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Research on the supply chain inventory management to GeN Garment Co. Ltd

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Research on the Supply Chain Inventory Management to GeN Garment Co. Ltd

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ABASTRACT

Title of Dissertation: **Research on the Supply Chain Inventory Management to GeN Garment Co. Ltd**

Degree: **Master of Science in International Transport and Logistics**

Abstract:

With the globalization of the economy, the apparel industry faces a very fierce competitiveness. Apparel industry is a comprehensive industry that requires a complete and highly efficient supply chain management system which links accessories suppliers, apparel manufacturers, distributors and retailers. So it is demanding for the apparel supply chain management. It is no doubt that inventory management is the core contents of apparel enterprises supply chain management, which is always a thorny problem for either apparel manufacturers or retailers. This paper attempts to take advantage of supply chain management theories to find a solution to solve the inventory problem for apparel enterprises.

The paper takes GeN Garment Co.Ltd, a typical Chinese apparel manufacturer, as an empirical case. It has serious problems in inventory management such as low demand forecast accuracy and excess inventory burden. In the paper, we analyze the existing problem in the GeN's supply chain inventory management. Then we put forward supply chain inventory optimization strategy for GeN according to its characteristics and situation based on the supply chain inventory management theory.

The paper, which consists of 6 chapters, is organized as follows. Chapter 2 introduces the basic theory of supply chain inventory management. Chapter 3 analyzes the present GeN Garment's inventory. Chapter 4 and Chapter 5 give the solution to GeN Garment for its supply chain inventory management. It chooses the strategy and optimization model for GeN's inventory management according to its business conditions. Chapter 6 presents conclusion and prospect to the supply chain inventory management for GeN and other apparel enterprises.

Keywords: Supply chain management; Apparel industry; Inventory management; CPFR; Demand forecast; Inventory control model

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LIST OF ABBREVIATIONS

SCIM	Supply Chain Inventory Management
EDI	Electronic Data Interchange
VMI	Vendor-Managed Inventory
JMI	Joint Managed Inventory
CPFR	Cooperative Planning, Forecasting and Replenishment
POS	Point Of Sale
IT	Information Technology
ERP	Enterprise Resource Planning
GM	Gray Model
CSCMP	Council of Supply Chain Management Professionals

Chapter 1 Introduction

1.1 Background

China is not only a huge clothing producing country but also a clothing consuming power. According to statistics in 2008, China's retail sales for clothing has exceeded 30 billion, with an increase of 20.3% compared to 2007. There are about 54,000 clothing manufacturing enterprises in Chinese market, with more than 450 million employees and nearly 315 billion annual clothing production capacity [1]. Therefore, it has practical significance to study the management of garment enterprises. And it is no doubt that the core content of garment enterprises management is inventory management, which is always a thorny problem for either garment manufacturers or retailers. Whether the big clothing brands or small garment enterprises, almost every enterprise has the burden caused by inventory. In order to control the inventory, we can find many enterprise adopt "discount sale" or "out-of-season sale" to reduce occupancy of storage capital and operation cost. Poor inventory management often leads to the tying-down of capital or even collapse of garment enterprises. Apparel products are fashion products with the nature that garment's value is inversely proportional to the time. The garment demand suffers a significant drop in the end of sales season. In order to reduce inventory, garment enterprises have taken several traditional ways:

[a] Put a small number of new products into market to test the market reaction, which often results in a mismatch between supply and demand and has seriously negative impact on business profitability

[b] Bring forward sales ahead of sales season, usually with unreasonable high price which is several times of the cost. It is a way to win the huge profit for

business but with the cost to hurt consumer’s interests.

[c] Promotion or discount sales at the end of the sales season. In most cases, it sells at the price at or even under the breakeven point, with pre-season earnings to compensate for loss of promotion. The sharp contrast in price before and after season will result in consumer’s psychological consumption barriers like "cheated", "wait", "wait and see" and etc.

[d] Closeout of the inventory with rather low price. Consumers are usually attracted by the cheap price rather than the style of the garments and make the impulse-buy decision. However, “Fashion” is the distinct characteristics for garments. The impulse-buy garments tend to become “trash” in the closet in the end, which is a way to pass on burden of inventory of the apparel enterprise to the consumer in fact.

[e] Product backlog of inventory is kept in warehouse for a long time which causes a great waste of social resources.

Such circumstances, coupled with the characteristics that apparel industry has a long supply chain, result in the trend that supply chain management philosophy need to be introduced into inventory control. However, many research found that nowadays there are only small number of Chinese apparel enterprises starting to use the supply chain inventory management methods. Most apparel enterprises’ inventory management models are not suitable. In other words, most domestic apparel enterprises have the inventory problems.

1.2 Literature review

The CSCMP (Council of Supply Chain Management Professionals) has given the definition to supply chain management as follows: “Encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities….(which) includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers and customers.” The supply chain literatures concern in different aspects----- from forecasting, procurement, production, distribution, inventory, transportation to customer service. They are also studying under different several perspectives----strategic, tactical, and operational. Supply chain inventory management (SCIM), who plans and controls the inventory throughout the entire network of co-operating organizations, i.e. from the initial supplier to the end user, is an integrated approach that aims at improving customer service, increasing product variety, and lowering costs [2].

In order to define an effective SC inventory policy, a number of studies have mentioned one of the most influential elements to the performance of inventory----uncertainty, which not only includes the uncertainty on supply (e.g. lead times) and demand, but also the information delays associated with the manufacturing and distribution processes [3].Liu, M. L., & Sahinidis, N. V. mentioned that in the market, not only the product demand and raw material supply but also commodity price and cost are the uncertainties for the participants of supply chain [4]. According to Hameri et.al., the determination of proper statement of the uncertain parameters is of greatest importance to incorporate uncertainties into supply chain modeling and optimization [5].Three distinguished methods, which were recommended by Chen, C.L., & Lee, W.C. are widely invoked for representing uncertainty[6]: (a) distribution-based approach. In this approach, the normal distribution with specified mean and standard deviation is widely used for modeling uncertain demands and/or parameters; (b) fuzzy-based approach. With this approach, we consider the forecast parameters as fuzzy numbers with accompanied membership functions; (c) the scenario-based approach. In this approach, the expected occurrence of particular outcomes are described by several discrete scenarios with associated probability levels

A lot of papers have been dedicated to studying supply chain management under uncertain conditions. For instance, Taskin Gumus& Guneri make the uncertain demand into consideration via a normal probability function and suggest a two-stage solution framework [7]. Gupta & Maranas proposed a generalization to deal with multi-period and multi-customer problems [8]. Tsiakis, Shah, and Pantelides depict demand uncertainties by using scenario planning approach [9].

Yuliang Yao and Philip Eversb suggest that any enterprise that plans to implement SCIM requires sharing of the information between the partners and the coordination and integration of supply chain processes between suppliers and buyers. Generally, buyers share the information like demand and inventory status with their upstream which can be defined as “information sharing”. Based on the sharing, suppliers can implement the functions of inventory control and purchasing for the buyers which can be defined as “process integration”[10].

A number of research papers have studied the benefit that information sharing brings to the supply chains, especially the influence on the bullwhip effect. The bullwhip effect is “the phenomenon whereby the size of inventory overages and shortages increases the further from final consumer demand in a supply chain”. A lot of literature has proved that information sharing in the supply chain do minimize the bullwhip effect. K. Xu & Y. Dong found the result that the decrease in the bullwhip effect lower inventory levels and reduce cycle times. So they reached the conclusion that information sharing leads to better supply chain performance [11].

A stream of researches has specifically studied the value of information sharing which is realized by VMI or similar programs. S. Cetinkaya, and C.Y. Lee developed an analytical model for coordinating inventory and transportation decisions in VMI systems. They found that the shipment-release policy in use is one parameter that partly determines the vendor's actual inventory requirement [12]. This result holds because vendors have the right to keep orders and they expect that an economical consolidated dispatch quantity will accumulate. So an order won't dispatch until an agreeable dispatch time is reached. Other researchers also assessed the influence of continuous replenishment programs (CRP) on the relationship between a manufacturer and its retailers from analytical perspective [13]. They discover that the value of CRP to inventory reductions is influenced by demand characteristics like the variance of demand; that is to say, when demand variability is comparatively high, inventory reductions which are achieved based on CRP tend to be low.

M. Fisher& J. Hammond hold the opinion that with the development of information technologies, the closer integration of relative enterprises in the supply chain can be achieved through electronic linkages like electronic data interchange. The crucial benefit of systems like JIT, CRP, VMI, quick response, and efficient consumer response which link and integrate the operations of supply chain members is the ability to smooth supply and demand. Thus the possibility of inventory overages or shortages can reduce [14]. Y. Dong collected the data from three different industries and finally found that just-in-time systems (JIT) lowered not only the purchasing, transportation, production and inventory costs of purchasers, but also lowered logistics costs of upstream enterprises by processing re-engineering at supplier locations [15].

However, some studies hold the opposite opinion to the view that supply chain integration necessarily results in benefits for both suppliers and buyers. Nooteboom presented that it is only the surface that the buyer's inventory costs reduced after the supply chain integration. In fact, the costs are only transferred to the supplier [23]. In particular, Hameri & Paatela's theoretical study found that suppliers get benefit from JIT only when they have high holding costs and low ordering costs compared with their customers [24].

According to researches, scholars showed us different approaches or models to deal with supply chain inventory management.

Ilaria Giannoccaro & Pierpaolo Pontrandolfo recommend a reinforcement learning approach to manage the inventory [16]. They think that if an enterprise hopes to establish a successful supply chain inventory management, a major issue is that all the supply chain actors including suppliers, manufacturers, distributors and retailers need to adopt the coordination of inventory policies which allow the smooth material flow and minimize costs while responsively meeting customer demand. The paper presents an approach which consists of three techniques: (a) Markov decision processes (MDP) and (b) an artificial intelligent algorithm to solve MDPs, which is based on (c) simulation modeling. This approach manages inventory decisions at all stages of the supply chain in an integrated manner, aiming at optimizing the performance of the whole supply chain. In particular, the researchers modeled the inventory problem as an MDP and used a reinforcement learning algorithm to determine a near optimal inventory policy when taking the average reward criterion. RL is proved to be a simulation-based stochastic technique which is pretty efficient when the MDP size is large.

Denise Emerson et. al held the idea that information visibility plays a crucial role for decision makers distributed across supply chains.[17] Uncertainties can be reduced by attaining information on price, demand, inventory level, lead times, etc. in addition, the information can help to alleviate problems associated with bullwhip effect. Denise Emerson et. al don’t think it was sufficient to study a static supply chain network configuration only which is assumed in most extant literature in this area.

The development in e-commerce allows order processing can be performed over the

Internet which leads to appropriate dynamic (re)configuration of supply chains over time. Any node in the supply chain can make independent decisions according to information collected from the next level upstream. Denise Emerson used a knowledge-based framework for dynamic supply chain configuration by which to assess the effects of inventory constraints. Besides, researchers also take "goodwill" into consideration as well as their effects on the performance dynamics of supply chains.

In H.T. Lee & J.C. Wu's paper, order batching, which is considered as one of the main causes of bullwhip effect, has been studied [18]. In general, there are commonly two types of inventory replenishment methods: the traditional methods, i.e. the event-triggered and the time-triggered ordering policies, and the statistical process control (. In order to demonstrate clearly, Lee et.al pick up a simplified two-echelon supply chain system with one supplier and one retailer. The actors are supposed to choose different replenishment policies. H.T. Lee's research results show that when the fill-rate of the prior model reaches 99%, the SPC based replenishment method performs better than the traditional method in the number of backlog and the categories of inventory variation. With a suitable replenishment policy, the cost of inventory and the number of backorder can be cut down.

Alev Taskin Gumus & Ali Fuat Guneri presented the way to build up effective multi-echelon supply chains under stochastic and fuzzy environments in their paper[19]. They set up an inventory management framework and deterministic/stochastic-neuro-fuzzy cost models firstly. In order to test the applicability and performance of proposed framework, then they presented a numerical application based on a three-echelon tree-structure chain. This method ensures the efficient forecast data and also examines the minimum total supply chain cost values under demand, lead time and expediting cost pattern changes in detail.

Jay D. Schwartz, Wenlin Wang et.al presented a simulation-based optimization framework with the means of simultaneous perturbation stochastic approximation (SPSA), which is able to optimally specify parameters of internal model control (IMC) and model predictive control (MPC)-based decision policies for supply chain inventory management under conditions of supply and demand uncertainty[20]. When we use the SPSA effectively, it can no doubt enhance the performance and functionality of this class of decision algorithms. The results of their case studies prove that with such technology, we can reduce safety stock levels significantly and achieve financial benefits while we still maintain satisfactory supply chain operating performance.

Yuliang Yao, Philip T. Evers et.al develop an analytical model to explore the effect that supply chain parameters have on the cost savings which is realized from collaborative policies such as vendor-managed inventory (VMI) [21]. Results show that benefits coming from inventory cost reductions can be generated from integration which is influenced by the ratio of the carrying charges of the supplier to the buyer and the ratio of the order costs of the supplier to the buyer. Results also show that these distributed benefits between suppliers and buyers are disproportionally.

Elgar Fleisch &Christian Tellkamp examine the influence that inventory inaccuracy brings to the retail supply chain performance in their paper [22]. They think inventory inaccuracy is a main business issue dealing with physical assets that the enterprise must focus on. They present a three echelon supply chain with one product with the assumption that end-customer demand is uncertain. In the base model, inventory information becomes inaccurate when it happens low process quality, unsalable items and theft because there is no alignment of physical inventory and information system inventory.

In a modified model, although the above factors are still present, physical inventory and information system inventory are aligned at the end of each phase. The results show that the improvement of inventory accuracy can reduce not only supply chain costs but also the out-of-stock level. Automatic identification technology helps a lot to achieve inventory accuracy.

1.3 Research content and structure of thesis

The paper takes GeN Garment Co.Ltd as an empirical case. We study the GeN Garment's inventory management based on the following considerations:

1. GeN Garment faces the same inventory management pressure. GeN Garment, to great extent, only focuses its own business----designs garments by itself, forecasts the demand with its own data and manufactures the products accordingly. It also implements a large number of one-time procurement, production and sales, which may bring great risks for enterprise to a large backlog of inventory or not to meet the market demand. We hope to take advantage of supply chain management philosophy to help GeN Garment out of inventory problem.

2. Foreign supply chain inventory management theory is relatively comprehensive and worth learning; and domestic supply chain inventory management study has just started;

3. Nowadays there are many researches on various aspects of the inventory control model but no specific one for GeN Garment according to its characteristics.

4. The case of GeN Garment is an empirical study and there are lots and lots of apparel enterprises in the similar situation with Gen. We hope more and more domestic garment enterprise could advance with the times and develop their competitiveness by applying suitable supply chain inventory management model.

Based on above consideration, the study of GeN Garment inventory problems has theoretical and practical significance. Due to the characteristics of apparel products, it is impossible for the individual enterprise alone to achieve the goal that reducing the inventory while maintaining the agile response to the market. Apparel industry is a comprehensive industry which requires to set up a complete and highly efficient supply chain management systems which links fiber production plants, clothing manufacturers and the market retailers. The Academic Alliance Forum suggests that the traditional competition of company versus company is changing toward a business model where supply chains compete against supply chains [25]. The idea is also applicable to the competition between the apparel enterprises and inventory management is one of the core elements for apparel enterprise's Supply Chain Management. Considering the intense market competition and serious existing inventory problem, GeN Garment needs to take measures, combined with supply chain management philosophy, to realize the optimization of the inventory. What model should GeN take? How does it control its inventory? That is the research purposes of this article. Main research context includes:

1. Investigate the research and application at home and abroad of supply chain inventory management and try to understand common problems existing in the supply chain inventory management and common supply chain inventory management strategies;

2. Based on the supply chain inventory management theory, we will put forward supply chain inventory optimization strategy for GeN according to its characteristics and situation;

3. We will classify GeN Garment's clothing product and establish inventory optimization model based on supply chain management theory. Meanwhile, we also

give the detailed analysis and design to this model.

The paper is organized as follows. Chapter 2 introduces the basic theory of supply chain inventory management (SCIM) including the problem in SCIM. Chapter 3 analyzes the GeN Garment's SC inventory. Chapter 4 and Chapter 5 give the solution to GeN Garment for its SC inventory management. It chooses the strategy and optimization model for GeN according to its business conditions. We use the grey model for the stochastic demand of clothing products and Three Cubed Curve Forecast Model for Seasonal Demand of Clothing Products.

Chapter 2 Basic theory of supply chain inventory management (SCIM)

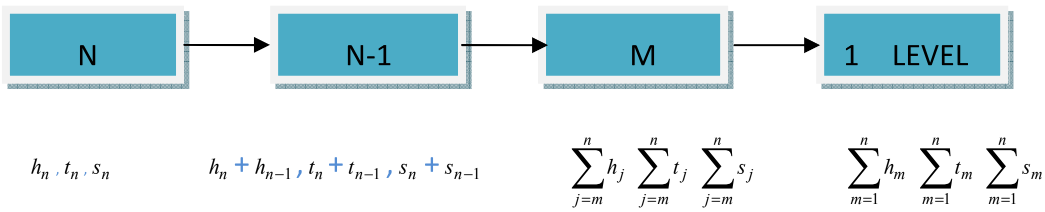
2.1 Characteristics of supply chain inventory management (SCIM)

Compared with the traditional inventory management, supply chain inventory management has some differences in the management philosophy and management performance evaluation methods. Traditional enterprise inventory management determines the optimal ordering quantity simply from the perspective of optimizing its own inventory cost and ordering cost. In contrast, supply chain inventory management is not only related to a number of internal enterprise departments but also many other external enterprises. It extends management functions from one particular enterprise to the enterprises in the upstream and downstream of the whole supply chain. Some traditional inventory control models and inventory management strategies need to be improved to keep up with the times. Generally speaking, supply chain inventory management has the following characteristics:

1. The goal of SCIM is to pursue of the overall supply chain inventory optimization. Considering the holistic and systemic characteristics, we can see that SCIM pursue the entire supply chain benefit. Therefore, coordinating inventory management activities among the knots instead of pursuing single one's lowest cost is the point to minimize the whole supply chain inventory cost.

   The supply chain inventory cost model is shown in Figure 2.1

Figure 2.1 Accumulation of supply chain inventory cost



In Figure 2.1, h_n , t_n , s_n respectively represents n-level inventory's unit inventory maintenance costs, transaction costs and shortage cost. $\sum_{j=m}^{n} h_j$ $\sum_{j=m}^{n} t_j$ $\sum_{j=m}^{n} s_j$ respectively represents accumulated inventory maintenance costs, transaction costs and shortage cost from n-level to m-level.

Then the supply chain inventory cost includes [26]:

(1) Inventory maintenance cost (c_h): Inventory maintenance cost is used to maintain a certain level stock at each stage of the whole supply chain which is in order to ensure continual production. It consists of the cost of capital, inventory, equipment depreciation, tax, insurance and so on. We assume h_m as unit inventory maintenance cost and v_m as the m-level inventory level. Thus, inventory maintenance cost $c_{hm} = h_m * v_m$ and the whole supply chain maintenance inventory cost $c_h = \sum_{m=1}^{n} h_m v_m$

(2) Transaction cost (c_t): Transaction cost refers to various costs which happen in the transaction process among supply chain cooperative enterprises, including price negotiation cost, order preparation cost,

commodity inspection fee, commission, etc. Transaction cost is determined by the cooperative relationships among the enterprises so that the strategic partnership allows the supply chain members to enjoy the lowest transaction costs. We assume c_{tm} as the transaction cost for m-level enterprise, then the whole supply chain transaction cost $c_{t'} = \sum_{m=1}^{n} c_{tm}$

(3) Shortage cost (c_s): Shortage cost is due to market opportunities losses and reparations which are caused by the short supply, that is, inventory is less than zero. Shortage cost is related to the inventory level, which means the larger stock the lower shortage cost and vice versa. In order to reduce the shortage cost, it is necessary to maintain a certain inventory level. But too much inventory will increase maintenance cost. In the multi-level supply chain, Information sharing and enterprise coordination is a good way to balance these costs. We assume c_{sm} as the shortage cost for m-level enterprise, then the total supply chain shortage cost $c_s = \sum_{m=1}^{n} c_{sm}$

In summary, the total supply chain inventory cost $T_c = \sum_{m=1}^{n} (c_{sm} + c_{hm} + c_{tm})$ and the optimal objective $Min(T_c) = Min[\sum_{m=1}^{n} (c_{sm} + c_{hm} + c_{tm})]$

2. Information sharing provides a powerful support for supply chain inventory management

The development of modern information technology ensures more efficient supply chain inventory management. As we mentioned before, if we hope to control the supply chain inventory from the overall perspective, we need to strengthen information sharing so that all nodes of the supply chain can obtain unified market information. Global supply chain information system based on internet and EDI technology provides a guarantee for rapid inter-enterprise messaging [27].

With the wider use of internet and EDI, each company on the supply chain can access to market information on customer demands. Information transmission is no longer in a linear way but in the way of transmission network and multi-source feedback. This information technology system generates several advanced techniques and models for inventory management.

3. The relationship among the supply chain nodes is not only the supplier and buyer but also strategic and cooperative one. It is necessary to have the mutual trust to ensure such relationship stable. Meanwhile, legal means also plays a very important role in such relationship.

2.2 Supply chain inventory control policy

Supply chain inventory control is one of the important parts of supply chain management. The task of supply chain inventory control is not just a simple demand forecasting and replenishment but optimizing profits for enterprise and better service for customer. At present, the main problems for supply chain inventory management are as follows: (1) information problem (2) operational problem (3) supply chain planning and strategy problem

In response to these problems, a number of advanced supply chain inventory management techniques and methods are introduced in the academic study and three of them are very popular, that is, vendor-managed inventory (VMI), joint managed inventory (JMI) and cooperative planning, forecasting and replenishment (CPFR)[28]. All the three policies are intended to reduce supply chain costs and improve supply chain competitiveness.

2.2.1 Vendor managed inventory (VMI)

Vendor managed inventory is a kind of cooperative inventory control method that appears between suppliers and buyers. In this way, supplier manages buyer's inventory with consensus so that they can minimize their overall inventory costs, In addition, in order to have continuous improvement, the supplier needs to regularly monitor and revise its operations.

In short, the main idea of VMI is that the supplier implements integrated inventory management for its downstream buyer. After given the permission and support from the buyer, supplier establishes inventory, determine inventory levels and replenishment strategy. The buyer needs to transfer any information on the change of the market demand to the supplier, which is the basis for the supplier to decide the prospective supply quantity. That is to say, the supplier has the right to manage and control buyer's inventory.

VMI strategy reflects principles of cooperation and mutual benefit thereby VMI can be used to reduce inventory, improve inventory turnover rate, maintain low inventories for both sides. By sharing market and inventory information, both sides can enhance their level of demand forecasting, replenishment planning, transport planning, etc.

VMI changes the traditional model that replenishment is generated by orders into the new model that replenishment is generated by actual or forecasting demand.

VMI's demand forecast and the automatic replenishment bring the enterprise superiority in such highly competitive market.

1. Types of VMI

VMI can be summed up in the following four types:

(1) Supplier provides buyer with all software products which buyer uses to implement inventory management decisions and buyer still have the inventory ownership. In this way, supplier's control to the inventory is limited and they have many constraints when involving in buyer's inventory management. So it isn't considered as vendor-managed inventory in essence.

(2) Supplier implements inventory decision-making on behalf of the buyer in buyer's location without the inventory ownership. Considering the inventory ownership does not belong to the supplier, supplier will have limited involvement in inventory decision-making.

(3) Supplier is in the buyer's location and on behalf of buyers to implement inventory management decision-making with inventory ownership. In this way, the supplier bears almost all responsibility for the activities without too much interference from the buyers. This model can be considered as a complete sense of VMI. Thus, suppliers will be very clear about the sales of their production and also be directly involved in sales activities.

(4) Supplier is not in the buyer's location but regularly sent staff there to implement inventory decision-making, manage inventory for buyer and supplier also has inventory ownership. Under this situation, supplier preserves inventory in the distribution centre or in the buyer's location so

that inventory can be replenished rapidly and well controlled by the supplier. According to the definition of VMI, only the third and fourth mode can be called VMI in essence.

2. Implementation steps for VMI

(1) Supplier and buyer negotiate together and reach a contract including inventory ownership, credit conditions, ordering responsibilities, information communication, performance evaluation (i.e. service performance, inventory level), etc.

(2) Supplier and buyer establish an integrated information system. In order to effectively manage inventory, supplier must be able to get the immediate information on the real demand of end-customer. Therefore, it is necessary to interface the retailers' POS system to supplier's information system to achieve real-time information sharing.

(3) Both sides determine related parameters and required information that is needed in the process of ordering and inventory controlling (e.g. the lowest inventory level). They also need to establish the standard for ordering (such as the EDI standard message) and integrate business functions such as ordering, delivery, and bill processing in supplier's information system.

(4) During the VMI implementation process, both sides need to work together to identify improvement areas in order to achieve continuous improvement.

3. The benefits and the problems of VMI

The benefits of the VMI are as follows:

(1) The upstream and downstream enterprises can have the close cooperative relationship and in that way of whole supply chain competitiveness is enhanced
(2) Bullwhip effect" can be reduced or well controlled
(3) The effective use of information technology helps to integrate information flow of internal and external business activities which improves the efficiency of the supply chain.
(4) It can reduce the uncertainty of demand forecasts
(5) The supply chain members take the risks and share the benefits together which is benefit to maintain a long-time cooperative relation among members.

In addition, it provides an opportunity to reorganize the relationship between supplier and buyer. For example, it eliminates redundant ordering departments and enables to realize the automation operations.

Of course, VMI inevitably brings some problems: the construction of information systems may cause the capital burden for the enterprise. Information sharing between buyer and supplier may result in the abuse of information and the leak of trade secret; supplier tends to bear more management responsibilities thus bears more capital burden. Therefore it needs to build a new reasonable mechanism for the distribution of benefits

4. the application scope of VMI
    (1) Supplier’s economy condition is well and has a strong capacity for inventory management and transportation.
    (2) Buyer’s inventory facilities are limited and buyer lack ability to manage inventory effectively.
    (3) Supplier and buyer have close cooperation.
    (4) only applicable to the cooperation between upstream enterprise and

downstream enterprise

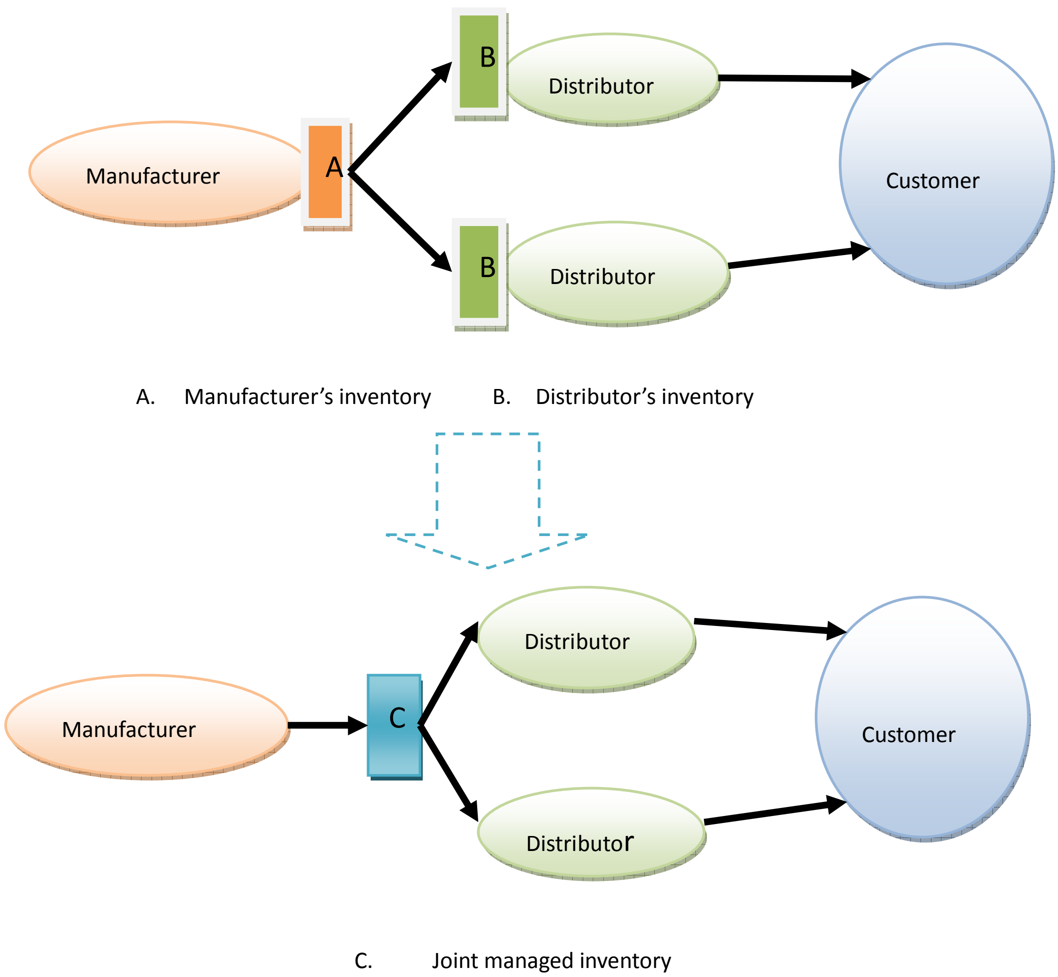
In short, VMI model transfers the inventory cost to supplier so the downstream enterprise must farm out parts of vested interests to the supplier as compensation otherwise the supplier will not have an interest in VMI.

2.2.2 Joint managed inventory (JMI)

1. Concepts of JMI

   JMI advocates the coordinative relationship among each node of the supply chain and it requires each node on the supply chain to participate in the inventory planning and management. In the management process, each node considers its inventory management from the coordinative perspective to ensure demand forecast result is a meeting of minds with the neighboring nodes. Thus, the bullwhip effect can be relieved. Any identification of demand is the result of coordination between supply and demand nodes, that is to say, inventory control is no longer any node's independent operations but the link of the supply and demand sides (as shown in Figure 2.2).

Figure 2.2 Joint managed inventory policy



2. Advantage of JMI

Joint managed inventory policy requires suppliers and buyers to share resources to each other. Compared to the traditional inventory management, its main advantages are:

(1) It provides the postulate to achieve synchronization of the supply chain operation

(2) It reduce inventory uncertainty and enhance the stability of the supply chain

(3) Inventory can be considered as a bond to for suppliers and buyers to exchange information and coordinate with each other which make it possible to expose deficiencies in supply chain management. That provides a reference frame to improve supply chain management.
(4) It reflects the supply chain management principle--- sharing resource as well as sharing risk.

3. The implementation of the JMI

As an innovative management model, JMI emphasizes to establish a coordinative management mechanism between among the supply chain nodes which is the premise for the effective implementation of the joint managed inventory.

Joint managed inventory policy contains the contents of four aspects

(1) All the parties need to stand to the principle of mutual benefit and mutual cooperation when establishing JMI.
(2) All the parties should clearly define the related parameters for inventory optimization, including safety stock level, demand forecast method , how to distribute inventory among a number of buyers, etc.
(3) Participants need to build up channels for information exchange so as to ensure the inventory information accuracy.
(4) Establish a fair mechanism for distributing benefits to incent multi coordination.

4. The application scope of JMI

(1) The participants have the similar economic capacity.
(2) JMI is not only suitable for the enterprises on different supply chain levels but

also applicable to the enterprises on the same supply chain level

However, JMI only coordinate inventory management of the adjacent nodes on the supply chain and just realize partial optimization to the multi-level supply chain. If we hope to have a synergistic overall optimization for the supply chain inventory, we need better model.

2.2.3 Collaborative Planning, Forecasting and Replenishment (CPFR)

1. Principle of CPFR

Collaborative planning, forecasting and replenishment policy (CPFR) is a new kind of collaborative supply chain inventory management technology which emerged in the end of the 1990's. This model evolved from VMI and JMI, retaining some of their advanced management ideas meanwhile overcoming their shortcomings. It is the trend of inventory management development.

Precisely, CPFR is a philosophy, covering the whole supply chain by a wide range of technology application. It improves the partner relationship among the buyers and suppliers through joint management of business processes and information sharing which may result in higher forecast accuracy, lower inventory and higher end-customer satisfaction.

CPFR's greatest strength is that it can timely and accurately forecast the sales peak and volatility which is caused by the promotions or other abnormal reasons so that suppliers and buyers can be fully prepared to the market change in advance. CPFR always considers from the overall point of view and regard supply chain inventory management as the core element to realize the “win-win” goals.

CPFR usually firstly establishes a program group whose members comes from the strategic partners. This group will decide which company presides over the core operational activities according to the ability to deal with the key supply chain business. Manufacturers and retailers collect data from different perspective and different level and repeatedly exchange business data and information. Eventually, the group gets the unique demand forecast result mainly based on the POS records and some other data collected by the members. The forecast result is the foundation of all the group internal planning activities for the supply chain members. Thus, it makes supply chain integration achieved.

2. CPFR implementation process

CPFR implementation process is shown in Figure 2.3 which can be divided into three stages, including nine steps[29]. The first stage is planning, including the steps ① and ②; The second stage is forecasting, including the steps ③ - ⑧; The third stage is supply and replenishment, including the steps ⑨.

Tabel 2.1 CPFR implementation process step

Stages	Step No.	Content	Process	Output
Planning	1	Reach preparatory cooperation agreement	Make guidance documents and establish operating rules to identify cooperative relationship among manufacturers, distributors and retailers.	Work out an agreement complied with the CPFR standards and identify the duties and obligations of different parties.
	2	Establish business cooperation	Partners exchange corporate strategy and business plan with each	Develop a business plan and clearly define strategies, specific

		plan	other so as to effectively reduce the exceptions	implementation measures, including the minimum production quantity, production rate, lead time, etc.
Forecasting	3	Establish sales forecast system	Collect POS data, real-time information and plan event information and then establish sales forecasts system	Manufacturers and vendors make sales forecast report together
	4	Identify exceptions to the sales plan	Manufacturers and distributors identify exceptions to the sales plan together	List of exceptions to the sales plan
	5	Cooperate to handle the exceptions	Resolve the exceptions by sharing data, e-mail, telephone, meeting, etc.	Amend the sales forecasts report
	6	Create order forecast system	Order forecast is based on the POS data, inventory data and inventory strategy. The actual quantity of orders changes over time and need to reflect the inventory level.	Time-based order forecast report and safety inventory

	7	Identify exceptions to the order forecast	Manufacturers and distributors identify exceptions to the order forecast together	List of exceptions to the order forecast
	8	Cooperate to handle the exceptions	Resolve the exceptions by sharing data, e-mail, telephone, meeting, etc.	Amend the report on order forecasts
Supply & replenishment	9	Generate order	Convert forecast orders into the confirmed order and replenish the inventory	Confirm receipt of orders

3. Application scope of CPFR

There is a close strategic partner relationship among the node enterprises and a good information platform as well as a supply chain collaborative labor division system. With the further formation of enterprise alliance, CPFR will be the trend for inventory management.

2.3 Chapter summary

This chapter systematically introduce the basic theory of the supply chain inventory management, especially focus on three typical policies of inventory control: Vendor managed inventory (VMI), joint managed inventory (JMI) and collaborative planning, forecasting and replenishment (CPFR). In the following chapter, we will discuss inventory management of Gen Garment Co. in detail.

Chapter 3 Analysis of GeN. Garment Co.'s supply chain inventory management

GeN Garment Co. Ltd was founded in 1995 and its headquarter is now located in Shanghai. It has about 1,200 employees and has relatively complete set of clothing and ironing equipments. GeN Garment has its own brand and own design department, planning department and manufacturing factory. It mainly produces women clothing, including suits, casual wear, underwear, etc. In the domestic market, GeN has built a huge marketing network and sells its product in 98 retail outlets in more than 20 provinces and its annual income reaches 105 million in 2008.The company has its own home page which is used to introduce the company and dealing with the online business. It also has the internal network. However, GeN communicates its suppliers and distributors primarily through phone, fax, express delivery and E-mail.

3.1 Characteristics of the apparel market

In clothing market, it is basic characteristics to make lean and agile response to customer demand. Time has become the criteria for apparel market competition. It is a big challenge for marketing department and logistics department to shorten product development time, speed up the response to market information and reduce the supply and replenishment time. Here, characteristics of clothing products can be summed up in five aspects.

1. Short product life cycles

   Apparel products life cycle is usually transient. Sales are often in a very short time, only 3 months or so, some even a few weeks.

2. Volatile consumer demand

   Consumer demand for apparel products is rarely stable or linear. It may be affected by the climate, promotion activities, etc.

3. Difficult to forecast consumer's demand

   Due to volatile changes in demand, it is difficult to forecast demand accurately.

4. Impulse purchase for apparel consuming

   The purchase decision to buy apparel products usually takes place at the purchasing point.

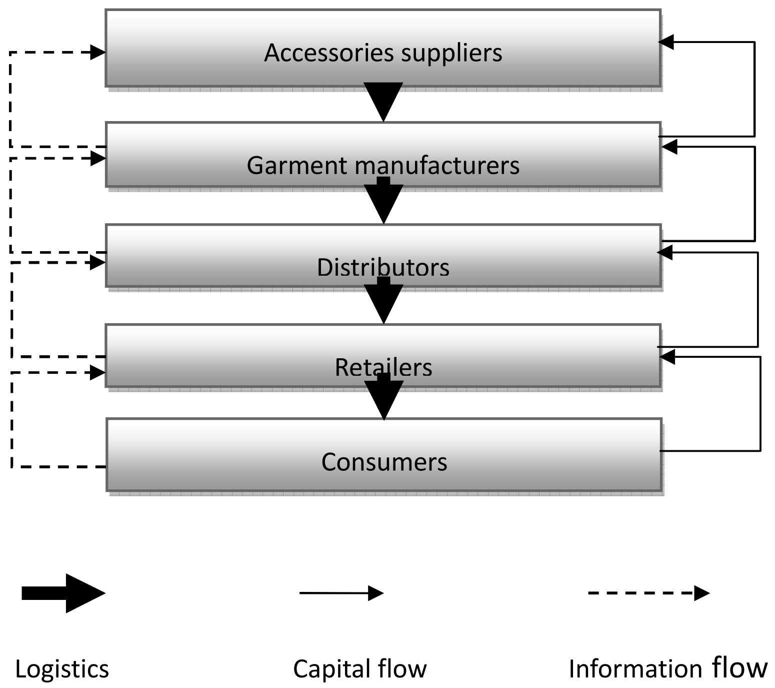
5. Serious imitation in apparel market

   There is no patent for clothing style, so imitation is very common and relatively easy in this industry. If the new product doesn't occupy the market quickly, apparel enterprise will easy to lose advantage.

3.2 Composition and structure of GeN Garment's supply chain

GeN Garment's supply chain includes accessories suppliers, garment manufacturers, distributors, retailers and end consumers. Their relationship is shown in Figure 3.1.

Figure 3.1 Traditional supply chain relationship in clothing



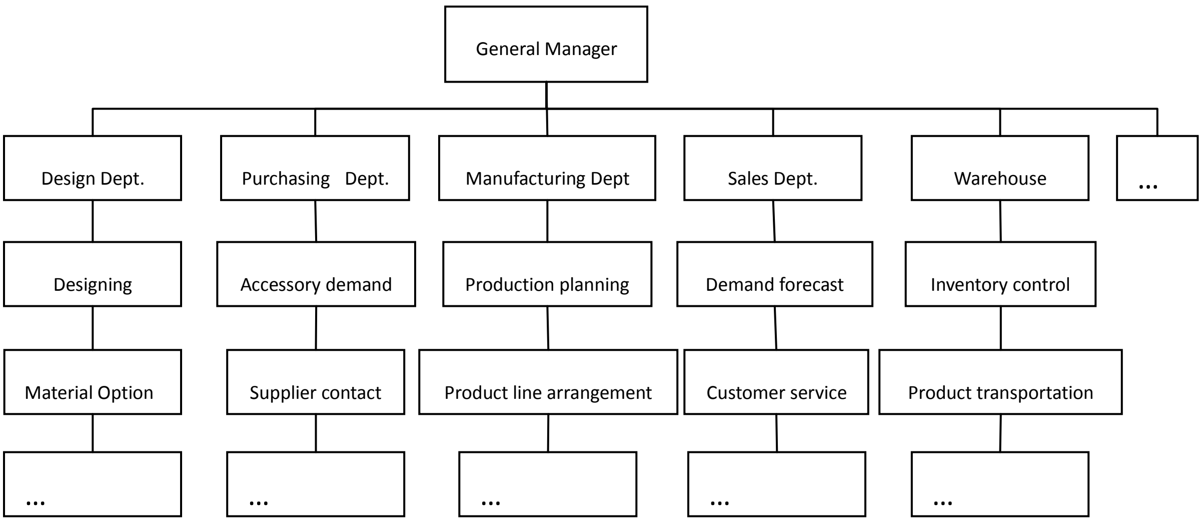
In this supply chain, accessories suppliers are in charge of manufacturing and providing accessories to the garment manufacturer. GeN Garment, as the garment manufacturer and the owner of the apparel brand, links the whole supply chain and become the core of the supply chain. Then the core enterprise builds its own market channels through franchise or self-owned retail outlet. Distributor means franchiser who joins this supply chain by franchise and set up cooperative relationship with the core enterprise. Distributors set up franchised store and have the management responsibilities. In this supply chain, all the information is transmitted level by level, which results in not only a long transmission line but also slow transmission speed. Distributors give the orders according to their own forecast and then GeN. arranges its production according to these orders. So the garment manufacturer GeN has only a little direct information about the retailer market.

This supply chain not only includes the movement of products from the manufacturer to their customers, but also the information flow and capital flow, which is particularly important among the supply chain members. Thus, successful supply chain management is a seamless process to coordinate all these activities and members.

3.3 GeN's internal organizational structure

GeN now has the organizational structure as follows:

Figure 3.2 GeN Garment's enterprise organizational



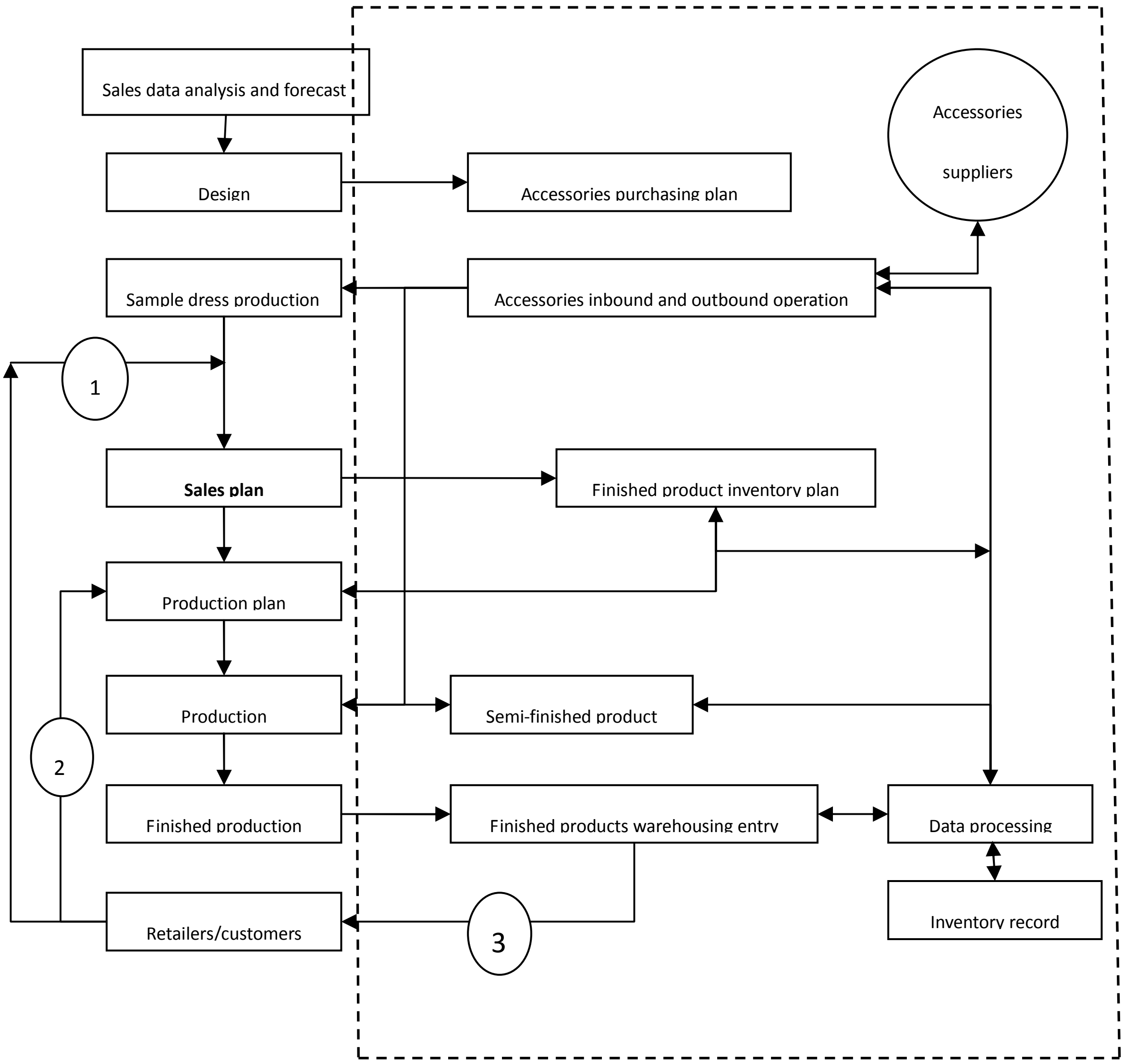
(Resource: GeN Garment Co.Ltd)

Such structure makes different departments relatively isolated and one complete business will be fragmented into pieces due to different departments involving which may increase the waiting time when handing over the task from one department to another.

3.4 Problems existing in GeN's inventory management

Nowadays apparel manufacturer must have agile response to the market. In this situation, it is general trend to use the supply chain management philosophy to control inventory reasonably. However, GeN's inventory management model can't meet current situation that result in a number of serious inventory problems. The GeN's operational process is shown in Figure 3.3:

Figure 3.3 Operation process and inventory management of GeN Garment



1. Confirm the ordering style and quantity
2. Additional orders
3. Delivery

The inventory management content is in the dashed framework

(Resource: GeN Garment Co.Ltd)

I. Irrational production plan

GeN has simple inventory strategy, that is, one-time procurement of accessories and mass production, which may bring high risk to GeN. According to the investigation, in the beginning of a new quarter, majority of GeN's seasonal garment products have been listed, which accounts about 90% for all the pre-sale products. If market doesn't have expected response for some reasons, such as the unexpected weather or low acceptability to new design style by customers, then a large quantity of products will be unsalable in retailers and then become the backlog.

II. Lack of collaboration between enterprises

GeN. has weak collaboration with its suppliers and retailers . It has blurry information about its supplier's production capacity and distributors' sale and inventory status. It never communicates with its retailers to implement demand forecasts. Sometimes it will change the accessory supplier just considering the purchasing cost which will lose the trust and cooperation basis of the former suppliers.

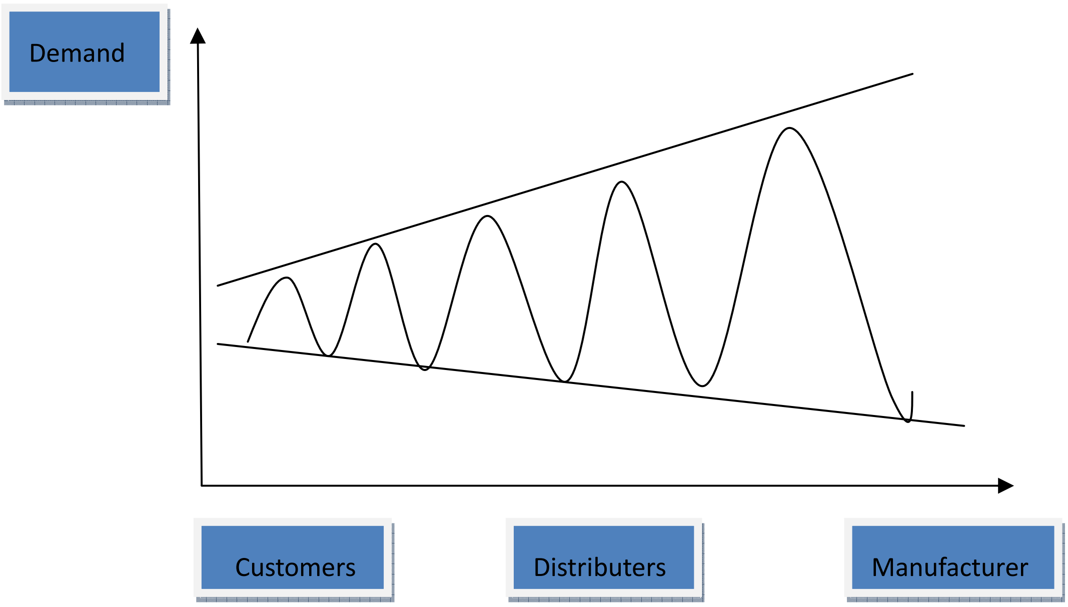
III.Inefficient information system

In GeN Garment, the support of information technology is still imperfect. It uses computer system to manage the business, but still in the initial stage. It sets up the internal network linked to the headquarters, which to some extent improves the management level, but hasn't set up network connections with suppliers and distributors. As to the forecast and inventory plans, GeN usually uses its experience and historical data to make decisions instead of decision-making support software on forecasting and inventory control which may bring poor inventory management.

IV.Bullwhip Effect

When enterprise implements its demand forecast and production plan solely according to the information from its adjacent upstream and downstream enterprise on the supply chain, the demand will lose the authenticity and be amplified along the supply chain upstream. This phenomenon is called “bullwhip effect”[30]. Considering the "bullwhip effect", the upstream suppliers are required to have higher level inventory management capability than the downstream enterprise. "Bullwhip effect" is shown as follows:

Figure 3.4 Bullwhip effect



Since GeN doesn’t set up well information network with its partners in the supply chain, it suffers bullwhip effect which brings great harm to the inventory management and causes additional purchasing costs, producing costs, warehouse costs and other costs.

V. Lack of standard supply chain inventory management performance evaluation system

Considering the continuous development of supply chain management, it is required to establish a corresponding supply chain performance evaluation method and the appropriate criteria to reflect the supply chain operation performance. Through the investigation we find that GeN has its own internal evaluation methods and standards, most of which are qualitative instead quantitative. That is to say, the evaluation system is relatively non-systematically.

3.5 Chapter summary

Inventory control performance will have a great impact on the garment business. Supply chain management helps the garment enterprises have agile response to the market and meet the market demand. Besides, it is also favorable to avoid backlog and reduce the inventory.

However, through the investigation we found that GeN Garment's inventory management is not suitable to supply chain management philosophy, which leads to serious inventory control problem. Therefore, how to change GeN Garment's unreasonable management model by learning from excellent supply chain inventory management model is the issue that GeN needs to be addressed urgently.

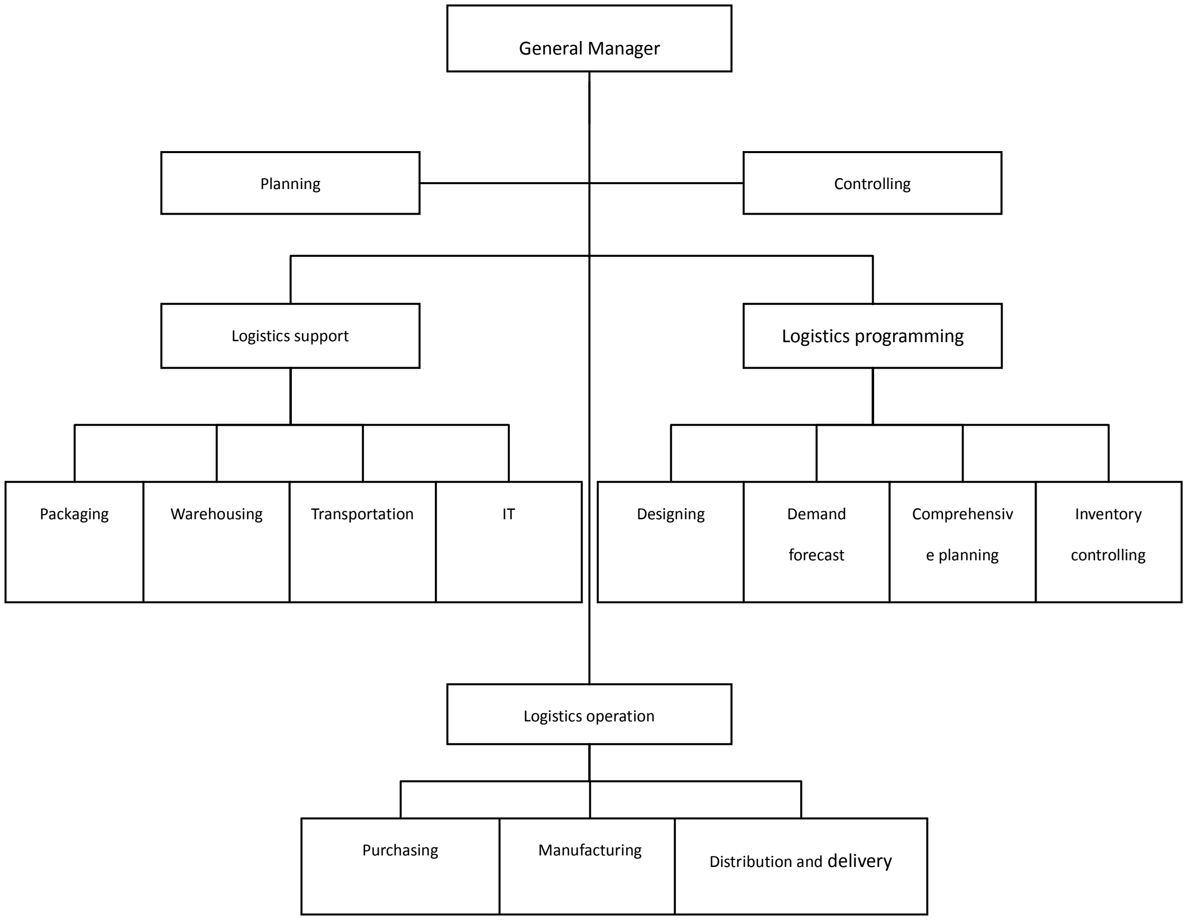
Chapter 4. Supply chain inventory management strategy for GeN Garment

This chapter is to solve the inventory control problem by using supply chain management theory combined with the situation of GeN Garment and the characteristic of the clothing product.

4.1 GeN internal organizational structure optimization

In order to achieve higher efficiency, we suggest GeN to implement team management to break the isolation among the departments. We can establish integrated logistics planning team by linking various departments of designing, technology, procurement, production, sales and warehouse. The team is composed of key personnel of different department, who will cooperate to make a unified operational plan. It is a communication channel and an effective way to avoid the conflict among the departments. Such organizational structure is flexible and adaptable and many works can be dealt in parallel so as to substantially reduce the new products development period and have agile response to the market, which is an effective way to reduce inventory. New enterprise organizational structure after the reorganization is shown as follows:

Figure 4.1 GeN's new enterprise organizational structure after the reorganization



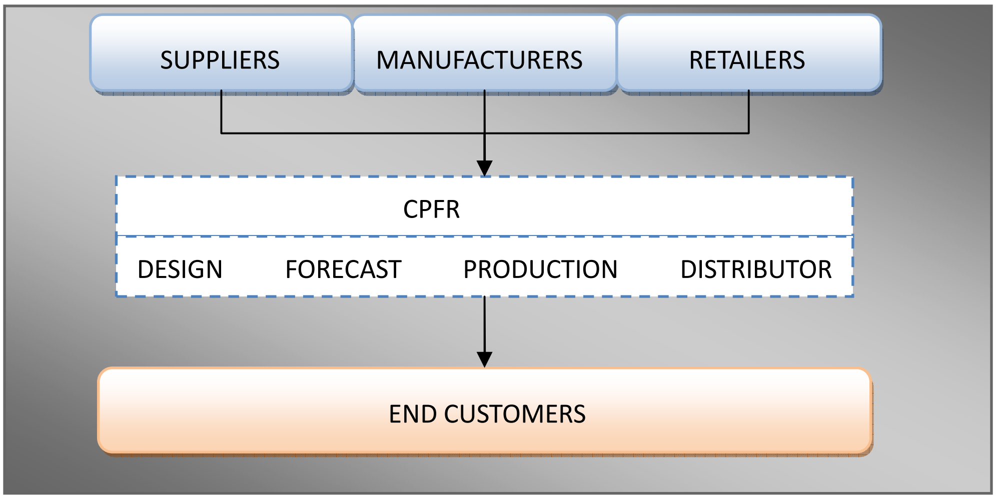
4.2 The supply chain inventory control policy for GeN Garment

With the supply chain management philosophy, GeN Garment should break the traditional management way----self-centered, self-design and self-forecast. It should establish closer collaboration with accessories suppliers, distributors and retailers to ensure smooth and open information communication. More importantly, GeN Garment needs to use a suitable inventory control model to optimize the traditional inventory so as to reduce inventory as much as possible.

When GeN Garment forecasts the demand or designs clothes style, it had better communicate with accessories suppliers, distributors and retailers thus let all nodes of supply chain involve in: what kind of style to design? What about the quantity of apparel production? When to purchase the accessories? How to distribute the cost due to the inter-enterprise cooperation? etc.

Considering that all nodes of the supply chain need to involve in the inventory management, Collaborative planning, forecasting and replenishment model (CPFR) is recommended to GeN Garment for its inventory management. Through collaborative management and information sharing, GeN will improve the relationship with upstream and downstream enterprises. It will also enhance the forecast accuracy and then reach the ultimate goal that reduce inventory and improve supply chain efficiencies as well as customer satisfaction.

Figure 4.2 GeN Garment's CPFR policy



With the development of the market, GeN Garment gradually realizes garment business tends to have the "multi-species, low-volume" characteristics. However, since there is no guidance, GeN still implements one-time mass procurement and mass production and then adjust the production quantity according to actual market demand.

This paper is to set up a forecasting and inventory optimization model in view of the characteristics of garment products.

4.2.1 Feasibility analysis of CPFR to GeN Garment

According to the analysis of GeN Garment's situation and the characteristics of CPFR, we can find that CPFR is comparatively effective inventory control strategy for GeN Garment Co. In this section, we will discuss the feasibility of CPFR for GeN Garment from three perspectives, that is, the availability of data, technical feasibility and economic feasibility.

(1) Availability of data

The successful implementation of CPFR needs a number of inter-enterprise data sharing, such as business plans, marketing plans, new product promotion plans, inventory level, lead-time, replenishment. Whether the obtained data is true and reliable is the critical factor that needs to be considered. If the supply chain members have the willingness and capability to cooperate, then the reliable and feasible data tends to be accessible.

(2) Technical feasibility

The prerequisite condition of technical feasibility is also the willingness and capability to cooperate. It doesn't need too complicated technology in the initial stage of CPFR implementation, so the enterprise needn't worry too much about the initial technical investment. With the gradual deepening of CPFR, enterprise then needs to input more investment to update the information systems to keep up with the market development. Nowadays there have existed such information systems and many consulting firms have put forward practical solutions, which provide the technical support for GeN Garment.

(3) Economic feasibility

From economic point of view, many enterprises mostly worry about excessive investment, particularly the investment on information technology because they fear the probable failure will bring enormous economic losses. However, as mentioned earlier, the key element of successful CPFR lies in the willingness and cooperation among the participants. So at the beginning of the implementation of CPFR, the investment on technology is acceptable.

To sum up, as long as the supply chain members have the willingness and capability, it is worthy for GeN Garment to implement the CPFR.

4.2.2 Application of CPFR to GeN Garment

4.2.2.1 Application of CPFR in apparel industry

CPFR was originally widely used in the retail industry and achieved good results. Subsequently, on Wal-Mart's initiative, especially after the CPFR guidelines was published by VICS of the United States in 1998, CPFR concept has gradually influenced other industries, including apparel industry, automotive industry and high-tech industries. They began to use CPFR to improve enterprise performance and CPFR has the increasing impact on the enterprise basic management model, which to some extent proves that CPFR tends to be the mainstream in today's supply chain management [31].

The core idea of CPFR is coordination mechanism, information sharing and mutual trust. Under the guidance of this concept, supply chain enterprises could establish the strategic partnership that ensure a high degree of information sharing which is the premise to develop business plans, forecasting and replenishment. Thereby

CPRF can enhance the forecast accuracy, reduce inventory cost and finally improve the enterprise's core competitiveness.

GeN Garment's inventory management problem is mainly caused by competitive pressures from the market. It has to expand its inventory to avoid shortage which easily loses customers. In the long run, it is not conducive to for growth of GeN Garment. GeN Garment needs to study the way how to reduce their inventories in the case of lower shortage rate and higher services level and more agile response to customers. CPFR is a business solution for GeN. It requires enterprise to re-examine existing business processes, and turn to establish a good relationship with the upstream and downstream business partners to achieve supply chain optimization.

CPFR provides supply chain integrated programs from three aspects, i.e. planning, forecasting and replenishment. It fundamentally changes the GeN Garment's dependent role into a strategic partner in the whole supply chain.

4.2.2.2 Implementation steps of CPFR for GeN Garment

We have mentioned the implementation steps of CPFR in chapter II, from which we can find CPFR should be gradually implemented step by step combining with the actual situation of enterprises and the implementation effect of CPFR. This section will present the CPFR implementation in GeN Garment based on its actual information technology level and inventory management level.

(1) Small-scale pilot run

Considering CPFR is a relatively new concept, it is necessary to conduct a pilot run in the enterprise which can avoid great losses caused by one-time large-scale investment. If pilot run successes, it can display CPFR effectiveness to organization staffs so that future resistance possibility to the new system can be reduced.

(2) CPFR expansion phase

After the first phase, appropriate adjustments should be taken according to the pilot run's implementation result and expand CPFR policy to other departments as well as supply chain upstream and downstream enterprises. Thanks to the experience of pilot run, the staffs have begun to understand the new concept. Thus GeN can invite more cooperation partners so that the enterprise can obtain greater results.

(3) ERP preparation phase

These years GeN has invested a lot on the construction of enterprise information system. However, some IT models are not developed on a unified platform, resulting in the low IT efficiency and barrier for information sharing. In this phase, GeN needs to achieve the integration of internal business IT systems, which contains:

① adjust the Group's internal business systems. Analyze the data of existing human resources management, financial management, equipment management, quality management, material inventory, sales management, production management to achieve the goal that the business data can be shared in a unified information management system.

② Integrate the business information systems as the preparation for the subsequent implementation of the ERP system

(4) Expanding ERP system phase

In this phase, GeN needs to select and set up cooperation relationship with its accessories suppliers and build accessories purchasing model in the ERP system.

(5) Expanding vertical sales management phase

GeN should integrate information flow of its physical sales channels by expanding its ERP system to the distributors and retailers vertically so as to form the enterprise sales and after-sales service system. Meanwhile, GeN also needs to put the logistics and distribution network into its ERP system.

(6) Building strategic partnership phase

In the preparation stage GeN should select potential suppliers and distributors and then actively invite them to participate in supply chain as strategic partners. It also needs to gradually change the information communication way from email, fax into inter-enterprise information integration. Strategic partners eventually reach "win-win" by establishing the good mechanism.

4.3 Chapter summary

This chapter introduced CPFR's applicability to the apparel industry and recommended CPFR as the supply chain inventory management strategy for GeN Garment as well as CPFR implementation steps in GeN. The collaborative forecast and inventory control model will be discussed in detail in the following chapters.

Chapter 5　GeN Garment's supply chain inventory optimization

In order to adapt to today's ever-changing demand of apparel products and avoid high risk of one-time procurement and production, GeN Garment should establish forecast and inventory distribution model according to the characteristics of apparel product so as to get the best inventory control programs.

5.1 Product category

There is a wide range of apparel products, such as suits, shirts, underwear, denim, sportswear and so on. However, when GeN manages inventory, it rarely manages based on characteristics of clothing but according to the experience, which easily results in substantial inventory backlog or shortage. If the enterprise forecasts demand and controls inventory in accordance with the category characteristics, it may be an effective way to solve the inventory problems.

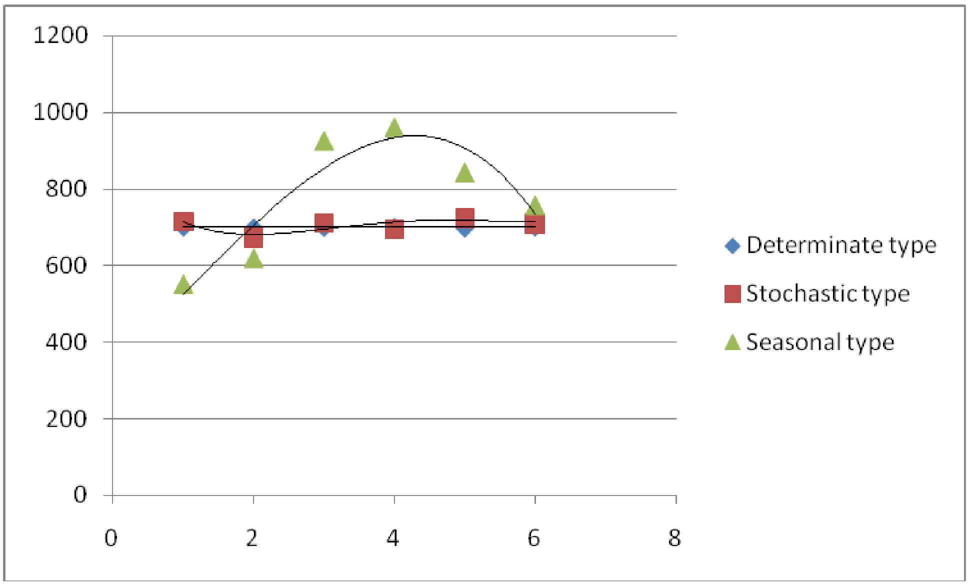
According to the main parameter of the model-— the demand, garments can be divided into three types----Determinate type, stochastic type and seasonal type[32]

(1) Determinate type, the demand of which changes little in a period of time. In other words, the demand is can be considered as a constant, e.g. the underwear.

(2) Stochastic type, the demand of which is random fluctuated around a constant. In addition, some parameters' random fluctuation, such as transportation and purchase, also will influence the determinate type. Stochastic type is more suitable for the practical situation. If random parameters are taken into account, the error will be smaller and we can get more accurate forecast result.

(3) Seasonal type, mainly for seasonal clothing, which refers to the garments which experience the whole life cycle, from the growing period to the peak and then a gradual decay (as shown in Figure 5.1), such as fashion clothes, swimsuit. The seasonal type model has broad applicability for most apparel products.

Figure 5.1 Garment product category



5.2 Demand forecast model

In enterprise inventory management, it is an effective way to solve inventory problems by improving the accuracy of the inventory data. However, if it is assumed as the purpose of inventory management, it is wrong. In fact, we should deal with inventory problem starting from demand forecasting. The start point for the enterprise is consumer's demand and the outcome is consumer satisfaction. Any change in the beginning of the supply chain will lead to significant changes in the end, which reflects importance of consumer's demand forecast.

There are many forecasting models and each model has a certain degree of applicability. After a variety of model comparison, we find gray model and three cubed curve forecast model are very effective for clothes demand forecast. Gray model has the advantage that it need less data, easy and simple collected but can get accurate result. It can be used for the determinate type as well as the stochastic type. It can simulate relatively stable economic development. The demand for seasonal apparel products may differ a lot, but it has the life cycle. We can use three cubed curve model to analyze the product's life cycle better than other forecasting model. Therefore this paper chooses the two forecasts models for different types of clothes.

5.2.1 Gray Model

Gray model is an effective approach and the most commonly used is the GM (1, 1) model[33]. We will use the model to forecast the clothing of stochastic type of GeN Garment. We take one style of GeN underwear (GeN sports series, black color) as an example. The weekly sale for this style underwear is shown in Table 5.1 as follows:

Table 5.1 Sales of GeN sports underwear (Black) in one week (Sep.21—Sep.27, 2008) (piece)

Day (i)	1	2	3	4	5	6	7
Sales $x^{(0)}(i)$	25	29	28	26	30	34	35

(Resource: Sales report of GeN Garment Co.Ltd, 2008)

Build gray model based on the sales data in table 5.1, the steps are as follows:

The first step: calculate $x^{(1)}(i)$

$$x^{(1)}(1)=\sum_{k=1} x^{(0)}(k)=x^{(0)}(1)=25$$

$$x^{(1)}(2)=\sum_{k=1}^{2} x^{(0)}(k)=x^{(0)}(1)+x^{(0)}(2)=25+29=54$$

$x^{(1)}(3)=\sum_{k=1}^{3}x^{(0)}(k)=x^{(0)}(1)+x^{(0)}(2)+x^{(0)}(3)$ =25+29+28=82

The same:

$x^{(1)}(4)$ =108, $x^{(1)}(5)$ =138, $x^{(1)}(6)$ =172, $x^{(1)}(7)$ =207

The second step: calculation

$\frac{1}{2}[x^{(1)}(1)+x^{(1)}(2)]=\frac{1}{2}(25+54)=39.5$

$\frac{1}{2}[x^{(1)}(2)+x^{(1)}(3)]=\frac{1}{2}(54+82)=68$

$\frac{1}{2}[x^{(1)}(3)+x^{(1)}(4)]=\frac{1}{2}(82+108)=95$

$\frac{1}{2}[x^{(1)}(4)+x^{(1)}(5)]=\frac{1}{2}(108+138)=123$

$\frac{1}{2}[x^{(1)}(5)+x^{(1)}(6)]=\frac{1}{2}(138+172)=155$

$\frac{1}{2}[x^{(1)}(6)+x^{(1)}(7)]=\frac{1}{2}(172+207)=189.5$

The third step:

$$A=\begin{pmatrix} -1/2[x^{(1)}(1)+x^{(1)}(2)] & 1 \\ -1/2[x^{(1)}(2)+x^{(1)}(3)] & 1 \\ -1/2[x^{(1)}(3)+x^{(1)}(4)] & 1 \\ -1/2[x^{(1)}(4)+x^{(1)}(5)] & 1 \\ -1/2[x^{(1)}(5)+x^{(1)}(6)] & 1 \\ -1/2[x^{(1)}(6)+x^{(1)}(7)] & 1 \end{pmatrix}=\begin{pmatrix} -39.5 & 1 \\ -68 & 1 \\ -95 & 1 \\ -123 & 1 \\ -155 & 1 \\ -189.5 & 1 \end{pmatrix}$$

$$B=\left(x^{(0)}(2)+x^{(0)}(3)+x^{(0)}(4)+x^{(0)}(5)+x^{(0)}(6)+x^{(0)}(7)\right)=\left(29 \quad 28 \quad 26 \quad 30 \quad 34 \quad 35\right)$$

The fourth step: calculate a'

$$a' = \begin{bmatrix} a \\ u \end{bmatrix} = \left(A^T \quad A\right)^{-1} A^T \; B^T$$

Put A , A^T , B^T into the Matlab program for calculation and get the result:

a ’= $\begin{bmatrix} -0.053 \\ 24.528 \end{bmatrix}$

That is $a = -0.053$, $u = 24.528$

The fifth step: solve the model

$x'^{(1)}(t+1) = (x^{(0)}(1) - \frac{u}{a}) e^{-at} + \frac{u}{a} = (25 + 462.8) * e^{0.053t} - 462.8$

Then the forecast model is $x'^{(1)}(k+1) = 487.8e^{0.053t} - 462.8$

The sixth step: test the model accuracy

Assume k=1, 2, 3, 4, 5, put the value into $x'^{(1)}(k+1) = 487.8e^{0.053t} - 462.8$, we can get the value

Table 5.2 Comparison between the original data and calculation result (Piece)

Original data	Calculation result
$x^{(1)}(2)$ =54	52
$x^{(1)}(3)$ =82	80
$x^{(1)}(4)$ =108	109
$x^{(1)}(5)$ =138	140
$x^{(1)}(6)$ =172	173
$x^{(1)}(7)$ =207	208

From the comparison, we can find that the maximum error is 2 pieces thus gray model forecast accuracy can be considered very high.

The seventh step: forecast

Then we can forecast sales data of the following seven days by the gray model.

Assume that k= 7, 8, 9, 10, 11, 12, 13, 14

$x'^{(1)}(8)$ =244, $x'^{(1)}(9)$ =283, $x'^{(1)}(10)$ =323, $x'^{(1)}(11)$ =366, $x'^{(1)}(12)$ =411, $x'^{(1)}(13)$ =458,

$x'^{(1)}(14)=508$

Table 5.3 Forecast sales of GeN sports underwear (Black) in one week (Piece)

Day (i)	8	9	10	11	12	13	14
Sales $x^{(0)}(i)$	36	39	40	43	45	47	50

5.2.2 Three cubed curve forecast model

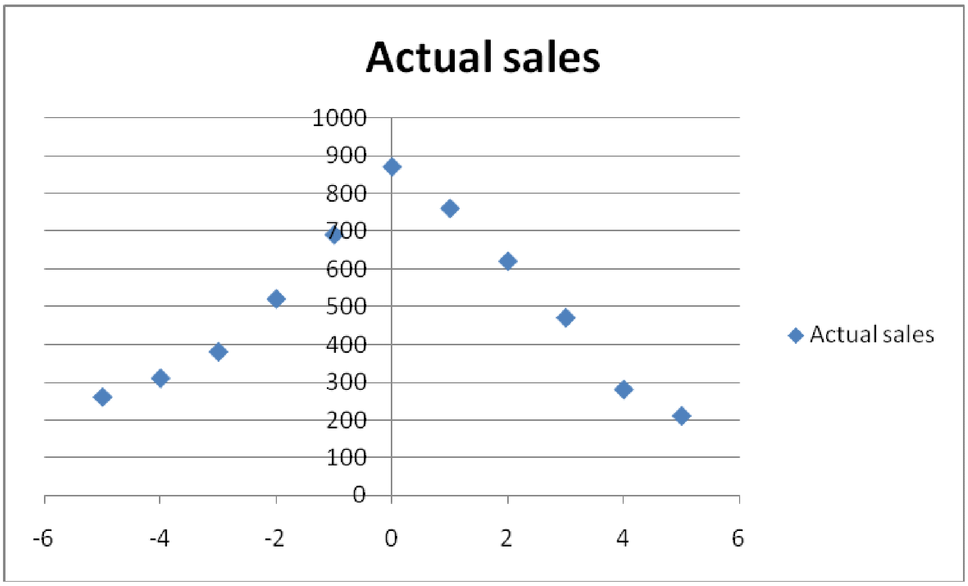
No matter the determinate type or stochastic type, their demand fluctuation rate is not very large. For seasonal garment, the product will experience a life cycle in the market. Although the garment sales are discrete random variables, the sale forecasts can be fitted as the sales curve and then be analyzed, which is the basis for inventory control model establishment. We take advantage of Excel to do this job. The following table shows sales of GeN's city life basic series wind coat (white) from Sept. to Dec. in 2008.

Table 5.4 Sales of GeN's city life series wind coat (white) of the 4th quarter in 2008 (piece)

Month	Sept.	Oct.				Nov.				Dec.	
Week	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd
No.	-5	-4	-3	-2	-1	0	1	2	3	4	5
Actual sales	260	310	380	520	690	870	760	620	470	280	210

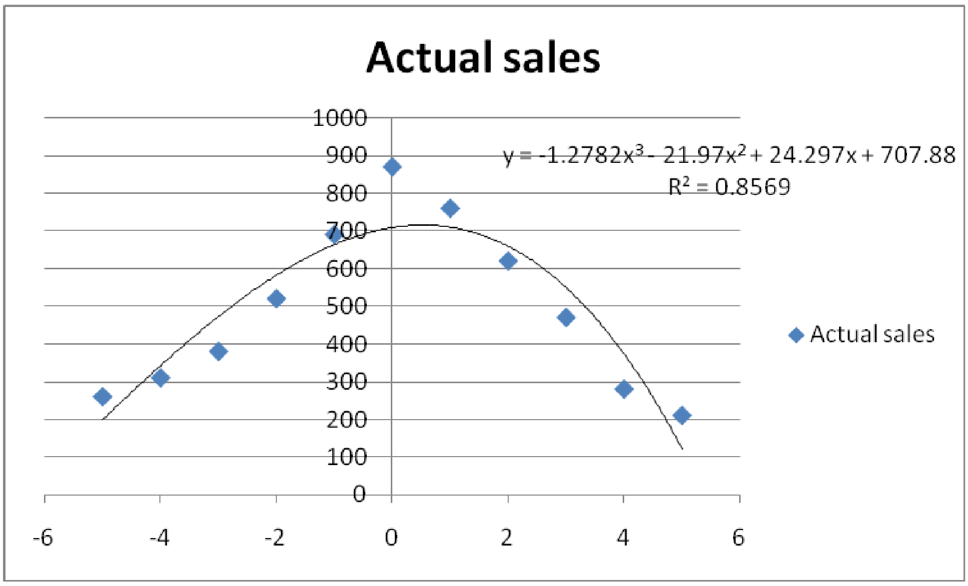
(Resource: Sales report of GeN Garment Co.Ltd, 2008)

Figure 5.2 Sales of GeN's city life series wind coat (white) of the 4th quarter in 2008 (piece)



We use the Excel to get the sales curve: $y = -0.1278x^3 - 2.197x^2 + 2.4297x + 70.788$, which can be considered as three cubed curve forecast model

Figure 5.3 Three cubed curve forecast model



At the same time, we need to take sales growth rate into consideration when implementing the sales forecasts. (Sales growth rate= this year's sales/ last year's sales)

Table 5.5 Sales of GeN's city life basic series wind coat (white) in 2007 & 2008 (Piece)

Year	2007	2008
Sales	1836	2201

(Resource: Sales report of GeN Garment Co.Ltd, 2008)

Based on two years wind coat sales, we can calculate:

Multiplier value of trend curve: 2201/1836=1.199

Then we modify the sales curve:

$y = (-0.1278x^3 - 2.197x^2 + 2.4297x + 70.788)*1.199$,

and we get the final sales curve of GeN's city life basic series wind coat (white) for 2009:

$y = -0.1532 x^3 - 2.6342 x^2 + 2.9132x + 84.8748$

5.3 Inventory Control Model

5.3.1 Related concept of inventory control model

(1) Safety inventory: It is a buffer stock which is used to meet the needs of volatility of demands, the changes in lead-time or the shortage caused by various factors

(2) Ordering cycle: time interval between two adjacent orders

(3) Optimal ordering quantity (optimal production quantity): that is the economic volume which is one of the most important decision-makings. The ordering quantity will directly affect the total inventory cost. When it reaches the

minimum inventory cost, we get the optimal order quantity.

5.3.2 Factors that influence the inventory optimization

In order to achieve the goal of inventory optimization, we will analyze factors that influence the inventory optimization in detail.

1. Demand: the purpose of inventory is to meet customer's demand, thus demand is the most important factor, which may be determined, stochastic or seasonal.

2. Lead time: the interval from the moment the supplier receives an order to the moment it is shipped

3. Costs: the main indicators to evaluate inventory control strategy. In the supply chain system, it involves all the charges happen in the process of procurement, production and sales

   (1) Ordering cost: it includes the cost of tracking orders, communications, transportation, sample inspection, etc.

   (2) Production preparation costs: In addition to ordering costs, there is also cost happened in the production preparation period, such as assembly costs, preparing parts cost, etc.

   (3) Inventory costs: it is the cost caused by product storage such as depreciation of fixed capital assets, energy consumption, insurance, warehouse staff salaries, inventory damage, etc.

   (4)Transportation and distribution costs: it is the cost that happens to distribute the product to the network nodes.

   (5) Shortage cost: It can be divided into two types. The first one is extra costs that the enterprise pays for the overtime wage and the expedited transportation fees due to a supply shortage. The other one refers to opportunity cost that happens because of the supply chain error, such as inaccurate forecast or

transport delay, which results in consumers giving up purchasing. Thus, the enterprise loses the sales opportunity as well as the potential profits.

5.3.3 Objectives of Inventory Optimization

The objective of inventory optimization is to provide a certain level service with minimum total inventory cost by balancing various factors so that the enterprise will boost profits. There is interaction between various kinds of inventory costs. The relationship between the costs is shown in the following figures.

Figure 5.4 Relationship between the ordering quantity and cost

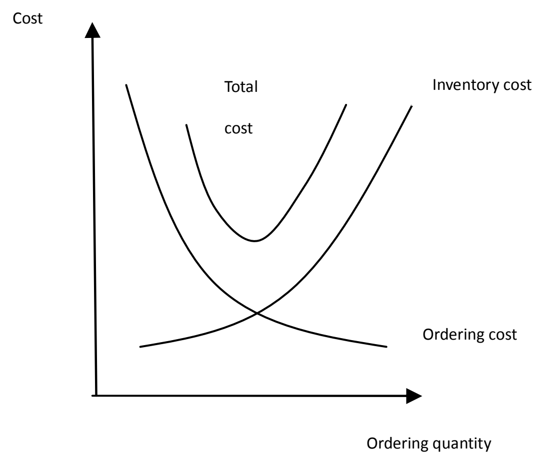
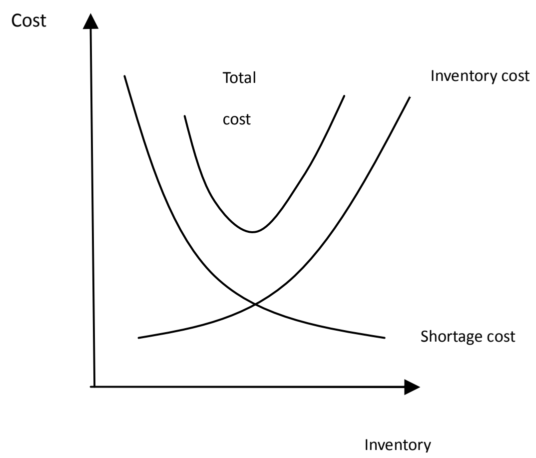


Figure 5.5 Relationship between inventory and cost



From the figures we can conclude that if we order in small batch but in high frequency, the inventory costs can be cut down but the ordering cost is high. While the inventory is in large quantity, the ordering cost and shortage cost can be reduced but inventory cost is high. Meanwhile, preparation costs for the production, transportation and distribution costs and some other costs also need to be considered and balanced when we build the inventory control model so that we can achieve the minimum total inventory cost and calculate the optimal production cycle and optimal inventory.

5.3.4 Inventory Optimization Model for GeN Garment

This model is an inventory control system based on the overall supply chain. We must think through all the factors, such as accessories supply, clothing production and sales, and then build the model. According to the different characteristics of apparel products, we respectively establish determinate inventory control model, stochastic inventory control model and seasonal inventory control model.

5.3.4.1 Determinate inventory control model

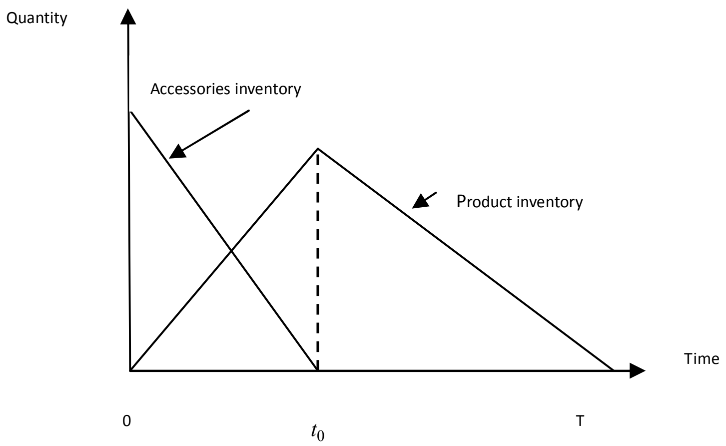
Model assumption: Before the production, enterprise prepares all the accessories and then starts production. In the process of production, accessories gradually reduced. Considering the excessive finished product will cause excessive inventory cost, so the enterprise stops producing at a certain point and only focuses on sales until the cycle ends and then starts another production cycle. Lead time is considered fixed.

In order to ease the model establishment and analysis, each parameter is marked as follows:

1. Production rate: P
2. Sales Rate: $D(D < P)$
3. Preparation cost for one production cycle: C
4. Unit inventory cost of finished product per unit time: A
5. Unit Inventory cost of accessories per unit time: B
6. Finished product quantity in inventory per unit time: W_A
7. Accessories quantity in inventory per unit time: W_B.
8. Total inventory cost per unit time: U
9. Optimal production time period: t_0
10. Optimal production quantities: Q
11. Optimal production cycle (including production time and sales time): T

According to the assumption, the inventory control inventory model is shown as follows in Figure 5.6:

Figure5.6 Determinate inventory control model



From the figure we can see: During [0 , t_0] period, enterprise sells products while producing and the accessories gradually reduce and until Time= t_0 they are used up. Finished product inventory increases gradually from time=0 to t_0 and to Max at the point of t_0. During [t_0 , T] period, finished product inventory decreases and to zero in the end. So finished product quantity in inventory per unit time is：

$$W_A = \int_0^{t_0} (P-D)(t_0-t)dt + \int_0^{T} D(t-t_0)dt \qquad = \frac{P}{2}t_0^2 + \frac{D}{2}T^2 + Dt_0T \tag{5.1}$$

Considering finished product quantity is equivalent to sales quantity to retailers, thus

$$\int_0^{t_0} Pdt = \int_0^{T} Ddt$$

Then $t_0 = \frac{D}{P}T$

$$W_A = \frac{D}{2P}(P-D)T^2 \tag{5.2}$$

Accessories quantity in inventory per unit time is:

$$W_{B'} = \int_0^{t_0} Ptdt = \frac{P}{2} t_0^2 = \frac{P}{2} * \frac{D^2}{P^2} T^2 = \frac{D^2}{2P} T^2$$

Plus preparation cost in one production cycle: C

Then the total inventory cost per unit time: $U = \frac{C}{T} + \frac{AD(P-D)}{2P} T + \frac{BD^2}{2P} T$ (5.3)

We assume $\frac{dU}{dT} = 0$

Production cycle $T = \sqrt{\frac{2PC}{D[A(P-D)+BD]}}$ (5.4)

The production quantity in one cycle $Q = \sqrt{\frac{2PD^2C}{D[A(P-D)+BD]}}$ (5.5)

We incorporate equation 5.4 with equation 5.5 and get the minimum total inventory cost in one production cycle:

$$U = \sqrt{\frac{CD[A(P-D)+BD]}{2P}} + A(P-D)\sqrt{\frac{DC}{2P[A(P-D)+BD]}} + B\sqrt{\frac{D^3C}{2P[A(P-D)+BD]}}$$

We can conclude that the determinate inventory control model is: T is optimal production cycle. Q/P is the production time period and the rest of the time is for sale. The production quantity for one cycle is Q. Before the next production cycle, the enterprise needs to purchase sufficient accessories.

5.3.4.2 Stochastic inventory control model

In actual procurement and sales process, some factors, such as the transportation and sales rate, often fluctuate. Therefore, safety inventory needs to take into account in stochastic inventory control model. Safety inventory is used to prevent all kinds of random factors that may lead to shortage situations and also related to the enterprise's service level.

We assume that average accessories lead time is L and mean square deviation of random fluctuations is ∂_1; Average daily demand is D and mean square deviation of random fluctuations is ∂_2. Then the safety inventory is $\beta\sqrt{L\partial_2^2 + D^2\partial_1^2}$. β represents the service level, which is related to the shortage rate and the β value is available in R.G. Brown's table of service level and safety inventory relation coefficient. So stochastic inventory control model for GeN is:

Production cycle is T. At the beginning of the first cycle, accessories purchasing quantity is $\sqrt{\frac{2PD^2C}{D[A(P-D)+BD]}} + \beta\sqrt{L\partial_2^2 + D^2\partial_1^2}$. From the second production cycle, enterprise just needs to purchase sufficient accessories that meet the demand of optimal production quantities of that cycle.

It is the similar situation for the production. The production quantity of first production cycle is $\sqrt{\frac{2PD^2C}{D[A(P-D)+BD]}} + \beta\sqrt{L\partial_2^2 + D^2\partial_1^2}$. Then in the following cycles it just produces the optimal production quantities.

5.3.4.3 Seasonal inventory control model

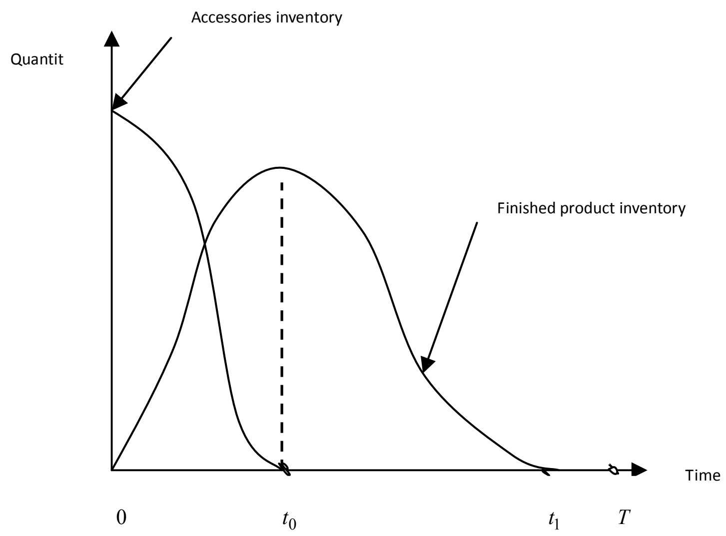
In order to ease the model establishment and analysis, each parameter is marked as follows:

1. We assume production rate is constant: $P(t) = P$
2. We assume sales rate according to the three cubed curve forecast: $D(t) = a + bt + ct^2 + dt^3 [P(t) > D(t)]$

3. Finished product inventory at t time: $I(t)$
4. Accessories inventory at t time: $I'(t)$
5. Preparation cost for one production cycle: C
6. Unit inventory cost of finished product per unit time: A
7. Unit inventory cost of accessories per unit time: B
8. Unit shortage cost of finished product per unit time: S
9. Finished product quantity in inventory per unit time: L_A
10. Accessories quantity in inventory per unit time: L_B
11. Shortage quantity per unit time: L_S
12. Total inventory cost of finished product per unit time: W_A
13. Total inventory cost of accessories per unit time: $W_{B'}$
14. Total shortage cost of finished product per unit time: W_S
15. Total inventory cost per unit time: W
16. Optimal production cycle: T

According to the assumption, we can know that GeN have four production costs: Preparation cost, accessories inventory cost, finished product inventory cost and finished product shortage cost.

Figure 5.7 Seasonal inventory control model



Are shown in Figure 5.7, GeN begins to consume accessories from time $T=0$ .When $T=t_0$, accessories is used up and the finished products inventory reaches the peak. At $T=t_1$, all the finished products sell out. In [t_1, T] period, the product is out of stock.

a) Accessories inventory at t time: $I'(t)$ satisfy the equation

$$\frac{dI'(t)}{dt}=-P \Rightarrow I'(t)=-\int_0^t Pdt+Q=-Pt+Q$$ (Q is arbitrary constant value)

Initially, $I'(t)=0 \Rightarrow Q=Pt_0$. Then we get the accessories inventory curve: $I'(t)=P(t_0-t)$

Accessories quantity in inventory in $[0,t_0]$ period: $L_B=\int_0^{t_0} P(t_0-t)=\frac{1}{2}Pt_0^2$

And total inventory cost of accessories per unit time: $W_B=\frac{BPt_0^2}{2T}$

b) Finished product inventory at t time satisfy the equation:

$$\begin{cases} \frac{dI(t)}{dt} = P(t) - D(t) & 0 \le t \le t_0 \\ \frac{dI(t)}{dt} = -D(t) & t_0 \le t \le t_1 \end{cases}$$

Initially, $I(t=0)=0$ and $I(t=t_1)$

$$\Rightarrow I(t) = \begin{cases} \int_0^t [P(t) - D(t)]dt & 0 \le t \le t_0 \\ \int_0^{t_1} D(t)dt - \int_0^{t_0} D(t)dt & t_0 \le t \le t_1 \end{cases}$$

Finished product quantity in inventory in [$0, t_1$] period:

$$L_A = \int_0^{t_0} [P(t) - D(t)](t_0 - t)dt + \int_0^{t_1} (t - t_0)D(t)dt$$

Total inventory cost of finished product per unit time:

$$W_A = \frac{A[\int_0^{t_0} [P(t) - D(t)](t_0 - t)dt + \int_0^{t_1} (t - t_0)D(t)dt]}{T}$$

c) Finished product inventory at shortage period satisfies the equation:

$$\frac{dI(t)}{dt} = -D(t) \qquad t_1 \le t \le T$$

Initially, $I(t=t_1)=0 \Rightarrow I(t) = \int_0^t -D(t)dt \quad t_1 \le t \le T$

Shortage quantity in [t, T] period,

$$L_S = \int_{t_1}^{T} D(t)(T-t)dt$$

Total shortage cost of finished product per unit time $W_S = \frac{S[\int_{t_1}^{T} D(t)(T-t)dt]}{T}$

d) Preparation cost for one production cycle is C , so the preparation cost per unit time is C/T

e) The total cost per unit time:

$$W = C/T + W_A + W_B + W_S$$

$$= C/T + \frac{A[\int_0^{t_0}[P(t)-D(t)](t_0-t)dt + \int_0^{t_1}(t-t_0)D(t)dt]}{T} + \frac{BPt_0^2}{2T} + \frac{S[\int_{t_1}^{T} D(t)(T-t)dt]}{T} \quad (5.6)$$

Since the production quantity in one cycle equals to the sales quantity in one cycle:

$$\int_0^{t_0} Pdt = \int_0^{t_1} D(t)dt \quad (5.7)$$

This model is established based on equation 5.6 and constraint condition 5.7. In order to simplify the calculation process, we don't consider the shortage factor, the equation 5.6 can be simplified as:

$$W = \frac{C}{T} + \frac{BPt_0^2}{2T} + A[\frac{Pt_0^2}{2T} - at_0 + (\frac{a-bt_0}{2})T + (\frac{b-ct_0}{3})T^2 + (\frac{c-dt_0}{4})T^3 + \frac{d}{5}T^4.] \quad (5.8)$$

By equation 5.7 we can get: $t_0 = \frac{1}{P}(aT + \frac{b}{2}T^2 + \frac{c}{3}T^3 + \frac{d}{4}T^4)$ (5.9)

Put 5.9 into 5.8, we get:

$$W = \frac{C}{T} + [\frac{Aa(P-a)+Ba^2}{1P}T + \frac{Ab(2P-3a)+3Bab}{6P}T^2 + \frac{A(3Pc-4ac-b^2)+2B(2ac+b^2)}{12P}T^3 + \frac{A(12Pd-10bc-15ad)+5B(3ad+2bc)}{60P}T^4 + \frac{(B-A)(9bd+4c^2)}{72P}T^5 + \frac{(B-A)cd}{12P}T^6 + \frac{(B-A)d^2}{32P}T^7]$$

Assume $\frac{dW}{dT} = 0$,

then $K_1T^2 + K_2T^3 + K_3T^4 + K_4T^5 + K_5T^6 + K_6T^7 + K_7T^8 - C = 0$` (5.10)

$$
\begin{cases}
K_1 = \dfrac{Aa(P-a)+Ba^2}{2P} \\
K_2 = \dfrac{Ab(2P-3a)+3Bab}{6P} \\
K_3 = \dfrac{A(3cP-4ac-b^2)+2B(2ac+b^2)}{12P} \\
K_4 = \dfrac{A(12dP-10bc-15ad)+5B(3ad+2bc)}{60P} \\
K_5 = \dfrac{(B-A)(9bd+4c^2)}{72P} \\
K_6 = \dfrac{(B-A)cd}{12P} \\
K_7 = \dfrac{(B-A)d^2}{32P}
\end{cases}
$$

This is an equation which tries to solve T on the basis of parameters a,b,c,d,P,C,A,B. We can know the a,b,c,d by the three cubed forecast curve and input the actual production rate P, preparation cost for one production cycle C, unit inventory cost of finished product per unit time A and unit inventory cost of accessories per unit time B into equation 5.10. With the help of MATLAB, we can get the optimal production cycle.

We still take GeN city series wind-coat as an example, the costs are as follows:

1. Production preparation cost: the expense for the production preparation activities: such as filling and tracking orders, accessories inspection, etc. Average cost of production preparation is approximately: RMB1,010

2. Distribution cost: distribution cost to the main sales points is about RMB12,300. Therefore, total preparation cost is as follows: 1,010+12,300 =RMB13,310

3. Unit inventory cost: including warehouse depreciation, capital occupancy cost, energy consumption, insurance, warehouse custody staff salary

   (1) Warehouse cost

   GeN has two warehouses. The finished product warehouse is 800 square meters and the accessories warehouse is 200 square meters. The total investment cost of warehouse and inventory facilities is RMB 5.1 million. We consider the depreciable life is 50 years. Based on the straight-line depreciation method, annual depreciation is 5100000/50 = RMB 102000/ year. Average monthly rent for retail outlets is about RMB 195000 / month, so the total annual rent: 195,000* 12 = RMB 2.34 million / year. GeN's total warehouse cost is RMB 2,442,000 / year

(2) Warehouse custody staff salary

The company has two warehouse custody staffs with the monthly salary RMB2000. Therefore the total amount of salary is: 2,000 * 2 * 12 = RMB 48,000

(3) Energy consumption

According to the financial statements provided by the company in 2008, the total consumption of water, electric power is about RMB 57,000. Retail outlets' total power consumption is RMB46,000 .

(4) Capital occupancy cost

Capital occupancy cost is the opportunity cost and it is hidden. We calculate the value of the company materials according to their purchase price and discount interest rate according to the bank annual interest rate. The average cost of each clothes is about RMB 48 and the annual interest rate is 2.25%. The quantity of the clothes inbound and outbound is 600,000 pieces/ year. Then the capital occupancy cost per year is 48 * 0.0225 * 600,000 = RMB 648,000

Through this analysis, we can calculate the total inventory cost as follows:

2442,000+48,000+57,000+46,000+648,000=RMB 3241,000

Average weekly inventory cost is: 324,1000/ 52week=RMB62,327

Average quantity of the inbound and outbound clothes between GeN and its retailers is 11,538 pieces per week. So the unit inventory cost is: 62,327/ 11,538= RMB 5.4/ week

Unit finished product inventory cost is: 5.4 * 800/1000 = RMB4.32/week

Unit accessories inventory cost is: 5.4*200/1000 = RMB1.08 / week

The productive rate of GeN city basic series wind-coat (white) is 504 pieces per week. Then the data for the inventory control model is shown as follows:

Table 5.6 Parameters of the inventory control model

Style	Production rate P(pieces/week)	Unit finished product inventory cost A(RMB/piece/week)	Unit accessories inventory cost B(RMB/piece/week)	Preparation cost	
				Production preparation cost RMB1,010	distribution cost RMB12,300
GeN city life basic series (white color)	504	4.32	1.08	13,310	

Considering the sales curve:

$y = -0.1532\ x^3 - 2.6342\ x^2 + 2.9132x + 84.8748$

So, a= 84.8748, b=2.9132; c=- 2.6342; d=-0.1532

Thus, we have the equation $K_1T^2 + K_2T^3 + K_3T^4 + K_4T^5 + K_5T^6 + K_6T^7 + K_7T^8 - C = 0$

$$
\begin{cases}
K_1 = \dfrac{Aa(P-a)+Ba^2}{2P} \\
K_2 = \dfrac{Ab(2P-3a)+3Bab}{6P} \\
K_3 = \dfrac{A(3cP-4ac-b^2)+2B(2ac+b^2)}{12P} \\
K_4 = \dfrac{A(12dP-10bc-15ad)+5B(3ad+2bc)}{60P} \\
K_5 = \dfrac{(B-A)(9bd+4c^2)}{72P} \\
K_6 = \dfrac{(B-A)cd}{12P} \\
K_7 = \dfrac{(B-A)d^2}{32P}
\end{cases}
$$

The parameters are as follows,

Table 5.7 Parameters of the inventory control model

a	b	c	d	P	A	B	C
84.8748	2.9132	- 2.6342	-0.1532	504	4.32	1.08	13310

We put the parameters into MATLAB Program and get the efficient solution: T=-2.26≈-2 and T=2.09≈2

From the previous sales data we can see:

Table 5.8 Sales of GeN's city life series wind coat (white) of the 4th quarter in 2008 (piece)

Month	Sept.	Oct.				Nov.				Dec.	
week	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd
No.	-5	-4	-3	-2	-1	0	1	2	3	4	5
Actual sales	260	310	380	520	690	870	760	620	470	280	210

(Resource: Sales report of GeN Garment Co.Ltd, 2008)

T =- 2 represents: from -5 to 5, the optimal production cycle is from -5 to -2, that is 4 weeks.

T = 2 represents: from -5 to 5, the optimal production cycle is from -5 to 2, that is 8 weeks.

According to the principles of agile response to the market, we choose (-5,-2) as the solution, that is, four weeks is the optimal production cycle.

Table 5.9 GeN’s production Schedule

month	Sept.	Oct.				Nov.				Dec.	
week	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd
No.	-5	-4	-3	-2	-1	0	1	2	3	4	5

▲ ▲ ▲

So the overall production plan for GeN city life basic series wind-coat (white) from the end of September to early December is: there are three production cycles and the production quantity is in accordance with the demand forecast. The accessories procurement needs to be implemented in advance considering the lead time. The ordering accessories should be delivered into the warehouse just before the beginning of each production cycle.

5.4 Chapter summary

In this chapter, we build inventory control model for GeN to optimize its inventory and this model improves the supply chain inventory management for GeN in four major areas:

(1) Effective information sharing relieves ordering concentration so as to avoid large price fluctuation and bullwhip phenomenon.

(2) Rational application of the forecast model and inventory control model make it

possible to achieve the lowest total inventory cost.

(3) Cooperation among the supply chain nodes effectively solve various bottleneck problems and ensure the smooth process of accessories procurement and clothing production which results in the improvement of customer service.

(4) Small batch ordering avoids high risk of mass ordering and the enterprise can take the initiative to have agile response to the market.

Chapter 6 Conclusion

6.1 Thesis summary

Inventory control plays a very important role in the garment enterprise, but GeN Garment still has serious problems of inventory management such as excess inventory burden and low inventory turnover rate. Supply chain management is an advanced management concept for this company to reduce inventory and improve customer service. This paper focuses on the content how to implement inventory control strategy to optimize the inventory under the supply chain management environment.

Through research and analysis, we found the present GeN Garment mainly rely on the experience to deal with the inventory management and lack coordinative relationships and adequate information communication with other enterprises on the supply chain, which makes GeN can't meet the requirement of agile response.

This paper establishes inventory control system for GeN based on relevant theoretical study and the analysis of GeN's current inventory problem. This system includes collaborative forecasting and inventory control model. According to the clothing product's different characteristics, we classify them into three types: determinate type, stochastic type and seasonal type. Then we use gray model and three cubed curve forecast model to implement the collaborative forecast. Meanwhile, we set up the inventory control model for the clothes of determinate type, stochastic type and seasonal type. Through the scientific and rational application of these models, we try to achieve the lowest total cost of inventory with lowest risk.

In one word, this paper is intended to provide practical and effective inventory solution for GeN. However, there will be still many uncertainties so GeN needs to improve and upgrade the system in the application process.

7.2 Prospect

It is really a complex process to establish supply chain inventory control system. This paper still has many inadequacies due to time limit. With the development of the supply chain theory, there is an increasing emphasis on supply chain coordination and cooperation between nodes. This paper doesn't have deep study in this perspective. The established model has some assumptions thus it has the gap with the actual inventory management. At present it only can be a reference for GeN. Considering there are a lot of uncertainties which will influence the operation of the inventory control model, we need to improve and perfect the model in the application process.

In today's clothing industry, it is a trend to manage inventory with supply chain management theory. With the development of the information technology, we believe more and more apparel enterprise will accept and use the advanced inventory management models.

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