Study on Inventory Optimization of Chain Supermarkets Based on EIQ-ABC Analysis Method

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Abstract: This paper mainly adopts EIQ analysis method and ABC analysis method to optimize the inventory of a chain supermarket in Northeast Sichuan. By adopting the statistical methods of Pareto analysis, frequency distribution analysis, ABC analysis and cross analysis, this paper analyzes the outbound volume of the chain supermarket in a period. After analyzing and calculating the characteristics of the customer and goods of the order, it classifies them according to the characteristics and selects the right storage place, facilities and equipment for the goods in the warehouse, which also provides some improvement strategies for the warehouse planning.

1. EIQ-ABC Analysis

1.1 Introduction to EIQ-ABC Analysis

The ABC analysis method follows the Pareto Principle. Class A is the key minority. Therefore, the outbound/inbound frequency is the highest, and the frequency of delivery and turnover are also the highest. It shall be placed in the most convenient location. The routine management is suitable for Class B, which shall be placed in a less important location. With a large quantity but small contribution, the general management is suitable for Class C, which shall be placed in the most inconvenient storage location, as shown in Table 1.

Table 1: Basis of ABC Classification

Class A	The proportion of varieties is 5%-15%, and the proportion of shipments is 60%-80%
Class B	The proportion of varieties is 15%-25%, and the proportion of shipments is 15%-25%
Class C	The proportion of varieties is 60%-80%, and the proportion of shipments is 5%-15%

EIQ analyzes the shipment on the basis of the Item (I), Entry (E) and Quantity (Q) of the order, which helps to understand the statistical characteristics of the order. The the result of ABC classification management for goods and customers provides the general planning strategy, as shown in Table 2.

Table 2: Contents of EIQ Analysis

Contents of EIQ Analysis	EQ:Quantity per order
	EN:Items per order
	IQ:Quantity per item
	IK: Number of orders per item

1.2 The Role of EIQ-ABC Analysis Method in Inventory

Combining EIQ analysis method and ABC analysis method, the EIQ-ABC analysis method follows the steps of EIQ analysis method. EQ analysis aims to understand the relationship between the order types and quantities, which helps to clarify the customer's order quantity and the proportion of orders from the characteristics in different orders. EN analysis aims to understand the relationship between the order types and the quantity, figure out the number of item types in the order, and determine the picking method. IQ analysis aims to understand the order quantity of each type of item, figure out the type of the best-selling commodity, and then arrange the placement of the commodity according to the best-selling commodities, which is convenient for entry and delivery, saving time and reducing costs. IK analysis aims to understand the number of orders for each commodity. While conducting EQ, EN, IQ, and IK analysis, ABC analysis method is applied flexibly. The combination of ABC and EIQ analysis method in the chain supermarket inventory optimization will help to reduce the inventory capital investment, improve the inventory structure, promote the development of warehouse modernization, and ultimately enhance the efficiency.

2. EIQ-ABC Analysis Method for the Chain Supermarket Distribution Center

2.1 Case Background

Founded in 2004, a chain supermarket is one of the most valuable local chain supermarket systems. Currently, the company has 53 standard / super stores, with the area of about 400,000 square meters. In the next few years, the chain supermarket will steadily march to many counties and cities in Northeast Sichuan, serve more customers and consumers, strive to become a local model of exquisite shopping, and provide more jobs and promotion opportunities for the staff. The supermarkets are mainly engaged in the daily necessities of food, articles of daily use, fresh food, household appliances and clothing. It owns A local warehouse distribution center, which is mainly responsible for the storage and distribution of goods required by the supermarkets in the production area. The informatization and intellectualization can be greatly improved, for it mainly adopts the manual loading, unloading and delivery, while equipped with some intelligent loading, unloading and delivery equipment. There are more than 80 employees and a reservoir area of more than 5,000 square meters in a warehouse distribution center of the chain supermarket. In addition to providing goods distribution services for its chain supermarkets, the reservoir area has also formed the strategic partnership with many small local convenience stores. With the advantage of capital proportion and the support of information technology, it builds up a relatively perfect warehousing and distribution service system. The daily order is mainly about the articles of daily use, knitwear and textiles, clothing, shoes, daily necessities, sanitary products and cosmetics.

2.2 EIQ-ABC Analysis of Order in an Inventory Center

2.2.1 EIQ Data Collation

This paper mainly optimizes the chain supermarket's inventory in the A inventory center, which involves the food and non-food departments, including 30 categories and 119 subcategories of wine and breakfast food. Since the warehouse involves the short-term cooperation with some small supermarkets and partners, the most representative 15 supermarkets under the chain supermarket are selected (five supermarkets in Nanwai, Xiwai and Beiwai respectively) to plan and meet most of the regular customers' requirements. After sorting out 420 outbound data sheets (ie orders), it is

concluded that the center has 119 shipment types, 375 orders, and 3,332 shipment data. The time is from November 1, 2021 to November 28, 2021-- a total of 28 days, 4 weeks, as shown in Figure 1.
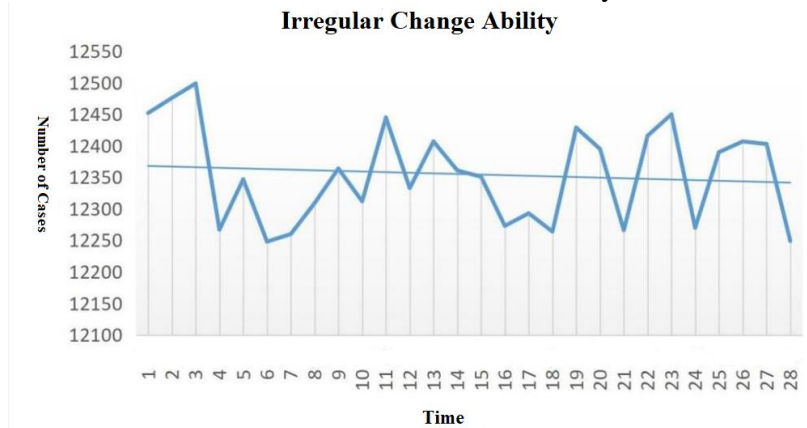

Figure 1 EIQ Chart from November 1 to 28, 2021

The change capacity of the total order quantity of each day can be obtained from the basic data. Figure 1 shows that the shipment quantity from No. 1 to No. 28 fluctuates from12,500 cases to 12,200 cases. The total fluctuation trend suggests a decreasing distribution.

Table 3: Summary of EIQ Analysis

	Time T (indicator)	Basic data period (month)	Second week (week)	November 15 (day)
1	Number of orders E	420 pcs	105 pcs	15 pcs
2	Number of shipment types I	117 items	117 items	117 items
3	Total order quantity GEQ	345726 cases	86531 cases	12351 cases
4	Average quantity per order	EQ(avg)=823 cases	824 cases	823 cases
5	Average shipments per item	IQ(avg)=2905 cases	727 cases	104 cases
6	Maximum order quantity	EN(max)=909 cases	895 cases	860 cases
7	Minimum order quantity	EN(min)=743 cases	758 cases	749 cases
8	Maximum order items	IQ(max)=113 cases	113 cases	109 cases
9	Minimum order items	IQ(min)=97 cases	100 cases	102 cases
10	Maximum shipment items	16924 cases	4232 cases	622 cases
11	Minimum shipment items	0 cases	0 cases	0 cases

From Table 3, the minimum shipment items in the second week and NO. 15 randomly selected in the basic data period are moon cakes and gift baskets, both of which are seasonal food. Except for the certain periods, there is less demand for both.

2.2.2 EQ Analysis (Quantity Analysis per Order)

EQ analysis is the analysis of the quantity of each order, which is based on single-day orders to plan the picking system. This analysis helps to figure out the number of cases per order. Taking November 15, 2021 as an example, its EQ distribution is shown in Figure 2.

From the EQ distribution chart on the 15th, the order quantity of the warehouse to these 15 chain supermarkets ranges from 740 to 860. According to the calculation of the standard deviation on the 15th, except for the lower order quantity of the 13th order, the rest are not particularly concentrated in a chain supermarket. It can be concluded that there is no need to focus on one of these 15 supermarkets. Therefore, the distribution center can adopt a more flexible management and use the universal equipment to adjust the location flexibly, which will improve the flexibility of
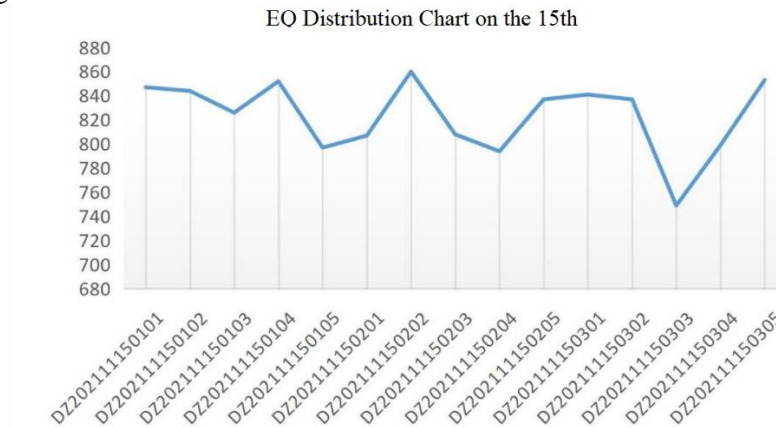
management and goods allocation and reduce the cost.

Figure 2 Single-Day (November 15, 2021) EQ

2.2.3 EQ Analysis Table

The number of items and the number of order items of each chain supermarket have been sorted out on the basis of the period of basic data. Therefore, the total shipment and the ratio between shipment and number of order items can be obtained. The ratio is applied to ABC classification method for classifying different chain supermarkets. According to the above steps, we can understand the order characteristics and the distribution requirements of different supermarkets. Therefore, ABC analysis can be adopted to obtain the proportion of each store according to the ratio of the order quantity of each chain supermarket to the total order quantity, which helps to optimize the inventory management.

According to ABC analysis of each store, A accounts for about 13%, B accounts for about 27%, and C accounts for about 60%. Shipment / Number of Order Item of Beiwai No. 1 Store and Beiwai No. 4 Store rank the top two in the statistics of the chain supermarkets (a total of 15), which are the supermarkets with the most frequent outbound. Shipment / Number of Order Item of Beiwai No. 3 Store and Xiwai No. 4 Store rank in the bottom two in the statistics of the chain supermarkets (a total of 15), as shown in Table 4.

Table 4 Shipment / Number of Order Item of chain supermarkets

No.	Store Name	Shipment (case)	Number of items (items)	Number of Order Items (Items)	Shipment / Order	ABC Classification
1	Nanwai No. 1 Store	22960	2960	28	820.00	C
2	Nanwai No. 2 Store	23095	2933	28	824.82	C
3	Nanwai No. 3 Store	23201	2945	28	828.61	B
4	Nanwai No. 4 Store	23153	2965	28	826.89	B
5	Nanwai No. 5 Store	22802	2944	28	814.36	C
6	Xiwai No. 1 Store	22799	2959	28	814.25	C
7	Xiwai No. 2 Store	23117	2949	28	825.61	C
8	Xiwai No. 3 Store	23111	2982	28	825.39	C
9	Xiwai No. 4 Store	22793	2937	28	814.04	C
10	Xiwai No. 5 Store	23164	2934	28	827.29	B
11	Beiwai No. 1 Store	23242	2948	28	830.07	A
12	Beiwai No. 2 Store	23177	2935	28	827.75	B
13	Beiwai No. 3 Store	22766	2935	28	813.07	C
14	Beiwai No. 4 Store	23214	2925	28	829.07	A
15	Beiwai No. 5 Store	23132	2981	28	826.14	C

Due to the limited inventory in the warehouse, ABC analysis of the supermarket can better manage the inventory and minimize the time and cost. Increasing the allocation of more resources to supermarkets with large outbound volume will avoid the excessive or insufficient resources in each warehouse, and thereby enhancing the efficiency of inventory and enabling both supermarkets and warehouses to have a win-win.
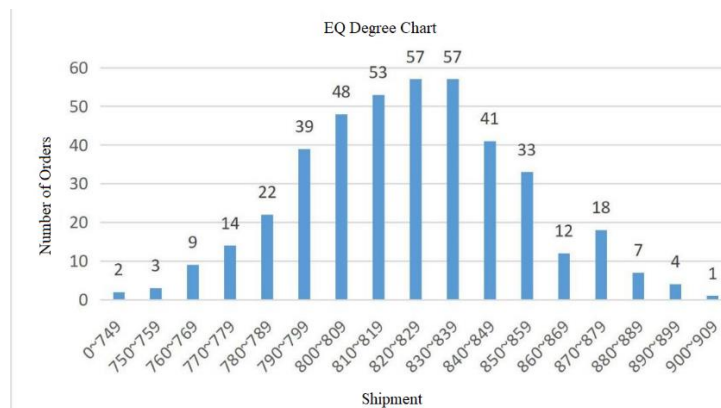
2.2.4 EQ Distribution Chart

Figure 3 EQ Degree Chart of Basic Data

It can be seen from the Figure 3 that the shipment of this order roughly presents a normal distribution. The goods of orders in 810 ~ 829 cases and 830 ~ 839 cases account for the largest proportion, which are 57 times. The goods of orders in 0 ~ 749 cases and 900 ~ 909 cases account for the least, which are 2 times and 1 time respectively.

2.3 Order Item(EN) Analysis and Suggestions
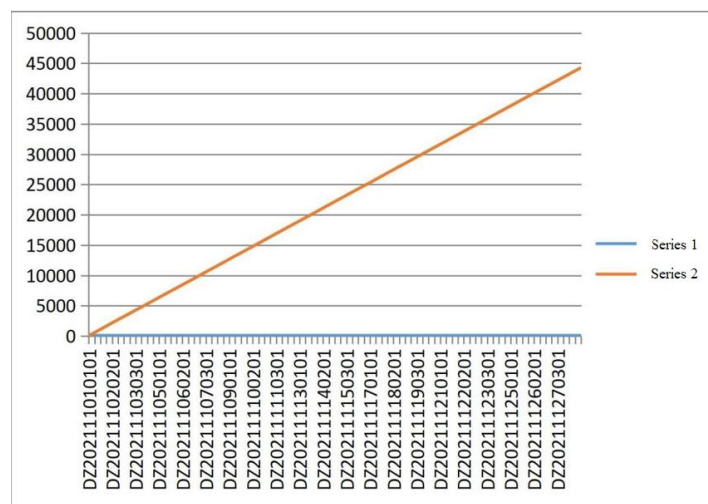
2.3.1 EN Analysis

Figure 4 Basic Data Distribution Chart

In Figure 4, there are a total of 420 orders in the basic data, among which the maximum number of items is 113, while the minimum number is 97. Among the 420 orders, the number of single order items is 105, a total of 62, accounting for $62 \div 420 = 14.76\%$ of all orders. The minimum number of single order items is 97 items, a total of 1, accounting for all orders $1 \div 420 = 0.24\%$.

And secondly, the median number of items is 105 [(113+97) ÷ 2] from the maximum number of items and the minimum number of items[(113+97)÷2] in the basic data order. The number of items in a single order of 62 is 105, accounting for 62 ÷ 420 = 14.76% of all orders. From November 1, 2021 to November 28, 2021, the number of order items is 105 and the order on November 12, 2021 is the most. According to the above analysis of the number of order items, the order data on November 12, 2021 is the most representative and suitable for EN analysis.

2.3.2 EN Analysis Table

It can be seen from Table 5 that the order with the largest proportion is EN=105, accounting for 33.33%, the number of orders is 5, and it is roughly normally distributed. Therefore, if the number of shipment orders is large, batch picking can be used for sorting while picking. If the number of shipment items in a single order is small, the flexible requirements for picking equipment and operating capacity is not high.

Table 5: Grouping Statistics of the Number of Shipment Items in a Single Order on November 12, 2021

	Number of Orders	%
EN=101	1	6.67%
EN=102	2	13.33%
EN=103	3	20.00%
EN=105	5	33.33%
EN=106	1	6.67%
EN=107	2	13.33%
EN=109	1	6.67%

2.4 Order Quantity (IQ) Analysis and Suggestions

2.4.1 IQ Analysis

From the data, the outbound quantity of each item in different periods can be obtained, and the basic data (November 1, 2021 - November 28, 2021), the data of the second week (November 8, 2021 - November 14, 2021) and the selected items of the best-selling commodities and the most unsalable commodities representing the data on November 15, 2021 can be obtained respectively. In the basic data (November 1, 2020-November 28, 2021), the total shipments were 345,726 cases, and the best-selling commodity (the commodity with the largest shipment volume) was tableware, which was 169,224 cases, accounting for 4.90% of 119 shipment items of the basic data. The three most unsalable commodities (the commodity with the smallest shipment volume) were moon cakes, gift baskets, and quilts, whose outbound volumes were 0 cases, 0 cases and 189 cases respectively accounting for 0.05% of 119 outbound items of the basic data.

In the data of the second week (November 8, 2021 to November 14, 2021), the total shipment volume was 86,531 cases, and the best-selling commodity was tableware, which was 4,232 cases, accounting for 4.89% of 119 shipment items in the week. The three most unsalable commodities were moon cakes, gift baskets and children's socks. Their outbound volumes were 0 cases, 0 cases and 43 cases respectively, accounting for 0.005% of the total outbound volume of 119 items of the week data.

On November 15, 2021, the total outbound volume was 12,351 cases. The best-selling commodity was kitchen supplies, which was 622 cases, accounting for 5.04% of the total shipment volume of 119 cases on November 15. The most unsalable commodities were moon cakes, gift

baskets and quilts, which were 0 cases, 0 cases and 6 cases respectively, accounting for 0.048% of the total outbound volume of 119 items on November 15.

2.4.2 IQ Analysis of Single Day and Basic Data in the Whole Period

IQ analysis can be used to plan the storage area. In planning storage areas, it is analyzed with a period of time. To ensure the practicability of the analysis, it is usually selected for one year. For the limitations of this research data, the whole period is 4 weeks (from November 1, 2021 to November 28, 2021). In the IQ cross analysis in the whole period and IQ of a single day, the focus is to observe whether the IQ in the whole period is symmetrical with that in a single day.

In this study, the number of outbound items on November 15, 2021 was 117, and the number of outbound items for daily orders was 15. Due to the characteristics of its chain, for each day of the four-week period, the number of items in the daily inventory was roughly 117, and the number of items in the daily order was 15. Therefore, November 15, 2021 can still be selected when observing IQ volume in the whole period and IQ volume in a single day.
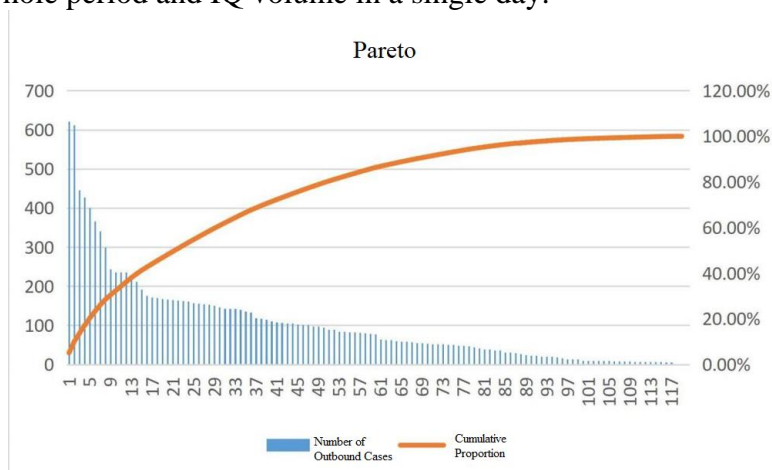

Figure 5 IQ Pareto Chart for a Single Day (November 15, 2021)

The Figure 5 is obtained from the proportion of each item in the data of a single day (November 15, 2021), and the items in the basic data are classified into ABC according to the Pareto chart. Class A commodities include kitchen supplies, table supplies, tableware, candy, convenience food, shampoo and hair care products, cookies, puffed food, cleaning supplies, chocolate, sanitary napkins, bathroom products, sauces, candied fruit, detergents, milk drinks, cooking supplies, hairdressing products, shower gels, insecticides, baby food supplements and soaps, a total of 24 kinds of commodities. The number of Class A commodities only accounts for $24 \div 119 = 20.16\%$ of the total number of commodities, while its outbound volume accounts for a high proportion of the total outbound volume, reaching $6600 \div 12351 = 53.45\%$.

Class B commodities include condiments and living room supplies, with a total of 39 commodities. The number of Class B commodities only accounts for $39 \div 119 = 32.77\%$ of the total number of items, and the proportion of its outbound volume in the total outbound volume reaches $4250 \div 12351 = 34.41\%$.

The remaining 56 commodities belong to Class C. The number of Class C commodities only accounts for $56 \div 119 = 47.06\%$ of the total number of items, and the proportion of its outbound volume in the total outbound volume reaches $1501 \div 12351 = 12.15\%$.

2.5 Analysis of the Number of Orders (IK) and Suggestions

2.5.1 IK Analysis

According to the data on November 15, 2021, the IK of varieties is sorted from large to small. And the IK calculation table of each variety is as shown in the Table 6.

Table 6: IK Statistics

Number of Shipments per Item IK	Quantity of Items	%
IK=15	89	74.79%
IK=14	1	0.84%
IK=12	1	0.84%
IK=11	2	1.68%
IK=10	6	5.04%
IK=9	3	2.52%
IK=8	6	5.04%
IK=7	7	5.88%
IK=6	2	1.68%
IK=0	2	1.68%

2.5.2 IK and IQ Cross-Analysis Table

On the basis of IK (number of order items) analysis and IK distribution chart analysis, IK and IQ cross-analysis is carried out. Based on the data of November 15, 2021, IK and IQ cross-analysis, supplemented by ABC classification, can make the specific picking strategies, as shown in Table 7.

Table 7: IQ and IK Cross-analysis

IQ \ IK	High	Medium	Low
High	I Kitchen supplies, supplies and tableware	II Edible oil, vermicelli, rice and flour	III Boxed facial tissue, facial tissue, umbrella etc.
Medium			IV Seafood, toilet paper, and poncho
Low			V Quilt, mat and gift box

From the figure 5, different picking methods can be selected for goods under different conditions. The batch sorting method can be adopted in the first type of products, for the proportion of IQ and IK is relatively high. IQ accounts for a medium proportion in the second type of products, while IK takes a high proportion. It is recommended to pick the order separately. IQ is low and IK accounts for a high proportion in the third type of products. It is recommended to pick the order separately and be placed close to the entrance. IQ accounts for a relatively low proportion and IK takes a medium proportion in the fourth type of products. It is recommended to pick the order separately. The proportion of IQ and IK is relatively low in the fifth type of products. It is recommended to be divided into sporadic picking areas.

3. Conclusion

This paper mainly uses the cases to plan the internal goods in inventory, and help the managers

make decisions on the placement of goods in the warehouse and the allocation of facilities and equipment. It adopts the statistical methods of Pareto analysis, frequency distribution analysis, ABC analysis and cross analysis. This paper analyzes the order of the inventory for four weeks of the chain supermarkets with EIQ analysis method and ABC analysis method, and puts forward the corresponding opinions. It provides strategic management and operation management strategies for the managers of the chain supermarket. What's more, since the supermarket chains are very common in life and are closely related to our lives, the data of the month is relatively stable, which is conducive to the inventory optimization. As there will not be any changes in the short-term category in the chain supermarket, the inventory optimization solutions can be maintained for a long time, which is very beneficial to the upstream and downstream customers of the chain supermarket.

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