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A Case Study of Supply Chain Management in a Manufacturing Company in China

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ABSTRACT: How to manage inventory is becoming an increasingly crucial issue for most manufacturing companies. R&D is a foreign direct investment (FDI) company engaged in producing electronic components. As the prices of raw materials and operation costs increased, R&D was challenged to maintain a smooth relationship among level of inventory, customer satisfaction and production efficiency. This paper first discusses the key factors that affect R&D's inventory level. It then combines recent supply chain management theories and relevant quantitative methods to arrive at optimal ordering policies and strategies to reduce overall costs, while at the same time satisfying customers in terms of service.

Keywords: Inventory management, safety stock, case study, VMI

JEL codes: L84, O14

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1.0 <u>Introduction</u>

1.1 Background

Traditionally, companies in a supply chain network focus mainly on their own processes and pay less attention to their suppliers or customers. However, globalization and the development of intensive relationships among companies have induced paradigm shifts in modern business management, including the management of supply chain networks (Lambert et al., 2000). Since holding inventory is expensive, effective inventory management is critical to supply chain operations. Uncertain demand and economies of scale underline the importance of keeping some inventory.

However, different functions of a company may disagree over inventory level. Marketing may want to keep inventory as high as possible, so that customers' demand can be satisfied immediately. Production may also want to maintain a high inventory to support long production runs and to realize economies of scale. Finance, however, may prefer a low inventory to reduce the current asset levels. Obviously, such conflict generates a question: what level of inventory should we maintain in order to simultaneously satisfy customers' demand and minimize operational costs?

Many foreign manufacturers in China have faced similar problems and this undermined their efficiency badly. Therefore, how to optimize inventory is a crucial issue that needs to be resolved. This paper aims to discuss the issue by analyzing the case of a selected company in order to suggest ways to tackle the issue using inventory management tools, such as the safety stock model.

1.2 Problem statement

The company selected for this case study is a foreign direct investment manufacturer headquartered in Germany, to which we have assigned the pseudonym R&D. It is in fact one of the largest manufacturing companies in the world producing electronic components, modules and systems. It has approximately 26,300 employees in its 20 different locations engaged in design and production. A comprehensive range of products are offered by R&D in the areas of information and communication technology, automotive electronics, industrial electronics and consumer electronics.

R&D's manufacturing locations and sales offices are distributed widely: from Europe, to Asia, to South and North America. The main production branch, which is located in Zhuhai, Guangdong province, makes piezo and protection devices, film capacitors and sensors. The Zhuhai factory has approximately 2,800 employees and was founded in 1998. On one hand, the broad diversification of products offers customers a range of choices and increases the company's market share, but stocking up on materials in preparation for uncertain demand and new project roll-outs have led to inventory management problems, including:

1. Early inventory with high service level.

2. Late inventory with low service level.

There are several reasons why we chose this company as a case study. First, R&D is representative of most foreign direct investment companies because it is an electronic components manufacturer that depends heavily on manpower. Second, this company used one of the most popular enterprise resource planning (ERP) systems — SAP — carry out customer order planning and inventory evaluation. It is a relevant for investigating information system application and inventory management tools.

1.3 Research objectives and contribution

This study sets out to:

1. Identify the key factors affecting inventory level and costs.

2. Investigate how to maintain a high level of service while keeping inventory levels low.

As more and more FDI manufacturing companies enter China, they will face similar issues to R&D which involve e local suppliers and distributors. Demand forecast is not accurate as demand fluctuates during different periods. Moreover, customer order time is typically short but production lead time is constant. Therefore, factories normally face two kinds of situations: production is unable to meet demand or supplies exceed demand. By analyzing the case quantitatively and qualitatively, we will use it as an example to solve problems related to inventory. We hope that this paper will act as a reference for companies that encounter problems similar to our case.

2.0 <u>Literature review</u>

Traditionally, supply chain management is viewed as a vertical integration of marketing, distribution, planning, manufacturing, and purchasing departments within an organization. Beamon (1998) divided a supply chain into two integrated processes: production planning and inventory control process, and distribution and logistics Process. The processes and movements of raw materials into finished products are illustrated in Figure 1.

Figure 1 Procedure of Products

With the development of supply chain management, advanced modeling approaches have been used to improve the efficiency of supply chains. Williams (1981) developed a dynamic programming algorithm which can minimize the average costs per period over an infinite horizon. Ishii et al. (1988) developed a deterministic model to prevent stock outs and minimize the amount of inventory. Newhart et al. (1993) designed an optimal supply chain to minimize the number of distinct product types held in inventory. Inventory holding costs can be between 20 to 40 percent of their values, so efficient inventory management is crucial in supply chain operations. Ballou (1998), Lin and Huang (2014) indicated that inventory management is a balance between customer service, product availability and the cost of inventory. Many companies working on inventory management recognize that too much inventory represent high risks and high costs. As shown in Figure 1, the channel from suppliers and manufacturers to distributors and retailers involves different kinds of inventory. Simchi-Levi et al. (2003) and Muniappan et al. (2016) explained the reasons why companies need to hold inventory, including unexpected changes in customer demand, uncertainty in the quantity and quality of supplies, lead times and economies of scale. Having considered the importance of inventory, it is necessary to define factors that determine inventory costs.

Chopra et al. (2007) divided the inventory costs into three parts: material costs, holding costs and ordering costs. There is some tradeoff between the cost of investing in and holding excess inventory. We need to buffer the effects of both demand uncertainty and production lead time. Fitzsimmons et al. (2001) introduced the notions of safety stock level and reorder point to deal with such problems. Safety stock is a level of extra stocks that is maintained to overcome uncertain demand and supply. Kouki et al. (2016) pointed out that an effective safety stock can help to prevent stock outs by combining cyclical volume planning and fair share mix decisions. The higher the level of safety stock a company keeps, the better it can satisfy its customers, but the more it costs to maintain its service level. Whenever stocks fall below specific level, the factory needs to reorder. The timing of the reorder is important: an early one will build up extra stocks, while a late reorder will reduce service level. Cachon et al. (2000) and Baralis et al. (2015) indicated that reorder point policies were optimal in a serial supply chain with batch ordering.

Vendor managed inventory (VMI) is a supply chain management tool. In a VMI partnership, it is not the customers or buyers but rather the vendors or manufacturers who decide when to replenish inventory. In other words, the buyers' or consuming organizations' inventory level is determined by the vendors or manufacturers through shared information and electronic data exchange. This reduces inventory risk and provides a stable level of service. Waller et al. (1999) pointed out that through centralized forecasting via EDI linkage between factory and supplier, the factory can reduce stock outs and inventory through limited production. At the same time, the factory can guarantee the materials will not be in shortage. As a result of higher product availability, buyers can reduce the cost of a lost sales caused by uncertain demand. The reduced costs apply not only to inventory but also to production through optimizing production and transportation.

Claassen et al. (2008) found that positive buyer perceptions of VMI implementation saved costs. Holmstrom (1998) indicated that VMI can solve problems of both vendors and retailers. To maintain high service levels, distributors and retailers may feel the need to buffer against supply disruptions, which can distort/enlarge the actual demand of end customers, leading to producers receiving incorrect information. This, in turn, will lead to inventory surplus in factories. Moreover, supply factories and retailers spend a lot of time and money on administration prior to implementing VMI, such as communicating order placements, customer demand, inventory level, delivery schedule etc. However, after implementing VMI, vendors will oversee these administrative tasks. Also, delivery charges will be reduced because of the stable mutual partnerships formed. If a vendor is the only supplier that offers VMI, it means that vendor will gain a competitive advantage among its competitors.

Simchi-Levi et al. (2003) explained that in a push-pull strategy, different stages of a supply chain use their own strategies. For example, the initial stage employs push strategies while the remaining stages operate pull strategies. The push-pull boundary is the interface between the push-based stages and the pull-based stages. Push-pull strategies combine the advantages of both push-based and pull-based strategies. At the same time, inventory costs are reduced and service levels improved. Kim (2008) noted that there are three primary benefits of push-pull strategy: (1) it reduces costs by keeping inventory at more generic levels and decreases its total value. (2) It offers greater security and less risk of salvage and obsolescence. (3) It enhances forecast processes. Hendry and Kingsman (1989), Raturi et al. (1990) and Mather (1992) all discussed push-pull strategy as beneficial for accurate production planning.

Postponement, the push-pull boundary, is a kind of delay in production or distribution. Simchi-Levi et al. (2003) indicated that postponement is the decision to delay manufacture of a specific product until demand is certain or more accurately known. Copper (1993) pointed out that postponement is widely recognized as an approach that can build a superior supply chain. Bowersox et al. (2013) expressed the view that the anticipatory risk of supply chain performance can be reduced by applying postponement strategies.

3.0 Case description

3.1 Company background

Being one of the top manufacturers of passive electronic components, R&D offers a broad portfolio including thermistors, disk varistors and multilayer varistors. These temperature- and voltage-dependent resistors are used mainly in automotive, industrial and consumer electronic appliances, where they are used either for protection or heating functions. Surge arresters – another ceramic protection device – mostly guard telecommunication systems against voltage surges, such as those that occur when lightning strikes.

R&D has more than 40 affiliates around the world but this paper, as noted earlier, focuses on R&D Zhuhai. For storing finished goods and raw materials, there is one warehouse in R&D

(FTZ Zhuhai), which is located opposite to the manufacturing building. Besides the warehouse, there are also buffer areas to load and unload finished goods and raw materials. One of the major products is the leaded varistor, with a production capacity per month of over 100 million units. The varistors take the forms of raw material (D3), semi-finished goods (D5), and finished goods (D9), all of which are found in the inventory. In the Ceramic Components segment, operating profits declined in the period under review to EUR 37 million (2011: EUR 57 million). The main reasons were the decline in sales and higher material costs, especially for metals.

This paper will analyze the inventory of one product, leaded varistors, which occupies an important role in R&D Zhuhai for its high capacity and standard production procedures. It is a good case to analyze since inventory influences production performance greatly. R&D Zhuhai uses one of the most popular enterprise resource planning (ERP) systems, SAP, to do customer order planning and evaluate inventory. R&D Zhuhai has employed the SAP module since 2013 but has encountered various problems in customizing SAP The approaches adopted for dealing with such problems are relevant to our analysis.

3.2 Product information

Leaded varistors are made from a kind of granule, D3 (see Figure 2 below). D3 raw material is stored in the warehouse and delivered to the receiving area. Then it will be pressed and sintered at high temperature into a fix mold, which we refer to as D5. It will then be modeled into the required shape at the production plant and converted into the finished product, D9. The finished goods, D9, will be sent to the warehouse and then delivered to the relevant customers. R&D needs to control its inventories at all three production stages.

Procedures work like this at the moment: (1) the materials planning department checks with SAP to find out how much of each material is left in the warehouse. (2) The materials planner estimates the amount of production needed and submits a purchasing order to vendor. The estimation is based on the historical data and the past long-term forecasting practices. Sometimes, the materials cannot be able to arrive as expected due to some reasons and this will cause production to decline or stop. So safety stock is necessary for such materials but materials stockpiled in this way occupy most of the warehouse. There are two ways to solve this problem. One is to strengthen the communication between production plant and the material planner so that both know when and how much stock will be needed. The other way is to consume the extra stock by producing more D5. Moreover, the relationship between D3 and D5 is one to many, which means that one specific D3 can produce several kinds of D5 as illustrated in Figure 2. But this may transfer inventory pressure onto D5 stock and produce more work in process (WIP) inventory. Therefore, the pull strategy, which produces according to customer demands, plays an important role in such situations. Extra D5 cannot be produced if customers do not demand it or if the warehouse has no space to store it.

Another issue involves monitoring the inventory. The relationship between D5 and D9 is one to many as illustrated in Figure 2. In other words, D5 is the raw material of D9. The inventory control of D5 is different from that of D3 because holding costs are higher and it directly influences the production of D9. If the stocks of D5 cannot be consumed, it will become dead stock. Obviously, D9 demand is the key factor determining the stock of D5.

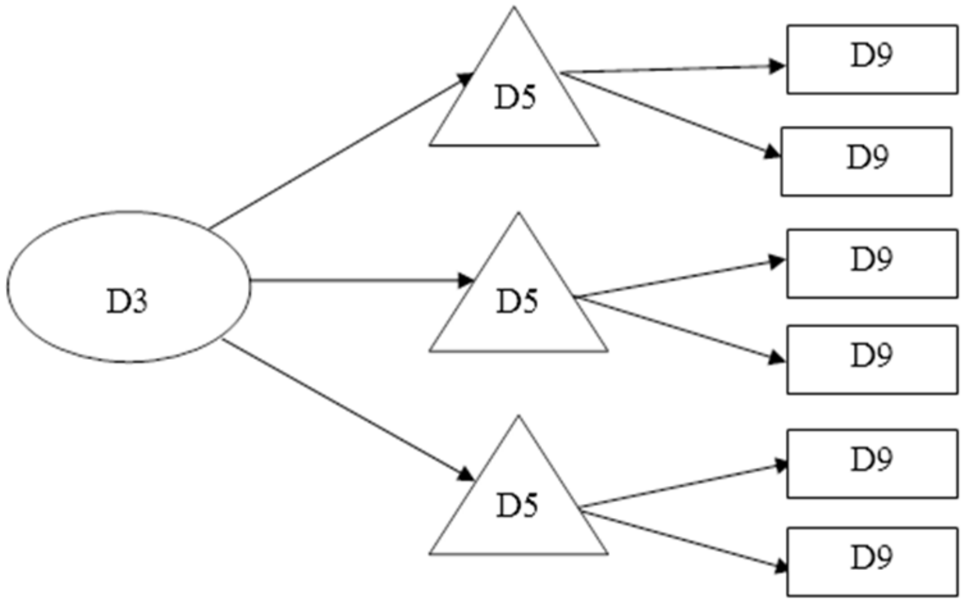


Figure2 Relationship between Products

D9 stock levels are based on the orders in hand and the experience of MRP controllers, who decide how much of each product needs to be produced. Under R&D's pull strategy, D9 safety stock is seldom build up. Sometimes this will affect service level since the strategy cannot meet short notice orders.

3.3 ERP system and information sharing

The ERP system used in R&D is SAP R/3, one of the most popular and practical ERP systems in the world. SAP R/3 consists of a range of modules: sales and distribution, materials management, production planning, quality management, plant maintenance, warehouse management, financial accounting, control, asset management, human resource, workflow model and project system. R&D bought five modules: material management, production planning, sales and distribution, financial accounting and control. Some functions of R&D's SAP are unique to assure the convenience and accuracy of operations. Therefore, SAP plays an important role in R&D's overall production procedures.

At the same time, R&D is a global company where information is difficult to share without a proper communication platform. Once you have a SAP account, you can access the information you need wherever you are. However, to avoid too much information exposure to each one, there is an authorization limit on users so that, SAP offers both a platform for global information sharing and has its own way of protecting business secrets.

3.4 Ordering policy and procedures

Due to its huge network and distribution facilities, R&D marketing department will normally approach end customers first. The sales department will then handle the successive ordering process and will be responsible for order confirmation, delivery, complaint and replacement. Once sales key-in the order into SAP, the system will generate the delivery schedule automatically based on the designed production capacity. If customers are not satisfied with the delivery schedule, the sales department will contact MRP controllers in the factory. Sometimes, MRP controllers need to adjust production schedule to meet customers' requests. But sometimes these requests cannot be satisfied due to short lead time or limited capacity. R&D pay great attention on ensuring reliable delivery and has sets a target to achieve each year. No-one can alter the delivery date once it has been confirmed with customers; a rule that has enhanced R&D's reputation among customers.

For reducing fluctuations in demand and production, many manufacturers use a quantity flexibility contract to get advanced orders from their customers. This kind of contract allows suppliers to give a full refund for returned (unsold) items on the condition that the number of returned does not exceed a certain amount. R&D applied this to arrange production based on forecast demand. Some long-term orders will have been placed a year ago, but the sales department will review those orders either monthly or weekly and double check customers' updated demands. Long-term orders, which are called scheduled agreements, will be filled out in the form of standard orders periodically. A price is set when orders are placed in the system. Normally, the quantity of the orders is not allowed to change without consulting with marketing and factory MRP controllers. Because production is arranged by demand, it is risky if customers reduce order quantities and it takes longer to produce extra units if a customer increases order quantities suddenly. Thus, R&D has regulations to control its customers as to when and to what extent they can change order quantities.

The regulations have dual parameters: within horizontal time and beyond horizontal time. SAP sets horizontal time as a time defense for customers' demands within the lead time and beyond the lead time. If the lead time is 7 weeks, SAP will set 7 weeks as a border to separate demands that fall within in it and those that fall outside it. Furthermore, the horizontal time rolls weekly, which means that the system will count the time automatically and keep the information consistent with demands. For orders that are beyond lead time, customers can adjust quantities freely without any restrictions. But for orders within lead time, the sales department needs to consult with the factory's MRP controllers to determine whether the quantity needs to be increased or decreased. Products are planned to be produced or are produced once demands rolls into horizontal time. The closer to the delivery time, the less room there is to adjust the quantity. If customers need to increase the quantities, the delivery time o will be re-arranged based on the actual situation.

R&D gives customers room to adjust their order quantities but it does not provide detailed regulations. If R&D has an agreement with customers regarding detailed regulations on flexible order quantities, it will bring more advantages to both customers and R&D itself. Customers will try to load orders as early as possible to secure production capacity and the company can arrange production in advance to gain the benefits of economies of scales. Table 1 illustrates the suggestions for regulating quantity flexibility.

Table 1 Quantity Flexibility Percentage (Assuming lead time is 7 weeks)

Period(week)	Quantity Adjustment Percentage(+/-)
1	0%
2	0%
3	10%
4	10%
5	20%
6	20%
7	30%
8	100%

Lead time is 7 weeks

Time Fence

3.5 Production flow and bill of material

Figure 3 shows R&D's production flow. There are thousands of materials stored in R&D's warehouse and SAP sets up bills of materials (BOM) to provide the solutions. Each level of production has its own BOM and production processes, which are set and saved in SAP. Figure 4 presents a simple example of a BOM.

4.0 Research design

4.1 Methodology

This paper use both quantitative and qualitative methods to analyze the factors that determine optimal inventory. Mathematical models are used to determine quantitatively both the optimal level of safety stocks and the re-order point. Qualitative enquiry involves applying relevant theory to the reduction of inventory.

4.2 Data collection

Most data used in this paper will be drawn from both documentary sources and from R&D's systems, including data from historical inventory reports, production reports and from the ERP database. In order to derive the optimal order policies, we need to obtain information on product demand and the cost of each product, including the holding costs, ordering costs and setup costs.

Customer demand varies throughout the year. During peak season, demand is high but when the economy declines, many customers delay or cancel orders to maintain cash flow. Therefore, demand in peak season and low season varies dramatically. At first, we selected data from 2013 to 2015 but then we discovered that data in 2013 and 2014 show great differences since the economy declined in 2013 and recovered slowly in 2014. We decided, therefore, to eliminate the data from 2013 and 2014 and focus instead on demand in 2015.

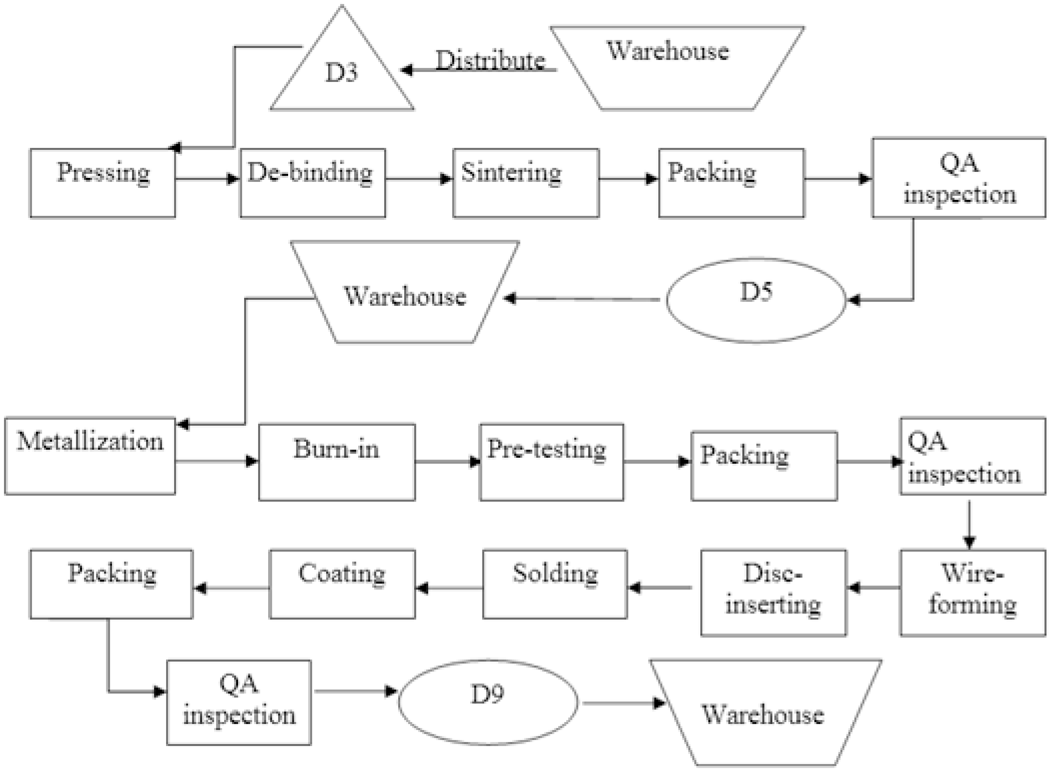


Figure 3 Production Flow

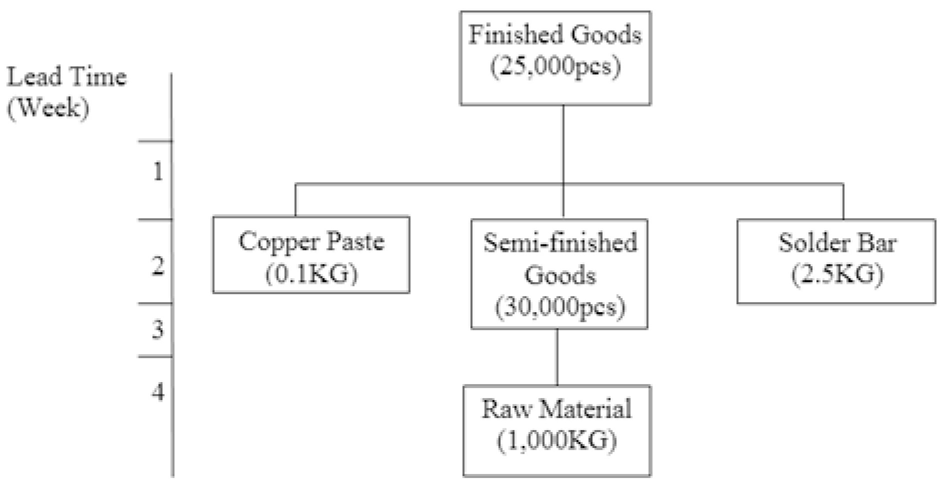


Figure 4 Simple Example of Bill of Material

The data collection procedure will involve questioning MRP controllers and logistics managers about inventory management strategy.

Main questions asked:

a) What kind of strategies is used by the company to manage the inventory?
b) What are the material and production planning strategies for both semi-finished and finished goods?
c) How can a low inventory level be maintained while still satisfying customers' requests?
d) Does R&D use VMI to manage the inventories? If yes, how do they use it?
e) Does R&D apply postponement strategy to manage inventories? How do they use it?

5.0 <u>Case analysis and discussion</u>

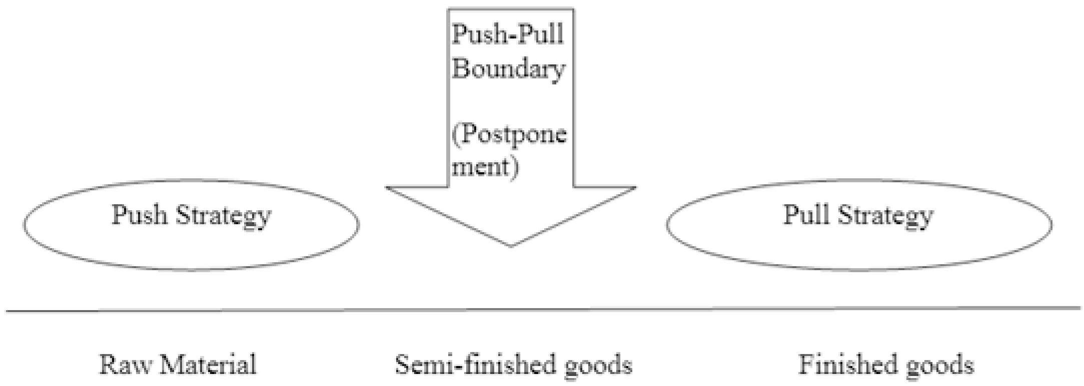
5.1 Supply chain strategy and postponement

Placing orders has a cultural aspect: European customers like to plan in advance, even a year ahead, and so they will normally place orders within lead time. Some customers that have long term demands placed orders one year ahead, and then reviewed the actual demand monthly. The non-European customers, on the other hand, including those from America, Australia, Africa, Hong Kong, China, and Taiwan etc., tend not to place long term orders. In other words, the risk of building inventory is high because uncertainty of demand is relatively high. As customer demand reflects orders on hand, R&D applies the pull strategy for finished goods.

How to balance the tradeoff between inventory and economies of scale? On one hand, R&D arranges production according to orders on hand. If demand were less than lot size, production would produce the amount of one lot size. If demand were higher than one lot size, production would produce the quantity that meets the customer's requirements. Generally speaking, MRP controllers arrange production according to their experience and historical demand data, but this can hardly define how many items should be kept as safety stock and there are no pre-determined instructions from the management.

The planning for raw materials is based on the demand for semi-finished goods. With the help of SAP, material planners aggregate information on both the finished goods semi-finished goods. However, the high scrap rate and long lead time of production make planning difficult. Moreover, it costs less to purchase huge quantities of raw material abroad via sea freight transportation. Thus, R&D applies a push strategy to arrange the purchase of raw materials. Sometimes stocks of raw material are plentiful, but sometimes, raw materials will be in shortage and this make the production line halt temporary, which wastes both capacity and time. Safety stock is built up but no one knows how much is appropriate and when to build it up.

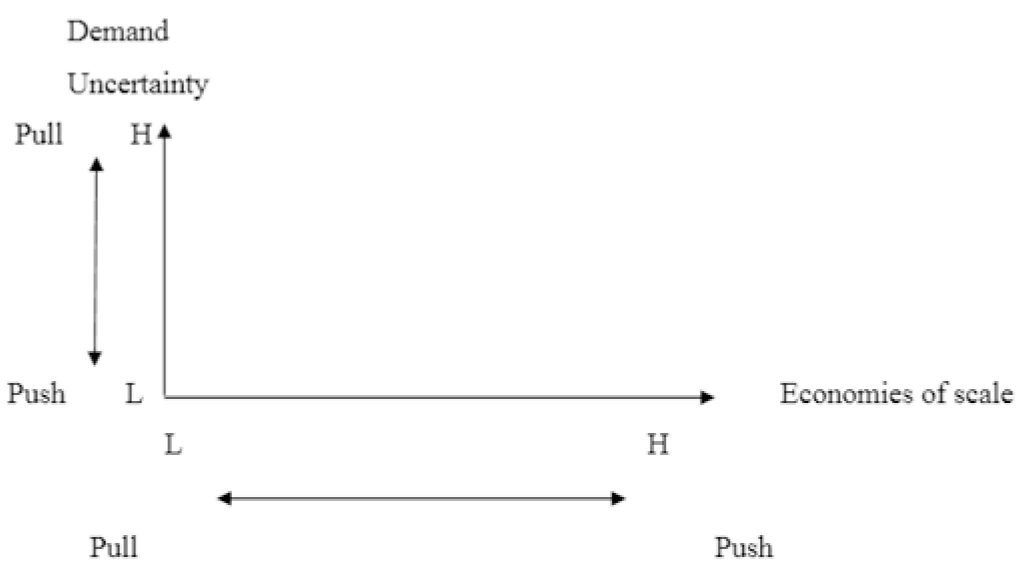
In sum, we can see that R&D uses three strategies to arrange productions, as illustrated in Figure 5.



Source: Simchi-Levi, D., Kaminshy, P. and Simchi-Levi, E. (2003). Designing & Managing the Supply Chain., second edition. Mac Graw Hill. pp, 123, figure5-1.

Figure 5 Supply Chain Strategy

Simchi-Levi et al. (2003) discussed supply chain strategies and their corresponding advantages and disadvantages. When demand uncertainty is relatively small and long-term forecasting is appropriate, the push strategy can be applied. When demand uncertainty is high, it is better to apply the pull strategy. Assuming everything else is equal, the higher demand uncertainty is, the more preferable a pull strategy is, and vice versa. Alternatively, the greater the importance of economies of scale in reducing costs, the greater the importance of managing the supply chain based on the push strategy becomes, as illustrated in figure 6.



Source: Simchi-Levi, D., Kaminshy, P. and Simchi-Levi, E. (2003). Designing & Managing the Supply Chain., second edition. Mac Graw Hill. pp, 124, figure5-2.

Figure 6 Matching Supply Chain Strategies with Products

When it is difficult to control customer demand and uncertainty is high as in D9 production, the pull-strategy is used to fulfill orders. When lead times become long and it is more important to pursue economies of scale, the push strategy is applied to save costs.

From raw material (D3) to finished goods (D9), takes at least 4 weeks to finish. Usually, customers will not wait such a long time. Compared to other competitors whose lead time is 2 weeks, R&D possess no advantage position in the market. Therefore, it is necessary for them to have buffers to handle unexpected orders. If buffers are built up in terms of raw materials, though inventory is far less than that of finished goods, it does not work for long lead times. If buffers are set up in terms of finished goods, the more materials are consumed and much higher costs and risks are incurred. A compromise boundary needs to be identified and a postponement strategy applied.

There are two kinds of postponement: manufacturing postponement and geographic postponement. R&D uses both kinds of postponement to manage its inventory. Before starting production of D9, R&D produces D5 first according to historical data and the experience of the MRP controller. Because components of D9 belong to different product families, one sort of D5 can be used for several kinds of D9 so R&D will not start to produce D9 until it has received confirmed orders from customers. The cost of D9 is much higher than D5so the risk of storing D9 is higher than that for D5. At the same time, producing some D5 in advance can achieve economies of scale and save production costs. Normally, it takes 4 weeks to go from D3 to D9. By applying manufacturing postponement, the lead time is shortened to only 1 week because D5 has been finished in advance. In applying manufacturing postponement, R&D reduces stock while maintaining good basic service level and economies of scale.

With regard to geographic postponement, customers of R&D are spread all over the world and European customers account for the main portion. Delivery volumes from Zhuhai to Europe are huge and transportation is expensive. Most deliveries are shipped out by air freight. While it is impossible to change shipping mode from air to sea for different customers, R&D decided to ship out stocks by sea to Europe on a large scale. Because R&D owns a factory in Austria that conveniently has access to all the countries in Europe. R&D decided to build up an inventory of selected parts in Austria. According to the historical data and the current order demands, R&D stores several kinds of D9 in Austria. By adopting geographic postponement, R&D reduces transportation costs dramatically and fulfills customers' requests quickly.

Nevertheless, it also faces problems in determining safety stock. It is difficult to correctly define how much to produce and which product should constitute safety stock. Cash flow is important in the company and it is not permitted to produce excess stock if there is no demand. Therefore, it is crucial to define safety stock level for R&D.

5.2 Safety stock level and reorder point

Safety stock is crucial at the postponement stage. From over 400 different types of D5, we chose one of the most popular products to analyze based on annual turnover. Table 1 illustrates the monthly demand distribution for 2015.

Table 1 Demand Distribution of Product

Month Total	Demand Quantity (pcs)
January-15	1,971,000
February-15	2,611,000
March-15	2,041,000
April-15	2,787,000
May-15	2,179,000
June-15	2,334,000
July-15	2,127,000
August-15	1,605,000
September-15	2,280,000
October-15	2,046,000
November-15	1,494,000
December-15	1,107,000

It is important to calculate the optimal safety stock based on the daily demand for the chosen product. With the Central Limit Theorem, demand during lead time is assumed to be normally distributed no matter what the daily demand distributions are. We collected customer data for 2011 combining them by month. We then carried out an analysis using SPSS 19. Setting the condition parameter (Confidence Interval for Mean is 95%); the results are demonstrated in Figure 7 (Daily data is divided by 30 or 30^2).

			Statistic (Monthly)	Statistic (Daily)	Std. Error
D5_652	Mean		2,048,500.00	68,283.33	135,309.33
	95% Confidence Interval for Mean	Lower Bound	1,750,686.18	58,356.21	
		Upper Bound	2,346,313.82	78,210.46	
	5% Trimmed Mean		2,059,777.78	68,659.26	
	Median		2,086,500.00	69,550.00	
	Variance		219,703,363,636.36	244,114,848.48	
	Std. Deviation		468,725.25	15,624.18	
	Minimum		1,107,000.00	36,900.00	
	Maximum		2,787,000.00	92,900.00	
	Range		1,680,000.00	56,000.00	
	Interquartile Range		624,000.00	20,800.00	
	Skewness		-0.5	-0.02	0.64
	Kurtosis		0.3	0.01	1.23

Figure 7 Descriptive of Demand

We defined holding costs as accounting for 20% of product cost and assumed that ordering cost is 100 Euro per order based on the average transportation cost and handling cost. Using an average lead time of 14 days, we were able to calculate both safety stock level and ROP, as shown in Tables 2 and 3.

Table 2 Cost and Demand

Product Identification	Unit Cost (CNY)	Holding Cost (CNY)	Demand in Units (pcs) per year
D5-652	0.04382	0.008764	24,582,000

Table 3 Safety Stock and Reorder Point

Product Identification	Standard Deviation	Safety Stock (95% service level) (Pcs)	Mean of product	LT	dL	Reorder Point (Pcs)
D5-652	15,624	96,460	68,283	14	955,967	1,052,426

Because the data is not rounded, it is not realistic to use it when we ordering or building up safety stock. Therefore, we deleted the decimal points and add them up as shown in Table 4.

Table 4 Round-up Figure for Safety Stock and Reorder Point

Product Identification	Standard Deviation	Safety Stock (95% service level) (Pcs)	Mean of product	LT	d_L	Reorder Point (Pcs)
D5-652	15,624	96,500	68,283	14	955,967	1,100,000

From the demand distribution, we can see that, even though it is almost evenly distributed, there were still some periods with a relatively high demand. In winter, such as November and December, demand drop to nearly half compared to the other seasons. There are several reasons behind this phenomenon. First, some customers need components to produce electrical home appliances like air conditioners for which sales are seasonal. Secondly, most customers are Europeans, who have long holidays at Christmas, thus reducing demand during winter.

Regarding safety stock, the standard deviation of daily demand and lead time are the main variables. Under normal circumstances, it is acceptable to keep 96,500 pcs as safety stock for D5-652 but if lead time drops from 14 days to 9 days, safety stock will be reduced dramatically. Though it is not defined how much safety stock should be up R&D use another way to reduce lead time. The company selects parts in high demand, and by not storing semi-finished goods, production can go from D3 to D9 directly. This action shortens lead time by 7 days and reduces the workload of the warehouse. To guarantee a 95% service level, it is important to define safety stock level. For product D5-652, R&D needs to keep a safety stock level of 96,500 units to satisfy customers' requirements.

Reorder point indicates when to replenish stock when goods are used up. In the past, R&D reordered according to historical data and experience However, if R&D set safety stock levels and reorder points for each material, as we suggest in this paper, it can avoid problems; thus saving time and cost. In addition, the customs declaration process is a constant issue in China and it is difficult to know how long it will take for customs clearance if something exceptional happens. Therefore, R&D should also consider this as a factor that can potentially affect lead time and transportation arrangements. Also, daily demands vary during different periods such as peak and low seasons, and so R&D should adjust its safety stock and reorder point level periodically.

5.3 Vendor managed inventory (VMI) and consignment stock

Some important customers like Huawei request urgent delivery frequently without giving notice. It is hard to fulfill such requests on time because the parts Huawei need are difficult to produce. Considering customer's special requests and service level, R&D decided to use VMI as an inventory management tool to manage its stock. Normally, VMI can optimize both vendor and customer inventory levels through a common information sharing platform such as EDI. But Huawei and R&D don't have such an information platform. Monitoring VMI is manual like email, phone and fax. R&D is not the only suppliers of Huawei, so Huawei may turn to other suppliers when R&D cannot meet its requirements on time. If R&D were to build up common information platform with Huawei, the company could enjoy the full advantages of VMI.

Another way that R&D uses frequently to control inventory is consignment stock. Consignments are goods that are stored at the customer location but which are owned by the vendor. The vendor delivers goods to customers first and stores goods in the customers' warehouse. Only when the stock is used by customers, can the vendor' bill the customers. The advantage of consignment stock is that inventory can be stored in customers' warehouses and customers have to manage it. Vendors need to monitor depletion of inventory so that it can be replenished in a timely manner.

Comparing VMI and consignment stock, R&D uses consignment stock much more frequently. R&D has access to inventory level for consignment stock via SAP. Thus, R&D can push customer to use its stock by monitoring and updating the data. On the other hand, consignment stock pulls the production demand and helps to achieve economies of scale to save production costs. The risks associated with consignment stock are much less than those associated with VMI stock. However, it is hard to judge which approach is better because successful use depends on both parties cooperating and deriving mutual benefits from the arrangement.

6.0 Conclusion

This paper analyzed a company's inventory strategy and management tools as an example to explain similar inventory problems encountered by manpower-intensive industries in China. By combining classical inventory models such as safety stock and ROP, this paper aimed to arrive at the optimal inventory level while maintaining a consistently good service level. The paper also discussed approached to inventory management such as postponement and VMI.

Though R&D is well-equipped with tools to manage its production and inventory, it still needs to build up safety stock in a better and cheaper way. Currently, R&D monitors inventory mainly by manual effort and does not make the most of available cross-platform automatic systems. Though the two kinds of postponements confer great benefits on R&D and save it a great deal of money, manual work is demanded from MRP controllers to maintain systems and monitor inventory levels.

The trade-off between inventory and service level is a never ending topic. It is difficult to decide which is more important. Management is the key factor that instructs employees how to set appropriate priorities. Nevertheless, R&D needs to improve operational processes and standardize them so that manual mistakes can be reduced.

The findings of this paper are based on a single year's data only and this places limitations on the validity of outcomes. However, there will be many opportunities for further research and by collecting more data, we can identify other related variables which can optimize inventory level and raise service level. We can also focus in future on knowledge management and customer relationship management.

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