

# Research on Collaborative Optimization of Clothing Agile Supply Chain Inventory under the Background of Digital Logistics

-- A Case Study of Wenzhou

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**Abstract:** China's digital economy and digital logistics have made rapid progress, and the clothing industry has also experienced rapid development. China has become one of the world's largest clothing production and consumption markets. However, at the same time, due to the perishable nature of clothing products and the time-based competition in the clothing market, inventory management of clothing has become increasingly important. For the clothing supply chain, optimizing inventory and building an agile supply chain are important aspects of improving the performance of the clothing supply chain. Therefore, this article takes Wenzhou A enterprise as an example to study the application of RFID intelligent sales in the clothing supply chain to optimize inventory coordination and improve its supply chain performance.

**Keywords:** Digital logistics, Clothing, Agile supply chain, Inventory collaborative optimization.

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## 1. Introduction

In recent years, China's digital economy has achieved remarkable development achievements, and its position in the national economy has become increasingly prominent. In the wave of digital economy development supported by digital technology, the clothing industry has also experienced rapid development, especially in the Wenzhou clothing industry, where a number of clothing companies such as Semir, Baoxinniao, George White, and Baixiande have emerged. However, at the same time, due to the perishable nature of clothing products and the time-based competition in the clothing market, inventory management of clothing has become increasingly important. For the clothing supply chain, optimizing inventory and improving supply chain performance is an important aspect of serving the digital economy. Based on the above background, this article focuses on the research of intelligent sales systems based on radio frequency identification technology (RFID) in the field of digital logistics for collaborative optimization of clothing supply chain inventory and the construction of intelligent sales systems. From downstream to upstream, clothing sales and inventory information are shared, reducing clothing supply chain inventory and optimizing the clothing supply chain. This provides reference for the clothing supply chain of Wenzhou clothing enterprises and helps promote the development of Wenzhou's digital economy.

The clothing industry is a typical labor-intensive industry, and its production, warehousing, logistics, sales and other business processes are very complicated, so there are many immature aspects in management. Therefore, in the field of clothing, more and more enterprises are seeking to use advanced technology to change this complex management situation. Through continuous application and practice in the clothing industry, RFID technology has formed a complete system. Clothing enterprises apply this technology to the sales, logistics, storage, and production links of the industry,

promoting the optimization and upgrading of the overall supply chain, and ensuring the efficient configuration and utilization of information in each link and node.

Compared with China, RFID technology has already been applied in clothing practice abroad, and the clothing industries in Portugal, Austria, Japan, Finland, Germany, the United Kingdom, and the United States have solved some of their own development problems through the application of this technology [1]. Gap Inc. in the United States utilizes this technology to ensure dynamic management of product sales, achieve real-time tracking, improve management efficiency and quality, and use RFID technology in retail to increase clothing sales volume [2]. British retailer Marks & Spencer, based on their own actual situation, has strengthened the dynamic tracking of clothing products and collected various product information through the application of this technology, creating benefits for the development of the enterprise [3]. DHL has implemented RFID in the distribution center of French company Cavaillon, thereby improving logistics management efficiency [4].

In China, the national economy has grown rapidly under the promotion of reform and opening up, and the clothing industry has gradually grown to meet the needs of national life. China has now become a major producer and consumer of clothing worldwide. Chinese enterprises have also been inspired by the use of RFID technology by foreign clothing companies, and have begun to use RFID technology for various aspects of management in the clothing industry. For example, the well-known clothing company Bosideng, which is already listed on the Hong Kong Stock Exchange, adopts RFID technology to take the path of branding. Bosideng implements RFID technology for production site operation management and obtains real-time dynamic production information through RFID technology. Based on this, it balances each production line and maximizes production efficiency [5]. In 2010, the well-known men's clothing brand Jinba implemented an RFID on-site management solution in

both its goods warehouse and clothing specialty stores. Firstly, RFID electronic tags were used to obtain real-time sales information from the specialty stores and sales outlets. Then, the obtained dynamic information was fed back to the headquarters and countermeasures were proposed. Through this timely information sharing method, the problem of inventory backlog and high supply chain inventory costs in Jinba's men's clothing warehouse was solved [6]. A large comprehensive shopping mall in Shanghai has designed a novel "smart fitting room" using RFID technology. Consumers can obtain the required clothing matching information through the "smart fitting room". Consumers only need to scan the barcode information on the clothing tag with a barcode scanner. The display screen of the "smart fitting room" will display various information such as clothing design, production, model display samples, and matching schemes, which facilitates consumer purchasing and is favored by fashionable people [7]. To make a long story short, RFID technology has a wide range of application markets, and its expandable space is enormous. The application of RFID technology will be a new driving force for the economic growth of the clothing industry.

## **2. Theoretical Basis**

### **2.1. Rfid Technology**

RFID technology, also known as radio frequency technology or wireless radio frequency identification, has attracted much attention in recent years as a key technology in the Internet of Things. It is a communication technology that can identify specific targets and read and write related data using radio signals, without the need for mechanical or optical contact between the identification system and specific targets to obtain information. The working principle of RFID system: The reader uses the antenna to send RF signals of a specific frequency, and when the tag enters the effective coverage range of the antenna, the tag will be activated due to receiving energy; The activated tag will send the relevant data information originally stored in the tag through its own antenna in the form of a signal; Once the antenna receives a signal, it will immediately send it to the reader/writer, which then analyzes the received carrier signal, demodulates and decodes it, and transmits it to the backend computer for processing; The backend computer processing system will analyze the information and make judgments on the relevant information of the tags based on logical operations, and finally process the decoded data received by the system according to instructions.

### **2.2. Intelligent Sales**

With the development of the economy, more and more intelligent technologies are being combined with industries to promote their growth. The most typical example is the retail industry, where the application of intelligent technology has facilitated consumers and managers. The term 'intelligence' encompasses a wide range of content, but its specific meaning still requires deeper exploration. So, currently no one has been able to provide a specific and precise definition for the word "intelligence". However, in general, this word can be expressed as follows: intelligence can be understood as a manifestation of higher-level activities in the human brain, and it should at least possess the following abilities: the ability to automatically acquire and apply knowledge, the ability to think and reason, the ability to solve problems, and the ability

to learn automatically. An intelligent system is generally understood as a computer system capable of generating human intelligent behavior.

### **2.3. Apparel Supply Chain**

The clothing supply chain covers all aspects of clothing production and sales, and achieves efficient operation of each node enterprise by strictly controlling the capital flow, logistics, and information flow of the entire supply chain. This includes the procurement of raw materials, the manufacturing of clothing, and the sales of clothing. A complete clothing supply network consists of consumers, retail stores, distribution centers, manufacturers, and joint suppliers. In this network, the supply chain can coordinate, unify, and control the flow of funds, information, and logistics through efficient operation of various nodes.

### **2.4. Newsboy Model**

The newsboy model can solve many practical problems in daily life. As a mathematical model, it can provide the correct direction for the operation and development of enterprises. For products with shorter production cycles, faster updates, and stronger seasonality, the more quantity purchased, the greater the profit obtained [52]. However, for perishable products, they are highly susceptible to seasonal influences, so if they cannot seize the best time to sell, it will cause significant losses. In addition, if there is a shortage of inventory causing a shortage, it will affect the loss of profits. This creates a problem that when managing inventory, excessive inventory can lead to losses, while insufficient inventory can make it difficult for individuals to obtain more profits. Therefore, a scientific and reasonable inventory strategy has become a concern for many industries, and the newsboy model has emerged from such thinking. The clothing industry, like newsboys selling newspapers, carries great uncertainty and is highly susceptible to external environmental influences.

## **3. Analysis of the Impact of Intelligent Sales on Inventory Uncertainty in the Clothing Supply Chain**

### **3.1. The Impact of Intelligent Sales on Inventory of Clothing Manufacturers**

For clothing manufacturers, it is necessary to combine product design and fabric procurement in all aspects of operation and management to ensure their efficient operation. In clothing manufacturing enterprises, raw materials account for a very high proportion of production, generally accounting for about 80%, especially in the clothing industry where the output of clothing is large. Due to the inability to track production progress in real time, there may be management confusion, resulting in the inability to deliver clothing products on time, which to some extent affects the satisfaction of downstream enterprises in the supply chain and increases the uncertainty of clothing supply chain supply. In order to avoid such uncertainty and improve customer satisfaction, clothing manufacturers will maintain inventory higher than demand in order to maximize profits.

### **3.2. The Impact of Intelligent Sales on Inventory in Clothing Distribution Centers**

Among various supply chains, logistics and warehousing

are the most influential factors involved. At present, if information input is done manually, it will result in low efficiency, high error rate, and accompanied by high labor costs. In the logistics and warehousing process of the distribution center, it is necessary to ensure accurate and fast delivery, picking, packing, and shipping operations; To reduce inventory backlog, control the supply cycle within a reasonable range, improve logistics efficiency, and ensure timely supply, it is necessary to rely on advanced technology to transform traditional manual management of clothing into intelligent management. On the other hand, the inventory stored in the distribution center may also be unable to grasp the retailer's inventory and demand data due to the uncertainty of downstream retailer demand, resulting in overstocked inventory and capital. Through intelligent sales, retail store inventory can be transmitted in real-time to distribution centers, which has a significant regulatory effect on predicting their own storage capacity, promoting the rationality of inventory, strengthening cooperation between retailers, achieving information sharing, and bringing more profit space to enterprises.

### **3.3. The Impact of Intelligent Sales on Inventory of Clothing Retailers**

Clothing, as a perishable product, has a short lifecycle, especially with strong seasonality. Therefore, the accuracy of retail information has the greatest impact on the overall performance and inventory of the clothing supply chain. Through practical research and investigation, it can be concluded that for clothing retailers, there are several shortcomings in the actual operation process, including the lack of real-time store sales data; Store inventory is time-consuming and labor-intensive; Difficulty in understanding customer preferences; The service efficiency and quality of physical stores are relatively low; The store itself has encountered a development bottleneck, with high variability in various businesses, and there is a "fake inventory" in the store, that is, the actual inventory does not match the system inventory.

## **4. Collaborative Optimization Strategy for Clothing Supply Chain Inventory Based on Intelligent Sales System - Taking Wenzhou A Enterprise as An Example**

### **4.1. Establishment of Clothing Supply Chain Inventory System Based on Intelligent Sales System**

The intelligent sales system studied in this article applies RFID technology in digital logistics technology. Therefore, the establishment of a clothing supply chain inventory system based on the intelligent sales system is also based on the application of RFID in the entire clothing supply chain by Wenzhou A enterprise. During the production and manufacturing stage, clothing is labeled with RFID tags and begins to write production and manufacturing information into the clothing. After writing the information, the clothing RFID tag has uniqueness and can be individually identified at the beginning of the production stage. Then, in the warehousing stage, the RFID tag is written with tray information, shelf layer information, etc. Combined with RFID intelligent shelf technology, the clothing is monitored

in real-time during the warehousing stage, ensuring the accuracy of clothing inventory. When the distribution center needs to transfer goods, clothing with RFID tags is also written into the transportation information during transit, and the transportation status of the clothing can be monitored in real time. When delivering to the clothing retail end, it begins to enter the store storage stage of the clothing retail end. At this time, the intelligent shelves using RFID technology monitor the inventory of clothing entering the store in real time. In the sales stage, clothing is also monitored in real time on the intelligent sales shelves. On the RFID technology-based intelligent sales shelves, the clothing picked up by consumers is recorded in real time by the RFID system. This type of information can be transmitted to clothing manufacturers to facilitate the production of clothing products that consumers are interested in, avoiding excessive inventory accumulation caused by clothing manufacturers producing too many clothing products that consumers are not interested in. Similarly, under the intelligent sales system, after clothing is purchased at the retail end, the amount of inventory reduction and the amount of existing inventory at the retail end are recorded through the intelligent sales system and can be transmitted in real time to the upstream distribution center. The distribution center adjusts its inventory quantity in a timely manner based on the inventory quantity of the retail clothing store, so as not to retain too much inventory or lack inventory. In retail clothing stores, an intelligent sales system based on RFID technology can real-time monitor the inventory quantity of clothing in the store, and there is no "fake inventory", that is, the system inventory does not match the actual inventory. Therefore, the application of RFID in the clothing supply chain and the implementation of intelligent sales systems in retail clothing stores can enable A company's clothing supply chain inventory to be synergistically optimized.

### **4.2. Collaborative Optimization Solution of Clothing Supply Chain Inventory Based on Intelligent Sales System**

#### **4.2.1. Problem description**

This article intends to establish a perishable clothing inventory model in the supply chain environment, which consists of a single manufacturer, a single supplier, and multiple retail stores. In this supply chain system, clothing manufacturers are responsible for supplying goods to distribution centers, which in turn supply clothing products to numerous downstream clothing retailers. When retailers sell clothing products, they also consider the problem of inaccurate inventory at supply chain nodes and the use of intelligent sales systems to share information with upstream clothing distribution centers and production manufacturers. With the goal of minimizing inventory costs in the clothing supply chain, a clothing supply chain inventory collaboration model is established to achieve effective inventory collaboration optimization in the clothing supply chain.

#### **4.2.2. Model Assumptions**

This model assumes that the sales market for clothing products is perfectly competitive, with continuous and normally distributed demand. The market demand is  $X$ , and the demand follows a normal distribution of  $N(\mu, \sigma^2)$ .  $f(x)$  and  $F(x)$  are the density function and cumulative distribution function of  $x$ , respectively, and the demand among retailers is independent of each other, so stockouts are not allowed.

The application of RFID technology on smart shelves in retail clothing stores can achieve real-time monitoring of inventory status and real-time updates of clothing inventory information in retail clothing stores. Therefore, retail clothing stores adopt continuous inventory counting and use RFID smart shelves to check their inventory levels in real time.

Adopting the ordering strategy of (R, Q), that is, when the retailer's inventory level drops to R (ordering point), they place orders with the distribution center DC, with each order quantity being Q and following the principle of economic order quantity.

The real-time monitoring feature of RFID technology can help retail clothing stores accurately monitor inventory. Assuming the reading rate of RFID tags reaches 100%, it can completely avoid inventory inaccuracy and losses caused by stockouts to the clothing supply chain.

The model in this article assumes that all nodes in the supply chain aim to maximize the overall benefits of the supply chain. Therefore, it is assumed that this clothing supply chain is a centralized decision-making supply chain, namely a branded clothing supply chain.

RFID technology enables information sharing throughout the entire supply chain, assuming that manufacturers can use the sales monitoring subsystem in the intelligent sales system to real-time understand the types of clothing that retail consumers are interested in, and based on this, arrange clothing production reasonably. Therefore, it is further assumed in this model that manufacturers have unlimited supply capacity for clothing that consumers are interested in, the delivery lead time of the supply chain is fixed as a constant, and retailers do not place orders at the end of the sales season. Therefore, it is assumed that the residual value of manufacturers' end of season clothing products is 0.

Assuming that the intelligent sales system can enable the distribution center to real-time understand the inventory information of retail clothing stores, and the inventory of the distribution center can store inventory that meets the reasonable needs of retail clothing stores.

Assuming that the intelligent sales system is implemented by a branded clothing enterprise, all of its clothing retail stores have established intelligent sales systems. By using RFID technology to establish the intelligent settlement subsystem and clothing management subsystem in the intelligent sales system, real-time inventory information of retail store clothing can be provided to the upstream.

#### 4.2.3. Parameter settings

- r: Sales price of clothing products
- w: Wholesale prices of clothing products
- s: Retail clothing residual value at the end of the sales season
- g: Unit product shortage loss
- c: Unit production cost of clothing products
- Q: System ordering batch
- L: lead time
- P: The demand observation values used by enterprises for demand forecasting
- α: Clothing manufacturers are interested in clothing retail consumers. Inaccurate understanding of clothing products leads to a mismatch between inventory (production) and demand, with an error ratio of  $0 < \alpha < 1$
- β: The inaccurate understanding of downstream clothing retail inventory by the distribution center DC leads to an error ratio between inventory and order quantity, with  $0 < \beta < 1$
- θ: The ratio of the error between the inventory level of the

retail clothing store system and the actual inventory level is not equal,  $0 < \theta < 1$

Assuming the following relationship exists between parameters:

$$s \leq c \leq g \leq w \leq r$$

This assumption ensures that the production cost of clothing manufacturers is greater than the residual value of the goods and less than the wholesale price, thereby guaranteeing the profits of clothing manufacturers; At the same time, the sales price of clothing products is higher than the wholesale price, ensuring the profit of clothing retailers; The existence of out-of-stock costs is a punitive measure for enterprises at various nodes of the clothing supply chain.

#### 4.2.4. Model solution

(1) Retail clothing stores do not implement RFID intelligent sales systems

When retail clothing stores do not implement intelligent sales systems, that is, retail clothing store information is not shared, upstream manufacturers' clothing production is uncertain, distribution center inventory is uncertain, and retail store inventory is uncertain. The actual inventory level of clothing products that ultimately meet the needs of end consumers through various links in the supply chain, such as production and manufacturing, distribution centers, and retail stores, is  $\alpha \beta \theta Q$ .

The profit of the clothing supply chain is:

$$\pi_{m1}^* = \pi_{m1}^{L*} + \pi_{m1}^{DC*} = (g - s) \int_0^{\alpha \beta \theta Q_{m1}^{L*}} x f(x) dx + (g - s)(\alpha \beta \theta Q_{m1}^{L*})^2 f(\alpha \beta \theta Q_{m1}^{L*}) \quad (1)$$

(2) Retail clothing stores implement RFID intelligent sales systems

The implementation of RFID intelligent sales system in retail clothing stores has enabled the retail end to share clothing information of interest to consumers with manufacturers, and to share real-time retail inventory information with distribution centers. Retail store inventory is monitored in real-time, including clothing production volume, distribution center inventory, and retail end inventory, with no uncertainty. Make  $\alpha=1, \beta=1, \theta=1$ , The clothing supply chain system has no inventory errors. The actual inventory level used by the system to meet consumer demand is Q.

The profit of the clothing supply chain is:

$$\pi_{m2}^* = \pi_{m2}^{L*} + \pi_{m2}^{DC*} = (g - s) \int_0^{Q_{m2}^{L*}} x f(x) dx + (g - s)(Q_{m2}^{L*})^2 f(Q_{m2}^{L*}) \quad (2)$$

Through analysis, it can be concluded that both the distribution function and density function are increasing functions, therefore the function is an increasing function with respect to, also  $0 < \alpha < 1, 0 < \beta < 1, 0 < \theta < 1$ , And it is known that  $\alpha \beta \theta Q_{m1}^{L*} \leq Q_{m2}^{L*}$ , available:  $\pi_{m2}^* - \pi_{m1}^* \geq 0$

Therefore, as analyzed and calculated in the previous text, it can be concluded that retail clothing stores using RFID intelligent sales systems can achieve collaborative optimization of clothing supply chain inventory, resulting in increased profits for the clothing supply chain.

This article validates the construction of an inventory model for the clothing supply chain based on the newsboy model. By using RFID technology in the clothing supply chain and implementing an intelligent sales system in retail clothing stores, the retail end can share consumer interest information with manufacturers and real-time inventory information of retail clothing stores with distribution centers.

A comparative analysis was conducted on the profitability of clothing supply chains in retail clothing stores with and without the implementation of intelligent sales systems. When retail clothing stores do not implement RFID intelligent sales systems, the inaccuracy of DC inventory in production manufacturers and distribution centers in the supply chain increases. Implementing RFID intelligent sales systems enables retail clothing stores to share information with upstream enterprises, reducing inventory inaccuracy. Finally, through comparative analysis, it is concluded that implementing an intelligent sales system for clothing in A company's retail clothing store can achieve collaborative optimization of clothing supply chain inventory and improve supply chain performance.

## 5. Conclusion

With the rapid development of the digital economy, China's clothing industry has also ushered in a prosperous period of development. However, clothing products have high value and perishable characteristics, and once they miss the sales time, they will depreciate. Therefore, the management of clothing is becoming increasingly important. In clothing management, the most important thing is the management of clothing inventory. Clothing inventory exists throughout the entire clothing supply chain, and inventory control at every link of the clothing supply chain becomes particularly important. Based on this, this article establishes an RFID intelligent sales system in the context of digital logistics, constructs a clothing supply chain inventory optimization strategy model based on the RFID intelligent sales system, and studies the collaborative optimization of clothing supply chain inventory and the improvement of supply chain performance under the implementation and non-implementation of the intelligent sales system. Comparative analysis shows that implementing an intelligent sales system

in the clothing supply chain can enable collaborative optimization of inventory in the clothing supply chain.

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