Optimization Analysis of Auto Parts Inventory Management Based on Fuzzy Evaluation Method

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Abstract. Warehouse center mode is the main way for the development of the automobile logistics industry, which not only provides professional services for the supply of spare parts, but also enables its own warehousing department to operate independently and realize industrial value-added. How to make its management level and informationization level reach the best becomes the key issue for the survival and development of enterprises. Taking the warehouse center of the automobile manufacturing enterprise as the research object, the current situation of the enterprise is analyzed, and the deficiencies of the management system in the enterprise are optimized. The ABC classification method is combined with the fuzzy evaluation method and applied to the inventory classification of the automobile parts. The deficiencies in the management mode and method are optimized, and a reasonable inventory classification model is established to realize the classification management of goods. Improve the information level of parts management.

Key words-Automobile production enterprise; Auto parts; Inventory management; Fuzzy evaluation method

1. Introduction

With the rapid development of China's automobile industry in recent years, automobile logistics has attracted widespread attention. Since automobile manufacturers generally adopt the mode of outsourcing parts and assembly production, its wide scope, difficult overall planning and scheduling, and many factors affecting variable cost are the reasons why supply logistics is more difficult than other logistics. Different enterprises have set up their own parts supply bases, sales networks and transfer warehouses, but the operation efficiency of parts distribution and transfer warehouses is generally low, and some only use less than 20% of the storage capacity of transfer warehouses, while the management fee and personnel salary and other expenses are quite high [1]. Most large automobile manufacturing enterprises adopt production line flow production and have strict requirements on the supply time and quality of automobile parts. However, due to the influence of transport routes, traffic conditions, vehicle arrangement, personnel scheduling, and even weather, the third-party logistics cannot guarantee such strict demand for automobile manufacturers. As a result, automakers' reliance on third-party logistics is low [2-3].

Under such conditions, automobile manufacturers are deeply thinking about how to abandon traditional management ideas, integrate enterprise resources, select satisfactory logistics

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partners through outsourcing to realize the borrowing of external resources, and focus on key businesses internally to truly improve the core competitiveness of enterprises, which is a very important strategic measure [4]. Warehouse center mode opens up a new road for the development of the automobile logistics industry, and brings double benefits for the automobile manufacturing enterprises. It not only makes the spare parts supply get professional services, but also enables the warehousing department to operate independently to achieve industrial value-added. However, the ensuing problem is that this new logistics mode is still in the stage of exploration and continuous improvement in management. How to make its management level and information level reach the best has become a key issue for the survival and development of enterprises. Based on this background, taking the warehouse center of automobile manufacturing enterprises as the research object, the current situation of the enterprise is analyzed, and the deficiencies in its management mode and methods are optimized, so as to optimize its management information system, and finally achieve the purpose of improving the management level and informatization level of the enterprise.

2. Inventory management status analysis

At present, most automobile manufacturing enterprises are composed of a final assembly plant (also known as the vehicle plant) and a number of sub-assembly plants. Assembly plants generally include body factory, chassis factory, transmission factory, engine factory, front axle factory, chassis factory and interior factory. Therefore, the complex assembly process makes the logistics inventory modes of each enterprise different, roughly there are zero inventory, joint inventory, supplier managed inventory, multi-pole inventory four basic inventory modes.

The warehouse center not only delivers auto parts to the final assembly plant, but also provides storage and distribution services for other companies. The management information system used by the warehouse center is developed and designed by a professional software company. Due to the lack of in-depth understanding of the internal business of the company, the product developed by the software company has some shortcomings in function. In addition, with the expansion of the warehouse center business, the management method is also used to manage small enterprises, which will inevitably cause management drawbacks. Furthermore, if there is no information support, even if the management can be improved, it still cannot achieve significant results. Therefore, ultimately it comes down to the backwardness of the warehouse management system.

These problems have hindered the sustainable development of the warehouse center and need to be solved in time. Through the optimization of warehouse management system to improve the internal management of enterprises, improve the level of information.

3. Inventory management method decision analysis

What method can be adopted to meet the current situation of the warehouse center and meet the needs of the enterprise, which is the bottleneck to solve the problem. From the analysis of the current situation, management is too simple, no hierarchy, no classification, therefore, the method used must be able to solve the classification of goods.

At present, ABC classification is widely used by various enterprises to classify inventory. The 20-80 principle for the warehouse center to effectively distinguish the management of the key and non-key, the operation of the priority, save the cost of capital, improve the work efficiency, clear the management ideas. However, automobile parts have many varieties, large quantities, different storage methods and different production needs, which are not taken into account by ABC classification. How to incorporate these characteristics of auto parts into classification criteria is the key to inventory management decisions. By introducing fuzzy evaluation method, combining with ABC classification method, and learning from the successful application examples of fuzzy evaluation method in other fields, the value quantity, the particularity of storage and the importance of production demand are creatively taken as factor sets to classify inventory more scientifically and reasonably.

If the inventory is classified strictly according to the fuzzy evaluation method, then it is necessary to establish accurate single factor evaluation matrix and evaluation factor weight vector for each variety of inventory, which will consume a lot of energy of management personnel and is not very meaningful. In addition, even after expert consultation, each factor of the single factor evaluation matrix cannot be guaranteed to be absolutely correct [5]. Therefore, in order to simplify the operation and ensure the rationality of classification, a flexible method can be adopted to combine the ABC classification method with the comprehensive evaluation principle, that is, the whole inventory is divided into three categories of ABC, and then each category is subdivided according to its demand law. The reason why it is subdivided according to its demand law is that different demand laws often correspond to different demand probability models.

In the inventory management system, in order to realize the dynamic maintenance of inventory classification, the system should make statistics on the consumption rule of each variety in the inventory and the proportion of inventory amount at any time, and calculate the percentage change based on the initial value of these two indicators [6]. Its calculation formula is as follows:

$$P_i = \frac{Q_i \cdot D_i}{\sum_{j=1}^{n} Q_j \cdot D_j} \times 100\% \tag{1}$$

where: P_i is the proportion of inventory amount currently occupied by Class i inventory, Q_i is the current inventory quantity of Class i inventory, and D_i is the current unit price of Class i inventory.

$$\Delta_i = \frac{|P_i - P_{i0}|}{P_{i0}} \times 100\% \tag{2}$$

where: Δ_i is the percentage change of inventory amount currently occupied by Class i inventory, P_{i0} is the proportion of initial inventory amount of Class i inventory

A minimum percentage change is specified. If a material changes in this index beyond this percentage, the system will alert the manager to consider reclassifying it [7-8]. In this way, the dynamic maintenance of inventory classification is realized and the classification result is always reasonable.

4. Inventory management optimization realization

4.1. Perform ABC classification

According to the percentage of the number of goods in stock to the number of goods in stock and the percentage of the amount of goods in stock to the total amount of goods in stock, the inventory is divided into three categories: A, B and C.

Take the direct delivery into the warehouse as an example, there are 120 kinds of auto parts in the warehouse, the inventory of the goods in the warehouse within half a year, the quantity out of the warehouse statistics, and focus on the inventory statistics, analysis. The information is sorted into a table to find the cumulative percentage. Statistics of quantity and value of goods in stock are shown in Table 1.

Table.1 Inventory quantity and value statistics table

Unit price of goods (yuan)	The number of	Ratio of quantities	Quantity cumulative ratio	Value (yuan)	Ratio of value	Cumulative value ratio
More than 1000	2	1.7%	1.7%	6882	20.3%	20.3%
901~1000	4	3.3 %	5%	3800	11.2%	31.5%
801~900	3	2.5 %	7.5%	2655	7.8%	39.3%
701~800	1	0.8%	8.3%	736	2.2%	41.5%
601~700	6	5 %	13.3%	3645	10.8%	52.3%
501~600	8	6.7%	20%	4010	11.8%	64.1%
401~500	6	5%	25%	2520	7.4%	71.5%
301~400	10	8.3%	33.3%	3425	10.1%	81.5%
201~300	12	10%	43.3%	2615	7.7%	89.2%
101~200	28	23.3%	66.6%	2900	8.5%	97.7%
0~100	40	33.4 %	100%	682	2.2%	100%
Sum	120	100%		33870	100%	

The ABC analysis diagram is drawn according to the statistical data in Table 1 (as shown in Fig 1). Then, according to the dividing standard of the ratio of value and quantity, the corresponding types of goods can be determined. The results shown in Table 2 can be approximately obtained from the data in the above example.

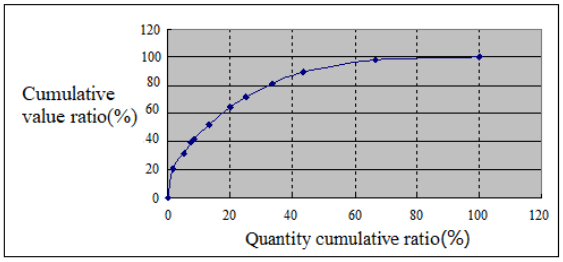

Fig.1 ABC analysis diagram

Table.2 Cargo classification table

The serial number	classification
1~6	Class A
7~9	Class B
10~11	Class C

According to the ABC analysis chart and the cargo classification table, different management methods can be applied to different categories of goods. The classification of goods in other warehouses is the same.

On this basis, each category is divided into three categories according to its demand law: the high-consumption category is H, the medium-consumption category is M, and the low-consumption category is L.

Inventory items match the ABC and the level of available {AI, AII, AIII, BI, BII, BIII, CI, CII, CIII} the six combinations. Each combination represents a class of stock pieces with specific characteristics. Below, the fuzzy evaluation method is used to calculate the comprehensive score of each type of stock.

4.2. Application of analytic hierarchy process modeling

(1) Establish the hierarchical structure model, as shown in Fig 2.

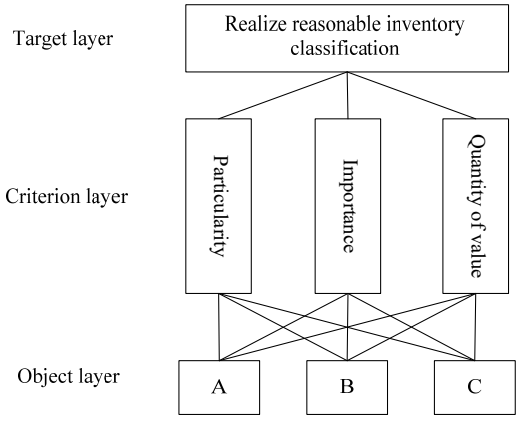

Fig.2 Hierarchical model of inventory classification

The specific meanings of each index of the criterion layer are as follows:

Specificity. For auto parts, its particularity is mainly reflected in the storage method. Auto parts need moisture-proof, heat-proof, sun-proof and pressure-proof; Some are not easy to mix, to isolate storage; There are also different fire extinguishing methods. For example, black metal parts will rust in 2-3 hours at the relative humidity of 100% and the temperature above 42℃.

Importance. The importance of auto parts is manifested in three points: first, the necessity of production is different. If some parts are in high demand, and the substitutability is small, the necessity is strong; Secondly, the simplicity of purchase is different. Some products are imported, which are complicated and expensive compared with domestic products. Third, the new degree of the product is different, some new parts than the outdated (or even about to be eliminated) products, more important.

Quantity of value. This refers to the price of the product itself [9-10].

(2) Construct the judgment matrix and calculate the maximum feature root, feature vector, consistency index and consistency ratio.

4.3. Fuzzy evaluation method to realize inventory classification

(1) Establish the evaluation factor set U and evaluation level set V.

The value in the weight system vector B represents the weight of each factor in the evaluation factor set. As the purpose of reasonable inventory classification is to ensure production and reduce inventory, the evaluation factor grade set factor is determined as safe inventory.

Evaluation factor set $U = (U_1, U_2, U_3) =$ (particularity, importance, value quantity)

Evaluation factor level set $V = (V_1, V_2, V_3) =$ (high safety inventory, general safety inventory, low safety inventory)

(2) Construct evaluation grade vector

No matter how many levels of evaluation factors there are, there is only one evaluation level, and the evaluation level determined by this model is (good, average, poor).

According to the expert scoring method (Delphi method), the comment line vector P of the three levels is set as:

$$P = (P_1, P_2, P_3) = (100,70,30)$$

Select management representatives, user representatives and relevant experts to form a review team, evaluate each factor according to the determined evaluation level, and determine the membership degree of indicators statistically according to the index evaluation form they fill in.

According to the index evaluation table, each factor U is evaluated by referring to the grade set V, and the evaluation matrix of each single factor is obtained.

The single factor evaluation matrix of AI is:

$$R_1 = \begin{pmatrix} 0.4 & 0.4 & 0.2 \\ 0.3 & 0.5 & 0.2 \\ 0.2 & 0.7 & 0.1 \end{pmatrix}$$

Comprehensive evaluation results are obtained by fuzzy synthesis:

$$B = AOR = (0.1 \quad 0.64 \quad 0.26)\begin{pmatrix} 0.4 & 0.4 & 0.2 \\ 0.3 & 0.5 & 0.2 \\ 0.2 & 0.7 & 0.1 \end{pmatrix} = (0.284 \quad 0.542 \quad 0.174)$$

Therefore, the assessment of AI is divided into:

$$W_1 = B_1 P^T = (0.284 \quad 0.542 \quad 0.174)\begin{pmatrix} 100 \\ 70 \\ 30 \end{pmatrix} = 71.56$$

The single factor evaluation matrix of AII-CIII is as follows:

$$R_2 = \begin{pmatrix} 0.3 & 0.4 & 0.3 \\ 0.2 & 0.5 & 0.3 \\ 0.1 & 0.5 & 0.4 \end{pmatrix} \quad R_3 = \begin{pmatrix} 0.2 & 0.4 & 0.4 \\ 0.1 & 0.3 & 0.6 \\ 0 & 0.3 & 0.7 \end{pmatrix} \quad R_4 = \begin{pmatrix} 0.5 & 0.3 & 0.2 \\ 0.4 & 0.4 & 0.2 \\ 0.3 & 0.6 & 0.1 \end{pmatrix}$$

$$R_5 = \begin{pmatrix} 0.3 & 0.4 & 0.3 \\ 0.2 & 0.5 & 0.3 \\ 0.1 & 0.5 & 0.4 \end{pmatrix} \quad R_6 = \begin{pmatrix} 0.2 & 0.4 & 0.4 \\ 0.1 & 0.4 & 0.5 \\ 0 & 0.3 & 0.7 \end{pmatrix} \quad R_7 = \begin{pmatrix} 0.7 & 0.1 & 0.2 \\ 0.5 & 0.4 & 0.1 \\ 0.4 & 0.6 & 0 \end{pmatrix}$$

$$R_8 = \begin{pmatrix} 0.4 & 0.5 & 0.1 \\ 0.3 & 0.6 & 0.1 \\ 0.2 & 0.8 & 0 \end{pmatrix} \quad R_9 = \begin{pmatrix} 0.2 & 0.5 & 0.3 \\ 0.1 & 0.6 & 0.3 \\ 0 & 0.7 & 0.3 \end{pmatrix}$$

Using the above algorithm, we can obtain:

$$W_2 = 59.06 \quad W_3 = 48.28 \quad W_4 = 74.56 \quad W_5 = 62.48$$

$$W_6 = 50.84 \quad W_7 = 81.46 \quad W_8 = 75.56 \quad W_9 = 60.52$$

The assessment points are arranged in order from most to least, as shown in Table 5.

Table.3 Fuzzy evaluation method to examine the arrangement table

Score of assessment	81.46	75.56	74.56	71.56	62.48	60.52	59.06	50.84	48.28
category	CI	CII	BI	AI	BII	CIII	AII	BIII	AIII

Because the spare parts of CI are very important in production and the price is cheap, the supply should be guaranteed and the safety stock should be larger. Class A and III spare parts are expensive, but they are not important parts in production. For this kind of spare parts, the inventory should be limited to the lowest level. The data in the table above confirm this.

According to the data characteristics in Table 3, these nine types of spare parts can be divided into four categories, as shown in Table 4.

Table.4 Inventory classification table

Comprehensive category	Class I	Class II	Class III	Class IV
Subcategory	CI	CII,BI,AI	BII,CIII,AII	BIII,AIII

4.4. Realize dynamic inventory classification

According to the dynamic inventory classification formula, determine the minimum percentage change Δ_i.

According to the inventory classification listed in Table 4, it can be calculated according to formula (1) that the average inventory amount proportion of the four types of inventory is $\overline{P_i}$ (=1, 2, 3, 4).

$$\overline{P_1} = 6.28\% \qquad \overline{P_2} = 26.91\%/3 = 8.97\%$$

$$\overline{P_3} = 36\%/3 = 12\% \qquad \overline{P_4} = 30.81\%/2 = 15.405\%$$

Calculate the percentage change of inventory amount between average inventory amount proportion 1.

$$\Delta_{1-2} = \frac{8.97\%-6.28\%}{6.28\%} = 42.8\% \qquad \Delta_{2-3} = \frac{12.\%-8.97\%}{8.97\%} = 33.8\%$$

$$\Delta_{3-4} = \frac{15.405\%-12\%}{12\%} = 28.4\% \qquad \Delta_{4-1} = \frac{15.405\%-6.28\%}{6.28\%} = 145\%$$

minΔ=28.4%, because when the change of a certain material in this index exceeds 28.4%, the classification is no longer valid and should be reclassified.

Apply this formula to a computer information system and the system will alert the manager to consider whether to reclassify it. In this way, the dynamic maintenance of inventory classification is realized and the classification result is always reasonable.

This comprehensive inventory method is applied to the storage center and has achieved obvious results in the running stage.

In terms of management, different types of inventory are managed and controlled differently by different personnel, so that managers can concentrate on the inventory of the same quality and realize the management of classification mode. Instead of the previous inventory of whatever nature by a single custodian, for a single management.

In terms of inventory quality, the inventory classification takes into account the particularity of the storage of the inventory, so the quantity of aging and deterioration (such as rust, paint removal, etc.) of the inventory is reduced. The test results show that the deterioration rate of the inventory decreases from 8‰ to 2‰, and if only ABC classification is applied, the deterioration rate only drops to 7‰. Practice shows that the comprehensive classification method is the most suitable method for the enterprise.

Formulate service level and safety stock coefficient. Through repeated experiments and researches in practice, the service level and safety inventory coefficient of various categories are formulated, as shown in Table 5. It lays the foundation for inventory control.

Table.5 Spare parts safety stock coefficient table

Comprehensive category	Class I	Class II	Class III	Class IV
Subcategory	CI	CII、BI、AI	BII、CIII、AII	BIII、AIII
Level of service	0.998	0.98	0.80	0.70

Safety inventory factor	3	2.05	0.84	0.53

5. Conclusion

ABC classification method combined with fuzzy evaluation method was used to classify the incoming parts in the warehouse center. Based on the original information system, it is optimized and improved to form a data operating system with better performance and more powerful functions, which can be used by the warehouse center of automobile manufacturing enterprises. It improves the shortage of inventory management and inventory operation in the original system, and adds inventory classification and inventory control system to the inventory management system, which can do a good job in the rationality and security of inventory storage, strictly implement inventory control, and greatly reduce the inventory cost; Adding resource allocation and storage positioning system to the inbound/outbound system can eliminate the waste of personnel and tools in the inbound/outbound operation, reduce the time of locating and handling the goods in/out of the warehouse, enhance the scientific nature of goods arrangement and improve work efficiency.

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