A Case Study of VMI using TOC

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Abstract

A vendor managed inventory (VMI) is a process whereby a supplier maintains an inventory for a retailer by generating orders for the retailer based on its demand information. In this relationship, the supplier is responsible for maintaining the retailers' inventory levels and transportation and transaction costs. The performance measurements that are associated with the theory of constraints (TOC) have been widely advocated as a mechanism of linking operational objectives to the global goals of an organization. In this paper, we use a case study of the Procter & Gamble to illustrate the application of TOC in VMI. The results show that the quality of service and the inventory level can be improved.

1. Introduction

Supply chain management (SCM) has become an important topic in many disciplines. The core objective of the SCM is to minimize system-wide costs while satisfying service requirements. Note that the supply chain is a dynamic relationship which includes all of the activities – i.e. manufacturing and assembly, warehousing and inventory control, distribution, and customer service – that are involved in delivering products or services from raw material providers to customers. Supply chain management (SCM) then coordinates and integrates all of these activities into a seamless process. With increasing global competition and the emergence of e-business, supply chain management is considered to be a powerful approach to cutting costs and increasing profits.

Marien [1] identifies strategic alliances as among the key supply chain enablers. Strategic alliances concern how external companies (customers, suppliers, and logistic-service providers) are selected as business allies and how inter-company relationships are built and managed whereby a supply chain links all of the chain partners, including departments within an organization, and the external partners, including suppliers and third party providers. A successful alliance enables managers in companies across the supply chain to take an interest in the success of other companies and to work together to make the whole supply chain competitive. Strategic partnerships typically lead to long-term strategic benefits for both partners.

However, demand forecasting is one of the most difficult tasks for both retailers and suppliers in a supply chain, especially when the product life cycle is short and made-to-order requests are common. In addition, the demand variation of suppliers is much greater than the variation of retailers due to the bullwhip effect [2]. Regardless of these difficulties and uncertainties, enterprises must still rely on forecasted demand to make managerial decisions, e.g. resource allocation, capacity planning, production planning, and cost control, etc. [3]. Thus, to achieve the congruent supply chain goal, it makes sense to create cooperative partnerships between suppliers and retailers to leverage the knowledge of both parties. Simchi-Levi et al. [4] state that various types of retailer-supplier partnerships (RSPs) can be placed on a continuum. The lowest degree of partnership (on the far left) is information sharing, whereby the vendor plans the demand based on limited information provided by the retailers, and at the other end (the far right) is a consignment scheme, whereby the vendor completely manages and owns the inventory until the retailer sells it. This partnership is implemented by the strategy known as vendor-managed inventory (VMI). VMI is a planning and management system that is not directly tied to inventory ownership. Under VMI, instead of the customer (the retailer) monitoring its sales and inventory for the purpose of placing replenishment orders, the vendor (the supplier) assumes the responsibility for these activities. In the past, many suppliers operated vendor-stocking programs whereby a representative visited a customer a few times in a month and restocked its supplies to an agreed-upon level. As popularized by Wal-Mart, VMI replaces these visits with information gathered from cash registers and transmitted directly to a supplier’s computer system via Electronic Data Interchange (EDI). Suppliers can now directly monitor sales of their products and decide when to initiate the replenishment process. However, VMI is an expensive proposition for suppliers. Investments must be made in new systems, software, and employee training. This brings us back to the question of whether there is a payoff.

Over the last few years a number of semiconductor companies have implemented shop-floor control procedures based on the theory of constraints (TOC), which was developed by Goldratt [5] and focuses on constraining resources, subordinating the remainder of the plant to keeping the bottleneck work centers running at their maximum capacity, and simultaneously working on elevating the bottleneck to improve its performance. The TOC is a problem-solving approach that can be applied to many business areas. The five steps of the TOC are: (1) identifying system constraints; (2) deciding how to exploit the system constraints; (3) subordinating everything else to that decision; (4) elevating the system constraints; and (5) if in the previous steps the constraints have been broken, then returning to step 1, but not letting inertia become a system constraint. The concepts of TOC have been used to develop production-scheduling rules that are collectively known as optimized production technology [3]. The TOC has been implemented in many different areas, such as operations, finance and measures projects, distribution and supply chains, marketing, sales, managing people [6], job-shop manufacturing [7], the service industry [8], project management [9], among others. Moreover, the performance measurement system in the TOC has been recognized as the global goal of many organizations, and it is profitable. We apply TOC to VMI to improve the quality of service and reduce the inventory level among suppliers and retailers. The remainder of this paper is organized as follows. Section 2 discusses related works on the development of VMI, and section 3 focuses on VMI adoption. Section 4 discusses the applications of the TOC in VMI, and section 5 provides a case study. Section 6 draws conclusions and provides suggestions for further research.

2. The development of VMI

VMI, which is sometimes called the continuous replenishment program [10], is a pulling replenishing practice that is designed to enable vendors to respond to demand by obtaining actual consumption data with additional forecasts from the retailer. In the retailer-supplier partnership (RSP) continuum, VMI is the highest degree of cooperation, and vendors make the primary decisions about placing orders and inventory control. The vendor is entitled to view every item that the retailer carries, as well as point of sale (POS) data. In VMI, the supplier decides the appropriate inventory levels of their products (within previously agreed-upon bounds), and the appropriate replenishment policies to maintain those levels. Holmstrom [11] reported that the demand variability for the vendor was reduced from 75% to 26% in the pilot implementation. Total stock was down 30% and the order/delivery lead-time was cut from 48 to 10 hours.

The history of VMI can be traced back to the early development of quick response (QR) between general merchandise retailers and their suppliers. Due to intense competition in the textile industry, leaders in U.S. apparel manufacture formed the Crafted With Pride in the U.S.A Council in 1984 [11]. The Council commissioned a supply chain analysis, and the results showed that the delivery time for the apparel supply chain was 66 weeks from raw materials to consumers, 40 weeks of which were spent in warehouses or in transit. To reduce the lead-time and inventory cost, the report proposed a QR strategy. A QR strategy is a partnership wherein retailers and suppliers work together by sharing information so that they can quickly respond to consumer needs. Under this strategy, suppliers receive POS data from retailers and use it to synchronize their production and inventory control with actual sales at the retailer. However, the retailer still makes the decision to generate orders and the supplier must improve demand forecasting and production scheduling by using POS data alone. Milliken and Company, a textile and chemicals firm, was one of the first to adopt QR, which reduced lead-time from 18 to 3 weeks [12].

Similar to the textile industry, a group of grocery industry leaders created a joint industry task force called the efficient consumer response (ECR) working group in 1992. The group appointed Kurt Salmon Associates Inc. [13] to examine the grocery supply chain to identify opportunities to increase competitiveness. The subsequent report identified a set of best practices, which if implemented could substantially improve overall performance. Kurt Salmon and Associates found that “by expediting the quick and accurate flow of information up the supply chain, ECR enables distributors and suppliers to anticipate future demand far more accurately than the current system allows”.

A further development from ECR was the continuous replenishment program (CRP). CRP is a move away from pushing products from inventory holding areas to grocery shelves based on consumer demand [10]. In a CRP strategy, which is sometimes called rapid replenishment, vendors receive POS data and use it to prepare shipments. In an advanced form of CRP, suppliers may gradually decrease inventory levels at the retail store or distribution center as long as the service level is met [14]. Thus, inventory levels are continuously lowered. Other topics in inventory replenishment are discussed by Waller et al. [15], Cetinkaya and Lee [16], and Chaouch [17].

In the history and development of RSP, one phenomenon stands out. That is, RSP was driven by competitors as they strove for survival and success. Such competition allowed the progressive development of RSP strategies and the establishment of industry standards through the joint efforts of companies that were originally at loggerheads. This implies that the partnership was extended from a single supply chain to multiple yet integrated supply chains. The implementation of RSP benefited both retailers and suppliers, and eventually the end-consumer. The RSP strategies are summarized in Table 1. When partnership moves from one level to the next on the RSP continuum, new skills should be learned and employed by the vendor.

3. The Adoption of VMI

Many success stories from various industries have been told of VMI. Examples include the Wal-Mart/P&G arrangement, Fasson MPD (which is a division of Avery-Dennison) and Worsleys (the only inter-merchant paper trader from the U.K. in continental Europe), Baxter International and a large number of hospital customers in North America, and YCH in Singapore [18]. Moreover, Stundza [19] showed that the application of supply alliances such as VMI could cut costs and reduce inventories in metal industries. Kaipia et al. [20] presented a time-based analysis for measuring the benefits of VMI in different circumstances. The results revealed that VMI was a much more efficient solution for low volume items. The motivation behind RSP and VMI strategy is that both parties work together to maximize the competitiveness of the supply chain. However, the most obvious benefits of VMI are the inventory cost reduction for retailers and total cost reduction for suppliers that arise from coordinated production and distribution with better demand forecasts. The identified benefits of VMI program can be found in the Simchi-Livi et al. [4] and Vendor Managed Inventory [18] studies.

Despite the numerous benefits of VMI, some concerns need to be taken into account. In the Aichlymayr [21] survey of VMI implementations, the concerns were as follows. (1) Vendors' administrative costs increased, as did their responsibilities and the amount of work that needed to be done. (2) The implementation time was long due to the trial and error approach. (3) The system was hard to use with volume discounts and special pricing – alternate pricing strategies were sometimes necessary. (4) In the short run the system was complicated because the roles of employees, vendors and customers could be unclear upon implementation. (5) Retailers risked loosing control and flexibility, especially when the adopted procedures were innovative. (6) There was potential for arguments about the handling of over-stocked or obsolete goods, and specific agreements were needed between manufacturers and retailers.

To implement VMI, three enablers are essential: organization infrastructure, information technology, and training [4]. VMI strategy involves a high degree of partnership between retailers and suppliers, and it changes fundamental ways of doing business. The commitment from the senior executives of both parties is the first attribute of organizational infrastructure that will ensure the success of a VMI program. The feeding of previously confidential sales and inventory data to suppliers necessitates determination and commitment from very high levels. A certain degree of mutual trust and a regular review scheme must be in place to maintain the alliance. Moreover, the introduction of VMI may also shift power from one group to another within an organization. This is because suppliers need to collect more information online and the daily contact with retailers moves from sales and marketing departments to logistic departments. This organizational change must be considered in the re-structured scheme, and job responsibilities have to be re-assigned.

Information technology, including the technology itself and integrated production systems, is another important enabler in VMI. Forms of technology such as bar codes are essential to accelerating the data input and maintaining data accuracy. Electronic data interchange (EDI) or Internet technology (such as XML) is also useful in creating direct links between retailers and suppliers. Note that a direct link can avoid entry errors and diminish data transfer time. Once real time data are available, an integrated enterprise system such as enterprise resource planning (ERP) [11] can be used to incorporate planning, inventory, production, and distribution into a fully implemented VMI strategy.

Beside organizational change and technological adoption, suppliers also need to adopt new skills and practices such as forecasting, inventory control, supply chain management, and retail management, etc, into their operations. Therefore, a comprehensive training program is important for the relevant managers and operators. The Simchi-Livi et al. [4] and Vendor Managed Inventory [18] studies provide a systematic approach to VMI system adoption in 5 stages.

Stage 1. Present & Align: The first stage covers the concepts, benefits, and requirements of VMI, and requires the participation of senior managers. These managers must commit to the possible costs involved, the human resources needed for establishment/ maintenance, and the concept of having someone else managing their inventory. They need to ensure that all employees who will be conducting the relevant activities into the VMI concept. Moreover, they must align the firm's objectives with those of its supplier, define the scope of the partnership, and formulate the contractual terms of the agreement. This should include decisions about ownership, credit terms, ordering responsibility, and performance measures.

Stage 2. VMI system design: A steering committee is formed to take control of the project. It defines the project schedule and scoreboard to assess feasibility against VMI requirements. Information is defined and logistic processes are established. The necessary information systems are identified and acquired. EDI formats are defined and EDI transmission testing is conducted before a VMI training program is implemented.

Stage 3. Pilot Run: The process is validated by user acceptance testing. Problems are identified and the process is refined.

Stage 4. Implementation: Dual systems (VMI and the original system) are run according to a transition plan. Then, VMI goes live if the system adoption works smoothly.

Stage 5. Monitor and review: The scoreboard is updated. Problems and improvement areas are identified and acted upon to achieve targets.

This implementation approach provides a general reference. Any stage can be modified to fit individual VMI program needs.

4. Applying TOC to VMI

As suggested by Goldratt and Fox [22] , three new measures can be added to the traditional measures such as net profit, return on investment (ROI), and cash flow. They are (1) throughput – the rate at which the system generates money through sales; (2) inventory – the money that the system invests in purchasing things to sell; and (3) operating expenses – the money that the system spends to turn inventory into throughput. Glodratt and Fox also presented a relationship among the global performance measures. That is, if throughput increases while inventory and operating expenses decrease, then net profit, ROI, and cash flow will increase. In contrast, if throughput decreases while inventory and operating expenses increase, then net profit, ROI, and cash flow will decrease. Based on the TOC performance measurement, throughput is equal to the final net sales rather than shipments or any other measures that are commonly used. Moreover, inventory is valued at the cost of raw materials rather than on a cost accumulation basis. Operation expenses take in all other costs. For example, all overhead costs that are traditionally allocated to inventory as it migrates through the production process are considered as operating expenses. The direct labor of employees is considered as part of these expenses. Thus, the TOC changes the accounting scheme for performance measures. Here, the

TOC performance measures will be used to relate functional measures to the performance of VMI. In addition, the repetitive TOC steps, i.e. identifying system constraints, exploiting system constraints, subordinating the firm's operations to those constraints, elevating the system constraints, and returning to the first step, are used for continuous improvement in VMI. Managers can also use "thinking system" techniques, such as evaporating clouds and effect-cause-effect diagrams, to facilitate their decision making [22]. These techniques help managers to challenge conventional thinking and to find the root causes of the problems that they face. A detailed application of TOC is described in the following case study.

5. Case study

As mentioned earlier, consumer demand drives replenishment orders and shipping in CRP. This process can be distributor managed, supplier managed, or third party managed (by an agent or outside service). The most common CRP is Vendor Managed Inventory (VMI), in which the vendor manages its customer's inventory and ensures that the replenishment process optimises the customer's warehouses or retail stores. The vendor must receive regular sales off-take and inventory data from the retailer, and forecast demand and deliver the required quantity to the retailer. VMI can operate at either the retailer's warehouse or store level, depending on the sophistication of business operations and information technology adoption. In implementation, the retailer's warehouse transmits daily inventory levels and off-take or store order data to the vendor; and the vendor is responsible for creating orders to ensure that the warehouse can meet the retailer's product need. In this paper, we use the VMI piloting program between Procter & Gamble (P&G) and Wellcome, a CRP software package called the Key Account Replenishment System (KARS), as the case study. The main function of KARS is to generate suggested order quantities based on retailers' off-take and inventory information. The logic behind the KARS calculation of order quantity is illustrated below.

A key factor in the success of VMI operation is the demand projection to cater for both normal demand and abnormal demand that arises from promotions, new product introductions, out of stock products, or seasonal variations. Other than demand projection, factors such as order calculation (considering the current stock level, order to delivery lead time, and others), safety stock requirements, and delivery optimization in terms of pallet and truck loads are important. In KARS, there is a built-in forecasting model for estimating daily demand off-take at a distribution centre (DC). The rationale behind the forecast calculation is to predict the amount of products that the will DC required according to sales off-take in the past 8 weeks. Note that the formula for demand forecasting considers the 8-week-averaged sales off-take as well as customer service level. The past 8 weeks off-take divided by the achieved customer service level is the base for future demand projection. The customer service level has been incorporated in this calculation to minimize the chances of underestimating future demand when products have been out of stock (OOS) in the previous sales period. Demand projection is converted into a suggested order by taking into account the stock requirement and delivery optimization. Stock requirement is determined by stock-on-hand, safety stock for demand variation, order frequency, and lead-time. Here, the safety stock requirement is based on the standard deviation of the past 8 weeks off-take. The delivery optimisation minimizes order sizes and determines pallet size and truck loads.

In this case study, non-cosmetic products (88 stock keeping units (SKUs)) are chosen to evaluate the performance of a VMI. The results of the key performance indictors are shown in Table 2, and are grouped into 2 categories: (1) success criteria, or the direct measurement of the degree to which VMI objectives have been achieved, e.g. reduction in inventory and increase in service quality; and (2) the process performance that is related to monitoring process efficiency and effectiveness, e.g. the line fill rate and on time delivery. Significant improvement after VMI implementation in phase I (from September, 1998 to April, 1999) led to an inventory reduction from 24 to 13 days, which was already very close to the target of 10 days. However, some areas demanded further improvements, such as the high occurrence of overrides (which are considered as constraints in the TOC). Manual intervention, in particular the modification of purchase order quantities by the retailer, occurred frequently and had an adverse effect on the automation process. Several potential causes of overrides were identified: demand created by new channel openings, manual input for promotional items, and manual input for new products. In phase II (May, 1999 to November, 1999), with the adoption of the five TOC steps, we ascertained the override quantity on how much inventory should be maintained was identified. The key performance measurement for inventory was the turnover rate (step 2 in the TOC). The performance measurement aspects of throughput, inventory, and operating expenses were used for internal management decisions. The management also used the effect-cause-effect and cloud decision-making techniques, and was trained in the use of underlying performance measurement methods. For override analysis, the occurrences were first compared against different causes of overrides. The objective was to identify the percentage of overrides that were caused by different factors, namely data related issues and the handling of promotional orders and new products. Special attention was needed to observe any override clustering among certain product categories, brands, or SKUs (step 3). Moreover, the success rates of both KARS suggested quantity and Wellcome override quantity were measured and compared to reflect the necessity and accountability of the override process. The formula to measure success in the proposed order quantity and override order quantity was as follows (step 4):

Success = inventory on hand + replenishment quantity – Wellcome DC off-take

The KARS suggested order quantity and Wellcome's override quantity were considered to be successful when the actual Wellcome DC off-take was less than the quantity that was recommended by either party plus inventory on hand. This implies that order quantity can fulfil actual DC demand. After applying TOC to VMI, the results of the performance indictors can be improved (step 5, see the last column in Table 2). This case study can aid in the understanding of how VMI implementation can be more effective and efficient.

6. Conclusions

VMI can help companies to (1) eliminate repetitive purchasing activities, (2) lower the cost of processing claims, (3) reduce inventory, (4) increase inventory turnover, and (5) solidify the supplier-retailer relationship. By implementing VMI, suppliers and retailers can focus on the same issue – how to sell the right products to the end customer at the right time. This changes the supplier's focus from encouraging the retailer to buy more to helping the retailer to sell more. Moreover, when the TOC is applied in VMI, its benefits increase. VMI is not a new concept – automated inventory replenishment by suppliers has been an issue in the retailing world for more than 30 years. However, as shown in our case study, VMI can be utilized through integration with TOC, information technology, and other elements. Similar trends, such as supplier management inventory (SMI) or joint managed inventory (JMI), are merely different ways of looking at the same thing.

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Table 1. Comparison of four major RSP strategies

RSP Strategy	**Decision Maker**	**Inventory Ownership**	**New Skills Employed by Vendors**
Quick response	Retailer	Retailer	Forecasting skills
Continuous replenishment	Contractually agreed levels	Either party	Forecasting & inventory control
Advanced continuous replenishment	Contractually agreed to & continuously improved levels	Either party	Forecasting & inventory control
VMI	Vendor	Either party	Retail management

Table 2. The performance of VMI

Indicator \ Time	Baseline (Target)	9/98-4/99 VMI (Phase I)	5/99-11/99 VMI -TOC (Phase II)	12/99- present
Inventory (days)	24 (10)	13	16	11
DC in stock (%)	NA (95)	94	98	98
Order generation turn-around time (minutes)	NA (15)	26	17	16
Order confirmation turn-around time (minutes)	NA (15)	45	20	16
Line fill rate (%)	94 (95)	95	93	95
On time delivery (%)	100 (100)	100	100	100
Billed accuracy (%)	99 (100)	100	100	100
Number of overrides (%)	NA (10)	20	9	8
EDI usage	NA (Yes)	Yes	Yes	Yes