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Customer-Classified Intracity Fruit Distribution Path Optimization: A Case Study in Jining, China

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Abstract

With the development of technology and economy, customer satisfaction is becoming increasingly important to businesses. Customers expect more in regard to product quality, personalised service and delivery date. This study randomly selected customers from a small-to-medium sized company in China as case study and used a K-Means cluster analysis approach to present the available management in logistics. The mileage saving method was also used to contribute the distribution path planning. This resulted in a more scientific distribution route based on comparative analysis, which helped the target company save resources and improve efficiency. This study helped companies effectively identify customer value by combining customer classification with intracity distribution path optimization. Simultaneously, it provides possible empirical reference to service quality improvement, the distribution path optimization, the resource wasting reduction and the companies' operation efficiency enhancement. It enriches the current literature about food distribution path optimization for small and medium sized food company.

Keywords:
Customer classification
Path optimality
Intra-city service
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1. Introduction

China is a large producer and consumer of agricultural products. The productivity of China's fresh agricultural products such as aquatic meat, fruits and vegetables ranks top in the world for many years. Due to the continuous development of China's economy and the steady improvement of residents' life quality, the consumption structure and demand of residents have also changed greatly. In the field of fresh agricultural products, people increasingly pursue high-quality products. The optimization of intracity shipping path can reduce the distribution time and mileage, increase the distribution efficiency, and improve the utilization rate of vehicles (Granillo-Macías, 2021; Singh, Kumar, Panchal, & Tiwari, 2021). As a consequence, it reduces the distribution cost and improves customer satisfaction (Li, Cao, Zuo, & Xu, 2020; Yadav, Singh, Raut, & Cheikhrouhou, 2021). In regard to the logistics industry, the advent of the era of big data reveals that big data has become the trend (Helo & Ala-Harja, 2018; Pal & Kant, 2019; Sharma, Zanotti, & Musunur, 2020). Logistics industry's characteristics of diversity, low value density and real-time are both challenges and opportunities (Melkonyan, Gruchmann, Lohmar, Kamath, & Spinler, 2020; Paciarotti & Torregiani, 2020).

In the distribution business, customer classification management has become one of the effective methods to improve customer satisfaction (Heard, Taiebat, Xu, & Miller, 2018; Tsang et al., 2018). Identifying and maintaining excellent customers not only avoid the waste caused by resource dispersion, but also promotes the continuous development of enterprises (Mittal, Krejci, & Craven, 2018). By collecting and classifying the data generated from the customer-enterprise transaction, the scientific rationality of the classification results is ensured, and the risks of invading customer privacy are avoided.

Both domestic and foreign scholars have conducted relevant studies regarding intracity fruit distribution. Dantzig and Ramser (1959) proposal on solving the vehicle routing optimization problem (VRP) quickly attracted the attentions of plan designers in the field of logistics technology, combinatorial mathematics and transportation and became a hot topic in the field of combinatorial optimization. Tang, Feng, and Gong (2018) summarized the common problems found in fresh product distribution. They established an optimization model that describes fresh agricultural products intracity distribution in an e-commerce environment, and they have applied a genetic algorithm for problem solving. Tan, Liu, Guo, and Yuan (2018) studied the transportation cost minimisation regarding the intracity distribution path optimization with time window. Their study gave an example of a certain express company's goods distribution and points out the irrationality of real life. Liu (2017) constructed an intracity distribution path optimization model based on an innovative mode. She used an improved tabu search algorithm to solve the intracity delivery problem with time window. Qu (2017) proposed an optimal delivery route selection scheme. She constructed a vehicle route optimization model with soft time window and customer priority delivery, and applied genetic algorithm to solve the problems. Qiu (2016) taking Xiamen as an example, analyzed the key factors that promote the coordinated development of urban distribution and urban economy. Also, he conducted a strategic simulation from three angles involving investment proportion, talent promotion mode and the degree of urban joint distribution and used the Vensim ple platform for real-life simulation.

To sum up, although many studies have suggested path optimization scheme from different perspectives, studies combining both customer classification and fruit distribution path optimization are rare. More specifically, current literature stress on mapping out the single path, lacking the study of optimized distribution path for specific consumers especially for small-medium sized fruit companies. Therefore, this paper examined the intracity fruit distribution path optimization based on customer classification. It involved a real-life customer classification case and used a mileage saving method for distribution path selection, which helped enterprises identify customer value correctly and improved operational efficiency.

The increase of time and temperature changes during fresh agricultural products transportation will affect the value of commodities and, more seriously, the health of the consumers. Therefore, ensuring the effectiveness of time has become the key of developing the fresh agricultural product industry. Due to limited resources, companies are less likely to immediately meet the needs of all users in the distribution process.

In order to maximize customer satisfaction and retain key customers for the target company. This study randomly selected 30 customers from the company and used a K-Means cluster analysis approach to divide customers into priority service and ordinary groups. Also, based on the cases of 10 customers, a mileage saving method was used to contribute the distribution path planning. This resulted in a more scientific distribution route based on comparative analysis, which helped the target company save resources and improve efficiency.

2. Theoretical Background

2.1. The RFM model

The RFM model is an important tool and approach of measuring customer value and profitability (Anitha & Patil, 2019). Among the many analysing models of customer relationship management, the RFM model is widely mentioned. The model describes the value of customers through three indicators: customers' last consumption (Recency), their consumption frequency (Frequency), and their consumption amount (Monetary) (Christy, Umamakeswari, Priyatharsini, & Neyaa, 2018). Studies have shown that the lower the customer's R value is, the higher their value to the company becomes; the higher the F value is, the higher the customer purchasing frequency becomes, and the higher their value to the company becomes (Heldt, Silveira, & Luce, 2019). The higher the customers' M value and the amount of their consumption is, the higher their value to the company becomes. Generally speaking, by comparing the average RFM and the total RFM figure of various customers and the size of individual index, customers' importance degree can be classified.

2.2. K-Means Cluster Analysis

Clustering analysis is an exploratory, unsupervised data analysis method. That is, to divide the given data elements so that the data elements with high similarity will be classified into one category and the data elements with low similarity are classified into different categories (Ren & Fan, 2011).

The level of similarity is determined by calculating the distance between two data elements. Commonly, formulas for calculating distance includes Euclidean and other formulas. Euclid's formula is:

$$\text{Dist}(x, y) = \sqrt{\sum_{i=0}^{n} (x_i - y_i)^2}$$

Using K-Means cluster analysis, customers classification can be processed .

2.3. An Optimisation Distribution Route Model Based on Mileage Saving

The mileage saving method is the most famous heuristic algorithm used for solving the uncertain amount of distribution vehicles.

The key idea is to sequentially merge the two circuits in the transportation problem into one circuit.

Every merging is an optimisation that minimises the total transportation distance. The merging continues until a vehicle reaches to its loading limitation, when the optimisation for the next vehicle begins.

The rationale of using the economy method to determine the distribution route is: to design a distribution plan that minimizes the total ton-kilometers of the total vehicle transportation based on the transportation capacity of the distribution center, the distribution center-user distance and the user-to-user distance. In addition, this method needs to meet the following conditions:

(1) Requirements of all users.
(2) Do not overload any vehicle.
(3) The total daily operating time or mileage of each vehicle does not exceed the prescribed ceiling.
(4) The arrival time of the distribution.

The procedures of applying the mileage saving approach includes:

(1) Conducting a distribution mileage table, listing the shortest distribution centre-to-customer distance and the user-to-user distance.
(2) Calculating the saved mileage.
(3) Sorting the figure of the saved mileage from large to small.
(4) Connecting each individual customer node to form a distribution circuit according to the constraint of the loading capacity and the saved mileage.

Table-1. (Customer Information Data Collation table).

Customer Code	Recency	Frequency	Monetary
HN-H	0.0000	0.9643	1.0000
XGF	0.0000	0.8571	0.1720
GGGZ	0.0000	0.8929	0.1433
KG	0.0000	1.0000	0.1636
DD	0.0000	0.6786	0.1223
SX	0.0000	0.5357	0.0297
XLJ	0.3077	0.2857	0.0157
LJGX	0.0000	0.7143	0.0285
GH	0.3846	0.1071	0.0104
HKGS	0.0000	0.3929	0.0308
TRX-Y	0.1538	0.4286	0.1215
TLSM	0.0769	0.2143	0.0160
XYXL	0.1538	0.0357	0.0064
LHCS-J	0.0000	0.3214	0.0155
QY-L	0.0769	0.3929	0.0332
80XG	0.0769	0.3929	0.0311
SGLZ	0.1538	0.3571	0.0103
YZ	0.0769	0.1786	0.0090
UCC	0.2308	0.1429	0.0031
TTXG	0.4615	0.2857	0.0142
QE	0.0000	0.1429	0.0019
QA	0.2308	0.1786	0.0034
CD	0.0000	0.5357	0.0239
JU	0.0769	0.2143	0.0132
ASK	0.3846	0.3929	0.0149
CF	0.0769	0.2143	0.0040
DX	0.2308	0.0000	0.0000
PO	0.2308	0.2143	0.0066
TTI	0.5385	0.0357	0.0036
JJK	1.0000	0.0357	0.0035

3. An Jining Company's Case Study

The dataset is based on a sales record of the *B2B fruit supply chain operating company* in Jining. This sales record begins from 1st, November, 2018 and ends by 02nd, December, 2018. This article uses the sales data of a B2B fruit supply chain operating company in Jining as a data model for research. The data interception time is 2018.11.01-2018.12.02.

3.1 Company Customer Data Collation

Since the variance of measuring units may interfere the clustering, data standardising was used to avoid the interference. The processing formula is:

$$X_i = \frac{x_i - min\{x_j\}}{max\{x_i\} - min\{x_j\}} \quad (1 \leq i, j \leq n)$$

Table 1 is the result of the customer's consumption information (to protect the company's privacy, the customer name is represented by a code).

3.2. Analysis of Clustering Results

Using the SPSS K-Means clustering algorithm analysis, the customer types were divided into a priority service group and an ordinary service group. Among the 30 customers, there are 8 customers belong to the priority service group and 22 belong to the ordinary group. The result of company's customer classification is shown in Table 2 and Table 3.

Among them, compared with ordinary customers, the priority service group shows a shorter average time between the most recent consumption at a certain point in time, a higher consumption frequency, and a larger consumption amount.

Table-2. Cluster Centre Via K-means.

The Final Cluster Centre		
Cluster Type		
	The Priority Service Group	**The Ordinary Service Group**
Recency	0.0000	0.2238
Frequency	0.7723	0.2256
Monetary	0.2104	0.0167

Table-3. K-means customer classification.

Customer Classification Via K-means		
Cluster	The Priority Service Group	8.000
	The Ordinary Service Group	22.000
Valid		30.000
Missing		0.000

Hence, the customer types that each customer belongs to is shown as Table 4.

Table-4. Customer Types.

Customer	Cluster	Type	Customer	Cluster	Type
HN-H	1	The Priority Service Group	80XG	2	The Ordinary Service Group
XGF	1	The Priority Service Group	SGLZ	2	The Ordinary Service Group
GGGZ	1	The Priority Service Group	YZ	2	The Ordinary Service Group
KG	1	The Priority Service Group	UCC	2	The Ordinary Service Group
DD	1	The Priority Service Group	TTXG	2	The Ordinary Service Group
SX	1	The Priority Service Group	QE	2	The Ordinary Service Group
XLJ	2	The Ordinary Service Group	QA	2	The Ordinary Service Group
LJGX	1	The Priority Service Group	CD	1	The Priority Service Group
GH	2	The Ordinary Service Group	JU	2	The Ordinary Service Group
HKGS	2	The Ordinary Service Group	ASK	2	The Ordinary Service Group
TRX-Y	2	The Ordinary Service Group	CF	2	The Ordinary Service Group
TLSM	2	The Ordinary Service Group	DX	2	The Ordinary Service Group
XYXL	2	The Ordinary Service Group	PO	2	The Ordinary Service Group
LHCS-J	2	The Ordinary Service Group	TTI	2	The Ordinary Service Group
QY-L	2	The Ordinary Service Group	JJK	2	The Ordinary Service Group

4. Distribution Path

Due to the large number of the distribution networks, five representatives from the priority service group (Customer A, B, C, I, and J) and five representatives from the Ordinary Service Group (Customers D, E, F, G,

H) have been selected. The distribution network diagram is shown in Figure 1. As shown in Figure 1, staring from the distribution center at 5 o'clock in the afternoon, the company began the distribution to these ten stores. The number on the route indicates the distance between two nodes (unit: km).

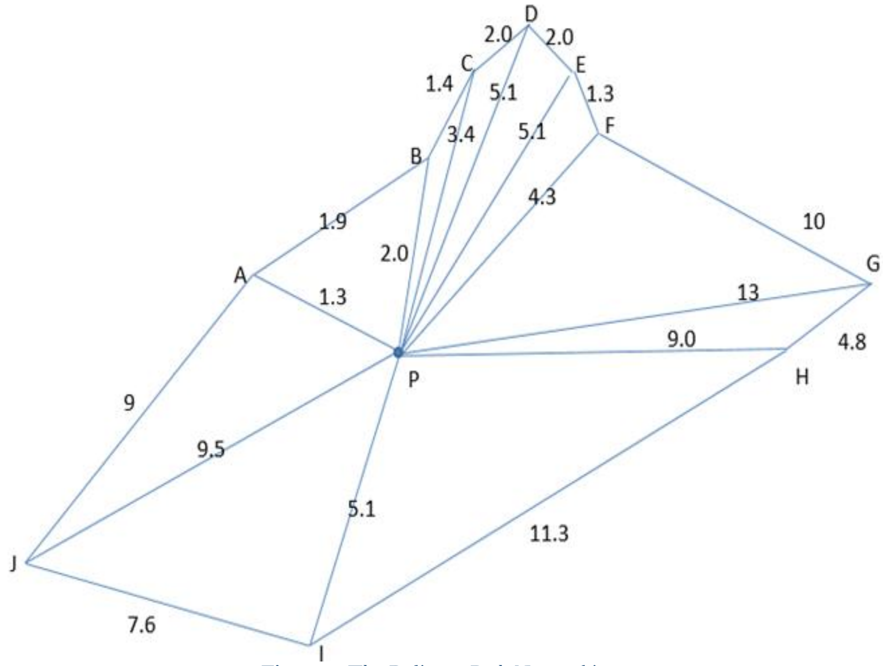

Figure-1. The Delivery Path Networking.

Table 5 reveals to the demand of every individual customer
(•) refers to customers from the Priority Service Group.
3 4t-vehicles are available in the warehouse.
Table 5.Typical shop networking's amount of distribution.

Table-5. Typical Shops' amount of distribution Unit: t.

Shop	**A(•)**	**B(•)**	**C**	**D(•)**	**E**	**F**	**G(•)**	**H**	**I**	**J(•)**
the Amount of Distribution	1.5	0.9	1.3	0.7	0.9	0.7	1.2	0.6	1.8	1.5

First, the shortest distance between the distribution center and every distribution point is calculated. (As Table 6 shows.)

Table-6. The amount of mileages among intra-networking shops.

	P										
A	1.3	**A**									
B	2	1.9	**B**								
C	3.4	3.3	1.4	**C**							
D	5.1	5.3	3.4	2	**D**						
E	5.1	6.4	5.4	4	2	**E**					
F	4.3	5.6	6.3	5.3	3.3	1.3	**F**				
G	13	14.3	15	16.3	13.3	11.3	10	**G**			
H	9	10.3	11	12.4	14.1	14.1	13.3	4.8	**H**		
I	5.1	6.4	7.1	8.5	10.2	10.2	9.4	16,.1	11.3	**I**	
J	6.1	9	10.9	12.3	14.3	14.6	13.8	22.5	18.5	7.6	**J**

Based on the shortest distance distribution table and the mileage saving approach, the result of the saved-mileage is shown as Table 7.

Table-7. Saved-mileage.

A									
1.4	**B**								
1.4	4	**C**							
1.1	3.7	6.5	**D**						
0	1.7	4.5	8.2	**E**					
0	0	2.4	6.1	8.1	**F**				
0	0	0.1	4.8	6.8	7.3	**G**			
0	0	0	0	0	0	17.2	**H**		
0	0	0	0	0	0	2	2.8	**I**	
1.8	0.6	0.6	0.3	0	0	0	0	7	**J**

Sorting the figure of the saved-mileage from large to small, Table 8 shows a summary of the mileages.

Table-8. The sequence of the saved-mileages.

No.	Path	Saved Mileage	No.	Path	Saved Mileage
1	G-H	17.2	13	H-I	2.8
2	D-E	8.2	14	C-F	2.4
3	E-F	8.1	15	G-I	2
4	F-G	7.3	16	A-J	1.8
5	I-J	7	17	B-E	1.7
6	E-G	6.8	18	A-B	1.4
7	C-D	6.5	19	A-C	1.4
8	D-F	6.1	20	A-D	1.1
9	D-G	4.8	21	B-J	0.6
10	C-E	4.5	22	C-J	0.6
11	B-C	4	23	D-J	0.3
12	B-D	3.7	24	C-G	0.1

By merging the circuits, there optimised paths are determined as fellow (Figure 2):
① Delivery Path 1 : P-D-E-F-G-P
Delivery Volume=0.7+0.9+0.7+1.2=3.5t < 4t
Delivery Distance=2+1.3+10+13+5.1=31.4km
② Delivery Path 2 : P-H-I-J-P
Delivery Volume=0.6+1.8+1.5=3.9t < 4t
Delivery Distance=9+11.3+7.6+9.5=37.4 km
③Delivery Path 3 : P-A-B-C-P
Delivery Volume=1.5+0.9+1.3=3.7t <4t
Delivery Distance=1.3+1.9+1.4+3.4=8 km
The Delivery Path is shown as Table 2.

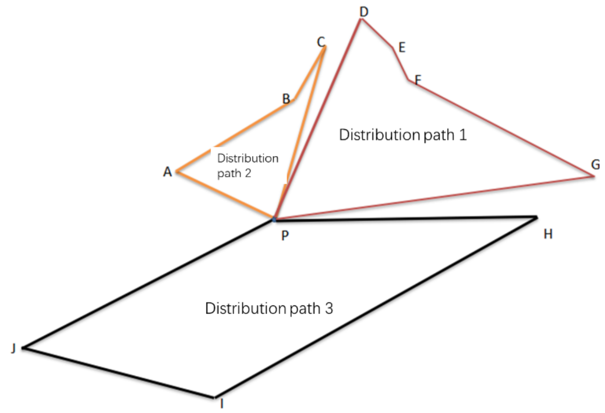

Figure-2. Distribution Path.

Considering the company development from a long-term, the company needs to locate its own key customers and build a good cooperative relationship with them. Hence, the supply need of the priority service group customers shall be considered prior to the supply need of the ordinary service group customers.

The Priority Service Group Customers' delivery are considered at the first place：P-A-B-P , P-D-P , P-G-P , P-J-P ；

Then, the Ordinary Service Group Customers' delivery are routed: P-C-P , P-E-F-P , P-H-I-P.

The total delivery distance obtained by the above distribution method is 103.3km. Since the warehouse has only three vehicles with a loading capacity of 4t, two of the delivery vehicles need to delivery twice, and one of the vehicles needs to delivery for three times.

Conspicuously, a comparison of the two delivery plans exhibits that using the mileage saving method to merge delivery allows the company to reduce the delivery distance when the amount of the delivery vehicle dwindles. Also, it saves the delivery time, the resource of the company and the cost. Therefore it would be the optimized option.

5. Summary

The intracity distribution is also known as the "last mile logistics". It aims at the maximisation of speed and efficiency. Logistics such as intracity distribution should not only consider the optimization of path and stowage, but also consider the improvement of customer service quality.

Imperfective information construction, poor service quality, the waste of resources and high logistics cost have become the main problems hindering the improvement of the intracity distribution efficiency.

To deal the aforementioned problems, this study helped companies effectively identify customer value by combining customer classification with intracity distribution path optimization. Simultaneously, it improved the service quality, optimised the distribution path, reduced the resource wasting and enhanced the companies' operation efficiency. It enriches the current literature about food distribution path optimization for small and medium sized food company.

(1) This paper collected the consumption data of the target company's customers. Based on the RFM model and factors including the latest consumption time, the consumption frequency and the consumption amount, the study used a K-means clustering algorithm to divide customers into ordinary and propriety groups. This contributed to a more effective distribution based on customer groups that helped companies precisely maintain the customer relations and improved the customers service quality and level.

(2) In the process of fruit distribution, reasonable and effective path optimization scheme can reduce the distribution time and save the company's resources. In this study, a more mature mileage saving method was used for scheme designing. This improved the scientificity and feasibility of the solution. The case study verified the avalibility and credibility of advanced milage saving method in helping logistics system map-out. However, the distribution process is always involved with many unexpected incidents. Hence, comprehensively solving these incidents, such as a sudden change of consumption decision, the road congestion, or a sudden vehicles damage, and giving reasonable and effective solutions in the distribution process will become a next study focus.

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