A Study of Supplier Management Inventory Management in a Supply Chain Environment

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Abstract. The importance of supply chain management is becoming more and more prominent as enterprises continue to refine their management. This paper specifically analyzes the feasibility of VMI implementation in Company F. It describes that Company F determines the materials for which the VMI model is to be implemented by adopting the ABC classification method to classify raw materials. For this category of materials, Company F designed the VMI implementation program and select the suppliers suitable for promoting the implementation of VMI. Practice has shown that after implementing VMI, Company F has effectively improved the problem of inventory backlog, on-time delivery rate has been significantly increased, and the level of customer service has been improved.

Keywords: supply chain management; inventory management; vendor managed inventory

1 Introduction

Vendor Managed Inventory (VMI) is a more advanced mode of managing inventory in supply chain management. Downstream enterprises share their inventory information and material demand plan to upstream enterprises, and upstream enterprises analyze this information to adjust their inventory in time and make production adjustments based on this information, which ultimately realizes inventory management, reduces inventory costs, and realizes the overall optimization of the supply chain.[1] The research object of this paper is a U.S.-funded company - Company F, which is engaged in cutting and welding equipment and ancillary equipment manufacturing enterprises, with the continuous development of the company, the company's production and business scope is getting bigger and bigger, the company is facing more and more significant inventory problems, the cost of inventory is rising year by year, inventory turnover is low, the delivery period is long, and the production efficiency is low. Based on the basic theories of supply chain management and inventory management, this paper analyzes the problems existing in the inventory management of Company F. Through the analysis of the results and problems achieved after the implementation of VMI in Company F for a period of time, it concludes that VMI is suitable for Company F, and at the

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same time, it also gives small and medium-sized enterprises some reference significance in the aspect of inventory management.[2]

2 Feasibility Analysis of VMI Implementation in Company F

There are certain preconditions for VMI implementation. Through the study of previous literature and research on enterprises that have implemented VMI, it is found that VMI implementation has the following conditions.

2.1 Product Characteristics Requirements

The material itself has a long life cycle with minimal possibility of change; the product quality is stable, no batch testing is required after the first certification, and the demand is high and predictable.[3]

2.2 Vendor Inventory Management Capacity

Supplier is an important participant in the implementation of VMI, bear the downstream manufacturer's inventory management tasks, but also need to be in accordance with the market specific production plan, material demand plan, timely replenishment, and the supplier should have excellent forecasting capabilities and inventory management capabilities, and the end of the operation of the time, the distance of the transport, to determine the corresponding goods inventory policy for the manufacturer to provide a more professional and high-quality service. The supplier should have excellent forecasting ability and inventory management ability.[4]

2.3 Strategic Alignment of Upstream and Downstream Companies

VMI can work on the basis of upstream and downstream enterprises' strategic alignment and the establishment of strategic partnerships.

2.4 Improved Information System Support

Another essential condition for the successful implementation of VMI is a well-developed information system. After receiving an order, the manufacturer will quickly carry out production planning to help suppliers meet their needs in a timely manner, thus facilitating the efficient operation of VMI.[5] Suppliers must understand the market demand in a timely and rapid manner, and in this way, realize the transparency of industrial information, and realize the accuracy of inventory management.

2.5 Good Logistics Support Platform

An important factor in the success of VMI implementation is the availability of good logistics capabilities on both the supply and demand sides. The logistics platform includes a complete logistics infrastructure and a strong logistics operation capability.[6]

2.6 Reasonable Risk Prevention Mechanisms

In the past research, many scholars found that the supply and demand sides in the implementation of the VMI process, the demand side from the beginning to the end can be profitable, the supplier in the implementation of the initial period is no profit to speak of, there may be a certain amount of loss, only in the long term only have a profit. Therefore, the implementation of VMI supply and demand sides in the profit and risk bearing is not equal, the supplier will be in the implementation of a period of time, will be unilaterally proposed to break the contract or reduce the quality of materials. For this reason, it is necessary to establish a reasonable risk prevention mechanism to avoid interruption of cooperation and other phenomena.[7]

3 VMI Program Objectives

Before designing a VMI, it is necessary to define the goal that inventory management should achieve for the organization. This objective is also the goal and direction of the enterprise in the implementation. Therefore, when developing the objectives of the inventory management program, Company F sets the following objectives from the perspective of the supply chain.

3.1 Reduce Overall Inventory Levels in the Supply Chain

After the implementation of VMI, part of Company F's inventory is managed by suppliers and safety stock is reduced due to timely information sharing. Suppliers can also adjust their inventory management strategies according to the inventory information shared by Company F and the demand plan. As a result, from the perspective of the entire supply chain, the overall inventory level has been reduced.

3.2 Improvement of Inventory Turnover

As the information of each node enterprise in the supply chain is shared and the information in the process of information transfer is reduced, the inventory cost and production cost are reduced, the utilization of production capacity will be increased, so the inventory turnover ratio will be improved accordingly.[8] The requirement of Group C to Company F is that the inventory turnover ratio should be increased by one turn compared with the previous year after the implementation of VMI and it is to be increased year by year.

3.3 Shortening of Delivery Period

After the implementation of VMI, the group management requested that the lead time be reduced to 30 days and eventually to 14 days. Because of information sharing, suppliers can grasp the changes in demand in a timely manner, so that they can make a quick response to reduce the risk of affecting production due to lack of materials, and to a certain extent, shorten the delivery period of Company F.

3.4 Enhancement of Cooperation with Suppliers to Improve the Overall Competitiveness of the Supply Chain

After the implementation of VMI, the contact between Company F and suppliers is closer, and the suppliers can make corresponding material replenishment plan for Company F through the inventory information and material demand information provided by Company F. In this way, the suppliers can establish a long-term and stable cooperative relationship with Company F, and finally achieve the win-win goal.

4 VMI Operational Programming

4.1 VMI Operating Model

Generally, VMI is divided into four operation modes. Company F adopts its own mode according to its own production characteristics and the distribution of suppliers, and determines the specific mode according to the distance of suppliers, i.e., for factories within 100 kilometers from Company F, the goods are in the supplier's place, and the supplier carries out the decision-making and execution of inventory and manages the inventory, while the supplier has the ownership of the inventory. For distances greater than 100 kilometers, the third model is drawn upon, but the person dedicated to managing the VMI is arranged by Company F, not the supplier.

4.2 Operational Process Design

VMI system usually includes 2 functional modules: Demand Forecasting Subsystem Module and Replenishment & Distribution Subsystem Module. The main role of the demand forecasting subsystem module is to determine the actual demand through statistical calculations by statistical tools, thus assisting suppliers to accurately forecast demand, the core of which is the integration of customer sales information and inventory information. The replenishment and distribution subsystem module is mainly to effectively manage the inventory level and determine the distribution replenishment plan based on the production plan and current inventory.[9]

Company F has adopted the following VMI process at this stage, based on the actual conditions of the internal and external environments.

(1) When Company F receives a demand forecast from a customer, the planner enters it into the JDE system and generates a Material Requirements Plan (MRP) based on the Bill of Materials (BOM) of the product being manufactured, and generally updates the

system data every month based on the customer's most recent forecast. In addition, when receiving purchase orders from customers, the planner also enters the orders into the JDE system, and at the same time, imports the data from the JDE system into the EKS system every morning, and the purchaser generates the orders according to the order management module in the EKS system, and sends them to the corresponding VMI suppliers. The purchaser generates the order according to the order management module in the EKS system and sends it to the corresponding VMI supplier.

(2) The supplier makes production arrangements based on Company F's Material Requirements Plan (MRP). In addition to preparing the quantities in the MPR plan, the supplier prepares a portion of safety stock for emergency orders. After receiving the formal order from Company F, the supplier will arrange the distribution plan to replenish the goods to Company F's VMI warehouse. Incoming and outgoing materials are managed by Company F's warehouse management.

(3) In order to ensure the supply of production materials, as well as the turnover and operation of the VMI warehouse materials, the supplier's control of the VMI warehouse materials shall be based on the maximum/minimum stock reserve of Company F's VMI materials.

(4) After the materials to the VMI warehouse, the warehouse personnel immediately report to the IQC personnel to ensure that the materials in the VMI warehouse are qualified products.

4.3 Demand Projections

Demand forecasting is crucial to the development of an enterprise. Good demand forecasting can balance an enterprise's production capacity, facilitate advance financing through the development of appropriate production and procurement plans, and further reduce the enterprise's production and operating costs.

Company F's demand forecasts were provided by its customers. Generally, customers in the United States updated their forecasts every month, customers in Australia updated their forecasts every six months, and some other customers provided demand forecasts once a year, while others never provided demand forecasts at all. Since the implementation of VMI, Company F has required that the U.S. and Australia update their demand forecasts on a monthly basis because these two customers account for more than 85% of Company F's sales, and changes in their demand can have a significant impact on Company F's and its suppliers' production schedules. Other customers are required to update their demand forecasts at least quarterly.

Table 1 shows the statistics of demand forecast and actual demand of Company F for the past one year. From this table, it can be seen that since January 2021, the actual demand fluctuates with the forecast in a more balanced way, which is close to the company's requirements. This shows the importance of updating demand forecasts in a timely manner.

Table 1. The ratio between the forecast and firm order

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr

Demand forecast K$	1,200	1,200	1,300	1,300	1,400	1,100	1,050	1050	1,000	1,000	1,210	1,200
Order K$	1,226	1,027	1,586	1,193	1,310	1,036	980	1010	980	975	1,180	1,220
Accuracy	1	117%	82%	109%	107%	106%	107%	104%	102%	103%	97%	98%

Source of data: provided by clients of Company F

4.4 VMI Inventory Setting

The material demand of the enterprise is not static, the demand always fluctuates with the market sales situation. At the same time, the supplier will also be due to a variety of man-made or natural factors of the impact of delayed delivery. Therefore, in order to better meet the demand for materials, we need to set up a safety stock before the implementation of procurement.[10]

The company implements VMI and focuses on the setting of four quantities: Safety Stock (SS), Maximum Stock (Qmax), Minimum Stock, and Economic Order Quantity (EOQ). The setting of the quantities in company F is as follows.

(1) Safety stock (SS)

Company F's SS is calculated by combining the previous year's sales data and demand forecasts to determine the daily requirement, multiplied by the lead time (22 days), and then multiplied by a safety factor of 1.05~1.2, which depends on the supplier's on-time delivery rate and lead time. The size of the safety factor depends on the supplier's on-time delivery rate and the length of the delivery period. If the on-time delivery rate and the delivery period are short, the safety factor will be set low. For example, a material 1435-0067, the annual sales data for 2014 is 10,000 units, the forecast for 2021 is 8,000 units, the delivery cycle is 45 days, the annual effective production time is calculated as 300 days, the specific calculation of the SS volume.

SS = (10,000 + 8,000) X 22 X 1.20 / (2 X 300) = 792

(2) Maximum stockpile (Qmax)

There is no standardized method for maximum inventory levels. Maximum stock levels are set in order to control the capital employed in inventory and to accelerate the capital turnover of inventory.

In business practice, some companies use the following calculation method to calculate the maximum inventory level. company F uses the same formula, and the maximum number of days of inventory is based on 22 days.

Qmax = Average Daily Production X Maximum Days in Stock (Equation 4.1)

(3) Minimum stockpile (Qmin)

The minimum stock level is set so that there is a certain amount of inventory that will not affect production or shipment in the event of non-arrival.Company F Qmin is set by the following formula, and the minimum procurement cycle is measured in 11 days.

Qmin = Average Daily Production X Minimum Purchase Lead Time (Equation 4.2)

(4) Economic order lot Q*

Company F's economic order lot is modeled using the classic economic order lot model. The formula of this model is:

$Q^* = 2DC / H$ (Equation 4.3)

D in the formula represents the total annual demand, C represents the cost of a single order, and H represents the annual inventory holding cost per unit of product.

For Company F, the total annual demand D can be derived from the forecasting method, C can be calculated based on historical data, and the annual inventory holding cost per unit of product H can be derived from the annual financial report of the enterprise, combined with a reasonable apportionment based on experience.

5 VMI Implementation Steps

5.1 Determination of Materials for VMI Implementation

Company F is a processing trade enterprise, so the procurement of raw materials from abroad accounts for 20%~30% of the domestic procurement. Considering the delivery cycle and transportation cost of these imports, these raw materials are not included in the scope of VMI implementation. Secondly, for the raw materials purchased domestically, according to the preliminary screening of product characteristics (see Table 2), Company F has selected stamping parts, machined parts, red punching parts, instrumentation and packaging materials as the preferred products for the implementation of VMI.

Table 2. Types and specification of raw material

Type of raw materials	unit volume	unit weight	unit value	Delivery time (days)
Stamping	small	repetition	general	30
Machined parts	big	unimportant	general	30
Red Punch	small	repetition	general	30
Fasteners	small	unimportant	lower	21
Meter (i.e. measuring instrument)	big	repetition	high	45
PCBA circuit boards	small	unimportant	high	60+
Electric cable	small	repetition	high	45

Injection molded part	small	unim-portant	general	30
Packaging material	big	unim-portant	general	25

Source: Company F procurement data

5.2 Selection of VMI Suppliers

The determination of suppliers is mainly based on the analysis of supplier risk, which mainly includes four aspects of quality risk, capacity risk, delivery risk and financial risk to be analyzed.

Company F has 185 suppliers, of which 25 are foreign suppliers and the remaining 160 are domestic. Among the domestic suppliers, 64 are from Ningbo area. One supplier is finally selected.

6 Evaluation of the Effectiveness of VMI Implementation in Company F

This paper focuses on the evaluation of VMI before and after implementation in terms of inventory cost, inventory turnover, on-time arrival rate, customer service level, procurement lead time, supplier transportation cost and supplier cooperation.

6.1 Reduction in Inventory Costs s

This paper focuses on comparing the changes in inventory before and after the implementation of VMI in Factory L and Company F to illustrate the impact of the implementation of VMI on inventory levels. As show in table 3.

Table 3. Inventory of L factory and F company in 2021

plant	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
L Factory K$	230	210	212	208	205	250	225	203	200	185	180	182
Company F K$	2,832	2,957	3,341	3,105	3,018	2,975	2,946	2,904	2,793	2,584	2,485	2,370

Data source: Inventory data collated from Company L and Company F

6.2 Increase in Inventory Turnover (ITO)

Inventory Turnover (ITO), which is planned to forecast the cash flow of the entire company from a financial point of view, is used to appraise the level of demand and supply chain operations throughout the company.F The company's Inventory Turnover (ITO) is dynamically tracked in terms of cost of products sold per month/value of inventory at the end of the month.

When Company F was operating traditional inventory management, the ITO was between 5.5 and 6.5. A few months after the implementation of VMI, the ITO improved significantly. As show in table 4.

Table 4. ITO of F company

plant	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Annual sales K$	18409	19126	19203	19218	19031	18529	17853	17413	17827	13120	14978	14624
In-ventory K$	3018	2975	2946	2904	2793	2584	2485	2370	2306	1858	2053	1979
ITO	6.1	6.4	6.5	6.6	6.8	7.2	7.2	7.3	7.7	7	7.3	7.4

Source: Data collated from Company F's annual report

6.3 Increased On-time Delivery (OTD) Rate

As a result of VMI, the supplier is aware of the quantity of Company F's inventory in a timely manner and is able to proactively arrange for deliveries.

As a result, on-time arrival rates have improved.

In the case of Plant L, Table 5.3 shows a comparison of the on-time arrival rates for the first half of 2021 and the second half of 2021.

The graph shows that since the implementation of VMI in May, the on-time arrival rate has improved significantly.

Table 5. OTD of L factory in 2021

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

OTD (%)	96.50	95.70	96.80	95.80	96.20	96.80	97.20	97.20	97.50	98.00	98.20	98.50

Data source: L Factory Sales Order Detail Data

6.4 Increased Level of Client Services

The level of customer service can be measured by two indicators of how quickly Company F responds to orders. One indicator is on-time shipment (OTS) and the other is lead time (LT).

(1) On-time shipment (OTS). After the implementation of VMI, Company F's on-time shipment (OTS) rate increased from about 95% to about 97% because the suppliers got the demand plan of Company F in time. Table 6 shows the statistics of OTS of Company F before and after the implementation of VMI. From the table, it can be seen that since the implementation of VMI in May 2021, the OTS of Company F has been improved.

Table 6. OTS of F company in 2021

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OTD (%)	94.70	94.50	95.20	94.90	95.50	95.50	95.70	96.00	96.20	96.50	96.40	97.00

Data source: L Factory Sales Order Detail Data

(2) Lead Time (LT) Company F had set the lead time at 60 days since its establishment, but in September, the fifth month after the implementation of VMI, the lead time was reduced from 60 days to 55 days, which is a reduction, but still a long way from the target of 30 days set by the company.

7 Conclusion

The above analysis shows that the implementation of VMI in Company F is feasible and necessary. By implementing VMI, Company F can improve the inventory backlog problem, on-time delivery rate and customer service level. However, the implementation of VMI also faces some challenges, such as supplier selection and cooperation, information sharing and communication mechanism establishment. Therefore, Company F needs to focus on strategy adjustment and continuous improvement during the implementation process to ensure the successful implementation of VMI and bring expected benefits.

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