Research on Optimization Strategy of Aftermarket Spare Parts Inventory Management for Company F

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Abstract. With the growth of the industrial scale of spare parts business in the post market and its promotion of the overall sales performance of automotive enterprises, the after-sale spare parts business has become a key business unit of automotive enterprises. Spare parts inventory management level is an important part of spare parts business. Improving inventory management level and enhancing the competitiveness of enterprise supply chain has become an important factor affecting the high-quality development of enterprises. This paper analyzes the current situation and pain points of after-sale spare parts inventory management of F company, and puts forward optimization suggestions in terms of spare parts classification rules and differentiated inventory strategies, so as to help F company improve the level of after-sale spare parts inventory management and enhance the competitiveness of the enterprise.

Keywords: After-sale spare parts; Inventory management; Spare parts classification; Differentiation strategy

1 Introduction

With the maturation of China's automotive market, profit centers are gradually shifting toward aftermarket services, accompanied by continuous expansion of the post-sales market scale[1]. The current Chinese automotive aftermarket represents a trillion-RMB industry, where maintenance services account for over 70% of market share and will continue to dominate[2]. In the commercial vehicle aftermarket sector, 2021 witnessed 143 million repair instances, totaling 350 million service hours [3]. For enterprises, the aftermarket spare parts supply chain has increasingly become a core driver of customer service and profit growth, emerging as a critical competitive differentiator. However, rapid market growth has exposed operational deficiencies and systemic challenges. To achieve high-quality development, enterprises must confront these issues and proactively devise solutions. Key competitiveness in supply chain management now hinges on optimizing three dimensions: operational efficiency, demand fulfillment rates, and inventory structure refinement.

Recent advancements in spare parts inventory management have established critical theoretical foundations for this study. Bacchetti et al. proposed a multi-dimensional

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classification framework integrating demand frequency and monetary value, which aligns with the ABC-XYZ classification methodology adopted in this research[4]. Cohen et al. empirically demonstrated that differentiated inventory strategies could reduce operational costs by up to 22% in automotive supply chains, validating the necessity of tailored policies for heterogeneous spare parts[5].In the context of China's automotive aftermarket, Liu and Zhang identified systemic inefficiencies in traditional inventory systems when managing over 100,000 SKUs, emphasizing the urgency for data-driven optimization[6]. Furthermore, Gupta et al. highlighted the effectiveness of hybrid (T,S) and (B,S) models in balancing service levels and capital occupation, directly supporting our dual-model approach for high-value/low-frequency parts[7]. Similarly, Sany Heavy Industry achieved a 40% improvement in inventory turnover for high-value spare parts by implementing a (B,S) model (analogous to this study's AX/BX category strategy), demonstrating the universal applicability of differentiated strategies in the construction machinery industry.

2 Company F Profile and Operational Challenges

2.1 Corporate Overview

Company F is one of China’s most comprehensive and largest commercial vehicle enterprises. Its commercial vehicle business encompasses two main sectors: complete vehicle manufacturing and services and intelligent connected vehicle applications. The vehicle manufacturing division covers five major business units, including trucks, buses, and commercial vehicles, and operates 15 distinct product brands.

2.2 Current Operations and Management Model

Company F employs a three-tier inventory management system for aftermarket spare parts, consisting of Central Distribution Centers (CDC), Regional Distribution Centers (RDC), and service stations, ensuring comprehensive supply chain coverage. The system includes 3 CDC warehouses and 25 RDC warehouses, with the latter primarily located in provincial capital cities. The spare parts portfolio encompasses over 200,000 part types in its master database, with more than 70,000 actively stocked SKUs and approximately 45,000 SKUs transacted annually. CDC warehouses conduct procurement twice monthly, with an average lead time of 30 days.

For spare parts categorization, the company currently utilizes a dual-dimension methodology based on historical 12-month data: unit price and outbound frequency. The classification rules are detailed in table 1:

Table 1. Original Spare Parts Classification Rules

Spare parts classification rules	Outbound Frequency (Past 12 Months)				
	A: [120, ∞)	B: [36, 120)	C: [12, 36)	D: [1, 12)	E: 0

price	1:[200, ∞)	A1	B1	C1	D1	E1
	2:[50, 200)	A2	B2	C2	D2	E2
	3:[0, 50)	A3	B3	C3	D3	E3

In terms of the calculation logic of spare parts planning, a class (T,S) inventory management model is adopted. The model rules are to regularly check the inventory, place orders, and directly reduce the inventory to the maximum inventory value S. When the CDC warehouse arrives at the purchasing date, calculate the required purchasing quantity and issue the purchase order to the supplier.

The specific calculation rule is as follows: Purchase volume = Maximum inventory S- In-stock inventory - In-transit inventory, where maximum inventory S= Preparation time* Demand forecast value. Company F sets the maximum inventory S as the monthly demand forecast value for three months.

2.3 Operational Challenges

Despite implementing a two-dimensional classification system for spare parts, Company F's methodology remains inadequate, resulting in ambiguous categorization outcomes, ineffective inventory strategy application, and suboptimal management efficiency.

For instance, consider three representative parts—Case Alpha (CA), Case Beta (CB), and Case Gamma (CG). While CA and CB demonstrate equivalent sales significance, they are classified into distinct categories (B2 and B3, respectively). Conversely, CA and CG exhibit a tenfold disparity in sales revenue yet are grouped under the same B2 classification. Additionally, the 12-month classification cycle fails to promptly capture demand fluctuations, causing delayed inventory policy adjustments. Overreliance on frequency-based categorization further undermines the system's ability to filter abnormal order quantities effectively. The classification rules are shown in table 2.

Table 2. Examples of spare parts classification for original rules

Spare parts	Outbound frequency	Outbound quantity	Unit price	Monthly sales	Existing classification methods	Degree of importance
CA	100times/month	10 pieces /time	100rmb	100,000rmb	B2	●
CB	100times/month	100 pieces /time	10rmb	100,000rmb	B3	●
CG	100times/month	1 pieces /time	100rmb	10,000rmb	B2	△

Despite implementing spare parts categorization, Company F has failed to leverage this classification effectively in its inventory management. The company persists in applying a uniform inventory strategy across all part categories, where maximum stock levels are uniformly set at three months of forecasted demand. This one-size-fits-all approach proves inadequate for addressing the heterogeneous requirements of parts with distinct operational characteristics.

This uniform approach has resulted in the following operational inefficiencies: Low delivery fulfillment rates due to irrational inventory allocations that fail to meet downstream demand; excessively high inventory levels across the supply chain, exacerbating capital immobilization and cash flow constraints while paradoxically coexisting with low fulfillment rates; elevated operational costs driven by frequent inter-warehouse transfers and stockouts caused by suboptimal inventory structuring; and increased management complexity, where administrators struggle to prioritize critical SKUs amid convoluted processes.

A detailed analysis of the inventory structure was conducted. Compared with the normal inventory structure diagram, the inventory structure of Company F presented an abnormal inventory structure. The proportion of slow-moving and slow-flowing spare parts was too high, the proportion of out-of-stock spare parts was relatively high, and the proportion of normal spare parts was too low.

3 Optimization Recommendations for Inventory Management Strategies

3.1 Proposed Optimization Directions

In response to Company F's operational context and the demand for improving spare parts inventory management, we propose optimization measures in two key areas: enhanced parts classification methodology and differentiated inventory management strategies.

3.2 Enhanced Parts Classification Methodology

The optimization rule for spare parts classification is to conduct spare parts classification calculation using the demand amount and frequency as a two-dimensional matrix. Specifically, it involves weighting the historical demand frequency over the past six months and decomposing the historical demand amount according to the ABC classification method to form an inventory strategy matrix as the benchmark.

➢ Monetary Value Configuration Rules:

(1) Monetary value = Demand quantity × Unit price

(2) Calculate the monetary value of demanded parts over the past six months, sorted in descending order

(3) Determine cumulative value ratios and classify parts into:

Class A: Top 75% of total monetary value

Class B: Next 20%

Class C: Remaining 5%

➢ Demand Frequency Configuration Rules:

1. Define monthly demand occurrences over six months n_1,...,n_6

$$n_i = \begin{cases} 1 & if\ demand\ >\ 0\ in\ month\ \mathrm{i} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

2. Weighting coefficient

$$x = 6n_1 + 5n_2 + 4n_3 + 3n_4 + 2n_5 + n_6 \quad (2)$$

3. Weighting coefficient

$$y = \mathrm{MAX}(1,7 - \mathrm{ROUNDDOWN}(((x-1))/3,0)) \quad (3)$$

The larger the x, the higher the frequency. The weighted frequency threshold can be set according to the specific business situation. The setting rules of the research case in this paper are shown in the table 3:

Table 3. Weighted frequency classification rule

Weighting coefficient(x)	Frequency(y)	Weighted frequency classification
19≤x	1	X
16≤x＜19	2	
13≤x＜16	3	Y
10≤x＜13	4	
7≤x＜10	5	Z
4≤x＜7	6	
x＜4	7	

Under the optimized classification rules, the previously described categorization of parts CA, CB and CG has been revised, as shown in table 4. By aligning part types with sales importance and demand frequency, algorithm coefficients are configured according to demand characteristics, enabling precise targeting of inventory strategies for specific parts. This approach achieves efficient resource utilization while incorporating monthly rolling updates based on the latest demand data, allowing rapid response to market fluctuations and dynamic inventory strategy optimization.

Table 4. Examples of spare parts classification for optimization rules

Spare parts	Outbound frequency	Outbound quantity	Unit price	Monthly sales	Optimizing classification methods	Degree of importance
CA	100times/month	10 pieces /time	100rmb	100,000rmb	AX	●
CB	100times/month	100 pieces /time	10rmb	100,000rmb	AX	●
CG	100times/month	1 pieces /time	100rmb	10,000rmb	CX	△

3.3 Optimization of Differentiated Inventory Management Strategies

The automotive aftermarket spare parts domain involves extensive part varieties with heterogeneous demand patterns and operational significance. A uniform management approach for all parts fails to address these diverse characteristics or meet enterprise operational objectives. Consequently, based on the classification results, we propose adopting differentiated inventory strategies tailored to distinct part categories to optimize management practices.

Leveraging Company F's operational data, all spare parts are classified using the aforementioned methodology, supplemented with price-tier characteristics. Without altering existing business constraints—including warehouse procurement calendars and supplier lead times—we formulate differentiated inventory rules across four dimensions: safety stock service levels, stocking days, storage policies, and inventory models.

This case study introduces the (B,S) inventory model, adapted from the apparel industry's "sell-one-replenish-one" framework [6], which effectively controls capital allocation for high-value, low-frequency parts while ensuring demand fulfillment. Concurrently, we refine the (T,S) inventory model with updated calculation rules, as detailed in the following formulas:

$$S = SS + \mu_D(\mu_{VLT} + NRT) + \mu_D * BP \tag{4}$$

$$SS = Z_k\sqrt{(\mu_{VLT} + NRT)\sigma_D{}^2 + \mu_D{}^2\sigma_{VLT+NRT}{}^2} \tag{5}$$

S denotes the maximum inventory level, SS represents the safety stock, μ_D is the average demand during the time period D (using forecasted values when actual demand is unavailable), μ_{VLT} signifies the average lead time, NRT refers to the procurement cycle, BP indicates the buffer period, Z_k corresponds to the standard normal distribution value for the target service level Z, $\sigma_D{}^2$ represents the historical demand variance, and $\sigma_{VLT+NRT}{}^2$ denotes the variance in procurement lead times. Detailed rules are shown in table 5.

Table 5. Details of Differentiated Inventory Strategy Rules

SPP	Price matrix	Stocking Decision	Inventory Model	Service Level	Stocking Days
AX	Ultra-Premium	Y	BS	-	-
AX	Economy	Y	TS	90%	20
AX	Premium	Y	TS	70%	0
AX	Upper-Mid	Y	TS	80%	0
AX	Mid-Range	Y	TS	90%	7
AY	Ultra-Premium	Y	BS	-	-
AY	Economy/Mid-Range/Upper-Mid	Y	TS	90%	0
AY	Premium	Y	TS	70%	0
AZ	Premium/Ultra-Premium	Y	BS	-	-
AZ	Economy/Mid-Range/Upper-Mid	Y	TS	70%	0
BX	Ultra-Premium	Y	BS	-	-
BX	Economy	Y	TS	90%	20

BX	Premium	Y	TS	70%	0
BX	Upper-Mid	Y	TS	80%	0
BX	Mid-Range	Y	TS	90%	7
BY	Ultra-Premium	Y	BS	-	-
BY	Economy/Mid-Range/Upper-Mid	Y	TS	90%	0
BY	Premium	Y	TS	70%	0
BZ	Premium/Ultra-Premium	Y	BS	-	-
BZ	Economy/Mid-Range/Upper-Mid	Y	TS	70%	0
CX	-	Y	TS	90%	30
CY	-	Y	TS	90%	30
CZ	Premium/Ultra-Premium	N	-	-	-
CZ	Economy/Mid-Range/Upper-Mid	Y	TS	70%	0

4 Optimization Recommendations for Inventory Management Strategies

4.1 Effectiveness of Enhanced Parts Classification Method

Classification calculations were performed on spare parts of Company F using both the original and optimized classification rules.The results are shown in table 6 and table 7.

Under the original classification rules, historical 12-month demand data for 109,340 parts with master data was analyzed, resulting in 15 categories. The E2 and E3 categories contained the highest number of parts, while A1 and B1 had the fewest. The excessive number of categories and fragmented distribution made it difficult to distinguish part characteristics or focus on critical components.

Table 6. Results of spare parts classification for original rules

Classification of spare parts		Classification of outbound frequency				
		A	B	C	D	E
price category	1	1377	1832	2959	11571	9443
	2	2600	3019	4533	14062	15101
	3	4119	4273	5550	13797	15104

Using the optimized classification rules, historical 6-month demand data for the same 109,340 parts was analyzed, reducing categories to 9. The results show:

- CZ-class parts accounted for 82,158 SKUs (75%), characterized by low demand frequency, minimal sales contribution, and low business importance. Inventory levels for these parts can be appropriately reduced.
- CX and CY-class parts totaled 15,095 SKUs (14%), exhibiting moderate demand frequency but low sales contribution due to their low unit prices.

Increasing stock for these parts can improve fulfillment rates without significantly raising inventory costs.

- The remaining 11% of parts contributed meaningfully to sales, with clearer classifications and fewer SKUs, enabling precise differentiated management strategies.

Table 7. Results of spare parts classification for optimization rules

Classification of spare parts		Classification of demand amount		
		A	B	C
Classification of demand frequency	X	1878	5743	7294
	Y	172	1481	7801
	Z	450	2003	82518

4.2 Effectiveness of Differentiated Inventory Strategy

Based on the optimized parts classification results and price-tier characteristics, we developed differentiated inventory management strategies and conducted simulation tests to evaluate their expected operational effectiveness. During the simulation, demand forecasting followed Company F's existing methodology, while inventory planning utilized both (T,S) and (B,S) models. Using demand forecasts, inventory models, and management strategies, we calculated CDC warehouse stock plans at the SKU level and projected demand fulfillment for the next procurement cycle. For comparison, parallel calculations were performed using the original inventory management logic over the same time frame. The simulation results are summarized as follows: Under the original logic, the inventory totaled 1,362,962 units with a value of RMB 159,562,476 and an 84.8% fulfillment rate. With optimized classification rules and differentiated strategies, inventory units increased to 1,611,284 (+18%), while inventory value decreased significantly to RMB 130,642,746 (-18%). Concurrently, the fulfillment rate improved to 89.5%, representing a 4.7%point enhancement. Detailed results are shown in table 8.

Table 8. the comparison and calculation results

	The original simulation calculation result	The optimized simulation calculation result	Variation range
Inventory quantity	1362962	1611284	+18%
Inventory amount	159562476	130642746	-18%
Fill rate	84.8%	89.5%	+4.7%

Drilling down to analyze specific fulfillment rates at the matrix dimension, AX-class parts achieved a 99% demand fulfillment rate, BX-class parts reached 97%, and CX-class parts attained 98%. For AZ, BZ, and CZ-class parts with lower fulfillment rates, inventory levels were strategically reduced due to their low demand frequency, achieving a balance between demand fulfillment and inventory cost optimization.

Table 9. The calculation of the satisfaction of spare parts demand in different categories after optimization.

Table 9. The calculation of the satisfaction of spare parts demand in different categories after optimization

Classification of spare parts	Demand for the time period	Demand satisfaction volume	Fill rate
AX	148940	147519	99%
AY	640	437	68%
AZ	6841	270	4%
BX	98565	95868	97%
BY	5239	3684	70%
BZ	7886	989	13%
CX	56867	55473	98%
CY	15788	12352	78%
CZ	17272	3704	21%

The strategy's effectiveness depends on the completeness and accuracy of the company's historical data. For the spare parts classification and differentiated inventory strategy optimization logic formulated by Company F, it can effectively reduce the inventory amount while improving the downstream demand satisfaction rate, achieving precise inventory preparation, enhancing management accuracy and inventory management level. The simulation validation of the optimization strategy was completed through historical data backtesting, with key parameters (such as demand volatility and lead time) repeatedly calibrated using sensitivity analysis.

5 Conclusion

This paper conducts research on optimizing inventory management models through analyzing Company F's aftermarket spare parts inventory management practices and operational pain points. The study proposes optimizations in two aspects: spare parts classification rules and differentiated inventory strategies, with simulated evaluations of the optimization effects. The customized spare parts classification framework and differentiated inventory strategy logic developed for Company F effectively achieve inventory cost reduction while improving downstream demand fulfillment rates. This optimization restructures inventory composition, enables precision replenishment, enhances management accuracy and inventory control capabilities, ultimately elevating the enterprise's supply chain competitiveness.

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