Research on Solutions for Small and Medium-sized E-Commerce Enterprises to Distribute Goods from Centralized Warehousing to Satellite Warehouses

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Abstract: In recent years, the e-commerce industry has developed rapidly, and consumers are demanding faster delivery of goods. The traditional centralized warehousing model employed by enterprises can no longer meet the dual needs of small and medium-sized e-commerce enterprises for both delivery efficiency and cost control. This paper takes a small and medium-sized e-commerce enterprise as the research subject, exploring a solution to shift from centralized warehouses to decentralized distribution, including key issues such as warehouse location selection, inventory management, and order fulfillment from the most suitable warehouse.

Keywords: Decentralized Warehousing; Supply Chain Costs; Cost-effectiveness; Inventory; SKU

1. Introduction

Today, online consumption has deeply permeated every aspect of people's daily lives and has gradually become the primary mode of shopping. The focus of online consumption has shifted from simply being able to purchase items to prioritizing efficiency and shopping experience. Among these, delivery speed has become increasingly important, influencing consumers' purchasing decisions, brand loyalty, and a platform's market position. For businesses and suppliers, the speed of delivery and the cost of shipping are critical factors that require careful consideration. As a result, multi-warehouse shipping has been widely adopted by large suppliers and e-commerce platforms [1], as traditional centralized warehousing presents numerous issues in inventory and delivery. This concentrated warehousing model often leads to excessively long cross-regional transportation routes, unstable delivery speeds, and persistently high trunk line logistics costs, making it difficult for enterprises to balance customer demands for fast delivery with cost control.

Large enterprises have achieved certain results in warehouse layout, but many small and medium-sized suppliers, especially those in the upstream of the supply chain, have not adopted a decentralized warehousing approach. This is because small and medium-sized suppliers still lack systematic cost-benefit analysis and optimization solutions for how to optimize warehouse configuration and goods distribution [2]. If warehouses are hastily constructed without thorough system research, it may lead to a rapid increase in fixed costs. Poor inventory planning could result in stockouts in certain areas or overstocking, as well as rising operational costs and increased challenges in warehouse management. The current lack of research in this area makes it difficult for them to make effective operational decisions.

2. Basic Information of the Research Case

Through specific corporate case studies, this paper explores the core issues that need to be addressed in the enterprise's warehouse distribution strategy, as well as how these problems are resolved. This approach enables more concrete and effectively implementable solutions.

2.1 Company Profile

Heilongjiang XX Specialty Co., Ltd., the subject of this analysis, is a medium-sized food production and sales enterprise located in Northeast China. The company primarily produces specialty products such as black fungus, hazelnut mushrooms, pine nuts, sweet corn, and Northeast rice, with sales mainly conducted through major domestic e-commerce platforms. Its production factory and central warehouse are situated in Suihua City, Heilongjiang Province, covering a total area of 2,500 square meters, with a monthly rental cost of approximately 10 yuan per square meter. Currently, the company's products enjoy extensive sales across the national market, primarily concentrated in North, East, Central, and South China, accounting for about 80% of total sales. Local sales in Northeast China make up around 10%, while other regions contribute the remaining 10% of sales.

The company currently processes approximately 650 orders daily, with an annual operating period of 350 days. Based on this, the total annual order volume amounts to 227,500 orders. At present, the sold products are categorized into 10 types. The existing warehouse arrangement involves establishing a central warehouse in Suihua, where all goods are stored collectively. This model results in long distribution distances and extended delivery times in major consumer regions, leading to persistently high logistics costs while also increasing the likelihood of stockouts.

To address these issues, this study developed new storage strategies for enterprises through cost analysis and systematic evaluation [3].

2.2 Detailed Data of Various Products of the Enterprise

Based on historical transaction data, we calculated the average daily order volume for various product categories and classified the products into ABC tiers according to their order share [4].

Table 1. Enterprise Product Data Table

SKU Number	Unit Price (yuan/piece)	Single piece Weight (kg/piece)	Daily average order quantity	Annual order quantity	order proportion	ABC classification
SKU1	30	3	50	17500	7.69%	B
SKU2	20	2	100	35,000	15.38%	A
SKU3	35	1.4	50	17500	7.69%	B
SKU4	60	0.5	50	17500	7.69%	B
SKU5	115	0.8	40	14,000	6.15%	C
SKU6	55	0.9	25	8750	3.85%	C
SKU7	72	3.5	35	12250	5.38%	C
SKU8	20	2	100	35,000	15.38%	A
SKU9	18	2.5	100	35,000	15.38%	A
SKU10	20	2.6	100	35,000	15.38%	A
Total	-	-	650	227500	100%	

Among them, Class A products include SKU2, 8, 9, and 10, all of which account for over 10% of orders, making up 61.52% of the total; B-class products include SKUs 1, 3, and 4, with order proportions ranging from 5% to 10%. In total, B-class products account for 23.07%; The C-class products are SKU5, 6, and 7, with an order proportion of less than 5%, totaling 15.38% for C-class products.

3. Warehouse Distribution Solution

The distribution of customers in this enterprise shows significant regional differences, with 80% of orders concentrated in the four economically active regions of North China, East China, Central China, and South China. The existing warehousing nodes are only located in Suihua, Heilongjiang, and orders in the core consumption areas need to be transported across provinces. Long distance delivery not only leads to low logistics operation efficiency and high express logistics costs, but also significantly reduces customer consumption experience. Therefore, building a distributed warehousing network has become an inevitable choice to solve the current warehousing operation problems of enterprises.

The core of warehouse distribution is not simply adding storage nodes, but systematically solving the four core problems of warehouse location selection, inventory configuration, order allocation, and supply chain total cost optimization. The following will adopt targeted methods to solve each of the above problems one by one.

3.1 Using the Center of Gravity Method to Solve the Problem of "Where to Choose Warehouse Location"

The basic logic of the center of gravity method:

To achieve the goal of minimizing logistics transportation costs, the distribution of enterprise customers is transformed into a geographic coordinate system, and the geometric center of gravity of all demand points is calculated through mathematical methods. The selection of warehouse nodes prioritizes the center of gravity area and surrounding logistics hub cities [5]. The core evaluation indicator for warehouse site selection is the proportion of orders in each region. The selection decision needs to be based on quantitative data calculation as the core method, and potential warehouse sites should be screened through quantitative analysis. At the same time, qualitative analysis should be combined to form the final site selection plan, in order to reduce the decision-making bias caused by subjective judgment.

calculation steps:

(1) Data preparation: Sort out the core customer areas of the enterprise. To simplify the research without affecting the validity of the conclusions, select the city with the highest order volume in each region as the regional representative, and use its geographical coordinates and order weights to represent regional demand. Based on the historical order data of enterprises in 2024, the representative cities and order weights of each core region are as follows: North China: Beijing, weight 0.6; East China: Shanghai, weight 0.15; Central China: Wuhan, weight 0.18; South China: Guangzhou, weight 0.07.

(2) Calculate the center of gravity coordinates: using the weighted average method, the formula is:

Center of gravity X coordinate=∑ (customer X coordinate x order weight),

Center of gravity Y coordinate=∑ (customer Y coordinate x order weight);

After calculation, the weighted center of gravity is located within the territory of Cangzhou City, Hebei Province, adjacent to the main urban area of Cangzhou, and belongs to the Beijing Tianjin Hebei region. Considering that the proportion of orders in the North China region accounts for 60% and needs to take into account the spatial distance from the Suihua centralized warehouse, as well as the logistics resource endowment of the warehouse location, including the availability of warehouse resources, reasonable rent, and logistics network maturity, shifting the weighted center of gravity northward by more than 100 kilometers, it is more reasonable to select Langfang City, Hebei Province as the location for the sub warehouse.

3.2 Optimize Order Quantity and Safety Stock Settings

The construction of the dual warehouse storage model has brought new operational challenges, among which inventory allocation is the core difficulty. Goods in separate warehouses need to be replenished uniformly by centralized warehouses. To minimize replenishment costs, the optimal replenishment quantity can be calculated through the Economic Order Quantity (EOQ) model; To cope with sudden market demand and supply chain supply delay risks, reasonable safety stock should be set up at each warehousing node [6].

The core objective of the economic order quantity model is to determine the optimal replenishment quantity, and to achieve overall cost reduction in the supply chain by balancing procurement costs (including mainline transportation costs) and warehousing holding costs (including site rental and goods loss costs); The calculation of safety stock is used to determine the minimum inventory level at each storage node, ensuring the continuity and stability of commodity supply. The case study of this article is the characteristic agricultural products of Northeast China. Although these products have the characteristic of easy storage, they still need to ensure sufficient spot supply. Therefore, the application of the economic order quantity model and the safety stock calculation method has a strong fit.

The specific parameters for this calculation are as follows:

D: Annual demand

K: The costs incurred for each purchase, including transportation arrangements, manual operations, and document processing, are generally fixed expenses.

H: The annual inventory storage fee is generally calculated at 15% of the commodity price in the industry, which includes warehouse rent, capital occupation, and natural loss of goods. The formula is H=unit price x 15%.

L: The average lead time for ordering, including long-distance transportation from Suihua to Langfang and the time required for warehouse inspection, generally takes 3 days.

Z: The Z value corresponding to the service level, such as a service target of 95%, corresponds to a safety factor Z of 1.65.

σ d: Daily demand variation, estimated based on 10% of the average daily sales volume.

Refer to Table 1 for other data.

The economic order quantity model is calculated using the following mathematical formula:

$$\mathrm{EOQ}=\sqrt{\frac{2KD}{H}} \quad (1)$$

The safety stock is represented by the following mathematical formula:

$$\mathrm{SS}=Z\times\sigma d\times\sqrt{L} \quad (2)$$

In practical operations, enterprises need to combine the results of EOQ model calculations with scientific safety stock strategies to develop inventory management plans that are in line with their own development, in order to effectively control inventory costs and enhance the market responsiveness and operational stability of the supply chain.

3.3 Suihua Centralized Warehouse+Langfang sub Warehouse Graded Stocking plan

As the core logistics hub of the enterprise, Suihua centralized warehouse mainly undertakes the functions of overall cargo reserve and batch replenishment. The core operational task is to maintain the main inventory level of all categories of goods, and its stocking quantity needs to meet both the replenishment needs of Langfang sub warehouses and its own safety stock requirements. The replenishment mode adopts a large quantity and low frequency approach, and the optimal replenishment quantity is calculated based on the EOQ model. As a fast delivery node for the core markets of Beijing Tianjin Hebei and its surrounding areas, Langfang Branch Warehouse mainly undertakes the function of immediate order fulfillment, focusing on storing and quickly distributing goods with high turnover rates. The core operational task is the local storage and rapid distribution of goods, and the inventory quantity is determined based on the daily sales volume and safety inventory calculation results. In operation, it adopts a small quantity and multiple replenishment mode to reduce the risk of inventory backlog.

Based on this, the graded stocking control strategy is formulated as follows [7]:

Langfang branch warehouse ensures sufficient regular inventory for A-class products SKU2, 8, 9, and 10, conducts centralized procurement based on the economic order quantity model, and implements weekly replenishment strategies; The Suihua centralized warehouse synchronously reserves the above-mentioned Class A products, providing replenishment support for the Langfang sub warehouse and ensuring efficient distribution in the Beijing Tianjin Hebei region.

For B-class products SKU1, 3, and 4, Langfang sub warehouses maintain regular inventory based on market demand forecasts and implement a ten day replenishment strategy; The Suihua centralized warehouse dynamically prepares goods based on actual market demand, responds to replenishment requests from Langfang branch warehouses, and achieves a dynamic balance between inventory control and supply guarantee.

For C-class products SKU 5, 6, and 7, Langfang branch warehouse only retains basic emergency inventory to optimize the efficiency of fund utilization and implement monthly replenishment strategy; As the core inventory node, Suihua centralized warehouse undertakes the main storage function of such goods. If there is a sudden shortage of goods in the Langfang branch warehouse, relying on an efficient mainline logistics system, materials can be allocated within 72 hours.

3.4 Using Greedy Algorithm to Solve the Problem of "Which Warehouse Should Orders Be Shipped From"

Greedy method, also known as greedy strategy, is a way of algorithm design. Its approach is to select the currently best looking option at each step. This method does not pursue finding the overall optimal solution, nor does it consider the arrangement of the entire process in advance, only focusing on the current easiest and most advantageous path. By continuously making such local choices, an acceptable overall result is ultimately formed [8].

The different commodity reserve schemes adopted by the Suihua main warehouse and Langfang sub warehouse essentially apply the core idea of greedy algorithm, which is to obtain the maximum local profit as much as possible at each step [9]. The specific methods include:

The first measure: focus on A-class core products. This type of order accounts for over 60% of the overall volume and is currently the main source of revenue and delivery. So, it is necessary to ensure sufficient inventory of Class A products and prioritize warehouse locations. This can maintain a stable supply of major orders, which is currently the most important task.

In the current situation, for the allocation of

Class B conventional materials, the supply method should be based on actual demand to reduce material backlog. This approach ensures the stability of supply and controls warehouse costs, thus finding a more reasonable solution.

The handling method for Class C niche products can adopt simplified inventory management. This approach can reduce capital occupation, lower backlog risks, and ultimately achieve the goal of cost savings and efficiency improvement.

On the basis of the dual warehouse structure of the main warehouse in Suihua, Heilongjiang and the sub warehouse in Langfang, Hebei, a system for evaluating the delivery of individual orders has been established. This system draws on the idea of "local optimum equals global optimum" in greedy algorithms, without considering the unified allocation of the entire inventory and cross warehouse scheduling arrangements, but focusing on real-time processing of each order. Select the most suitable shipping point each time, taking into account delivery speed, transportation costs, and inventory availability. When making decisions, first ensure inventory availability, then consider delivery speed, and finally look at cost levels.

After receiving the order, the first step is to check the inventory status of the SKU in both warehouses. Exclude warehouses with insufficient or zero inventory, and only retain warehouses with sufficient stock available for shipment. Step 2: Select the warehouse with the fastest response (locally optimal) based on the delivery location. This algorithm only considers the delivery speed of the current order, without taking into account future orders and the overall inventory situation, completely following the principle of "selecting the closest one". When the warehouse turnover speed is similar, sites with lower delivery costs will be chosen for delivery. If the delivery time difference between two warehouses is small, priority should be given to the solution with lower logistics costs. Once the warehouse location is confirmed, the shipping process begins immediately and cannot be changed or revoked [10]. This step follows the basic idea of the greedy algorithm of "advancing without retreating, executing immediately".

4. Achievements of Warehouse Distribution

After research, it has been found that the use of separate warehouse distribution in this case has brought benefits from both financial and non-financial dimensions.

(1) Reduce the total cost of the supply chain. The supply cost mainly includes transportation costs, warehousing costs, inventory holding costs, and shortage costs [11]. By dividing warehouses, transportation and stockout costs are reduced, while warehousing and inventory holding costs are increased. However, overall, supply chain costs are reduced by 13.46% compared to centralized warehousing models.

(2) Additional non-financial benefits include:

Delivery efficiency improvement: The delivery time for the main service areas (accounting for 80% of the business volume) has been reduced from 3-4 days to 2-3 days, while other areas still maintain a delivery speed of 3-4 days, resulting in a significant increase in customer satisfaction.

Product supply optimization: The situation of insufficient inventory has been reduced from 6% to 2%. This not only reduces customer dissatisfaction, but also avoids customers from repurchasing. In the long run, it helps to enhance the brand's reputation.

The dual warehouse model enhances the stability of the supply chain. By setting up two warehouses, it is possible to avoid the entire system from crashing due to extreme weather or transportation disruptions. This approach makes overall operations more reliable.

5. Avoiding Misconceptions

In the case of a small number of orders (less than 200000 per year), if the warehouse is too widely distributed, it may affect profitability and even normal operations due to high costs. The main warehouse is the key to the entire system and must store all types of goods, while the auxiliary warehouse can only serve as a supplement to alleviate the pressure on the main warehouse and avoid stockouts due to insufficient inventory. So whether to split warehouses needs to consider multiple factors, the most important of which are the total annual order volume and customer distribution.

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