ISSN: 2688-9323

Research on Warehouse Optimization based on EIQ-ABC Analysis Method

-- Take M Company for Example

Mingyuan Yang

University of Electronic Science and Technology of China, Zhongshan Institute, Zhongshan, 528400, China

Abstract

With the end of the New Crown epidemic, promoting a return to high economic growth in the post-epidemic era has become one of the most important tasks for the country's development at this stage. country's development at this stage. In today's economic development environment, logistics has become an important artery of national economic development. In today's economic development environment, logistics has become an important artery of national economic development. In the whole logistics system, warehouse management is in the core position.However, there are also some problems in the management of In the whole logistics system, warehouse management is in the core position.However, there are also some problems in the management of warehousing, such as the imperfect warehousing management systems, so how to optimize the warehousing management has become the focus of the current This paper takes Company M as an example, through fieldwork, and finds that the enterprise has problems in warehouse management. management. Therefore, this paper relies on the EIQ-ABC analysis method, with the help of Excel 16.0, to analyse the data of orders within an order cycle in the warehouse and distribution center through the EIQ-ABC analysis method. the warehouse and distribution center through the EIQ analysis method. Then, with the help of ABC classification, according to the analysis results, the Then, with the help of ABC classification, according to the analysis results, the goods of the enterprise are classified, and the goods are placed in the corresponding space for storage, and the storage space optimization management plan of M Company's warehousing and distribution center is obtained. Finally, the new and old schemes are compared to show that the optimized scheme has Through the optimization management design of the storage space of goods in the storage and distribution center, we hope to play a certain role. Through the optimization management design of the storage space of goods in the storage and distribution center, we hope to play a certain role in improving the operational efficiency of the storage center of M company and provide reference for the optimization of the storage space of other companies. Through the optimization management design of the storage space of goods in the storage and distribution center, we hope to play a certain role in improving the operational efficiency of the storage center of M company and provide reference for the optimization of the storage space of other similar enterprises.

Keywords

EIQ Analysis Method; ABC Classification; Storage Location Optimization; M Company.

ISSN: 2688-9323

1. Introduction

1.1. Background and Significance of the Study

1.1.1. Background of the Study

With the end of the new crown epidemic, in post-pandemic era, the economy resumed its rapid development has become one of the most important tasks at this stage of China's development. In today's economic development environment, logistics has become an important artery for the development of the national economy and one of the pillar industries, but also an indispensable and important part of people's lives. According to the data disclosure of China Federation of Logistics and Purchasing (CFLP), since entering 2023, China's logistics industry boom index has shown an upward trend for two consecutive months, and the development of the whole industry has shown a steady to good development trend. In the entire logistics system, warehouse management is at the core. In the logistics sector, warehousing costs can account for about 70% of the total logistics costs, so through reasonable warehousing design and management, can effectively reduce the cost of production and operation of enterprises, so enterprises can not ignore the importance of warehousing in the development of the link. However, in today's environment, China's warehousing industry is still in an unbalanced state of development, large enterprises and small and medium-sized enterprises in the development of the focus has a large difference, this imbalance has led to the development of China's warehousing industry at a relatively low level. At the same time, the enterprise's management of warehousing there are some problems, such as warehousing management system is not sound, the lack of professional warehousing management personnel and other issues caused by the low level of enterprise warehousing management, affecting the quality of service and efficiency of logistics enterprises. How to optimize the warehouse management, reduce logistics costs, improve the market competitiveness of enterprises has become the focus of the current logistics enterprise reform.

1.1.2. Significance of the Study

This essay plans to investigate and study the operation and management of the warehousing and distribution center managed by M Company, analyze the problems existing in the management process, formulate the corresponding optimization plan according to the existing problems, and finally reach the goal of optimizing the management of warehousing and storage layout. The research significance of this thesis is that the optimization of storage space in the storage center of Company M can improve the efficiency of the storage operation of Company M to a certain extent. This paper is based on the EIQ-ABC analysis method and combines the production and operation data of a cycle of the enterprise with the help of EIQ analysis method to analyze the order quantity and goods quantity of the enterprise. Based on the results of the analysis, the goods are then classified into classes by ABC classification. According to the classification results, complete the optimization design of the storage center cargo storage space scheme, in order to achieve the optimal management of the enterprise storage center. Meanwhile, M's warehousing center is located in the company's own logistics park. In addition to Company M, a number of companies have been contracted to reside in the park, and among these companies, some of the types of warehouses and the nature of goods stored in them are similar to those of Company M. The company's warehouse is located in the same building as Company M. The company's warehouse is located in the same building as Company M. Therefore, the results of this research and the optimization scheme have a certain reference value for the management of the same type of warehouse in the park.

ISSN: 2688-9323

2. Design of Warehouse Optimization Scheme

2.1. Theoretical Analysis of the Construction of Warehouse Optimization Methods

Optimization management of warehousing is to analyze the goods, equipment and facilities in the warehousing area, so that manpower, financial resources, material resources and human, information and logistics flows are the most cost-effective and reasonable arrangements, so as to obtain the best utilization rate of warehousing, and to obtain the maximum benefit through the minimum input. In the research of warehouse optimization management, KJ Roodbergen (2012) studied the relationship between layout, routing and storage space selection, studied how the three interact with each other, introduced the method of storage space assignment, built a simulation model, and found that storage space assignment is only related to the size of the picking order, and there is no need to consider the actual layout[18] . An Shuke et al. (2018) used the hierarchical analysis method to establish a weight indicator analysis model of cigarette storage operation process with multilevel indicators. And based on the ABC classification method to establish the storage space optimization allocation model, to achieve the optimization of the storage operation process[19] . Fu Huawei et al. (2014) for the optimization of explosives warehousing process management, put forward the online explosives warehousing optimization operation method based on RFID and genetic algorithm, which improves the space utilization rate of the warehouse, and better solves the optimization operation problem subject to the constraints of explosives expiration date and so on.[20] Yan et al. (2018) mainly considered the size, shape structure, and other volumetric elements of the product, and optimized it with the goal of achieving the minimum storage space to improve the utilization of warehouse space in order to reduce the storage cost[21] . Peng et al. (2022) carried out a systematic analysis of workshop logistics interrelationships and non-logistics interrelationships through the SLP method, established a mathematical model of the workshop, and carried out a layout optimization design for the equipment of the ship's tube machining workshop in order to reduce the logistics cost and achieve layout optimization design[22].

In summary, in the existing research on optimization of warehousing management, most of the existing warehousing layout or logistics system and other aspects of the analysis, to find out the shortcomings, and management mode improvement, to achieve the goal of optimization of warehousing management. However, most of the studies are mainly from the macro and meso perspectives, and there are fewer theoretical studies on specific needle single enterprises. Based on this, this paper relies on the EIQ-ABC analysis method, based on the research results of scholars, combined with the actual situation of a warehousing enterprise, puts forward the optimization management plan of the goods storage position of the warehousing and distribution center based on the EIQ-ABC analysis method, and carries out the optimization design of warehousing storage position, so as to shorten the distance of the picking path of the warehousing center, and enhance the operational efficiency, in order to achieve the optimal management of the warehousing and distribution center.

2.2. Construction of Warehouse Optimization Methods

This paper is in the design of a storage optimization program. Optimization scheme design for storage using EIQ-ABC analysis. EIQ-ABC analysis method can be divided into cargo areas according to the ease of access to the goods, the frequency of storage, etc., and ultimately complete the optimization of the vertical and horizontal aspects of the goods storage management. Operationally, the sales of goods in a production cycle of the study subject are first collected, and with the help of EIQ analysis, the number of shipments and the total number of shipments of a single order and a single piece of goods in the production cycle are analyzed. This provides data support for the development of optimization programs. Then the ABC

ISSN: 2688-9323

classification method is used, according to the analysis results of EIQ analysis method, based on the turnover rate of the goods, the goods of the research object will be divided into three categories of A, B and C. Different management strategies will be adopted for different categories of goods.

After completing the above analysis process, the goods are assigned the optimal storage location according to the results of the classification of the goods. Optimization of storage space can be done horizontally or vertically when developing a storage optimization plan for a warehousing and distribution center. Based on the turnover rate of goods, the entire storage area is divided into three parts, which are high, average and low turnover rate of goods. In terms of horizontal zoning, the area with the highest turnover rate is planned to be easy to work in and close to the access area, i.e., cargo storage area A. Facilitate the movement of such goods in and out of the distribution center. The opposite is true for areas with a low turnover rate, which are planned at the very bottom of the warehouse, i.e., the cargo storage areas C1 and C2, in such a way that they do not interfere with the handling of goods of categories A and B. The area with average turnover is placed in the middle of the two, i.e., the goods storage B area. The specific division is shown in Fig. 1(a). In terms of vertical zoning, the storage area is similarly divided into three parts for management. Vertical area generally for the shelf area, in this type of area, the first and second floor for the more convenient location of the goods, especially the second floor is the best operation of the vertical position of the staff, for the higher frequency of shipments of goods, should be placed in the layer, so that you can speed up the speed of such goods out of the warehouse. As the placement area for goods that are shipped more frequently, the second level of the shelf is also Zone A of the vertical area. And the third layer is the staff need the help of tools to operate the storage level, picking out of the warehouse time-consuming and laborious, the turnover rate of goods is less placed in the middle of the layer, but also a non-influence on other types of goods into the access area, so the third layer of the shelf is the vertical area of the C area. Finally, goods with average turnover are placed on the first level of the shelf for storage, so the first level of the shelf is Zone B of the vertical area. The specific division is shown in Fig. 1(b). Through the optimization of the design of the cargo storage space, can be convenient for cargo access at the same time to reduce the handling distance of the goods, improve the operational efficiency of warehousing, and realize the optimization of the management of the warehousing and distribution center.

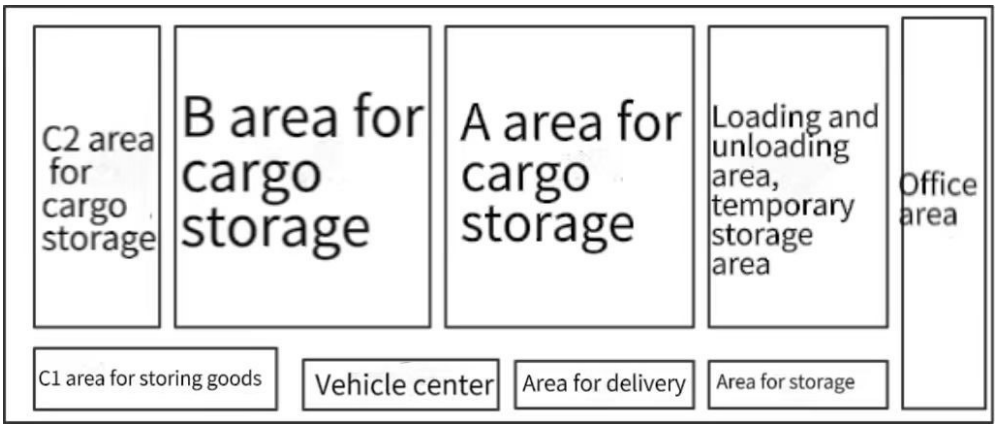

Fig. 1 (a) Warehouse lateral area design by EIQ-ABC method

Area C (the 3rd floor)
Area A (the 2nd floor)
Area B (the 1st floor)

Fig. 1 (b) Warehouse longitudinal area design by EIQ-ABC method

ISSN: 2688-9323

3. Analysis of the Current Situation of Company M's Warehouse and Distribution Center

3.1. M Company Profile

M was founded in 1991, the company started with the development of air-conditioning home appliance retail and wholesale, through years of continuous operation to realize the development of cross-regional chain operation; in 2006, in addition to retaining the retail and wholesale of home appliances, agency business transformation of logistics warehousing, supply chain, and e-commerce, international trade, commercial hotels and real estate, and other diversified business group companies. Based on home appliance retailing, the company has realized the synergistic development of multiple industries, with Shenzhen as the headquarter, expanding its business outward, and developing its business to a total of 6 cities both at home and abroad so far. In terms of warehousing, the company owns a logistics park in Longhua District, Shenzhen, which covers an area of 304 acres for the storage of the company's goods, as well as third-party warehousing will be leased out to Coca-Cola, Foxconn and other enterprises. It also owns a bonded warehouse in Futian Free Trade Zone in Shenzhen for the storage of goods for foreign investment. In terms of transportation and distribution of goods, the company has its own fleet of vehicles, which are used to deliver goods to operating stores or consumers' homes through D2D distribution. In this paper, M company in Shenzhen warehousing and distribution logistics park as the object of research, the warehousing and distribution of goods in the park is mainly distributed to the M company in Shenzhen region under the electrical appliances directly store and the hotel's household appliances and household stoves.

3.2. Layout of Functional Areas of Company M's Warehousing and Distribution Center

The functional areas of M Company's warehousing and distribution center mainly include loading and unloading handling area, temporary storage area, office area, goods storage area, shelving area and vehicle center. As shown in Fig. 2.

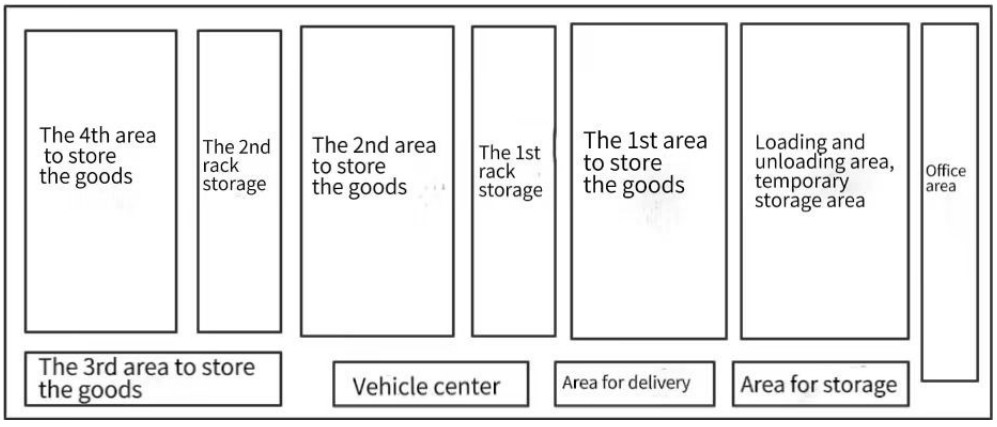

Fig. 2 Layout plan of Company M's warehousing and distribution center

The goods stored by Company M at the warehouse consisted mainly of household appliances, household cooking utensils, construction equipment and other miscellaneous goods. E.g. washing machines, refrigerators, range hoods, etc. In terms of layout planning, through exchanges with the staff of the warehouse during the site visit and their own work experience, it was found that there was no clear boundary between the temporary storage area and the loading and unloading handling area of the warehousing and distribution center of Company M.

ISSN: 2688-9323

The two areas shared the same operating platform, which resulted in confusion in the use of equipment and storage, and the staff were not sure whether the goods in the area had completed the warehousing and registration in the process of their work and were thus unsure whether the goods could be moved to the rear storage area for preservation. It is not clear whether the goods in the area have been registered in the warehouse, so the staff is not sure whether the goods can be carried to the rear storage area for preservation. Ultimately, this affects productivity.

3.3. Company M's Warehousing and Distribution Center Space Storage Strategy

Company M's warehousing and distribution center consists of four goods storage areas and two racking areas. Goods in the cargo storage area are generally stored by stacking goods for cargo storage. The shelving area is built shelves, shelves in the form of 3 layers of 15 columns, the direction of the row for the east-west direction, the use of shelves for the storage of goods.

Company M storage center to random storage as the enterprise storage method for the storage of goods, due to company M storage center mainly for household appliances and other goods, its volume and weight is relatively light, so that can be stacked in the storage area for preservation, but also can be placed in the shelves for storage. Based on this, after arranging for the goods to be warehoused, Company M stores the goods arbitrarily, without corresponding storage strategies and storage areas. Generally, the goods are transported from the temporary storage area to the storage area 4, and gradually placed outward from the innermost part of the warehouse, without a reasonable allocation of storage space for each item of goods according to the sales of goods and other influencing factors, resulting in a long distance of handling of the goods, inefficiency in the discharge of goods, and inconvenience in the search for the goods. At the same time, some of the goods that have not been ordered for a long time and the company's miscellaneous goods, due to the purchase of the earlier, its own volume and weight is large. At that time, the goods were only handled by human labor, so that the goods were located close to the entrance and exit of the warehouse. Occupying the storage space at the same time, seriously affecting the other goods in and out of the warehouse handling. At the same time, most of the employees in the warehousing and distribution center of Company M are older employees, these employees do not receive systematic training and their own cultural level is general, so that some of the more advanced warehouse management methods and equipment can not be used in the distribution center. It makes the cargo handling distance of M Company's warehousing and distribution center long and the operation efficiency slow.

4. Optimization of Storage Space in M's Warehousing and Distribution Center

4.1. Case Study based on EIQ-ABC Analysis

In order to better analyze the problems in the logistics and warehousing operations of Company M, the article selects the order data in a sales cycle of Company M in the year 2022 to be analyzed, and the orders in this cycle are shown in Table 1. The following is an example validation analysis using the problem model described above.

4.1.1. Classification of Goods based on the EIQ-ABC Analysis Method

Combined with the company's daily production data, the analysis was performed using the EIQ analysis table in Table 2 above, and the resulting data results are shown in Table 6 below. The EIQ statistic table has been counted and calculated to get the EQ, EN, IQ, and IK data of the goods of Company M. The EIQ statistic table has been used to calculate the data of Company M's inventory goods. In this paper, based on the EIQ form, the data provided by the company is analyzed by EQ, IQ, IK, and IQ and IK cross-analysis.

ISSN: 2688-9323

Table 1. EIQ Statistics

Shipping order (E)	Number of outgoing items (I)														Quantity shipped in the order (Q)	Number of items shipped in the order (N)
	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15		
E1	340	380	200	70	105	320	200	190	85	143	123	90	15	30	20	2311	15
E2	350	370	180	55	90	300	170	197	65	130	100	80	0	0	0	2087	13
E3	305	340	165	60	100	200	160	177	0	132	0	95	0	0	0	1734	10
E4	295	334	140	65	90	232	175	143	0	120	130	80	0	0	0	1804	11
E5	225	230	160	64	80	190	165	127	76	140	110	85	0	0	0	1652	12
E6	260	215	154	50	85	200	145	144	66	90	90	0	0	0	0	1499	11
E7	400	300	120	75	60	240	138	140	0	86	0	40	0	0	12	1611	11
E8	320	256	163	64	85	130	0	108	0	102	120	45	12	22	0	1427	12
E9	260	235	115	0	55	120	88	107	78	105	100	25	0	14	0	1302	12
E10	193	165	135	25	40	170	110	86	0	100	80	30	0	0	0	1134	11
E11	140	130	85	0	47	234	104	79	83	0	0	0	0	0	15	917	9
E12	110	125	113	45	0	230	90	66	103	90	124	0	0	0	0	1096	10
E13	130	113	130	0	60	255	0	83	0	95	102	0	0	0	0	968	8
E14	102	120	100	64	0	240	130	102	77	90	75	15	0	0	0	1115	11
E15	140	115	80	0	0	195	143	120	63	102	0	30	0	0	0	968	9
E16	105	100	98	55	30	235	120	132	0	106	100	40	0	0	0	1121	11
E17	120	110	102	76	0	210	146	0	85	110	90	10	16	0	12	1087	12
E18	135	105	83	35	0	180	98	104	90	122	87	15	24	17	0	1095	13
E19	120	135	0	0	46	122	120	102	0	104	0	30	0	0	0	779	8
E20	165	110	123	0	57	143	75	96	100	103	120	0	0	0	0	1092	10
E21	200	134	90	0	0	205	65	0	102	102	110	24	0	0	0	1032	9
E22	135	102	115	36	0	230	120	130	0	80	90	50	0	0	6	1094	11
E23	129	120	100	32	20	160	133	150	0	0	0	65	13	24	0	946	11
E24	120	120	90	54	36	176	103	176	134	132	100	0	0	30	0	1271	12
E25	110	100	102	0	44	180	85	137	0	127	90	36	0	0	0	1011	10
Shipments per product	4909	4564	2943	925	1130	5097	2883	2896	1207	2511	1941	885	80	137	65	32173	272
Number of shipments of a single product	25	25	24	17	18	25	23	23	14	23	19	19	5	6	4	— —	270

Note: Data in Table 1 was provided by an internal employee of Company M

1) Order Quantity (EQ) Analysis

Based on the sales data provided by the company, the order quantity of the company is first analyzed. By performing EQ analysis, it is possible to understand how much a company is ordering for a single order. Categorizing orders according to how much they are ordered makes

ISSN: 2688-9323

it easier for companies to arrange the delivery of goods according to the importance of the order. Sort the EQ analysis results by the number of shipments. As shown in table 2.

Table 2. EQ Data Sheet for Company M

Outbound orders (E)	Outbound Quantity (EQ)	Percentage of shipments	Outbound orders (E)	Outbound Quantity (EQ)	Percentage of shipments
E1	2311	7.18%	E24	1271	3.95%
E2	2087	6.49%	E10	1134	3.52%
E4	1804	5.61%	E16	1121	3.48%
E3	1734	5.39%	E14	1115	3.47%
E5	1652	5.13%	E12	1096	3.41%
E7	1611	5.01%	E18	1095	3.40%
E6	1499	4.66%	E22	1094	3.40%
E8	1427	4.44%	E20	1092	3.39%
E9	1302	4.05%	E17	1087	3.38%
E25	1011	3.14%	E21	1032	3.21%
E15	988	3.07%	E11	917	2.85%
E13	968	3.01%	E19	779	2.42%
E23	946	2.94%	(grand) total	32173	100.00%

In order to more clearly see the enterprise shipments of different types of goods, with the help of Excel 16.0 to draw an EQ analysis chart to assist the EQ analysis table for analysis, the analysis chart shown in Fig. 3.

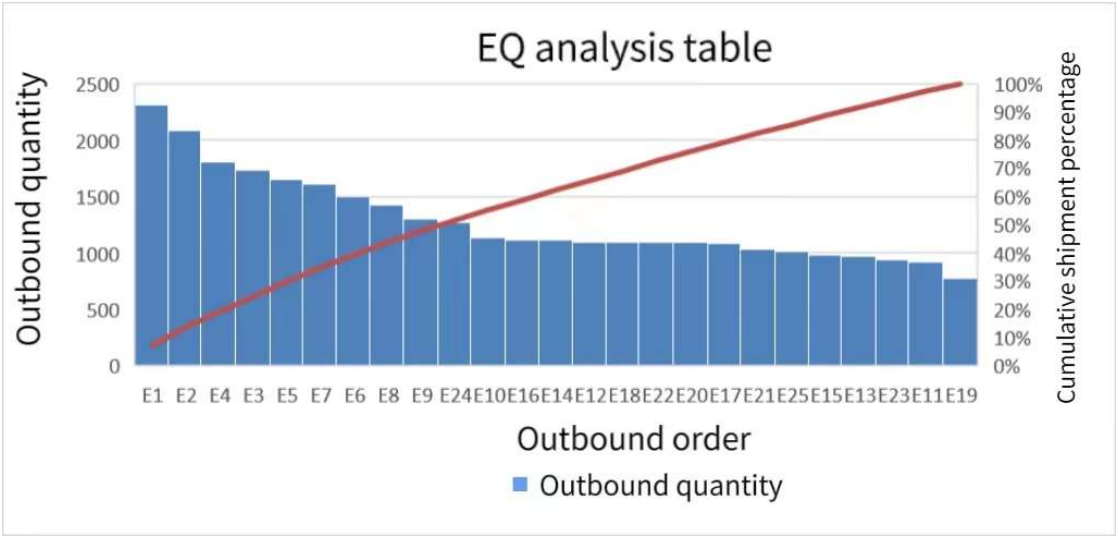

Fig. 3 EQ analysis of Company M's warehousing and distribution center

From the analytical table combined with the analytical chart, it can be seen thatamong the outgoing orders, there is a bifurcated order trend. That is, sales at the beginning and end of each sales cycle will be better than sales in the middle of the sales period. This also indicates that the company's partners generally replenish their goods only after the very first sales cycle and sales period is over. Therefore, companies are required to pay more attention to the stockpiling of

ISSN: 2688-9323

goods at the beginning and end of each cycle. Prepare the appropriate stock in the warehouse in case there is a shortage of stock, resulting in a loss of orders for the company.

2) Item Quantity (IQ) Analysis

Based on the data presented in Table 1, IQ analysis is used to analyze the total number of orders for the same variety in the ordering cycle, and to get an idea of how much goods have been shipped for the item in this time period. Sort the results of the IQ analysis by the number of orders. As shown in table 3.

Table 3. IQ Data Sheet for Company M

item	Order quantity for a single item	Cumulative percentage of shipments (%)	item	Order quantity for a single item	Cumulative percentage of shipments (%)
I6	5097	15.81%	I4	925	2.87%
I1	4904	15.21%	I12	885	2.74%
I2	4564	14.16%	I14	137	0.42%
I3	2943	9.13%	I13	80	0.25%
I8	2896	8.98%	I15	65	0.20%
I7	2883	8.94%	(grand) total	32241	100.00%
I10	2584	8.01%			
I11	1941	6.02%			
I9	1207	3.74%			
I5	1130	3.50%			

In order to more easily see the goods shipped in this period, with the help of Excel 16.0 to draw the IQ analysis chart to assist the data table for analysis, the analysis chart shown in Fig. 4.

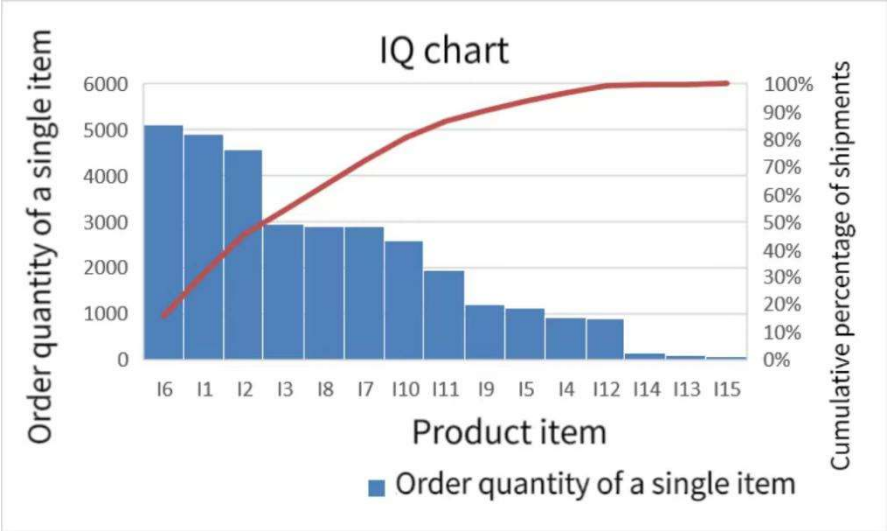

Fig. 4 IQ Analysis of Company M's Warehouse and Distribution Center

Through the IQ curve in Fig. 6 and the data content in Table 8, it can be found that the shipment of goods of Company M presents three levels. Classify and manage the merchandise of Company M according to the ABC classification. The products in category A are known to have three categories, I6, I1 & I2, based on sales out of stock. These three types of products account for 20% of all varieties sold out of the warehouse, while the total sales volume of the products is 14,565 pieces, which accounts for 45% of all products sold out of the warehouse, and can be identified

ISSN: 2688-9323

as Category A products. There are four categories of B products, namely products I3, I8, I7 and I10. The total sales volume of the four categories of products is 11,637 pieces, accounting for 35% of all sales out of the product, at the same time, the four categories of products accounted for 20% of all out of the sales varieties, according to which the above four categories of commodities can be categorized as Class B products for management. And eight categories of products, such as I11, I9 and I5, accounted for 54% of all varieties sold out of the warehouse. The overall sales volume was 6,370 pieces, or 20% of all products sold out of the warehouse. From this, eight categories of products such as I11, I9, etc. can be categorized as Category C products for management. With IQ analysis, products can be stored in separate areas based on how much they are shipped, i.e., how important they are to the organization. For Category A products, as their sales volume represents a large percentage of the total sales volume. Therefore, these products need to focus on management, the need for monthly inventory of the stock situation, to understand the stock situation, the storage area should be set up in the nearest location from the entrance and exit, to facilitate the entry and exit of the goods. It is also possible to improve the efficiency of cargo handling and cargo picking through RFID and other technological devices. For B products, these products, although there is a certain amount of sales, but the overall sales are not as good as A products, so its storage place only needs to be relatively easy to enter and exit the warehouse operations can be, while quarterly inventory of the inventory situation, to understand the inventory situation. Finally, for C products, as it is generally slow-moving products and sales are not large and other characteristics, so the frequency of inventory counting should be moderate, can be in the end of the year inventory of the corresponding material inventory, to grasp the inventory of such products, in the warehouse can be placed in a secondary location.

3) Analysis of the Number of Items Ordered (IK)

IK analysis is an analysis of the frequency of shipment of goods. IK analysis facilitates the understanding of the ordering frequency as well as the shipping frequency of various goods. And the results can be combined with the conclusions of the IQ analysis to determine how the goods are warehoused and picked. The IK data table of the enterprise is derived from the production and operation table of the enterprise, as shown in Table 4.

Table 4. IK data table for Company M

item	Deposit frequency	Cumulative percentage (%)	item	Deposit frequency	Cumulative percentage (%)
I6	25	9.26%	I5	18	6.67%
I1	25	9.26%	I4	17	6.30%
I2	25	9.26%	I9	14	5.19%
I3	24	8.89%	I14	6	2.22%
I10	23	8.52%	I13	5	1.85%
I7	23	8.52%	I15	4	1.48%
I8	23	8.52%	(grand) total	270	100.00%
I11	19	7.04%			
I12	19	7.04%			

From Table 4 it is not easy to classify the types of goods stored in the enterprise according to the frequency of shipments of each type of goods. Therefore with the help of Excel 16.0 draw Fig. 5 to analyze the data of the company by combining the charts.

ISSN: 2688-9323

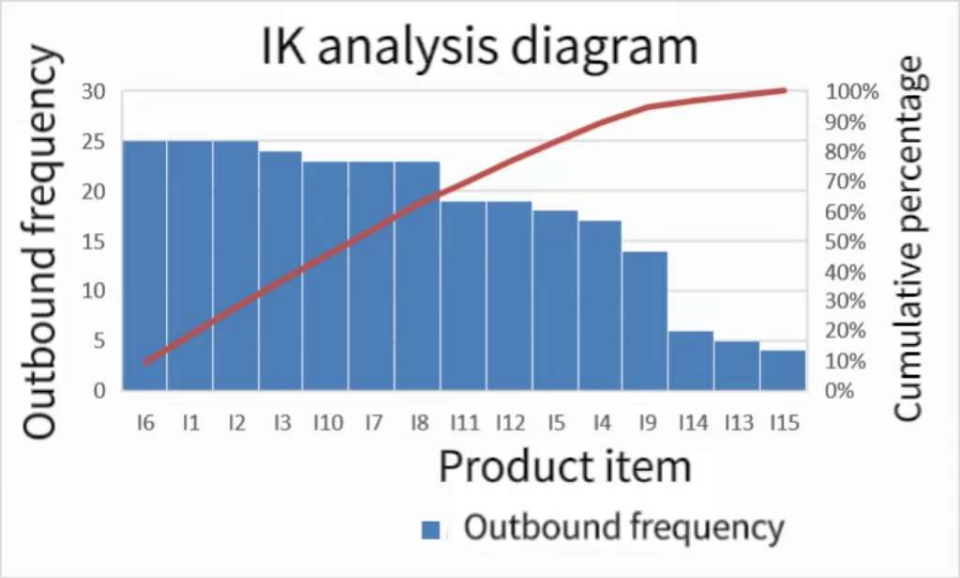

Fig. 5 IK Analysis of Warehouse and Distribution Center of Company M

The IK analysis table shows that the number of shipments of both A and B products in Company M is 23 and above, which is at a high shipment frequency. As you can see, basically every order contains products from both A and B categories. And even for C products, the frequency of product shipments is more than 1/2 of the total frequency of shipments. It shows that there is a certain demand for all products in Company M, regardless of the category, making the frequency of shipments of all types of items relatively high. Through the above analysis, the three types of products I6, I1 and I2 with K=25 can be managed as Class A products, and these types of products are prioritized in the warehouse. The products with K=23-24, i.e. products I3, I10, I7, I8 are managed as B products, while the remaining products are managed as C products because the shipment frequency is not particularly high compared to A and B products.

4) IQ and IK Crossover Analysis

Table 5. Data table of IQ and IK cross-tabulation analysis of Company M

item	volume of goods shipped	Percentage of IQ	Number of shipments of a single product	Percentage of IK
I6	5097	15.65%	25	9.23%
I1	4904	15.06%	25	9.23%
I2	4564	14.01%	25	9.23%
I3	3132	9.62%	24	8.86%
I8	2987	9.17%	23	8.49%
I7	2934	9.01%	23	8.49%
I10	2584	7.93%	24	8.86%
I11	1941	5.96%	19	7.01%
I9	1207	3.71%	14	5.17%
I5	1130	3.47%	18	6.64%
I4	925	2.84%	17	6.27%
I12	885	2.72%	19	7.01%
I14	137	0.42%	6	2.21%
I13	80	0.25%	5	1.85%
I15	65	0.20%	4	1.48%
(grand) total	32572	100.00%	271	100.00%

ISSN: 2688-9323

After completing the above analysis, in order to further understand the relationship between the quantity of goods shipped and the frequency of shipments,

both need to be analyzed, and the results of the analysis also become the data base for the ABC classification method. Therefore, the data were cross-analyzed for IQ and IK, and the statistical results are shown in Table 5.

In order to visualize the relationship between the shipments of goods and the frequency of shipments, therefore, the IQ and IK cross-analysis graphs are plotted with the help of Excel 16.0, which aids in analyzing the tabular data for the final results. The analysis diagram is shown in Fig. 6.

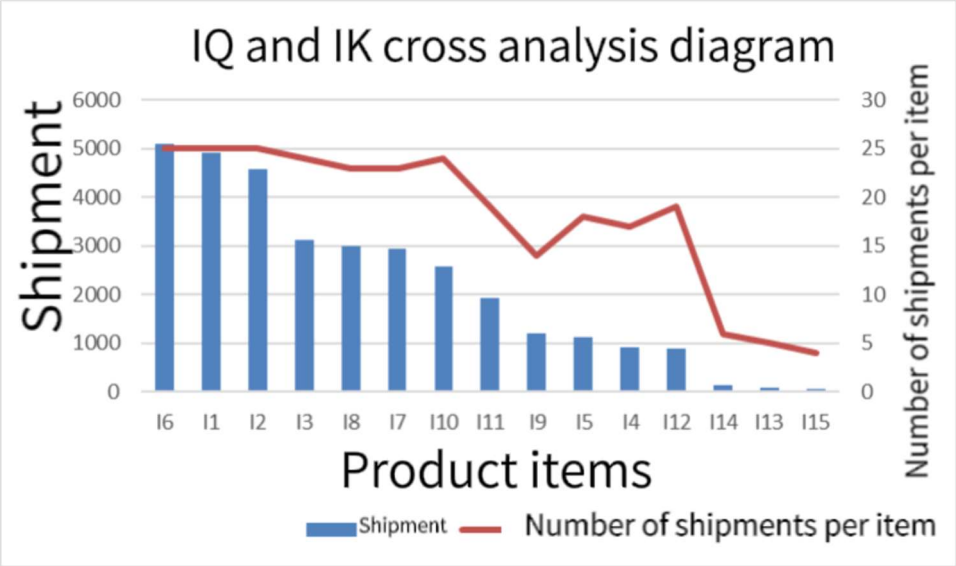

Fig. 6 Cross-analysis of IQ and IK in Company M's warehousing and distribution center

A comprehensive analysis based on the datasheet graphs reveals that. In most cases, when the shipment of goods is relatively large, the number of orders is also relatively large, that is, the number of enterprise shipments and the number of orders show a positive relationship. Based on this it can be shown that the results of the IQ and IK cross-analysis are closer to the results of the IQ analysis. To summarize, products I6, I1 & I2 are focused on as A products. For this kind of product should often inventory inventory, easy to understand the sales situation in a timely manner and the product replenishment. At the same time can be equipped with some electronic equipment such as RFID to ensure the efficiency of goods in and out of the warehouse. Products I3, I8, I7, and I10 are managed as Category B products, which have a median average single order quantity in the overall order, and can be regularly managed in terms of inventory quantities on a monthly or quarterly basis. The remaining eight categories of products, such as I11 and I9, are generally slow-moving products due to small order quantities, etc., and orders may be generated only when the enterprise sells at a discount or when there is an internal demand for them, so they are managed as Category C products, and only a little control is required for these products, with half a year or a year as the period for inventory checking and management of the goods.

4.1.2. Warehouse Storage Optimization based on EIQ-ABC Analysis Method

Based on the results of the EIQ analysis above, complete the ABC classification of Company M's inventory products. Of these products, I6, I1 & I2 were sold in 14,565 units, or 45% of all products sold out of the warehouse, and were determined to be Class A products. Four product categories, I3, I8, I7 and I10, accounted for 35% of all products sold out of the warehouse and were determined to be category B products. The remaining eight categories, I4 and I5,

ISSN: 2688-9323

accounted for 20% of all products sold out of the warehouse and were identified as Category C products. The ABC classification is shown in Table 6.

Based on the results of the ABC classification of goods, the goods in the warehouse of Company M are divided into storage spaces. The storage area of the goods is shown in Fig. 1 (a) and Fig. 1 (b), as the goods in and out of the enterprise using the first-in-first-out method of handling, while the enterprise's main goods for home appliances, the weight and volume of the product with the industrial products compared to the smaller, so in the storage area or shelves can be stored. Based on this, in combination with the field layout of M's warehousing and distribution center, Class A goods are placed in Goods Storage Area A, i.e., Goods Storage and Shelving Area 1, to facilitate the handling of goods. Wherein I6 is placed on the second tier of the shelves and is closest to the entrance and exit of the warehouse, I1 is placed on the first tier of the shelves and in the middle position of the storage area, and I2 is placed on the third tier of the shelves and at the end of the storage area. The goods of category B are placed in the goods storage B area, i.e. the goods storage with shelves area 2, wherein I3 is placed on the second level of the shelves, I8 on the first level of the shelves, and I7, I10on the third level of the shelves. The order of placement in the storage area is the same as the order of placement of the goods in the A area. Place Class C cargo in Cargo Storage Area C. Wherein the products I11, I9, I5 & I4 are stored in the goods storage C1 area, i.e. the goods storage area 3. The remaining four products, I12, I14, I13 and I15, are stored in storage area C2, i.e., goods storage area 4, which is located farther away from the access area, due to their smaller sales volume. Thus, the handling of Class A and Class B products will not be affected. Through the above categorization, and then a reasonable planning for the warehouse goods of Company M. In addition to facilitating the management of goods and mastering the situation of goods, it also facilitates the handling of goods, which helps to improve the efficiency of warehousing.

Table 6. ABC Classification Table for Company M

Type (% of items)	Number (% share)
Category A (20.00%)	14565 (44.72%)
Category B (26.67%)	11637 (35.73%)
Category C (53.33%)	6370 (19.56%)
(grand) total	32572 (100%)

4.2. Evaluation of the Optimization Plan for Sstorage Space in the Storage Center of Company M

4.2.1. Qualitative Analysis

Table 7. Comparison of operational effects before and after optimization of storage allocation

	Cargo storage methods	In terms of efficiency of cargo operations
Reserve allocation pre-optimization	Goods are stored randomly, goods are stacked from back to front, empty space is the storage area, there is no designated storage area.	Cluttered cargo placement and low space utilization. Increased goods picking time and low operational efficiency.
	Summary: Before the optimization of storage space, there is no relative fixed storage location for goods, disordered placement, low space utilization and low efficiency of warehousing operations.	
Reserve allocation post-optimization	Goods are stored according to categorization standards, neatly arranged, with obvious storage partitions, and the storage area goods are visible at a glance.	Reduced chaotic stacking of goods, easy to find goods, increased space utilization and improved operational efficiency
	Summary: After the optimization of storage space, according to the type of goods stored in zones, placed in an orderly manner, high space utilization, warehousing operations to achieve improved efficiency.	

ISSN: 2688-9323

After completing the optimization of storage space allocation in the storage and distribution center of Company M, compared with the original plan, the new plan is optimized in the following aspects, which can be compared with the effect of operation before and after optimization through the table.

4.2.2. Quantitative Analysis

1) Evaluation of Average Cargo Handling Distance

Before the optimization of the storage space, the goods in the storage area were randomly placed, and the average inbound and outbound handling had to walk half the distance of the warehouse, slowing down the speed of goods circulation[23] . Assume that the average number of moves in the storage area before storage space optimization is 100 and the number of goods in the partition is 1. After optimizing the storage position, the data is set according to the optimization result. The results of the IK-ABC analysis method were used as the number of times the goods were moved. The results of the IQ-ABC analysis method were used as the zonal cargo space quantity coefficients. The distance coefficients are all 0.5, as shown in Table 8. After calculation, the results of average cargo handling distance before and after optimization of storage space allocation are obtained.

Table 8. Comparison of average cargo handling distance before and after optimization

Before storage optimization				
	Number of moves	**Number of cargo spaces by zone**	**distance coefficient**	**Subtotal**
All goods	100	1	0.5	50
add up the total				50
After storage position optimization				
	Number of moves	**Number of cargo spaces by zone**	**distance coefficient**	**Subtotal**
Class A goods	28	0.45	0.5	6.3
Class B goods	34	0.35	0.5	5.95
Class C goods	38	0.20	0.5	3.8
add up the total				16.05

As can be seen from the comparison in Table 13, after optimization of the cargo storage space, the average handling distance of the cargo is reduced by 67.9% compared to the pre-optimization period. It can be seen that the efficiency of the warehouse operation is significantly improved after optimization. Therefore, using EIQ-ABC for storage space allocation planning can effectively improve the operational efficiency of the distribution center and shorten the average handling distance of goods.

in the warehouse area. It is proved that this optimization method is applicable and can achieve the optimal management of the storage level.

2) Evaluation of Warehouse Storage Space Programs Based on Weighted Factor Approach

In this article, we refer to the 4M1E rule for the setting of influencing factors. In the weight setting, the first key factor to consider is whether the operation process of the warehouse center is scientific, whether the optimization has achieved the improvement of the operational efficiency of the warehouse. This is in addition to avoiding circuitous logistics routes and minimizing the reuse of personnel. Therefore a weight of 0.4 is assigned to logistics operational efficiency and 0.2 to human flow rationalization. In addition, making full use of every square footage within the storage center and rationally carrying out the layout of the cargo space to maximize the use of inventory is also one of the reference criteria for whether optimization is achieved, so the weight given to the spatial layout is 0.2. Whether the equipment can be reasonably utilized is also a reference factor to ensure the efficient operation of the storage

ISSN: 2688-9323

center, but since the storage and distribution center of Company M does not have too many machines and equipment, the weight of the equipment utilization rate is thus set to 0.1. The comfort level of the work environment has no direct effect on the workflow, and all of them were set to a weighted value of 0.1. After completing the selection of evaluation factors, the head of the logistics department of the warehousing and distribution center of Company M and the front-line staff were invited to evaluate and score the solutions before and after optimization in five aspects, including logistics operation efficiency. Based on the weighted values of the evaluation factors and the results of the staff evaluation, the planning program evaluation form was obtained as shown in Table 9.

Table 9. Evaluation of Optimization Options for Warehouse Centers

Evaluation factors	weighted value	Original program evaluation	Optimization of programme evaluation
Logistics efficiency	0.4	E(3)	A(4)
Rationalization of abortion	0.2	I(2)	E(3)
spatial arrangement	0.2	I(2)	E(3)
Equipment utilization	0.1	E(3)	E(3)
Comfort in the working environment	0.1	I(2)	I(2)
add up the total	1	2.5	3.3

The statistical results in Table 9, comparing the rating scores of the original and optimized solutions, show that the evaluation score of the optimized solution is higher than that of the original solution by 0.8 points, which translates into a percentage of difference in evaluation, which is 32% higher for the optimized solution than for the original solution. The optimized solution was also evaluated better than the original solution in terms of logistics operation efficiency, rationality of human flow and space layout. The resulting validation of the two scenarios through the Weighted Factor Comparison (WFC) method concludes that the optimized scenario will be more suitable for the warehouse management of Company M. The optimized solution makes the enterprise logistics operation efficiency improve, logistics and human flow operation smooth, in line with the characteristics of M company's commodity features, warehouse layout is more reasonable. It also proves the feasibility of the optimized solution.

5. Conclusion and Outlook

5.1. Conclusion of the Study

This paper studies the optimized management of warehouse storage space in enterprises, taking the warehouse distribution center of Company M as an example. Field investigation of the center, found that it has problems in the management of warehousing goods, relying on the EIQ-ABC analysis method, for the resulting problems to put forward the optimization of the management of warehousing storage space program. The turnover of various types of goods was determined by analyzing the order situation for an order cycle through the EIQ analysis method. Classify goods according to turnover with the help of ABC classification. According to the rank classification of goods is different, stored to the corresponding storage location, to get the storage position optimization management scheme of the storage and distribution center to facilitate the storage of goods. Comparative analysis of the old and new solutions through qualitative and quantitative methods, proved that the optimization of the solution in warehousing operation efficiency and other aspects of the improvement, so that the enterprise to achieve the optimization of the management of warehousing storage space.

ISSN: 2688-9323

The main findings of this paper are as follows: the study combines the EIQ analysis method with the ABC classification method to optimize the design of horizontal and vertical storage spaces in the warehousing and distribution center of Company M, which is divided into three regions, A, B and C. Cargo is also managed in a hierarchical manner. The storage of goods to the corresponding area is based on the grade of the goods. Finally, the effectiveness of the program was verified, and it was found that this division facilitates the access of goods, ensures the continuity of the whole process, and realizes the improvement of the efficiency of warehousing operation. It is a fast-acting and efficient program. Meanwhile, the findings of the study are also informative for the management of the same type of warehouses in the park.

5.2. Research Outlook

Although this study has achieved the intended purpose of the study, there are still some areas that need further improvement due to the limitations of our own research level:

First, the model used in this paper for warehouse planning is relatively homogeneous, and it is only analyzed by combining the EIQ analysis method with the ABC classification method to plan for the goods in the warehouse. If possible, the follow-up can be used in other warehousing planning methods such as SLP system layout design method combined with the analysis of warehousing for a more comprehensive planning and design, so that the enterprise warehousing layout and warehousing processes and other aspects of the optimization of management can also be achieved.

Secondly, in conducting the EIQ analysis, an optimized design of the company's warehoused goods was made from the current situation of the company. However, when conducting weighted factor analysis, it is subjective and arbitrary to determine the evaluation factors only by communicating with the enterprise's warehousing staff. It is hoped that this can be followed up by inviting experts in the field for scoring or practicing in the daily production life of enterprises. This makes the optimization method more authoritative.

References

[1] Zhu Lingyao,Zhou Li. Optimization Research on Storage Layout of Modern Warehouse Center[J]. Journal of Engineering Mathematics,2022,39(06):862-874.

[2] An Dongqi,Gui Kunpeng. Optimization of urban logistics and warehousing land layout in Guangzhou[J]. Planner, 2021, 37(10):20-25.

[3] FU Huawei,HE Xiaomin,XU Liang,et al. Real-time explosives storage optimization operation based on RFID and genetic algorithm[J]. Computer Engineering and Science,2014,36(02):286-291.

[4] Zhang Genlin,Tian Linlin. Research on the application of genetic algorithm in RFID intelligent storage system[J]. Manufacturing Automation,2022,44(08):166-168.

[5] LIU Jiansheng, ZHANG Yougong, XIONG Feng, et al. Research on the optimization method of cargo space allocation in Flying-V warehouse layout[J]. Operations Research and Management, 2019, 28(11):27-33.

[6] Devinder Kumar, Rajesh Kr Singh, Ruchi Mishra,etal.Applications of the internet of things for optimizing warehousing and logistics operations: a systematic literature review and future research directions[J]. Computers & Industrial Engineering 171 (2022)108455.

[7] Daosen Zhai, Chen Wang, Haotong Cao,etal.Deep neural network based UAV deployment and dynamic power control for 6G-Envisioned intelligent warehouse logistics system[J]. Future Generation Computer Systems 137 (2022) 164-172.

[8] Sun Junhua,Li Lin. Research on decision-making model of distribution center equipment based on EIQ and PCB[J]. Industrial Technology Economics,2011,30(03):96-100.

[9] Wang Qianshou. Research on Warehouse Optimization of Company A Based on EIQ Model and SLP Method[J]. Logistics Engineering and Management,2022,44(09):34-38.

[10] MA Yunfeng,WU Beiping,JIN Yuqing. Partition design and ABC classification analysis of grid-tightened storage systems[J]. Operations Research and Management, 2022, 31(04):91-97.

[11] Li J.T., Qiu W.M., Wen W.M. Application of EIQ-ABC Analysis in Warehouse Management in Logistics Centers[J]. Logistics Science and Technology,2020,43(05):161-165.

[12] CHEN Cheng,LIN Qiuting,LI Qina,et al. Warehouse Layout of Steel Logistics Park Based on EIQ-ABC-SLP Method[J]. Journal of Jimei University (Natural Science Edition),2020,25(04):279-286.

[13] Wang XH, Zhang Y. Application of EIQ-ABC analysis method in tobacco distribution center planning--Taking Shandong H tobacco distribution center as an example[J]. Logistics Engineering and Management,2016,38(07):102-105.

[14] Su, Hongxin. A study on the improvement of warehouse management in SF's F city warehouse [D]. Dalian University of Technology, 2022.

[15] Xu Shasha.Research on the optimization strategy of warehousing layout and process in Company X[D]. China University of Mining and Technology, 2022.

[16] Feng Yanfang,Chen Yongping. Site selection analysis of logistics distribution center based on weighted factor method--Taking Yixing, Jiangsu as an example[J]. Journal of Chongqing Three Gorges College, 2008(06):91-94.

[17] WANG Jiarui,ZHAO Yu'e. Exploration on the development of sea water rice cultivation in Dongying City based on weighted factor method[J]. Guangdong Sericulture,2022,56(01):28-30.

[18] Roodbergen K J. Storage Assignment for Order Picking in Multiple-Block Warehouses[J]. Warehousing in the Global Supply Chain, 2012:139-155

[19] AN Shuke,XU Liangjie,QIAN Lianghui. Cigarette warehousing operation process optimization method and simulation[J]. Logistics Technology,2018,37(09):115-119.

[20] FU Huawei,HE Xiaomin,XU Liang,et al. Real-time explosives storage optimization operation based on RFID and genetic algorithm[J]. Computer Engineering and Science,2014,36(02):286-291.

[21] YAN B,YAN C,LONG F,etal.Multi-objective optimization of electronic product goods location assignment in stereoscopic warehouse based on adaptive genetic algorithm[J]. Journal of Intelligent Manufacturing,2018,29(6):1273-1285.

[22] PENG Jianhua,WANG Yue,Lv Feng,et al. Equipment layout design of ship tube processing workshop based on SLP and genetic algorithm[J]. Ship Engineering,2022,44(10):15-21+106.

[23] Hu Xuan.Analysis and optimization research on the control factors of cold chain logistics warehousing in Company T [D]. China University of Mining and Technology, 2019.