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# ***VMI: what are you losing if you let your customer place orders?***

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## **ABSTRACT**

Managing the order-delivery processes between organisations has been a key issue in supply chain management. Despite of the increasing application of JIT, lean and agile practices and new information systems that increase the visibility in supply chains, a lot of problems still remain. Surveys among European companies indicate that no significant improvements have taken place in delivery performance during last decade.

Vendor managed inventory (VMI) is a recent alternative for the order-delivery process. The fundamental change is that the ordering phase of the process is abolished, and the supplier is given both authority and responsibility to take care of the entire replenishment process. Despite of its advantages VMI has not yet become a standard mode of operation in very many companies.

In this paper we will analyse the benefits of VMI from the viewpoint of managing the replenishment process of the entire product range, not the viewpoint of a single stock keeping unit (SKU). The case and simulation studies about VMI benefits have had so far focused on a single SKU or average SKU of a single supplier. The problem is that such a focus may not reveal the most substantial benefits from VMI.

A time-based analysis method is developed for measuring the benefits of VMI in different situations. The hypothesis explored that by taking the whole product range viewpoint the advantages of VMI are more readily identified. The hypothesis is tested by using real-life demand data from three different grocery supply chains.

**Keywords:** *Supply chain management, logistics, vendor-managed inventory (VMI)*

## **INTRODUCTION**

One of the most challenging issues for fulfilling customer needs is to manage the order-delivery processes between organisations. The major goal is to develop such processes between suppliers, manufacturers, wholesalers and retailers that minimise the waste of time and enable fast and reliable reactions to demand changes.

A traditional order-delivery process is based on the principle that the customer company defines the amount and timing of deliveries of each item needed from the supplier. The supplier's task is to fulfil this as exactly as possible. Exactly how this is done varies depending on the industry and the company. Retailing industry places purchase orders for each delivery, while manufacturing industries commonly apply delivery schedules and call-offs supported by information systems.

Fast transfer of information between organisations has since the introduction of EDI been considered a key issue in improving the performance of supply chains. Just-in-time and agile practices - small lot sizes and frequent deliveries - have been applied to make the supplier's react faster to changes in customer's demand. The customer requirement has been towards ever shortening delivery times from suppliers. According to an European survey (ELA, 1999), this trend is also expected to continue in the future.

These development efforts appear to be successful in many industries, but this may really be a mirage. For example in grocery retailing, the order to delivery lead-time is today less than 48 hours, or less than 24 hours for fresh goods. However, there are several serious problems hidden below the surface in this demand fulfilment solution.

First problem is that the actual item level replenishment cycle is far slower than the order fulfilment cycle. With up to 20.000 items in the assortment the retailer often has difficulties in managing the ordering process. An order may be placed when the product is already sold out or so late that the product will be out of stock before the delivery arrives. Also, using too large wholesale packages compared to retail sales, and forecasting errors may lead to high inventory levels and best-before problems in the store (Anon. 1996).

A second problem is at the supplier's side. Because of the short delivery lead-time and high service level requirement the inventory levels are kept high at the supplier. There is little time to react to shortages once the retail orders have arrived. Typically, there exists accurate information neither about retail sales nor about out-of-stocks along the chain. Therefore the supplier is not aware of the lost sales. This means that the real trade-off between providing a good logistics service level and cost level remains hidden from the supplier. These are also the main reasons for demand amplification in the supply chain that are called either the Forrester or bullwhip effect (see e.g. Lee & al. 1997, Towill 1992)

In manufacturing industries, too, there exists a lot of problems in the performance of the order-delivery process. According to a survey by European logistics association the rate of late and incomplete deliveries have remained at very high level (appr. 10%) among European companies during last decade (ELA, 1999) in spite of the increasing use of sophisticated information systems. Thus it is not only the information systems that need to be put in place, but also an effective process solution for how to transfer demand. The point is that the order is an inefficient form of transferring information.

Vendor-managed inventory, VMI, is an alternative for the traditional order-based replenishment practices. VMI changes the approach for solving the problem of supply chain co-ordination. Instead of just putting more pressure on suppliers' performance by requiring ever faster and more accurate deliveries, VMI gives the supplier both responsibility and authority to manage the entire replenishment process. The customer company provides the supplier access to inventory and demand information and sets the targets for availability. Thereafter the supplier decides when and how much to deliver. The measure for supplier's performance is no more delivery time and preciseness, it is availability and inventory turnover. This is a fundamental change that affects the operational mode both at the customer and at

the supplier company. Therefore the advantages to both parties must be evident to make the shift to VMI happen.

For example Waller (Waller et al. 1999) has investigated the impacts of VMI through simulation. The study shows how replacing purchase orders with inventory replenishments enable suppliers to improve service while reducing supply chain costs. The reason for this is that in a VMI set up the inventory situation of the average product is reviewed more frequently than purchase orders were placed before. For the average item, the more frequent review in the VMI approach eliminates the ordering delay in the information flow.

Other cases of VMI benefits (Cottrill 1997, Anon, 1998, Nolan 1998) also focus on single SKU or average SKU or on a relationship-level.

However, this earlier information reach reduces the need to keep buffer stocks for a supplier with a wide range of different product variants. Instead of getting an order every day with a few items, the supplier gets a stock list with all the items. The introduction of VMI gives the supplier more time to react – i.e. it levels demand - and this way brings benefits in production planning. Especially when the supplier has little extra capacity it is useful to know which deliveries can be delayed without causing lost sales for the customer. An interesting side-effect is that for the supplier's other customers that are not engaged in VMI, the delivery service also improves. This is the result of the supplier's better possibilities to plan production and in that way improve delivery service to all customers.

It is important to note that the more frequent inventory review in VMI does not require more frequent deliveries. It is exactly this requirement for frequent deliveries that has in many cases caused problems for suppliers when the customer has introduced the just-in-time (JIT) concept.

There are numerous case examples of successful VMI implementations (see for example Cooke, 1998 and Holmström, 1998). However, VMI has not become a standard way of managing replenishment processes in the supply chain. There seems to be some practical issues that slow down the implementation of VMI in many companies. The requirement for standard product identification and integrated information systems in the supply chain is one example. The two parties may also be unwilling to share information and lack of trust often exists (Fraza, 1998). And, sometimes purchasing – not sourcing - is seen as a core competency of a company, and the customers may insist on purchase orders (Cooke, 1998).

The lack of trust between the trading partners and the uncertainty about the potential benefits of VMI are difficult obstacles. For establishing trust a company should be able to demonstrate for the trading partner the benefits of shifting to VMI. Also it should be considered that VMI is not a standard solution for all replenishment processes. The benefits of VMI vary in different supply chains and according to product demand. There may be situations in which no benefits can be gained.

In this paper we present a time-based analysis method to measure the potential benefits of VMI in a customer/supplier relationship. The purpose is to provide information for trading partners about the potential benefits of shifting to a order-less replenishment practice. The viewpoint of the replenishment process is that of the entire product range, not the viewpoint of the average stock keeping unit (SKU). This is a different approach from that taken previously in case and simulation studies on VMI benefits. Focusing on the product range will reveal in a customer/supplier relationship which products will benefit most from introducing VMI.

Next, the analysis method will be presented. Then, the method is tested in three real-life cases.

### ***THE ANALYSIS METHOD***

To convince a sceptical trading partner a practical method to measure the benefit of VMI is needed. The analysis presented in this paper can be performed before closer collaboration practices have been established and it is specifically aimed at assessing the development

potential of not ordering, but instead using VMI. The objective is to demonstrate the benefits of collaboration and to help both the customer and supplier organisations understand how much of a waste of time ordering is in their specific relationship.

The unit of measurement is time. The result - the time saving from eliminating the ordering delay - is the time benefit a supplier gets, when being able to act based on the inventory situation of his customer. The time benefit comes from collaboration being extended to cover the inventory management of the customer, and the supplier getting information earlier than when acting on the basis of orders. The key is that the supplier can decide on when to replenish. Sharing inventory data, but with the customer still expecting the supplier to deliver on short notice when the customer chooses to place a purchase order, is not extending collaboration to inventory management. The available response time does not increase unless the supplier can decide based on the inventory situation of the customer.

The goal of the analysis is to provide SKU-level information for the entire product range about the effects of changing the replenishment system. The output of the analysis is the time available for the supplier to plan deliveries. The more time the supplier has for planning, the better it is able to serve customers and optimise operations. We call the increase in time available for the supplier the 'time benefit'. The analysis will also reveal cases, where VMI does not bring any benefit in the current replenishment practice.

The analysis method takes the following steps

1. Describe the existing mode of replenishment process – the so called base case – and one alternative mode.

*Example:* The base case is operating based on purchase orders and the alternative is operating based on VMI.

2. Collect demand data for the alternatives to be examined.

*Example:* The input for the base case is the purchase orders placed by the customer on the supplier and for the VMI, the alternative, the consumption by the customer or the sales to the customer's customer. The time period, which is examined, need to be long enough for quantifying the delays between these two demand flows for all products in the product range.

3. Calculate for each item in the product range, and for both the base case and the alternative solution the following:

- Mean absolute deviation of demand (MAD1, MAD2). In our example in the non-VMI situation MAD1 is calculated from the order data from the customer to the supplier. In the VMI situation MAD2 is calculated from the consumption data of the customer.
- Reorder point (ROP1, ROP2). The supplier's and the customer's safety stock and reorder point are counted according to the principles presented in Appendix 1.
- Response time (RT1, RT2), which is the time the supplier has available for fulfilling the demand. In our example in the non-VMI situation response time (RT1) is the same as the delivery time. In a VMI situation response time (RT2) is the time between the inventory count and the moment supplier has to replenish to avoid a stock-out situation.

In Appendix 1 is a detailed description of the formulas used.

4. Calculate for each item in the product range the:

- Time benefit =  $RT2 - RT1$ . In our example, estimating the potential increase in the response time for the VMI solution, the supplier's inventory before the shift to VMI is needed as an input. The benefit follows from that, that in the VMI situation this buffer is not needed because the only relevant service level is to the customer's customer.
- Reordering amplification =  $MAD1 / MAD2$ . The reordering amplification, which describes the strength of the bullwhip effect, is calculated from the demand data. First, variation of demand is calculated from the order data from the customer to supplier (mean absolute deviation, MAD1), and from the consumption of the customer (MAD2). Reordering amplification is the relation of these two variations. If the reordering amplification is 2, it means that on average the item is sold on to the consumer twice as frequently as it is purchased. For details see Appendix 1.

5. Graph for each product item in the product range the time benefit and reordering amplification (MAD1/MAD2) of demand.

The steps of the time benefit analysis are carried out on a single SKU level for the entire product range. The results are therefore both accurate and show the effects of the change to the whole. Next, the method will be applied to real-life cases.

## **THE CASE ANALYSIS**

### **CASE 1: A GROCERY MANUFACTURER AND A SALES COMPANY**

The replenishment process between a grocery manufacturer and its sales company is analysed in the first case. The manufacturer produces and markets groceries near Helsinki. The sales company is located in another Nordic country and it runs a warehouse to fulfil the needs of the local market. Though the partners of the case belong to the same corporation, replenishments were based on a traditional order-delivery process. The sales company generated orders every second week and the delivery took place the next day. In between an extra fulfilment was made if needed.

The analysis will be carried out in two situations, this means that the analysis method going through the steps 1 to 5 will be made twice.

First we analyse the shift from the initial situation to VMI. The base case is arms-length purchasing and the alternative is VMI.

Second, we analyse what would be the effects if the VMI system was changed to a just-in-time (JIT) system, meaning frequent deliveries defined by the customer. The objective of this second analysis is to reveal the benefits of shifting the authority to decide about replenishments from supplier back to the customer. In both VMI and JIT there are frequent deliveries, but in the base case planning and decisions are made by the supplier (VMI), and in the alternative situation planning and decisions are made by the customer (JIT).

#### ***Situation 1 – from arms-length order-delivery process to VMI***

In the base case the sales company places orders for the manufacturer every second week and the manufacturer delivers the next day. This arms-length purchasing process was the actual situation in the year 1998. This way of operating was compared to a VMI-solution, in which the manufacturer monitors daily the inventory level of the sales company and replenishes every product when needed.

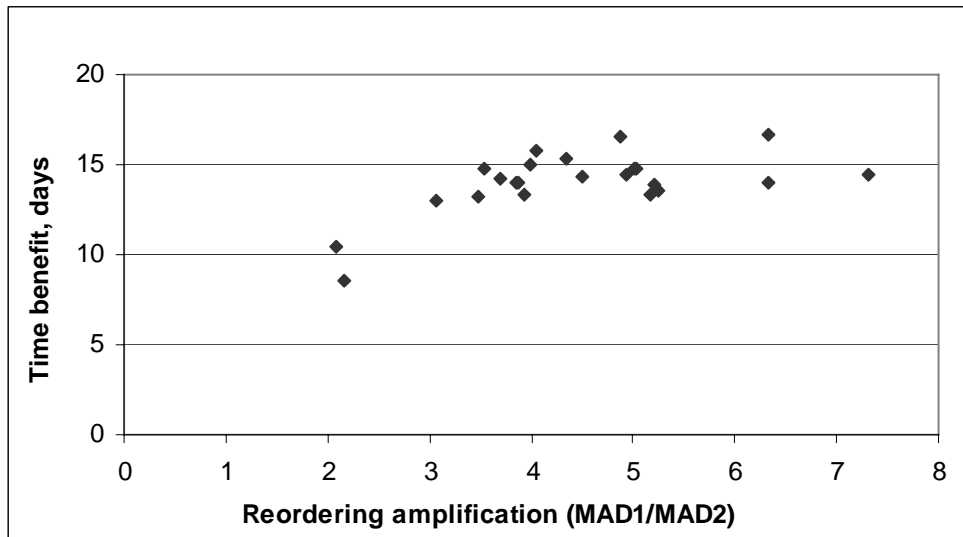
Altogether 20 products representing one product group was analysed. Orders from the sales company to the manufacturer and the sales from the sales company to its customers were used as demand data. The data was collected on a daily basis from a time period from the beginning of 1998 until May 1999. The average number of orders from the sales company was about 70 per product.

The results of the calculations show a time benefit of about 15 work days, or three weeks, in the supply chain for all but two of the products (Figure 1). If the supplier is able to respond to the consumption of the sales office, it will get this much additional time available to use for its own purposes. In this case order-delivery process is really a waste of time because the two parties of the supply chain belong to the same company.

In Figure 1 the time benefit is presented as a function of reordering amplification. For the individual products the reordering amplification, calculated from the mean absolute deviations of demand, was between 2 and 8. There is a clear correlation between the reordering amplification and the time benefit, which is quite expected.

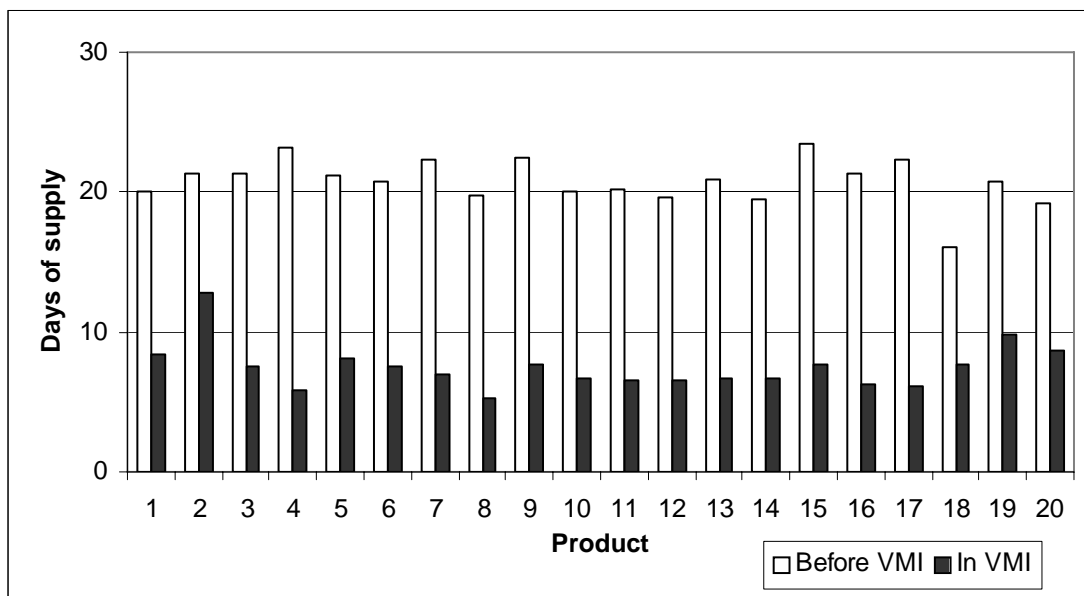
In the base case, the customer required the same order fulfilment lead-time for products where the minimum shipment was large relative to daily demand, as for products where it was small. The analysis revealed, that for many product items a replenishment could just as well be scheduled by the supplier based on the inventory report with three weeks lead-time, with no additional risk for increased lost sales.

Figure 1. Time benefit of an internal order flow. One point represents one product.



Also the effects of the change on the inventory level was calculated. In Figure 2 the estimated inventory level reductions by product in the pipeline is presented. The reorder points are used to mirror the change, and they are displayed as days of supply.

Figure 2. Reduction in pipe-line inventory level when shifting to VMI.



### Situation 2 – After implementing VMI

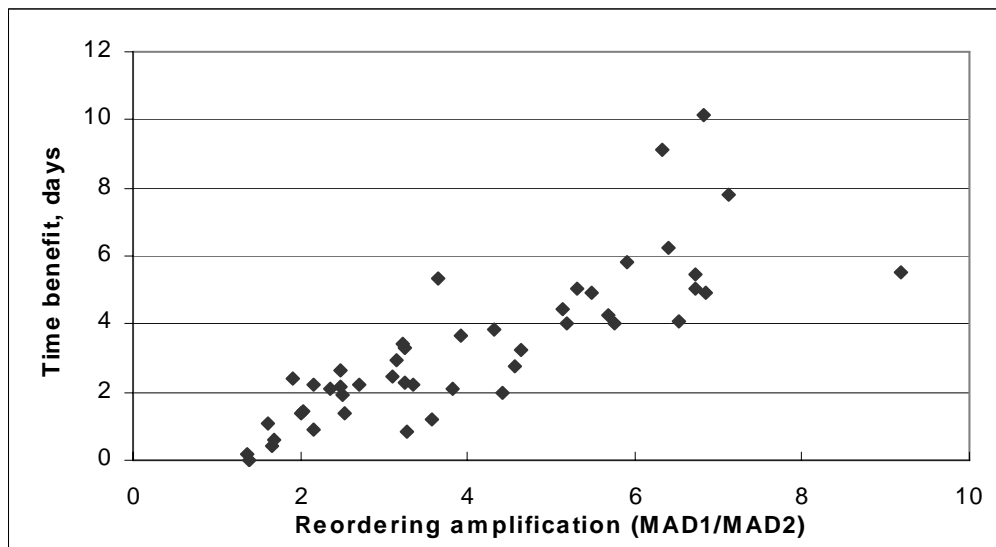
The Finnish grocery manufacturer realised that implementing VMI between the factory in Finland and the sales company was urgent. The operations model was changed in May 1999,

when a vendor managed inventory system was in place. The responsibility for the replenishments was moved from the sales company to the manufacturer. Purchase orders were given up altogether. Inventory is now checked 4 times a week and replenishment shipments can be scheduled for the next day. Not every product is shipped daily, but the possibility to adjust daily is there for every product in the product range.

A new analysis is carried out in this situation going through the steps 1 to 5. Now, the base case is VMI and the alternative is frequent orders from the sales company (JIT). Input data is the replenishments from the supplier to the sales company and the sales from the sales company to their customers. The analysed time period is from May 1999 until the end of September 1999.

The result of the analysis is shown in Figure 3. There exists a significant time benefit for the supplier in VMI compared to JIT, varying from one day to six days depending on the product. This is a remarkable result. Even though the delivery frequency is high, or at least the inventory is monitored frequently, the supplier has got this much more reaction time. If the sales company started ordering again, and requiring the supplier to deliver the next day, the available response time of the supplier would go down substantially.

Figure 3. Time benefit of VMI compared to JIT. (one point = one product).



A more detailed study (Hellström 1999) revealed that the company has been able to effectively utilise the increased time available - the time benefit. The direct result was reduced inventories as shown in Figure 2. Within the two first months of VMI the buffer fell to an average of 8 days of supply and no stock-outs occurred. The cost of obsolescence (products not sold before the 'best-before' due date) went down from 8 % of sales to 2 %, and it is projected to be 1 % in the year 2000.

**CASE 2: CONSUMER PAPER PRODUCT MANUFACTURER AND WHOLESALER**

The second case handles the relationship between a consumer paper product manufacturer and a wholesaler. Again arms-length purchasing and VMI are compared. In the base case situation, the wholesaler generates purchase orders for the supplier of consumer paper products once or twice a week. The supplier delivers the ordered goods to the wholesaler's warehouse the next day. The alternative situation is VMI.

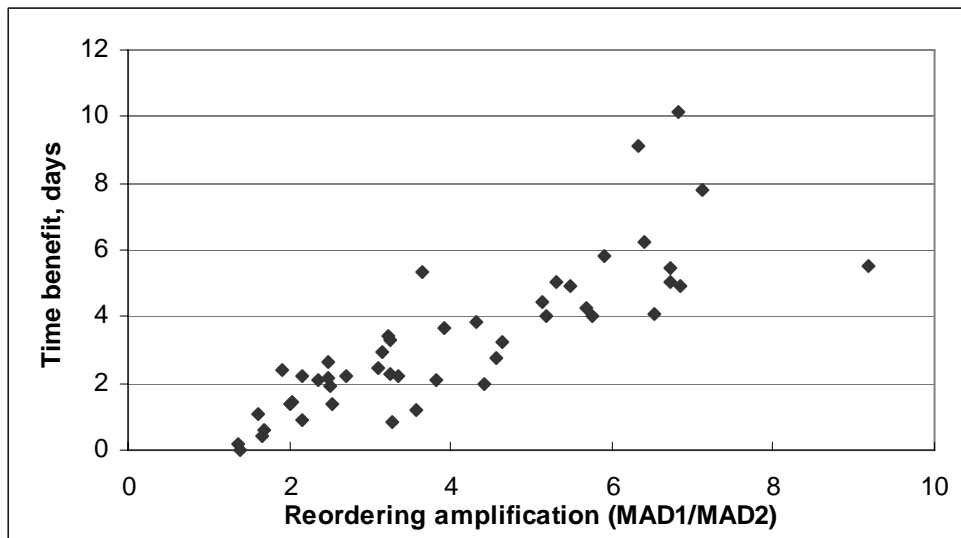
For calculating the ordering amplification, the current purchase order flow from the wholesaler to the supplier was compared to the demand from the wholesaler's customers, that is the retailers. The time period of the analysis is 8 weeks, covering August and September 1999. The number of products is 50, which is the whole product range offered by the supplier.



The time benefit from shifting to VMI would be for the supplier between 0 and 10 days, the average being three and a half days (Figure 4). The time benefit clearly depends on the current delay between shipments to the retailers and incoming shipments ordered by the supplier.

Because the time benefit is biggest for products with high reordering amplification, the supplier and the wholesaler ought to implement a vendor managed inventory –solution that cover the full product range. It is noteworthy that the lower ranking B and C- items in the product range benefit most from a VMI solution.

Figure 4. Time benefit of shifting to VMI in Case 2 (one point is one product).

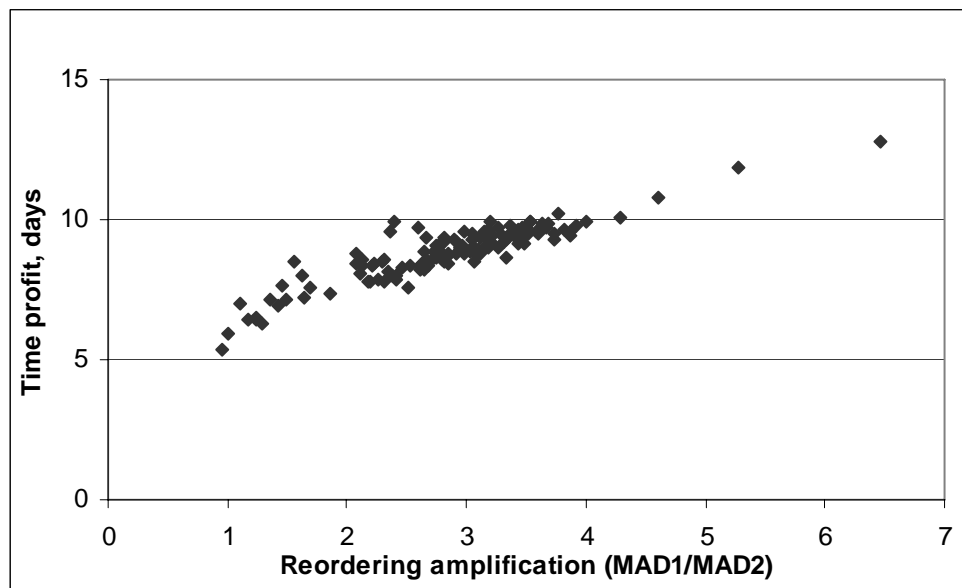


### **CASE 3: A HYGIENE PRODUCTS SUPPLY CHAIN**

This case compares a grocery supplier’s deliveries to the distribution warehouse of a group of retail chains, and the deliveries from that warehouse to the points of sales. The comparison is between continuing VMI and moving to frequent call-offs (JIT). The supplier is currently responsible for the replenishment of the warehouse according to VMI principles. Thus, the base case is VMI, and the alternative is operating by order-delivery process with daily call-offs by the customer. Replenishment and consumption data for the warehouse was collected from the time period of April 1997 until the end of January 1998.

The results are presented in Figure 5. The average time benefit of VMI over daily call-offs is 9 days and even at its lowest it is more than 5 days. This means that there exists a margin of one week, which would be lost, if the distributor would replace VMI with daily purchase orders. Also, the supplier would have to locate inventory very close to the customer. In VMI there is longer response time available, so it is possible to have the inventory at production plants.

Figure 5. Time benefit in a hygiene products supply chain.



### SUMMARY OF THE CASE RESULTS

All the cases concern typical situations in supply chains of consumer products. First, we summarise the results from the analyses about shifting from a conventional order-delivery process to VMI. The average time benefit for product items in the different cases are shown in Table 1.

In the case 1, where the product group had only 20 items, the time benefit was big enough to allow synchronising a weekly production schedule to demand. In other words, forecasts would not be needed if inventory levels are kept at the same level in VMI as before VMI. In the second example the product range is too large and the time benefit is too small for synchronising production with demand.

TABLE 1. TIME BENEFITS WHEN SHIFTING FROM ORDER-DELIVERY PROCESS TO VMI.

	<i>Number of product items</i>	<i>Average time benefit for product item, days</i>
Case 1, situation 1	20	14,0
Case 2	50	3,5

Next we summarise the results from cases, where base case was VMI and daily call-off ordering was the alternative. The results showed that the supplier would lose the time benefit of VMI if the ordering process was resumed, even if working with a JIT principle. The results are presented in Table 2. In the case 3, where the products are made in half a dozen factories around Europe, the time benefit from VMI would allow synchronising production with demand. The challenge for the supplier is to get more customers to adopt VMI.

TABLE 2. TIME BENEFITS OF VMI COMPARED TO JIT

	<i>Number of product items</i>	<i>Average time benefit for product item, days</i>
Case 1, situation 2	20	2,2
Case 3	98	8,9

When comparing the time benefit for different product items the analysis shows that if the reordering amplification is big, then the time benefit is considerable. Usually, though not always, the amplification is at its biggest concerning low volume products. Low volume

products are consumed continuously – just as high volume ones are – but they are ordered more seldom and there are often a very high number of different variants. In practice this means that demand seen by the supplier is easily distorted.

In developing operations the most attention in firms is directed to high volume products and their operations model is well polished up. However, it is in the operations model for low-selling products where the big potential for improvement is. As the cases show, there are more time benefits in the supply chains of these products, and therefore it is important to specifically include these product items in a VMI solution.

## **CONCLUSIONS**

In the analysis of the cases we focused on time performance, which is an essential measure for supply chain management. The analysis method was able to reveal the time benefits available when shifting to VMI from traditional order-delivery process. In addition, we were able to show the differences of performance between frequent deliveries based on ordering and frequent deliveries in VMI. The analyses showed that even if the supplier can deliver every day and maintain a high service level in VMI, this does not mean that the supplier could deliver all products in the product range with a one-day order lead-time in the order-based system. Compared to JIT, the supplier is in a better position in VMI because it can better level demand peaks and plan operations. In JIT, the supplier must adjust its activities very quickly according to the customer, and may end up keeping unnecessary inventories or extra capacity dedicated to the customer.

The significant time advantage of VMI compared to JIT leads us to conclude that visibility and frequent exchange of information are not enough to make the supply chain effective. It is of fundamental importance to shift the responsibility and authority of the replenishment decisions to the supplier. When the supplier decides the delivery lot sizes and timetables, the entire chain from supplier's process to customer's process can be optimised.

The cases also point out that in many supply chains there is a significant improvement potential in product categories with many different product items and variants. The analysis also revealed that especially for low volume items VMI is a much more efficient solution than frequent purchase orders. This is against the commonly stated argument that benefits can be gained only by starting VMI with the high volume products (Benfield 1998, Nolan 1998). The results of our study are supported by a supplier reporting that by introducing VMI the slow moving inventory of the customer declined from 10 to 4 % of the total inventory (Fraza 1998).

Even though the benefits of VMI may be shown at a general level, the customer's perceived lack of control may hinder or slow down the implementation of VMI. Here, the time benefit analysis method presented in this paper may help companies to better understand the benefits of VMI. Because the analysis can be done beforehand and because it analyses the actual supply chain, the method brings valuable information, which helps companies adopt a new and more efficient operations model.

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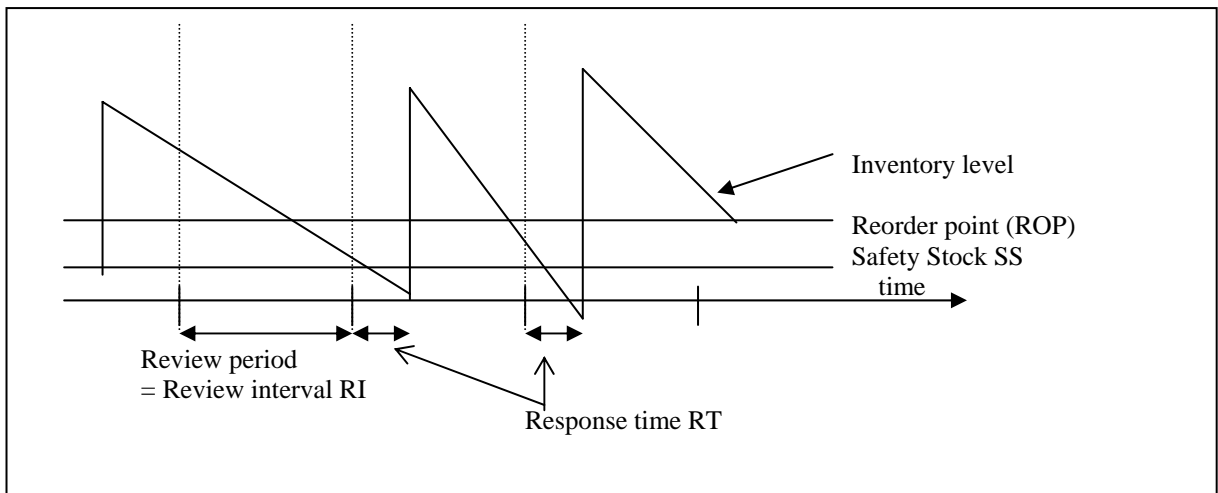
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## APPENDIX 1.

The inventory system used for the time benefit estimate is the optional replenishment inventory system. In this system the review period is fixed. When the inventory level has reached the reorder point, an order is placed. The quantity ordered varies according to demand variations (Tersine 1982). In the next figure the terms used in this article are illustrated.

### THE OPTIONAL REPLENISHMENT INVENTORY SYSTEM.



The safety stock level and the reorder point are defined according to principles presented by Vollmann (Vollmann et al. 1992). The probability of stocking out is used as the safety stock criterion. The safety stock level and the reorder point are computed using the normal distribution.

$$\text{SafetyStock} = Z * \sigma$$

where:

Z = safety factor determined on the basis of service level. The Z is the appropriate value from a table of normal distribution probabilities.

Examples of the Z values for some probabilities of stocking out:

Probability of stocking out	Z
0,10	1,282
0,05	1,645
0,010	2,326

$\sigma$  = forecast error distribution standard deviation. The value of  $\sigma$  can be approximated by  $1,25 * MAD$  (mean absolute deviation) when forecast errors are normally distributed.

If the forecast interval is not the same as the replenishment lead time, an adjustment must be made to MAD value. The adjustment is

$$\text{SafetyStock} = Z * (1,25 * MAD) * \sqrt{m}$$

$m$  = the replenishment lead time expressed as a multiple of forecast interval

Here  $m = (RI + RT) / PL$ ,

where  
 RI = Review interval  
 RT = Response time  
 PL = Period length = (52\*5)/number of forecasting periods

$$SafetyStock = Z * (1,25 * MAD) * \sqrt{\frac{RI + RT}{PL}}$$

Reorder point (ROP) is determined as the sum of mean demand during the replenishment lead time and the safety stock.

$$\begin{aligned} ROP &= DF * \frac{RT + RI}{PL} + SafetyStock \\ &= DF * \frac{RT + RI}{PL} + Z * (1,25 * MAD) * \sqrt{\frac{RT + RI}{PL}} \end{aligned}$$

where  
 DF = demand forecast.

Response time formula derived from the reorder point formula:

$$RT = \frac{-2 * DF^2 * RI + 2 * DF * PL * ROP + PL * SF \left[ SF - \sqrt{(SF^2 + 4 * DF * ROP)} \right]}{2 * DF^2}$$

where

$$SF = Safety Factor = Z * 1,25 * MAD$$

The response times are calculated for both alternatives defined in the analysis. The difference of the two response times is the time benefit of replenishing instead of ordering.

$Time\ benefit\ of\ VMI = Response\ time\ for\ replenishment - Response\ time\ for\ order\ fulfilment$
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