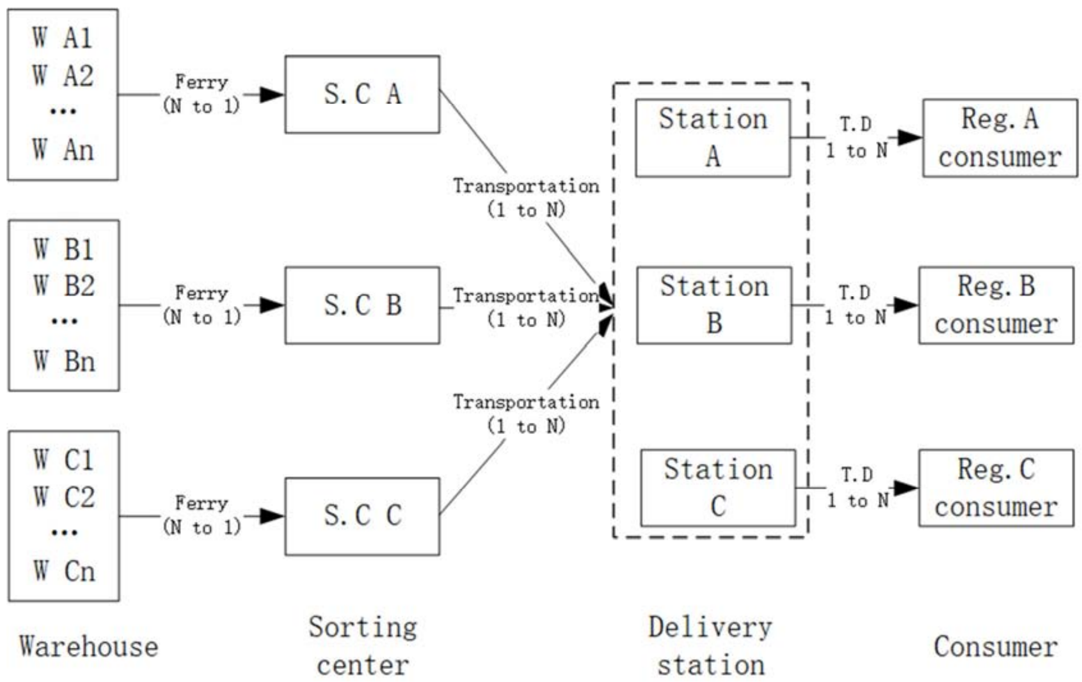

Figure 1. *JDL delivery process.*

3.1.1. Delivery Cost

The delivery cost mainly includes the equipment usage costs and labor costs in the three stages of sorting, transportation and terminal delivery.

The equipment usage costs can be divided into two parts: the fixed costs and the variable costs. The fixed costs occurred in the use of equipment in the three links. The variable costs occurred due to the volume of orders, which include operating cost of the sorting equipment, rental cost of the site, units fixed cost of transport vehicle, fuel costs, toll and so on. In addition, the number of working facilities and the operating time are affected by factors such as order quantity, delivery frequency, sorting equipment efficiency, and unit load of transport vehicles.

Labor costs are composed of fixed wages and performance wages for employees in the three links mentioned above. The employees include direct employees who are vehicle drivers and indirect employees who are managers. The number of employees is affected by factors such as order quantity, transportation efficiency, delivery frequency, and the number of transport vehicles. Performance wage is determined by the actual amount of work performed during the delivery process. Sorting staffs consist of sorters and on-site logistics personnel. The sorter is the person who operates on the sorting equipment. The on-site logistics personnel is the person who puts the sorted goods into a mail packages and places them on a pallet and then sends it to the transportation vehicles. The number of sorting staffs is influenced by factors such as the amount of cargo, the number of sorting equipment, the worker's efficiency, the sorting time requirements, the area of sorting venues, the number of logistics personnel in the yard, the delivery frequency and so on.

3.1.2. Resource Operational Efficiency

Resource operational efficiency refers to the ratio of the operating number and the available number of workers and material resources. This article considers the utilization efficiency for the facilities, personnel, and technology such as turnover rate of transportation vehicles, the utilization rate of delivery site, and the delivery personnel loading rate, etc., which are put into the sorting, transportation, and terminal delivery links. The utilization rate of transportation vehicles is calculated by dividing the actual traffic volume at each sorting center by the vehicle capacity. The utilization of the site space is obtained by dividing the actual leased area of the site by the available area. The usable area of the site consists of public area and working area. The personnel load rate in the process is calculated by dividing the actual workload by the authorized workload.

3.2. Influencing Factors of Delivery Frequency

The delivery frequency refers to the number of times of terminal delivery by the company in unit time (in days). The increase in the delivery frequency will result in the following two changes: first, the increase in consumer satisfaction; second, the corresponding changes in the cost and resources operational efficiency. The first change may prompt the increase of customer orders and corporate income Therefore the company will increase the investment in delivery facilities and equipment, and thus increase the delivery frequency and service capabilities. As for the latter, given JDL's current batch-by-batch delivery mode, the increase in delivery frequency will reduce the fixed cost allocated to each delivery operation. At the same time, the factors such as sorting time requirements, proportion of per-order batch, efficiency of the delivery personnel, and unit fuel consumption of the vehicle, will have a direct impact on the delivery frequency.

Based on the surveys of JDL and interviews with related professionals, this paper summarizes 55 influencing factors on delivery frequency. These factors present a complex, nonlinear, and inverse relationship between each other. Therefore, this paper uses the causal loop method of system dynamics to analyze the relationship between the factors.

As is shown in Figure 2, 58 causal loops are formed. Among them, the positive loop represents that there is a mutually reinforcing relationship between the factors, while the negative loop indicates that there is a balanced relationship between factors (Such as: Delivery frequency ——> + Consumer demand response ability ——> + Impact of demand response capacity ——> + Consumer satisfaction ——> + Order quantity due to change in satisfaction ——> + Total daily order quantity ——> + Per batch delivery order quantity——>+ Sorting center cargo volume——>+ Number of on-site logistics personnel——> - Onsite logistics personnel operating time——>+On-site logistics personnel costs——>+ Sorting personnel costs——>+ Sorting costs——>+ Total cost ——> Total profit ——> + Delivery facility input ——> + Delivery frequency).

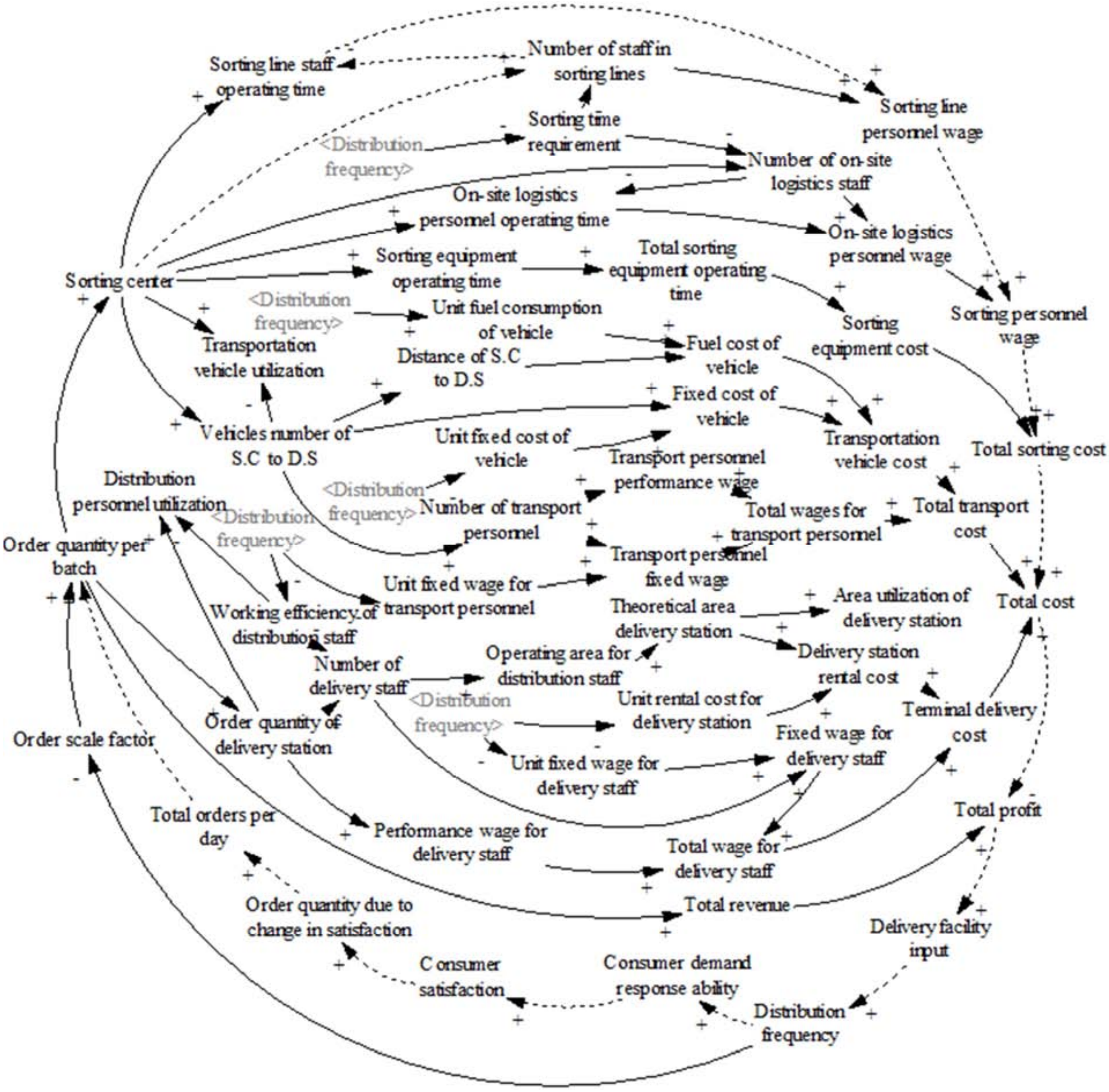

Figure 2. *Causal loop of influencing factors for delivery frequency.*

3.3. System Dynamics Simulation Model for Delivery Process

According to the influencing factors above, a simulation model of the system dynamics has been built as shown in in Figure 3.

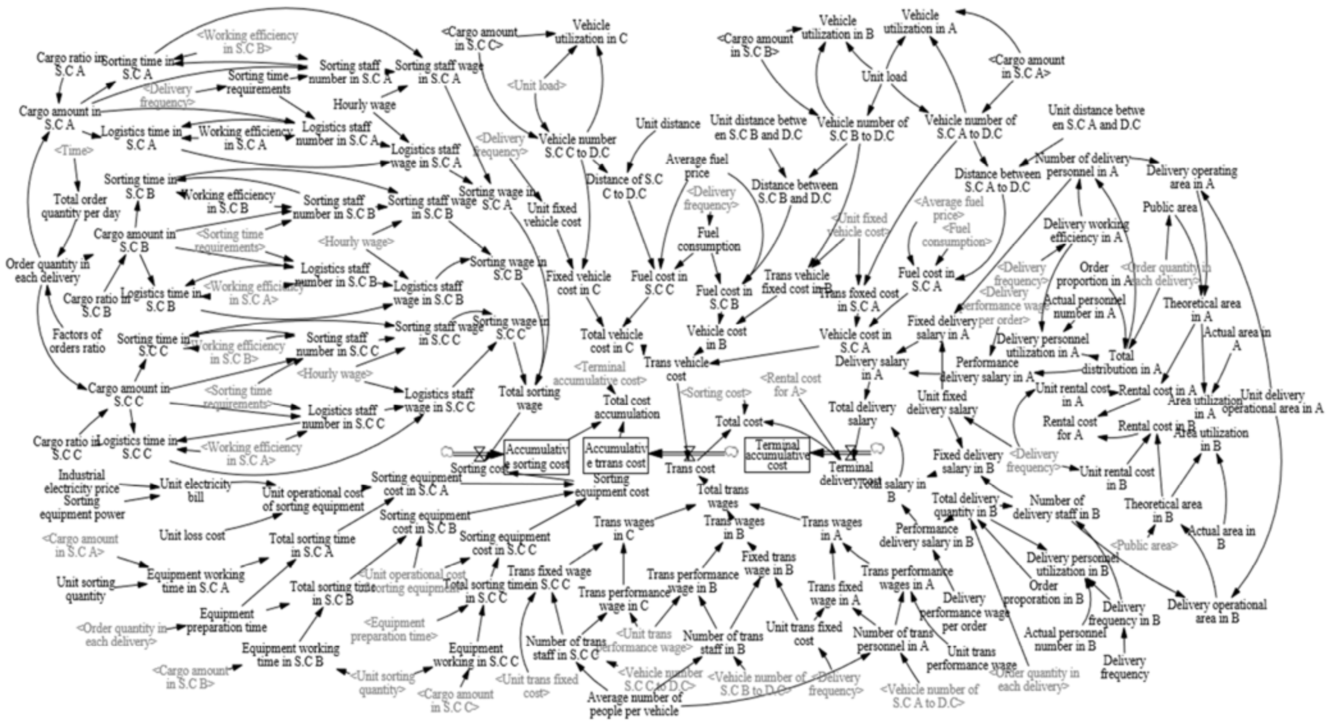

Figure 3. System dynamics model for JDL delivery.

3.4. Model Validation

This model passed the mechanical error checking and dimension consistency testing by VENSIM. The extreme condition when the order quantity equals to zero was examined as well. After that, the validity of the model was verified though the error analysis by comparing the simulation data and actual operational data, which includes the average cost of sorting, transportation and terminal delivery. The main parameters involved in the model are as follows:

(1) Total quantity of orders per day: according to the survey results, the 30-day order quantity in the delivery site within the scope of the study is: 2478, 3154, 2828, 2341, 1651, 1761, 2720, 2790, 3086, 2436, 2469, 2406, 3005, 3251, 2316, 2459, 2445, 2128, 1585, 1496, 2493, 2350, 2567, 2480, 2279, 1737, 1650, 2530, 2179, 2128. In order to obtain a more generalized results, 10 data points are selected every 200 in the range of 3500 to 5300 for simulation.

(2) The relevant constant variables in the model are shown in Table 1, and the explanations are shown in Table 2.

Table 1. Constant values in the model.

Industrial electricity prices	1 RMB/KW.h	Actual area of station A	50 Square meters
Sorting equipment power	75 KW	Actual area of station B	70 Square meters
Unit loss cost of sorting equipment	100 RMB/h	Order ratio in station A	40.8%
Preparation time of sorting equipment	0.3 h	Order ratio in station B	59.2%
Average number of people per vehicle	1 person/vehicle	Distance of sorting enter A to delivery station	40.6 km
Transport staff performance pay	40 RMB/time	Distance of sorting enter B to delivery station	45 km
Delivery staff average performance pay	1.5 RMB/package	Distance of sorting enter C to delivery station	60.6 km
Actual number of staff in station A	13 person	Unit operating area for delivery personnel	4 Square meters/person
Actual number of staff in station B	23 people	Cargo volume ratio in sorting center A	33%
Public area	30 Square meters	Cargo volume ratio in sorting center B	32%
On-site staff working efficiency	10 vehicle/h	Cargo volume ratio in sorting center C	35%
Average fuel price	6 RMB/L		

Table 2. Explanation for constant.

Constant name	Explanation
Average number of people per vehicle	Refers to the number of personnel on each vehicle, generally in a vehicle, a driver is responsible for the transportation of goods to the delivery station and for the handover with the site.
On-site staff working efficiency	Refers to the efficiency of the loading of the pallet into a transport vehicle by logistics staff in the yard.
Distance of sorting enter to delivery station	Refers to the distance from the sorting center to the delivery station when transporting a shipment of goods.
Cargo volume ratio in sorting center	Refers to the proportion of goods sorted by each sorting center. Because different sorting centers are responsible for different types of goods, the proportions are calculated based on actual measurements.
Delivery staff average performance pay	In addition to the fixed salary, JDL have to pay the performance wages for the delivered orders to the

Constant name	Explanation
	workers.
Order ratio in station	Refers to the proportion of orders at each site to the total orders, which is calculated on the base of actual statistics.

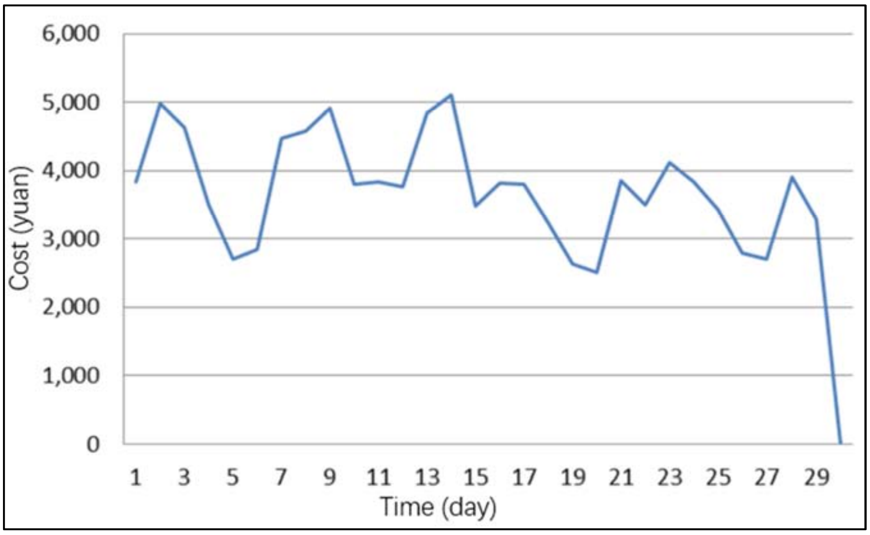

Figure 4. *Cost test in extreme condition.*

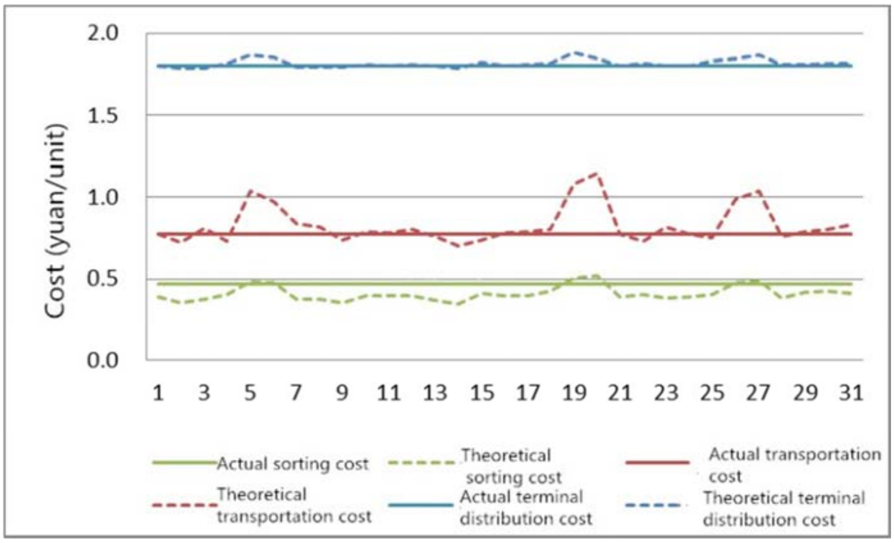

Figure 5. *Error analysis.*

After simulation, the validity test results were obtained and are shown in Figures 4 and 5.

Figure 4illustrates that when the order quantity is zero, the corresponding cost is also zero. Therefore the extreme condition test is satisfied. In Figure 5it can be seen that except for a few days, the cost of each delivery link in the simulation fluctuates around the actual value, and the value on the 31st day is equal to the average value of the first 30 days, and the actual cost error is within 10%, which is consistent with the consistency test.

4. Simulation Analysis

In this paper, four different schemes of delivery frequency were set up for simulation analysis. The proportions of the order quantity for each batch under different schemes are shown in Table 3, and the setting reasons for each scheme are shown in Table 4. Different delivery frequencies have different splitting ways of total order quantity per day. Since the current order quantity of each batch is mainly determined by the consumer’s shopping habits, which cannot be arbitrarily changed, this paper splits the orders of the first batch (60% of the total orders). Therefore, the simulation calculates the utilization rate of the largest batch after splitting when considering the operational efficiency of resources. On the other hand, the cost index was calculated based on the summed number of shipments as JDL adopts single-batch delivery.

Table 3. *The proportion of order quantity for each batch (%).*

Frequency (times/day) \ Scenarios	First	Second	Third	Fourth
1	60	30	40	20
2	30	30	20	20
3	10	30	30	20
4	—	10	10	30
5	—	—	—	10

Table 4. *Setting reason for each scheme.*

Scenarios	Setting reason for each scheme
First	The delivery frequency in each city is three times per day, and the proportions of the orders for each batch are obtained through statistics of actual delivery data.
Second	JDL intends to adopt a schedule to improve delivery service, that is, to deliver 4 times per day by splitting the 60% of orders in the first batch.
Third	Setting control plan for scenario 2, which is 4 times a day. In addition, considering placing more orders to the consumers as soon as possible to improve their satisfaction, while the percentage of the splitting orders cannot be too large, otherwise the splitting will be meaningless. So splitting 60% of the orders in the first batch into 40% and 20%.
Fourth	In order to adapt the future development, considering setting the frequency five times per day. At the same time, dividing the 60% of orders into three equal parts to alleviate the tension of delivery resources.

After simulation, the relationship between delivery frequency with delivery costs and resource operational efficiency was obtained when the total order volume was the same.

4.1. Simulation Analysis of Delivery Costs Under Different Delivery Frequencies

4.1.1. Analysis of Total Delivery Cost

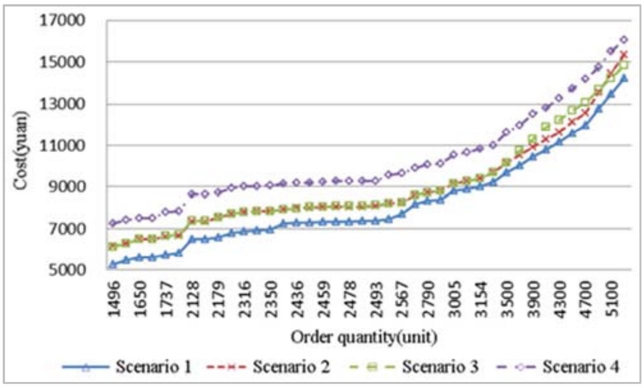

Figure 6. *Total delivery cost.*

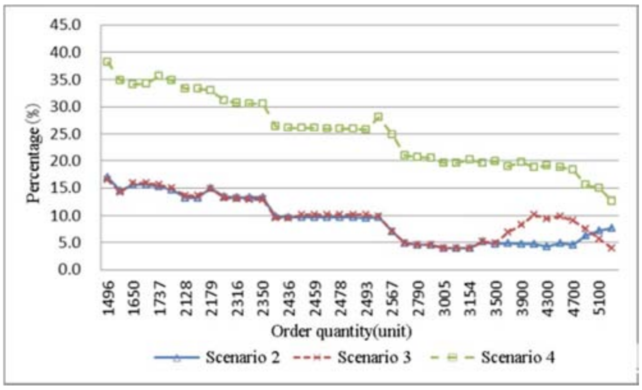

Figure 7. *Increased percentage of delivery cost.*

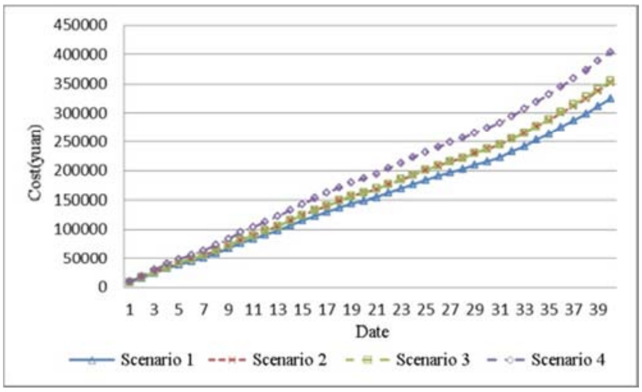

Figure 8. *Accumulative delivery costs.*

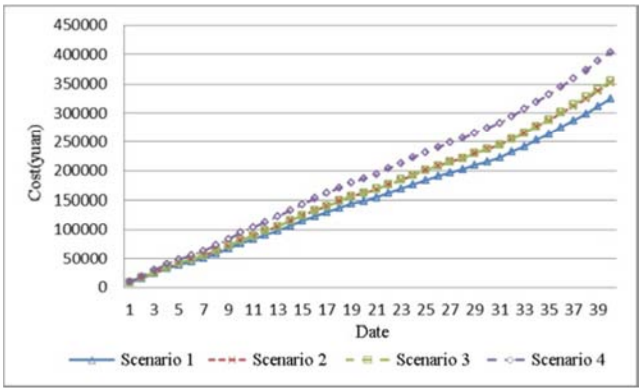

Figure 9. *Average costs of each order.*

As shown in Figures 8 and 9, in terms of total delivery cost, a negative correlation between frequency and cost cannot be reached all the time. The delivery frequency in scenarios 2 and 3 was increased by 9.5% over that in scenario 1. When the volume of orders increased from 1496 to 5300, the increased percentage of total delivery cost showed a downward trend followed by an upward trend. The minimum value of 3.9% appeared in the order volume of 3086-3154 units.

In scenarios 2 and 3, when the order quantity was lower than 3,500, the differences between the total delivery costs in different scenarios were very small; when the order quantity was higher than 3,500, the increased rate of cost in scenario 3 was higher for a while than that in scenario 2. The reason is that in scenario 3 the sorting center dispatched more vehicles in advance, which increased the cost of transportation. Since the difference in total delivery cost between the two scenarios was not significant and scenario 2 is better than scenario 3, scenario 3 will be neglected in the following analysis.

The total delivery cost in scenario 4 was increased by 25% in average than that in scenario 1. As the order volume increased, the increased percentage of total cost tended to decrease in fluctuation. After the order volume reached 5,100, the total delivery cost in scenario 4 showed a downward trend and reached the minimum. In this situation, the delivery frequency should be increased accordingly.

Within the orders volume ruled in this paper, the delivery frequency and the cumulative delivery costs are positively correlated. The four scenarios showed a lower average unit cost when the order quantity was around 4,700 units indicating that this order quantity was a batch of economic orders.

4.1.2. Analysis of Sorting Cost

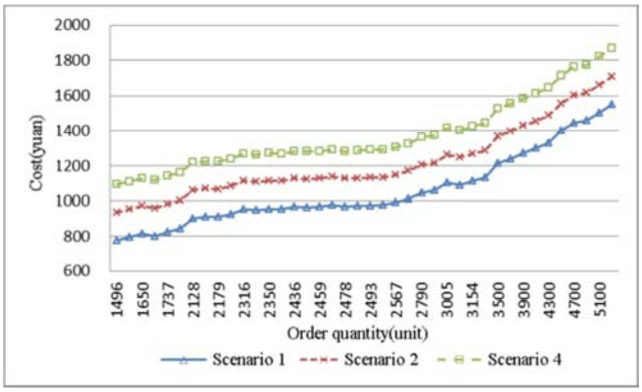

Figure 10. *Total sorting costs.*

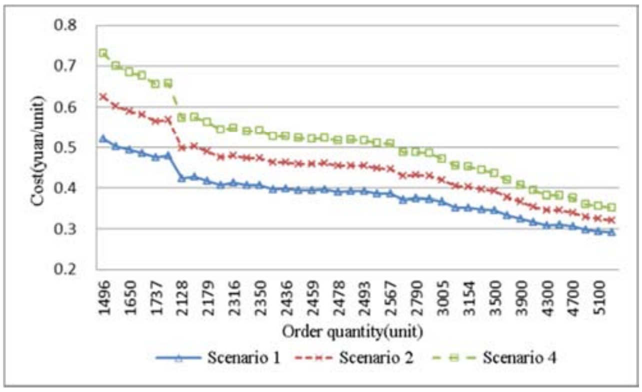

Figure 11. *Average unit costs.*

In Figures 10 and 11, it can be seen that the sorting cost of scenario 2 increased by an average of 157 yuan per day compared to scenario 1, which was due to the increase of delivery

Higher frequency led to an increase in the total working time of sorting equipment and equipment costs. Due to the increase in the delivery frequency, the unit average time required to complete the sorting operation became shorter while the number of sorters and the salary of personnel increased.

Compared to scenario 1, scenario 4 had an average increase of 315 yuan per day in total sorting costs. This is because that under the current total delivery volume, the order quantity after splitting in the scenario 4 was higher. Regarding on the sorting efficiency equipment, the operation time of sorting equipment became longer and the sorting cost increased.

The difference of average unit sorting costs among scenarios 1, 2 and 4 decreased as the order increased, which is because the change in the sorting costs under different order quantities was small and the difference in the delivery order quantity increased.

4.1.3. Analysis of Transportation Costs

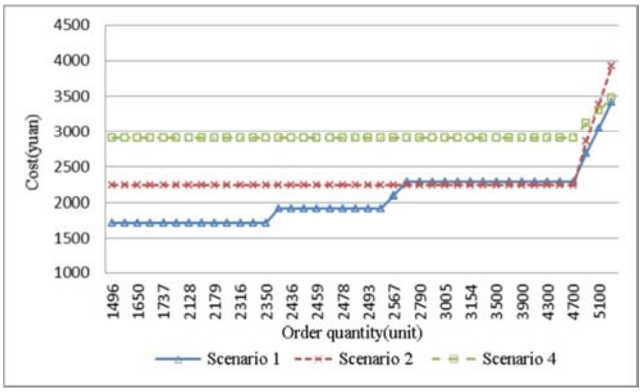

Figure 12. *Transportation costs.*

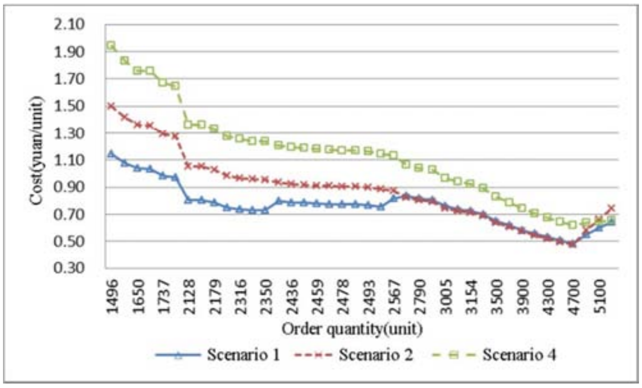

Figure 13. *Unit average costs of transportation.*

Figures 12 and 13 show that the transportation cost in scenario 2 was increased by an average of 14% than that in scenario 1. The increased percentage behaved a negative growth trend followed by a positive growth trend as the order increased.

The transportation cost in scenario 4 was increased by an average of 45% over scenario 1. In addition, scenario 4 has the lowest transportation cost among the three scenarios as it has a higher order volume.

The transportation cost in scenario 1 showed a rising trend with the increase of orders. When the order volume was 2406, 2530 and 4700, the transportation cost rose rapidly. This is because the sorting center needs more vehicles to carry the corresponding batch of goods.

Due to the splitting of order, the transportation costs of scenarios 2 and 4 remained unchanged when the order volume was small.

When the volume of orders increased to a certain value, the transportation cost of scenario 1 became the highest among the three scenarios. The main reason is that in this case the number of transportation vehicles at the sorting center was fixed. In scenarios 2 and 4 the orders can be met by just increasing the frequency of existing vehicles, however, in scenario 1, new vehicles were needed to meet the transportation needs, which resulted in higher transportation costs. In the aspect of unit average transportation cost, similar trends were also emerged among the scenarios mentioned above.

4.1.4. Analysis of Terminal Delivery Cost

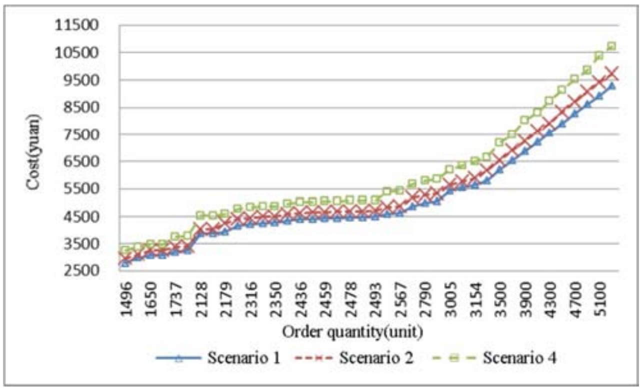

Figure 14. *Terminal delivery costs.*

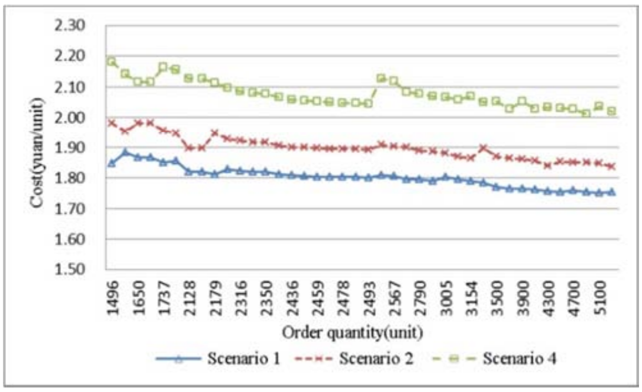

Figure 15. *Unit average Terminal delivery costs.*

Figures 14 and 15 illustrate that the terminal delivery cost of scenario 2 was increased by an average of 5% compared to scenario 1, and the cost in scenario 4 was increased by an average of 15% over that in scenario 1. The main reason is that the increase in the delivery frequency improved the demand for the number of delivery personnel and caused the delivery time of delivery personnel to be shorter in a single batch. As a result, the overall efficiency of the delivery staff was reduced. At the same time, the increase in the delivery frequency also improved the rental cost of the delivery station.

In terms of unit average terminal delivery cost, all three scenarios have shown a tendency of fluctuating decline, and some of the rises are due to the increase in the costs of delivery personnel and facilities.

4.2. Analysis of Vehicle Utilization

4.2.1. Vehicle Utilizations in Different Sorting Center

Figures 16, 17 and 18 demonstrate that the delivery frequency hade different effects on different transportation vehicles. The vehicles utilizations of the three sorting centers in scenario 1 showed the first drop point when the order volume was 2530, 2567, and 2350, and the second drop point occurred at 5000, 5200, and 4800. The reason is that the proportions of the sorting orders taken by the three sorting centers were different. Thus the number of additional vehicles under different order quantities was different. The difference between the vehicle utilization efficiency in scenarios 2 and 3 increased with order volume until it reached 3600 units.

The vehicle utilization efficiency for the three sorting centers in scenario 4 increased with the order volume since only one transportation vehicle was required to be dispatched from each sorting center within the current order volume.

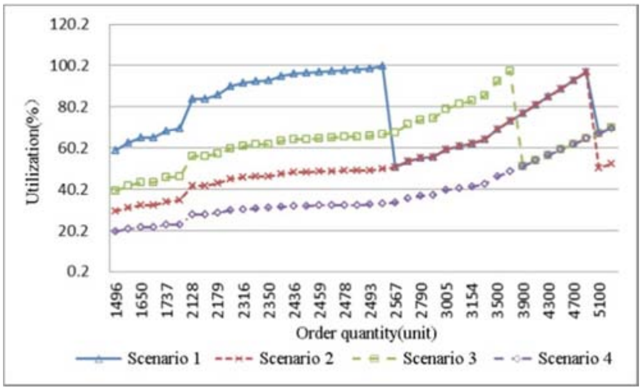

Figure 16. *Vehicle utilizations in S.C A.*

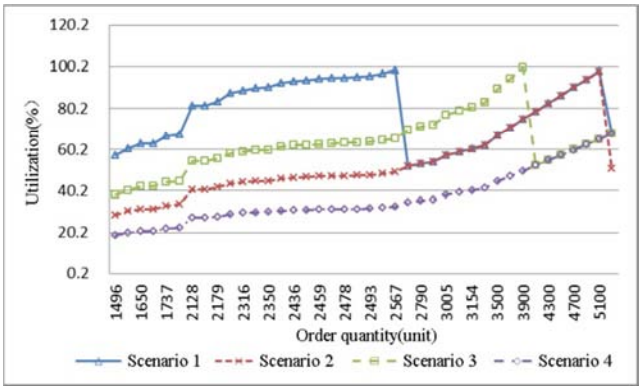

Figure 17. *Vehicle utilizations in S.C B.*

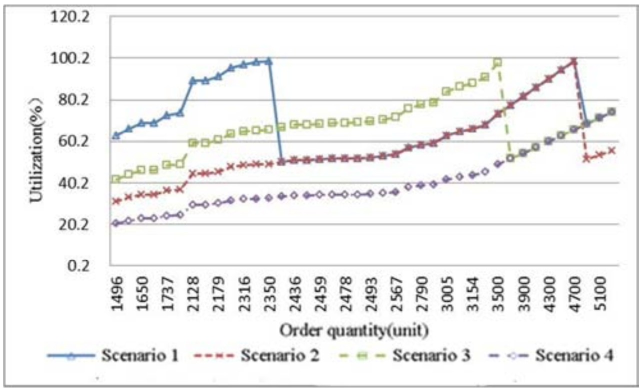

Figure 18. Vehicle utilization in S.C C.

4.2.2. Analysis of Area and Personnel Utilization Efficiency

Figures 19, 20, 21 and 22show that the delivery frequency had different effects on terminal delivery operations. In most conditions, the area utilization efficiencies of the delivery site in scenario 1 were higher than that in scenarios 2 and 3. In some cases, the area utilization efficiencies in Scenario 1 and Scenario 3 were the same. This is because the difference of orders volume in the largest batch between two scenarios was small.

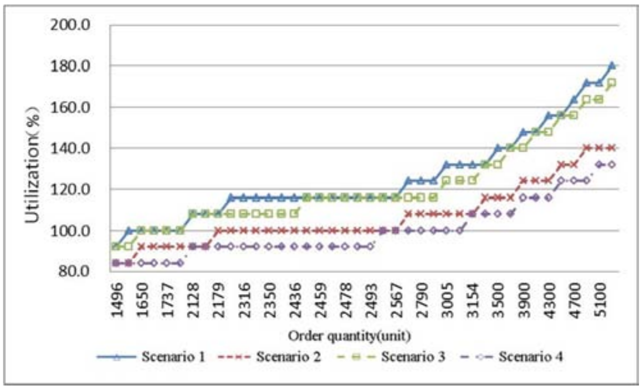

Figure 19. Area utilization efficiency of delivery station A.

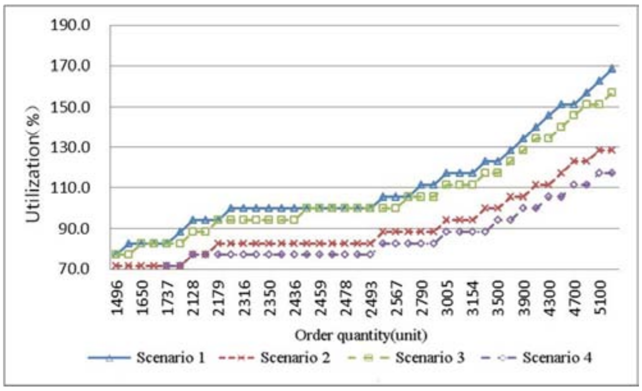

Figure 20. Area utilization efficiency of delivery station B.

In addition, the delivery area utilization efficiency was the same at some points between scenario 4 and scenario 2. This is because the order volume was so small in scenario 4 that in the unit batch delivery personnel was working inefficiently. As a result, the company had to increase the number of delivery personnel and the area of shipments.

As shown in Figures 21 and 22, the overall utilization efficiency of delivery station A was approximately 5% higher than that of delivery station B. This is because that the ratio between the order quantity and the actual number of delivery personnel at the delivery site was not equal. In addition, scenario 4 can effectively ease the utilization of area and personnel in the delivery site.

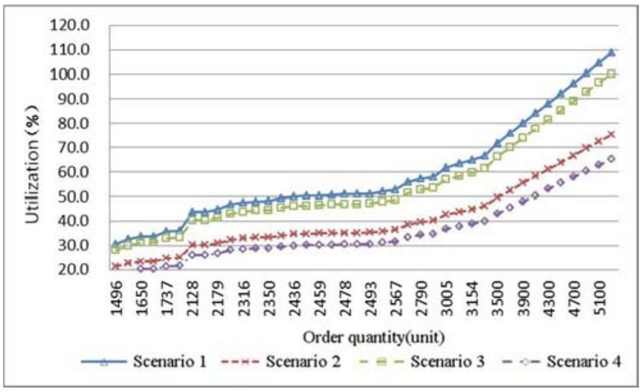

Figure 21. Personnel utilization efficiency of delivery station A.

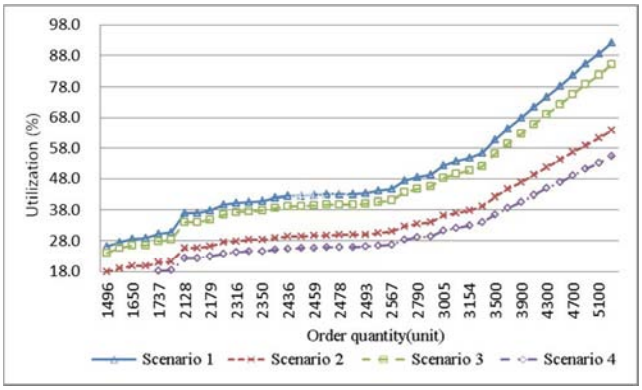

Figure 22. Area utilization efficiency of delivery station B.

5. Conclusions and Recommendations

5.1. Conclusions

The results of this study indicate that under the impact of order volume there is no fixed relationship between delivery frequency with delivery cost and resource operational efficiency. With the same delivery frequency, the orders splitting ratio influences delivery cost and resource utilization efficiency significantly. The change of delivery frequency has different effects on the resource operational efficiency in different stages of the delivery process.

5.2. Recommendations

Recommendation I: one should properly allocate the amount of orders and splitting ratios to achieve an economic increase in the delivery frequency.

With the same delivery frequency, different order splitting ratios affect delivery cost and resource operational efficiency. Therefore, JDL needs to consider the increase in delivery frequency, the increase in delivery costs, the overloading of resources, and the ratio of orders and splits. For example, when the JDL order volume fluctuates between 3086-3154, one should adopt scenario 2 or scenario 3; when the order volume is greater than 5100, scenario 4 should be adopted.

Recommendation II: one should consider constraints such as delivery resources and consumer satisfaction to achieve the appropriate decision of delivery frequency.

With different delivery frequency, JDL's delivery resources and consumer service quality are different. The increase in delivery frequency can, ease JDL's resource utilization in the links of sorting, transportation, delivery, and other aspects, and provide consumers with fast delivery services. In addition, the average split of order quantity can effectively reduce the tension of delivery resources. In the same delivery link the demand for delivery resources can be different due to different delivery operational capacities. Therefore, JDL needs to consider different constraints when making delivery frequency decisions. When transportation vehicles are in tight supply, the delivery frequency should be increased when the order volume is 2530. In this case, if scenario 2, 3, or 4 is adopted, one can increase the total number of order shipments by 2,400, 1,400, and 4,450 units respectively without increasing the number of transport vehicles. When the delivery frequency is increased from 3 times per day to 4 times per day, scenario 3 should be adopted from the perspective of increasing consumer satisfaction; scenario 2 should be adopted when the area of delivery stations and the delivery personnel are tight.

Recommendation III: One should reasonably arrange vehicle loading, staff scheduling and distribution station leasing.

The delivery frequency has different effects on the resource operational efficiency in different delivery stages. Therefore, JDL should combine the simulation results with the actual situation before making the delivery frequency decision. Since the average personnel utilization efficiencies of delivery both stations A and B are lower than 60%, the delivery personnel can be reasonably scheduled to improve the utilization efficiency and consumer satisfaction. In addition, the area utilization efficiency of delivery stations may exceed 100% under large orders. Therefore, according to the actual situation, it is necessary to increase the delivery frequency or expand the area of delivery sites.

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