

Sustainable Supply Chain Distribution Model of Fashion Market Based on Improved Ant Colony Algorithm

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Abstract—The fashion clothing brand marketing cycle is notably brief, and its supply chain system is comprehensive, significantly reducing the time from clothing design to production. This agility enables swift responses to consumer demands, aligning with the fast-paced consumer market. This paper delves into the intricacies of marketing and supply chain management within the fashion clothing brand sector. It introduces an optimized management model for fashion marketing supply chains, built upon the foundation of Particle Swarm Optimization (PSO). Simulation results demonstrate distinct characteristics among different decision methods. Decision method 1 exhibits notably higher inventory levels, which largely contribute to its increased cost when compared to decision methods 2 and 3. Decision method 2 presents relatively stable inventory levels for IMI (Item-Managed Inventory) and IPI (Item-Produced Inventory), with average inventory levels of 4.56 and 4.86, respectively. In contrast, decision method 3 achieves even lower inventory levels for IMI and IPI, with averages of 1.52 and 1.42, respectively. This slight increase in IMI and IPI inventory under decision method 2 underscores the effectiveness of decision method 3 in maintaining lower inventory levels. The model proposed in this paper embodies sound supply chain management principles and exhibits practicality and operability. To realize swift fund withdrawal, mature enterprises must efficiently manage logistics, information flow, and capital flow within this model.

Keywords—*Improved ant colony algorithm; Fashion marketing; Supply chain optimization; Management model*

I. INTRODUCTION

In the process of China's sustained economic and social development, various industries have maintained good development potential, and various types of market players have been increasing, which has enhanced the vitality of China's market economy development and promoted the realization of China's modernization development goals [1]. China is the country with the largest population in the world, with high consumption demand in various fields, especially with the sustained development of China's economy, it has become the world's largest clothing consumer and producer. In recent years, China has attached great importance to the development of clothing industry, and a large number of enterprises have begun to participate in the development of the whole industry. The strong rise of China's clothing

industry, the prosperity of China's clothing brands and the expansion of clothing scale have great practical significance and far-reaching strategic significance for the adjustment of China's industrial structure and the improvement of people's quality of life [2]. In the process of traditional clothing marketing, the marketing cycle is very long, and the investment in marketing activities is also relatively large, which leads to its inability to adapt to market changes. The marketing cycle of fashion clothing brand is short, and its supply chain system is complete, which can greatly shorten the time from clothing design to clothing production, respond to the needs of consumers quickly, and fit in with the current fast-paced consumer market [3]. In the process of supply chain optimization, we must adhere to the guidance of consumer demand and control the cost to drive the development of the whole supply chain, so the prediction of customer demand becomes the key to solve the management optimization problem [4]. In the existing research, the uncertainty of supply and demand is generally realized by random, forecasting and fuzzy methods. The actual work content of supply chain management is complicated and difficult. If the traditional management method is still used, the overall work efficiency will decrease, which will seriously hinder the development of fast fashion clothing brands. In view of this, fashion clothing brands need to make full use of information technology in the process of supply chain management, give full play to its role, and make all-round innovation in management mode based on information technology. In this regard, this paper optimizes the fashion clothing brand marketing supply chain based on PSO, simulates the strategy of ant colony path optimization, and works out a unified material demand, production and distribution plan through the balance between local cost and global cost, so as to unify and coordinate the control of all business divisions [5]. In order to maximize the benefits of supply chain management system and improve the management level of supply chain system, on the premise of customer demand-driven, PSO and short-term and long-term memory network models are used to predict customer demand, and the supply quantity of suppliers and the distribution volume of processing plants are taken as decision variables, and a supply chain optimization management model is established in order to provide some help for practical activities [6].

II. THE DISTRIBUTION MODEL OF FASHION MARKETING

A. *Virtual business model*

In the production and operation of enterprises, reducing operating costs is a key consideration. The outsourcing association in the United States once proposed that a main way to reduce operating costs is to virtualize non core business operations. This approach can effectively improve the company's grasp of sales processes, in order to obtain more prominent economic benefits. In terms of promotion, it can be noted that Fast fashion clothing brands rarely advertise, usually spending advertising on brand image building. Specifically, the stores of these Fast fashion clothing brands will choose prosperous business districts, and also keep a relatively close distance with some international well-known luxury brands to optimize their brand image in the eyes of consumers [7-8]. The distribution center stores most of the inventory in the supply chain, while each seller only stores a small amount of inventory. When needed, sellers can quickly replenish their scarce inventory from the distribution center. This inventory management concept reduces the inventory pressure on various sellers and effectively reduces the bullwhip effect.

With the rapid development of the clothing market, Fast fashion clothing brands can fully integrate the marketing needs of online retail and offline retail by means of omni channel retail. If the sales of a certain piece of clothing online are very prominent, the display position of the same offline goods can be adjusted to make the goods more obvious to consumers [9]. Due to the variability of fashion itself, brands will minimize market reaction time and strive to integrate the current popular elements into clothing as quickly as possible. In the industrial chain, there is a clear division of labor, so each link, such as logistics and transportation, brand promotion, and information management, is more professional. This has outstanding significance for the strict implementation of quality monitoring, and this approach also has a certain role in innovation of management models.

B. *SPA business model*

In the choice of distribution mode, many "fast fashion" clothing brands have chosen the SPA business model, and the most typical one is Uniqlo. At present, many fast fashion clothing enterprises have established a rapid response mechanism, but in the actual operation process, due to the excessive concentration of demand, it often leads to problems in the connection between enterprises in the supply chain. Many garment enterprises often complain that textile fabric suppliers can't supply the style fabrics that consumers want, and there are often problems such as the wrong version and low quality of the goods produced by manufacturers[10]. In order to reduce the price, fast fashion clothing brands need to start from the cost and minimize the production cost. Specifically, the first thing to do is to improve the turnover efficiency of inventory. The company is mainly responsible for designing products and building brand image, and outsourcing the production, processing

and sales links to other institutions, which makes the industrial chain links harmonious, and carries out strict quality control in logistics and transportation, brand promotion and information management, and realizes the transformation of innovative management mode.

At present, the time from design to shelf of products of major fashion clothing brands has been reduced to less than ten days, which is in sharp contrast with the one-month lead time of traditional clothing enterprises. By analyzing the advantages of this model, we can know that its outstanding feature is that it can quickly grasp the information of the consumer market, so as to realize the accurate prediction of the market, which is of great significance in terms of efficient supply. In sales, the main emphasis is on direct stores, which greatly improves the convenience of management and makes the price allocation more unified. In terms of channels, the vertical distribution system is widely used by fast fashion clothing brands, so that the whole process of clothing from design, production to sales can be accurately controlled at the supply chain level, and the cycle is short, and the clothing can be delivered to consumers at the fastest speed.

III. RESEARCH ON OPTIMIZATION MANAGEMENT MODEL OF FASHION MARKETING SUPPLY CHAIN

A. *Modeling*

Many fast fashion brands still cling to conventional management and operational models, resulting in suboptimal coordination between upstream and downstream enterprises within their supply chains. In this context, it is imperative for all entities in the fast fashion clothing industry's supply chain to collaborate in enhancing demand management. To achieve this, companies should explore opportunities to leverage each other's production capacities and outsource production to partner enterprises, all while embracing a virtual operational profit model. Concurrently, they should upgrade their information platforms to accelerate the product replacement cycle. In selecting outsourcing partners, businesses should diligently seek ways to maximize resource integration and utilization, enabling rapid product circulation and satisfying consumers' demands for timely clothing updates. At the marketing demand level, traditional clothing companies typically devise market strategies through their marketing and retail departments, considering real supply and demand dynamics, and subsequently implement these strategies through their stores. At each intersection, the artificial ants choose the path by balancing the Pheromone representing the global information and the visibility of the local information, and find the shortest path through the positive feedback of the artificial ant colony. This method of selecting the optimal path by balancing local and global information can effectively unify the decisions of each local optimal path into the decisions of the global optimal path. In general optimization algorithms, the following equation is used as the objective function:

$$TC(k) = C_{s2p} \cdot F_{s2p}(k) + C_p \cdot F_p(k) \quad (1)$$

Based on material balance and related capacity constraints, it can be concluded that:

$$I_{MI}(k) = I_{MI}(k-1) + F_{s2p}(k - t_1) \quad (2)$$

Among them, k is a discrete time unit; $TC(k)$ is the total cost to be paid by the core enterprise of k time unit; $F_{s2p}(k)$ is the quantity of raw materials that k time unit S needs to transport to P .

In the supply chain system, the production, supply, and distribution processes of the supply chain are driven by the needs of customers in different regions. Due to the uncertainty of customer demand in different regions of the supply chain system, this article establishes a PSO based fashion marketing supply chain optimization management model (see Figure 1).

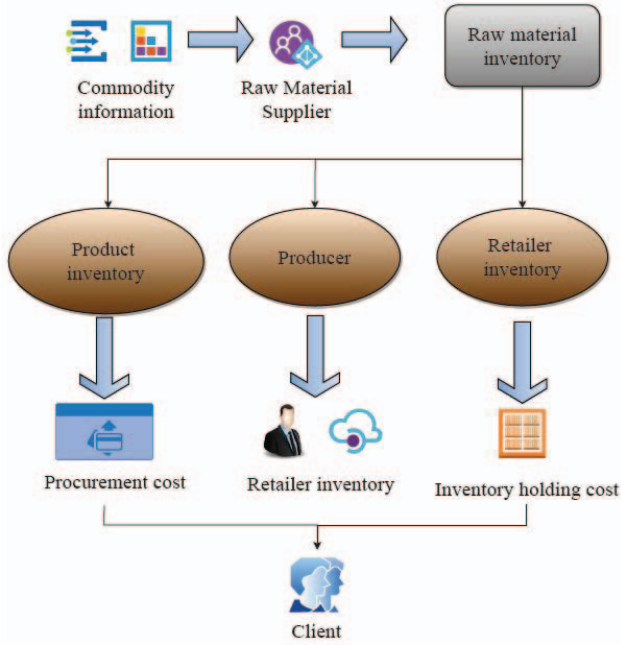


Figure 1. Fashion Marketing Supply Chain Optimization Management Model

At the beginning of each sampling cycle, goods are received from upstream enterprises according to orders and shipped to downstream enterprises according to orders; At the end of each sampling period, collect various types of information from each node, including inventory information, sales records, etc., and determine the decision variables for the next sampling period through optimization control algorithms. To facilitate quantitative cost calculation, the total cost of supply chain decisions that core enterprises need to pay per unit time cycle is procurement cost, production cost, transportation cost, inventory holding cost, product out of stock cost, and product unsold cost. In

PSO, this comprehensive measure is the probability of ants transitioning from their current position to the next position, and in optimization algorithms, it is the probability of ants transitioning from $F^k(i-1)$ to F_{ij}^k , set to P_{ij}^k , and

$$P_{ij}^k = \frac{\tau_{ij}^k(t)}{\sum_{u=1}^{n_i} \tau_{iu}^k(t)} \quad (3)$$

Where: $\tau_{ij}^k(t)$ is the Pheromone residue on F_{ij}^k when the t ant searches, and its physical meaning is the memory obtained from empirical knowledge, which changes dynamically with the ant colony search time. At the initial time, the Pheromone amount of each node is equal.

Therefore, clothing brands need to upgrade their supply management in the supply chain and shift their focus to supplier relationship management, rather than focusing solely on orders and prices. Due to the fast updating speed of products, market demand and inventory management issues should be handled more cautiously, as any carelessness may lead to being abandoned by the market. The clothing industry should adopt a more refined and systematic procurement model based on market demand and consumer preferences, and minimize the expected inventory quantity as much as possible. In addition, enterprises need to establish a supplier capability evaluation system, fully tap into the potential of suppliers themselves, fully mobilize their production enthusiasm, and enable them to participate in production activities in all aspects.

B. Simulation study

If we want to fully realize the integration between the upstream and downstream of the supply chain, we need to establish a win-win relationship, which is also the basis for long-term cooperation. Inventory management plays a very important role in supply chain management, so does the supply chain management of clothing industry. Especially for clothing brands, the circulation speed of products is often relatively fast, so it is necessary to strengthen inventory management. Different supply chain management modes need harmonious links in all aspects of the supply chain. Good supply chain nodes can reduce the market risk of enterprises, and adequate information communication can reduce unnecessary costs. In the actual marketing process, enterprises need to fully refer to their own inventory situation, arrange orders reasonably, minimize inventory and avoid the backlog of goods. In the process of supply chain operation, if enterprises want to achieve win-win or even win-win, they should not simply be limited to the maximization of one party's interests, but also strive to maximize the interests of many parties. Commodity planning is in the hands of enterprises, which can make full use of consumer information in the released commodities, so as to realize the rapid withdrawal of funds. In some mature enterprises, brands must manage logistics, information flow and capital flow well to run this model.

To achieve full integration between the upstream and downstream segments of the supply chain, it is imperative to establish a mutually beneficial relationship, serving as the foundation for long-term collaboration. Inventory management holds significant sway in the realm of supply chain management, and this holds true for the clothing industry's supply chain, particularly for clothing brands. Given the swift turnover of products in this industry, robust inventory management is essential.

Different modes of supply chain management necessitate seamless connectivity across all facets of the supply chain. Well-managed supply chain nodes can help mitigate market risks for businesses, and effective information communication can curtail unnecessary expenses. In the practical marketing process, companies should meticulously consider their inventory status, make well-considered orders, minimize excess inventory, and steer clear of stockpiling. To promote a win-win or even multi-party win outcome, businesses should avoid getting trapped in a limited perspective that merely seeks to maximize one party's interests. Instead, they should endeavor to optimize the interests of all involved parties. Enterprises have control over product planning, allowing them to leverage consumer information when crafting their offerings, facilitating swift fund withdrawal. In the context of mature enterprises, it is imperative for brands to proficiently manage logistics, information flow, and capital flow to effectively run this model.

Marketing needs to meet the specific needs of users through existing goods or services, that is, to meet the different requirements of both marketing parties through an exchange. The specific connotation of marketing is related to the research object. At present, marketing is generally related to various marketing activities of enterprises, involving channels, pricing and promotion, which are the core parts of marketing and will directly affect the final marketing effect. As can be seen from the sales performance in Table 1, the company has shown a good development momentum by 2021, and the sales in 2022 decreased slightly, suggesting that the development has encountered a bottleneck. If it is not paid enough attention, it will affect the healthy development and bigger and stronger of the enterprise.

TABLE I. SALES SITUATION IN THE PAST THREE YEARS

Brand	2020	2021	2022
Huashang District	2.4	4.1	3.5
Huamei Life	1.1	2.7	1.7
Gorgeous wardrobe	8.7	10.3	9.9

Unit: 100 million yuan

It is necessary to be cautious in dealing with market demand and Inventory control problems, because improper handling will lead to abandonment by the market. In order to further validate the effectiveness of the algorithm in fashion marketing supply chain management, this chapter will conduct further analysis through simulation experiments. A rolling optimization decision method based

on improved Ant colony optimization algorithms. Simulate and compare the three decision-making methods, and the results are shown in Figures 2 to 4.

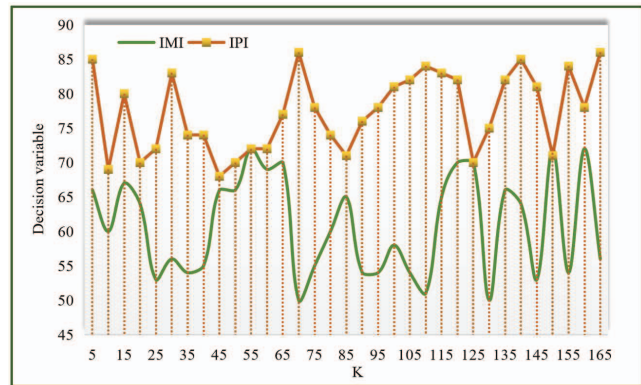


Figure 2. Simulation Results of Decision Method One

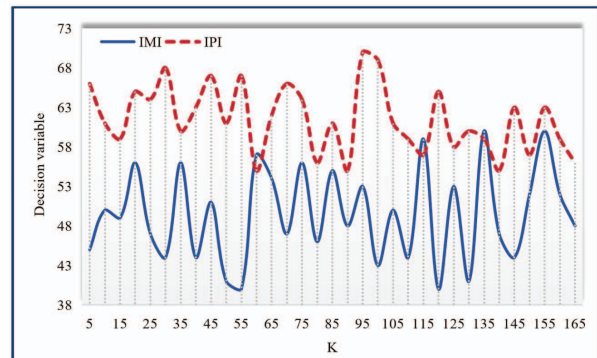


Figure 3. Simulation Results of Decision Method 2

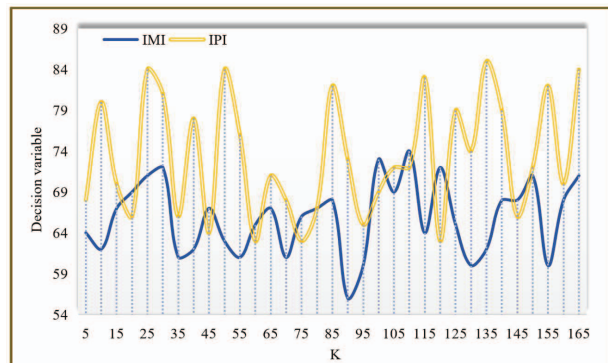


Figure 4. Simulation Results of Decision Method Three

Figures 2 through 4 provide clear insights. In comparison to the three phases of Decision Method 2 and Decision Method 3, Decision Method 1 exhibits notably higher inventory levels, which significantly contribute to its elevated costs. Conversely, Decision Method 2 demonstrates more stable inventory levels for Inventory IMI and Inventory IPI. Under Method 2, the average inventory levels for IMI and IPI are 4.56 and 4.86, respectively, while under Method 3, they stand at 1.52 and

1.42, respectively. Consequently, Method 2 marginally surpasses Method 3 in terms of IMI and IPI inventory levels.

IV. CONCLUSIONS

The market of fashion clothing brands is relatively large, the consumer groups are relatively stable, and the development space is very large. Supply chain management plays a very important role in promoting the development of fast fashion clothing brands. In this study, the marketing and supply chain management of fashion clothing brands are discussed in detail, and the optimization management model of fashion marketing supply chain is constructed based on PSO. Because of the rapid update of goods, the market demand and inventory management should be handled more carefully, and it will be abandoned by the market if it is careless. In the process of supply chain operation, if enterprises want to achieve win-win or even win-win, they should not simply be limited to the maximization of one party's interests, but also strive to maximize the interests of many parties. Commodity planning is in the hands of enterprises, which can make full use of consumer information in the released commodities, so as to realize the rapid withdrawal of funds. Finally, the simulation results show that compared with decision method 2 and decision method 3, the inventory level of decision method 1 is too high, which is the main reason for the highest cost. Compared with decision method 3, the inventory level of IMI and IPI in decision method 2 is more stable. The average inventory of IMI and IPI under the second method is 4.56 and 4.86, respectively, and under the third method is 1.52 and 1.42, respectively. Therefore, the inventory level under the second method is slightly higher and the sustainability is higher. The model constructed in this article reflects the concept of supply chain management and has certain practicality, operability, and sustainability.

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