Supply Chain Integration in Vendor Managed Inventory

Rajkumari Mittal[1], Habiba Abbasi[2], Sarla Pareek[3],

[1]*Assistant Professor, IILM Gurgaon, Haryana, INDIA.*

[2]*Assistant Professor, IILM Gurgaon, Haryana, INDIA.*

[3]*Professor, DST, CMS .Banasthali University (Raj.), INDIA.*

Abstract

This paper tries to find-out variations within different parameters of any industry's supply chain. It shows impact on cost savings which can be analyzed by different approaches followed these days like Vendor managed Inventory (VMI), Just in time (JIT), synchronized VMI, etc. Outcome of this analytical paper describes that VMI may benefit the supplier and buyer both even when the supplier imposes some transportation cost upon the buyer. The demand is increasing function of time if they share the information on time with each other, with appropriate predefined trading conditions like, How much will be the ordering cost? , What will be the transportation cost policy?, What will be the ratio of profit distribution if they agree for these terms etc?

Keywords: Vender managed inventory (VMI), Just In Time(JIT), Supply chain integration, Information sharing, EDI (Electronic-Data-interchange), Third party logistics..

1. Introduction

Vendor Managed Inventory (VMI) is the group of business models where the buyer (Retailer) shares the customer demand data with its upstream supplier (wholesaler) in the supply chain for a particular product. The supplier takes the ownership of managing an agreed inventory of required materials for the buyer at his place (retail outlet /location/ware house). This process can be very well coordinated by involving a third party logistic provider who tries to manage the buyer's inventory by reducing the gap between demand and supply with in the specific time provided. If VMI is described as a composite structure of relationship between buyer and supplier, which not only reduces the inventory in the supply chain and avoids shortages of goods, but also helps the buyer(retail outlet vendor) in proper display of products by training the store staff for, How to arrange and clean the various product lines for their respective stores?

One of the important aspect to implement VMI is that both the supplier and buyer share equal risk associated with their trades, like if the buyer (retailer) can't sell the product, the supplier may take it back providing full money back to the buyer or the product may lie with the buyer (at his out let) but is not owned by him until the sale takes place, or the supplier assists the buyer in sale. All the products are exchanged for a predetermined commission or profit.

With VMI, if suppliers get advantages having more control on displays and more connections to induce knowledge in employees, buyers also have less risk being equipped with knowledgeable staff(who brings in Brand loyalty for both the supplier and buyer) and reduced holding or maintenance charges. Due to this reason VMI business models are used by some of the famous international retailers like Wal-Mart.VMI also helps in developing a more proximate relationship between the supplier and buyer by using various EDI(electronic data interchange formats like EDI software's and statistical methodologies) to predetermine and hold correct inventory through the whole supply chain. Even after so much description, VMI VMI had received extra attention producing everyday inching doubts in the minds of researchers and traders like,

1. Under what condition does VMI actually produce benefit?
2. Where do the benefits from VMI surface among participating parties?
3. According to which ratio or rule the benefits amongst the participants will be distributed?

A clear understanding of these issues will provide deep insights for decision making and negotiations for trading firms those in supply chains. Though numbers of researchers have explored various factors affecting the benefits which are generated by VMI or other integrated supply chain initiatives and distribution of them in between the various supply chain players. In one of the earlier studies with the help of analytical models it was being described that if order release policy for any product uses VMI, it affects the inventory level required for the buyer parallel affecting the inventory cost for the supplier also. (Cetinkaya, S & Lee, C.Y 2000).

In one more same kind of research work it was found that the quantity of continuous replenishment programme is affected by the features which consumer demand has (Raghunathan, S, 1999); means when the demand has more variance, inventory size reduces due to continuous replenishment programmes. In another empirical study following Just in time(JIT) practices which is very frequently used in conjunction with VMI , it was found that if benefits are analyzed in terms of inventory reduction, they flow mainly towards the buyer rather than supplier (Dong, Y. 1998).

One more analytical model developed by (Yao et al, 2007) explained that inventory reduction benefits which occur after implementing VMI are not equally distributed between the buyer and supplier as a result of which one player of supply chain receives all benefits while the other has to bear with extra costs, moving the inventories upstream, from retailers to wholesalers or even to manufactures. These discoveries were challenged by (Piet Vander V list et al., 2007) including transportation cost also in the previously discovered cost model. This challenge was further revisited by (Lee, H.L et al., 2000) justifying both the previous done works up to an extent, concluding that both were right in exploring their research, but under different set of parameters.

We extend their work, taking the modified version as a base model but the demand is not constant, rather it's increasing function of time and along with ordering cost and carrying cost, logistic cost (transportation cost) is also included in total cost parameters.

Our major findings are

(1) The benefits for the complete supply chain can be higher if the ordering cost of the supplier is low relative to the buyer prior to VMI implementation or high relative to the buyer after implementing VMI.

(2) Benefits received by the buyer due to inventory cost savings will be more while the supplier receives a high inventory level before applying the VMI, but the benefits can be evenly distributed after applying synchronized VMI and some predefined trading condition even when demand is increasing function of time.

2. Literature Review

To implement VMI, it is required to share the information, co-ordinate and integrate the processes between buyer and supplier, as well as transparency of transportation charges by the supplier from the buyer. Generally, the buyer shares the consumer demand and his inventory status with respective supplier by "Information Sharing" and supplier take over the inventory control and purchase function with the buyer by "Process integration'. Suppliers also negotiate their transportation charges due to which none of them is facing burden and profits can be proportionately shared among the two. Keeping this in view, we tried to explore the literature on all the three points.

Information sharing

The performance of supply chain depends seriously on how its members co-ordinate their decision, and co-ordination can't be imagined without some form of information sharing. A significant part of supply chain research is devoted to understand the role of information in achieving supply chain coordination. In supply chain every single member has perfect information about himself but uncertainties occur due to lack of perfect information about other members. If the members are willing to share the information, each of them will contribute a lot to improve systems performance. This co-operative mode of information sharing among different partners can be described as supply chain partnership, with which negative features of supply chain like "Bull whip effect" can be eliminated or minimized (Cachon, G & Fisher, M 2000; Chen, F. et al. 2000; Gavimeni, S & Kapuscinski, 1999; Lee, H.L et al., 1997; and Lee, H.L et al., 2000). Bullwhip effect decrement is really an improvement in the performance of supply chain (by lowering inventory levels and reduction in cycle time), (Cachon, G & Zipkin, P.H. 1999; Waller, M. et al., 1999). Many researchers have identified the significance of information sharing through VMI or similar programs and developed economic lot size models for collaborative inter organizational relationships and found that well coordinated relationships can really enhance the total cost benefits when real time information is shared between the two adjacent players (Landeros, R.and Lyth, D.M. 1989). In other paper with the help of an analytical model it was presented that coordinated inventory should include transportation decisions also in VMI systems and found that exact inventory requirement of the vendor is partly determined by the parameters used for shipment release, (Cetinkaya, S. and Lee, C.Y 2000). Other researchers also examined the impact of continuous replenishment programs on the relationship between a supplier and buyer.

Supply Chain Integration.

Integration in supply chain necessitates excellent communication between the buyer and seller. The communication and relation which exists between the ordering and shipping points (buyer and seller) should be strong enough to ensure that the product being ordered is available for shipment and to maximize the effectiveness of the supply-chain. The IT/computer infrastructure of two companies should be strong enough. It was assumed that with the help of various electronic-linkages (EDI- Malone,T.W. et al,1987) information technology provides a closer integration between the two adjacent firms of supply chain. VMI, CRM, JIT, quick response, and efficient customer response are some options which smoothen-up the supply and demand and reduce inventory overages and shortages by integrating the operations of various supply chain members (Fisher, J. 2000)

Many more studies described the flow of supply chain integration, which doesn't necessarily result out in benefits for both supplier and buyer, as inventory cost of a buyer may be reduced because it has already been shifted to the supplier (Dong, Y.and Xu, K. 2002; Fandel, G. & Reese, J. 1991; Raghunathan, S & Yeh, A.B 2001 and Wan Tsu Wang et al., 2010). A Particularly analytical study found that JIT benefits suppliers only when their holding costs are high and ordering costs are low relative to their buyer (Dong, Y. 1998).

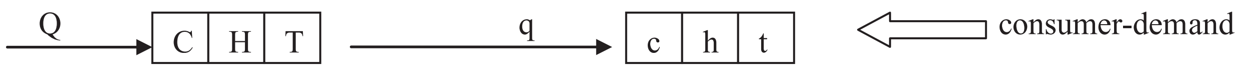
Transportation Cost

Logistic/ Transportation is unique: It never stops! Logistics is happening around the globe twenty four hours a day, seven days a week, and fifty two weeks a year. Few areas of business operations involve the complexity and span of geography typical of logistics. Logistics is concerned with getting the products and services when they are required where they are required.

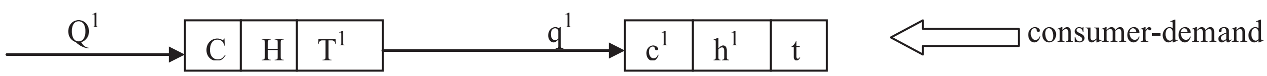
3. Modeling Frameworks

To realize the benefits and their distribution in any supply chain after implementing VMI ,we generate a two level supply chain, carrying a supplier(whole seller) and a buyer(retailer) and inspect the difference in their inventory management practices before and after applying VMI.This simple supply chain between the two consecutive players can be further extended to a more complex model from the raw material supplier to the end user. Assumptions are for a specific kind of goods (Electronic goods in this case whose demand suddenly increases during festive season or when they are new to the market like consumption or exchange of TV and fridge or new mobile gadgets).A single unit is transferred from the supplier to the buyer when the buyer receives the demand from the consumers which is increasing with time for a particular period. In supply chain if VMI is not functional supplier receives the consumer demand indirectly through the buyers ordering policy but after following VMI the supplier can directly know the demand by sharing of real demand data with the buyer. The carrying charges of supplier and buyer are respectively H and h,ordering charges are C and c (without VMI) and C and c' with VMI. There is no need to define C' since it is assumed that VMI doesn't change the supplier's order- cost.

The delivery costs to the suppliers and buyer are T and t. Here as the demand is increasing function of time so t can't be ignored [like P. Vander v list et al]. The cost T of the outgoing shipments at the supplier is impacted by the buyer's decision and the transportation cost t at the buyer will depend upon the demand by the customer.



Without VMI



With VMI

In the models of (Yao et al), the delivery costs T and t were overlooked, which was modified by (Vander vlist et al), highlighting that delivery costs to the customers of the buyer can't be impacted by the buyer's ordering pattern and therefore in the model represent sunk costs, so t indeed can be ignored but costs T of the outgoing shipments at the supplier however can't be neglected, as they are impacted by the buyer's ordering decisions. These costs include costs for order picking, shipping, and transportation, and are really considerable as they can run to over 50% of the supplier's logistics cost found in the Dutch food retail sector. In our model we have followed some notations as defined by (Van der Vlist et al), because all costs effecting the purchasing decision were not included in (Yao et al) but the demand is an increasing function of time. For comparing the various cases including VMI and No-VMI, as developed by (Vander v list et al) after enhancing the work of (Yao et al). We proceed as (Wan-tsu wang et al) following case-2 as the base-case. From the work of (Vander v list et al), it's clearly described that to recoup his cost the supplier factors the delivery cost into the pricing scheme and two cases were delivered which were.

- Supplier applies unit pricing by setting on all inclusive fixed prices per unit bought by the buyer. Means no charges are made for the delivery cost as such, so somehow unit price covers the delivery costs, but the unit price doesn't depend upon the ordering strategy of the buyer.
- The supplier applies service based pricing meaning that on top of the base price per unit the supplier charges a fee for each delivery made.

So the different cases are mentioned below

Case-1 No-VMI fixed unit price (FUP)

Applying non-zero delivery costs doesn't affect the optimal order sizes q* at the buyer and Q* at the supplier so

$$q_1^* = \sqrt{\frac{2\,c\,a(1+bt)}{h}}$$

And $Q_1^* = Q^* = \sqrt{\frac{2\,c\,a(1+bt}{H}}$

As the delivery costs, being borne by the supplier don't affect the buyer's decision, but they do affect the total cost per unit of time. So under optimal order quantities, the optimal cost,

TC_1^* will be

$$TC_1^* = \sqrt{2.a\,(1+bt)}\,\left(\sqrt{CH} + \sqrt{ch}\right) + T\frac{\sqrt{h.a\,(1+bt)}}{2c} \quad \text{(FUP)} \qquad \text{(I)}$$

Case-2. No-VMI service based pricing with service based (SBP)

In service based pricing (SBP) the supplier charges the buyer on top of a base price, as the delivery costs T per order. The cost rate function is then

$$TC_2 = \frac{c.a\,(1+bt)}{Q} + \frac{HQ}{2} + (C+T)\frac{a.(1+bt)}{q} + \frac{hq}{2}$$

Here $q_2 = \frac{\sqrt{2(C+T)a\,(1+bt)}}{h}$,

and $Q_2^* = Q^*$ with the total.

Costs per time unit equal to

$$TC_2^* = \sqrt{2.a\,(1+bt)}\;\left(\sqrt{CH} + \sqrt{c+t}\right)h) \quad (II)$$

3.2 VMI - Inventory At The Supplier Is Managed Differently Under The Three VMI-Cases.

Case-3 VMI Yao +

The VMI total cost analysis carried out by Yao et al, assumes that the buyer's order size and the suppliers order size are chosen such that k = $\frac{Q}{q}$ is a natural number in order to set up a function for the costs per unit of time. In the process of arriving at their solution (yao et al) relax the condition that K be a natural number. For the timing of replenishment orders at the supplier (yao et al) assume an order is issued when suppliers inventory hits zero. The expected inventory at the supplier can be computed for this replenishment policy as.

$$Is_{,3} = \frac{1}{K}\sum_{i=1}^{K}$$

$$(Q–(i–1)\,q) = \quad Q - \frac{(K-1)q}{2} = \frac{Q+q}{2}$$

and the cost rate function becomes

$$TC_3 = \frac{c.a\,(1+bt)}{Q} + \frac{H\,(Q+q)}{2} + (C^1+T^1)$$
$$a(1+bt) + \frac{h^1 q}{2}$$

The optimal order sizes that result from minimization of this cost rate function are

$$q_3^* = \sqrt{\frac{2\,(C^1+T^1)a\,(1+bt)}{(h^1+H)}}$$

And $Q_3^* = Q^*$

So

$$TC_3^* = \sqrt{2.a\,(1+bt)}\;\left(\sqrt{CH} + \right.$$
$$\sqrt{(C^1+T^1)(h^1+H)} \quad (III)$$

Case-4 – VMI with (unlinked timing of replenishment orders).

In the case of unlinked timing of replenishment orders, the supplier orders at a random moment within the time window between the buyers order that exhausts the supplier inventory and the next order from the buyer which happens q/r time periods later. The average inventory level at the supplier in this case is in between the level for Yao+ case and the synchronized case, described in upcoming section where replenishment is postponed until the next order of the supplier is due. The average inventory at the supplier thus is Q/2 with unlinked timing of replenishment orders. The cost rate function then is a simple sum of EOQ type cost rate function like

$$TC_4 = \frac{ca(1+bt)}{Q} + \frac{HQ}{2} + \frac{(C^1+T^1)a(1+bt)}{q}$$
$$\frac{h^1 q}{2} \quad (IV)$$

Consequently optimal order sizes are

$$q_4^* = \frac{2\,(C^1+T^1)a\,(1+b}{h^1}$$

And $Q_4^* = Q^*$

With an implied total costs per time unit of

$$TC_4^* = \sqrt{2\,a\,(1+bt)}\;\left(\sqrt{CH} + \sqrt{(C^1+T^1)h^1}\right.$$

Case-5 VMI Synchronized (Syn)

When the supplier inventory hits zero, the next requirement from the buyer is not due until q/r time periods later. So any replenishment order of the supplier can be delayed by that length of time. This new VMI strategy called the synchronized strategy yields as the supplier's average inventory.

$$Is,5 = \frac{1}{K}\sum_{i=1}^{K} (Q\text{-}iq) = Q - (K+1)\frac{q}{2} = \frac{Q-q}{2}$$

Based on this, the cost rate function for the synchronized case becomes

$$TC5 = +\frac{ca(1+bt)}{Q} + \frac{H(Q-q)}{2} +$$

$$\frac{(C^1 + T^1)a(1+bt)}{q} + \frac{h^1 q}{2}$$

Minimization of this function while relaxing that Q/q is a natural number gives

$$q_5^* = \frac{\sqrt{2(C' + T')a(1+bt)}}{h' - H}$$

And $Q_5^* = Q^*$ with an implied total cost per time unit of

$$TC_5^* = \sqrt{2\,a\,(1+bt)}\;\left(\sqrt{CH} + \sqrt{(C^1+T^1)(h^1-H^1)}\right) \quad (V)$$

Note that $(h^1 - H)$ is the added (Echelon) holding costs upon transferring a unit from supplier to the buyer. If $h^1 \leq H$ then q = Q. Hence the different optimal order quantity for the supplier and buyer and total optimal cost can be summarized as per the table given below

[Table: 1]

Case	*Total cost TC per time unit*	*q**
No-VMI Fup	$\sqrt{2\,a(1+bt)}(\sqrt{CH} + \sqrt{ch}\,(1+\frac{T}{2c}))$	$\sqrt{\frac{2c\,a(1+bt)}{h}}$
No-VMI Sbp	$\sqrt{2\,a(1+bt)}\,(\sqrt{CH} + \sqrt{c+T)h})$	$\sqrt{\frac{2(c+T)a(1+bt)}{h}}$
VMI Yao	$\sqrt{2\,a(1+bt)}(\sqrt{CH} + \sqrt{(c^1+T^1)(h^1+H)})$	$\sqrt{\frac{2(c^1+T^1)a(1+bt)}{h^1+H}}$
VMI Unl	$\sqrt{2\,a(1+bt)}\,(\sqrt{CH} + \sqrt{(c^1+T^1)h^1})$	$\sqrt{\frac{2(c^1+T^1)a(1+bt)}{h^1}}$
VMI Syn	$\sqrt{2\,a(1+bt)}(\sqrt{CH} + \sqrt{(c^1+T^1)(h^1-H)})$	$\sqrt{\frac{2(c^1+T^1)a(1+bt)}{h^1}}$

4. Analysis

Minimizing the total cost functions and relaxing the requirement that k be an integer, leads to the various cases of the values as listed in table 1.

For all the cases $Q^* = \sqrt{\frac{2\,ca\,(1+bt)}{H}}$

To combine the various studies we link the relationship between parameter values in the no-VMI and VMI.

- We assume that c>>c1, as under VMI the buyer doesn't need to place order with the supplier.
- h1≤h the value of the unit holding cost rates h and h1 at the buyer depend upon the valuation of good. In No-VMI situation the value of goods is determined by the commercial transaction between supplier and

buyer, but in the VMI situation it can be any of the two.

- The supplier and buyer have made an arrangement with a lower transaction price in order to let the buyer benefit from the overall lower costs under VMI.
- The supplier still owns the inventory at the buyer (Consignment stock) in which case he might value the stock at production cost but the transportation cost will be finally tolerated by the "buyer majorly" and "supplier minorly."

5. Comparisons

Comparisons will be done for the cost rates and shipment sizes from the supplier to buyer.

Cost Rates

If we compare the different VMI cases we see that.

$TC_5 \leq TC_4 \leq TC_3 \leq TC_2$, for $H > 0$

Shipment sizes from supplier to buyer.

(i) From (Vander v list et al) the buyers optimal sizes for

VMI Yao+ and No-VMI

(SBP) are q*3 and q*2 respectively so

$$\frac{q_3^*}{q_2^*} = \sqrt{\frac{(C^1+T^1)/(C+T)}{\frac{H}{h}+\frac{h^1}{h}}} \quad \text{when}$$

$$\frac{C^1+T^1}{C+T} \approx 1 \text{ when } \frac{C^1+T^1}{C+T} \approx 1$$

be less than or equal to one with its exact value depending on the value of H/h. as the demand is increasing with time so there should not be much difference between the supplier and buyer inventory, so order with VMI will be approximately equal to No VMI (SBP)

(ii) $$\frac{q_4^*}{q_3^*} = \frac{\sqrt{\frac{2(C^1+T^1)a(1+bt)}{h^1}}}{\sqrt{\frac{(h^1+H)}{2(c^1+T^1)\,a(1+bt)}}}$$

$$\Longrightarrow \sqrt{\frac{1+H}{h^1}}$$

Since $h^1 << h^1$ and H remains same in both VMI and No VMI. Hence after incorporating VMI, and transportation cost in the total cost on whatever trading terms the supplier and buyer have agreed upon, the order size increases in case of unlinked VMI then the Yao+ model.

(iii) $$\frac{q_5^*}{q_4^*} = \frac{\sqrt{\frac{2(C^1+T^1)a(1+bt)}{(h^1-H)}}}{\sqrt{\frac{h^1}{2(c^1+T^1)\,a(1+bt)}}}$$

$$\Longrightarrow \sqrt{\frac{1-h^1}{H}}$$

Since h1 << h, so h1 < h also hence or $q_5^* < q_4^*$

so we can say that in case of linked VMI the optimal order size decreases between supplier and buyer in comparison to the unlinked VMI.

6. Conclusions

Table 2, lists the various parameters for No-VMI (SBP) and VMI (Yao+, unlinked, and linked) and conclusions are as mentioned below.

- Vendor managed inventory (VMI) – The vendor managed inventory may benefit the people following it but results show that amounts of benefits are mainly depending upon the suppliers and buyers holding costs (h, h1, H). If buyer's holding cost h > the suppliers holding cost H, then the results will be according to the description in table, else they may vary.

Distribution of benefits between supplier and buyer will solely depend upon the terms and conditions of trading between supplier and buyer.

[Table: 2]

S.No.	Various Cases	No-VMI (sbp)	VMI yao+	VMI-unlinked	VMI- synchronized
1	Supplier to buyer order quantity	"increase"	"uncertain"	"Decreases"	"Decreases"
2	Cost	TC_2 >	TC_3 >	TC_4 >	TC_5

VMI may benefit the people and its benefits are mainly depending upon holding costs of the suppliers and buyers.

As benefits are mainly depending upon, the holding costs so if h > H then the benefits will be according to the table else they may vary change.

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