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Vendor Managed Inventory in the inbound Supply Chain in the Soft-Drink Industry

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KEYWORDS

Discrete Simulation; Vendor Managed Inventory; Soft-drink Manufacturer; Inbound Supply Chain

ABSTRACT

The ever growing competition in the soft-drink market led to manufacturers introducing the concept of Vendor Managed Inventory (VMI) with their suppliers. The goal of this concept is to reduce costs by letting the supplier manage the replenishment process of the customer. By sharing demand forecast and stock level information, the customer enables the supplier to plan its productions as effectively and efficiently as possible. The supplier is able to further improve the efficiency of production when he is able to hold a certain amount of stock for the customer, which in turn guarantees purchase. The maximum quantity, that the customer conforms itself to, is dictated by the maximum supply chain stock. For VMI it is important to analyse the required value for this constraint, in order to provide insight in the agreement that should be made between supplier and customer. The analysis is performed using a discrete simulation model of the VMI process of the inbound supply chain. Several scenarios with varying input parameters, such as the demand forecast accuracy, are tested.

INTRODUCTION

The process of VMI in the inbound supply chain shifts the control over the replenishment process from the customer to the supplier. This shift can be deduced from Figure 1 and Figure 2.

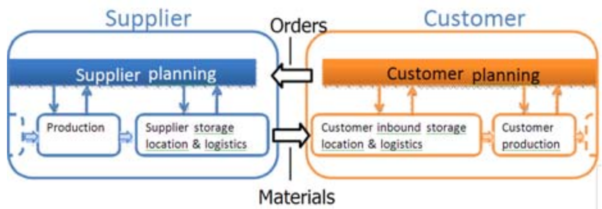

Figure 1: Traditional supply chain structure

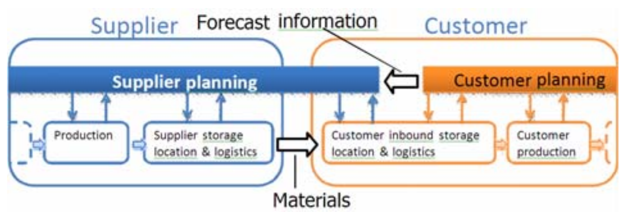

Figure 2: VMI supply chain structure

The figures show that under VMI, the supplier manages the material replenishment of the customer's storage location. To calculate the delivery size and timing, he uses forecast and inventory level information. He is then able to anticipate the requirements of the customer and optimise his own production planning accordingly. This process will therefore reduce production costs at the supplier, reduce planning control load at the customer (Kumar and Muthu, 2003), (Sari, 2008), and should lead to lower inventory levels at its storage location (Carey et al. 2005), (Mroz, 2001) at a higher supplier service level. The last two benefits emerge from the fact that with help of the forecast information, the supply chain becomes more transparent for the supplier.

Simulation of VMI has been used on multiple occasions to analyse the performance of the process and the possible benefits, (Southard et al. 2005). The focus of these simulations has been primarily on a

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vendor – retailer supply chain, investigating cost savings by reducing stock keeping costs and increasing service level. In most cases it was found that the downstream member benefits the most, especially when VMI was imposed on the supplier. In the latter case often stringent criteria for maximum and minimum supply chain stock restricted the optimisation of the latter's process.

This research focuses on analysing the performance of VMI by setting wider targets for the VMI constraints. The important discrepancy with other VMI agreements is that in this case the customer will guarantee purchase for products up to a predetermined maximum supply chain stock. This implies that the supplier can maximise its production run size up to the optimal balance between unit production costs and unit stock keeping costs. Since the risk of not selling excess stock is taken away by the customer, the suppliers' incentive to carry out this optimisation is increased.

The aim of this paper is therefore to investigate the performance of VMI under the conditions stated above and to analyse the minimal values for the supply chain constraints to adhere to the maximum possible service level.

VENDOR MANAGED INVENTORY

Under VMI, the planning process of replenishments shifts from the customer to the supplier. Effectively this implies that the planning of productions and deliveries are now integrated at the supplier. The structure of the replenishment process is depicted in Figure 3.

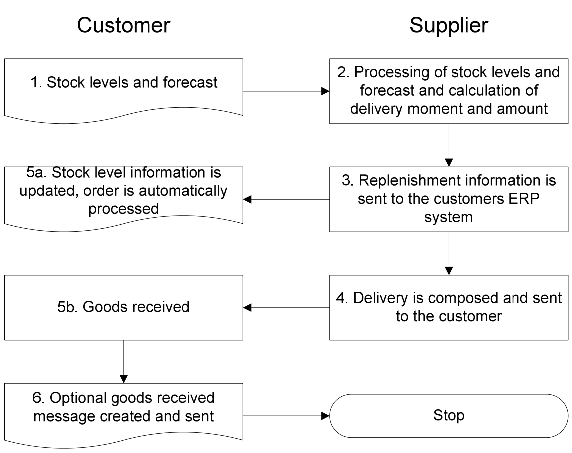

Figure 3: VMI replenishment process

Studying this VMI process shows that once the supplier has received or retrieved the stock level and forecast information of the customer, the process continues until the required materials are received at the customer's storage location. This implies that no intermediate checks or confirmations by the customer are necessary, although optionally these messages can be sent.

The initialisation and execution interval of the VMI process is dependent on the product and supply chain characteristics. Typically it is on a daily or weekly basis. In the latter case the interval between forecast updates is the leading factor. This case is the subject of the present research. This choice is based on two factors: First of all the soft-drink company that initiated this investigation works with weekly updates of the forecast; secondly replenishment planning is carried out on a weekly basis, except for a few materials of which the investigation lies outside the scope of this research.

The VMI process makes use of demand forecast and stock level information. All calculations are based on this data and it is therefore imperative that this information is correct and clear.

MODELLING

The discrete simulation model was developed in the TOMAS for Delphi package (Veeke and Ottjes, 2000). This package adds process-interactive based simulation properties, which facilitates the analysis of VMI. The model accepts both historical as well as stochastic input data, which is why solution by simulation was chosen. The historical data is based on actual demand, demand forecast and material information of the soft-drink manufacturer. This provided interesting insight in how the replenishment process would have performed if VMI had been used. The stochastic data was used to perform analysis of outliers, analyse the robustness of the VMI process in the model and determine the values for the VMI constraints.

Next to applying VMI, the simulation model is also capable of running the replenishment process in the traditional way, of which the structure is presented in Figure 1. The VMI and traditional model can then be compared to assess the performance of both. This is deliberately done to rule out the human factor in planning, since a human planner is capable of making adjustments outside the normal restrictions of the replenishment process. These are for instance temporarily shortened lead times, last minute changes to the delivery size or even rescheduling of its own production planning when a material is unavailable.

The simulation model assumes identical production lead times for both the traditional and VMI process.

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Under VMI however, the delivery lead time is shortened to one week, since the supplier is able to deliver from stock.

Both the processes in the model have been validated with help of the historical input data, and the information from the manufacturers' enterprise resource planning (ERP) system. The validation results for the traditional model are depicted in *Table 1*.

Table 1: Traditional process validation results

Value	Model difference
Average stock level	-39% (± 3)
Deliveries	1.0% (± 0.2)
Service level	-5.0% (± 0.3)

It can be seen from the results that the simulation model accurately represents the number of deliveries per year. The stock level and service level however show discrepancies. The model significantly underestimates the stock level and this underestimation even leads to out-of-stock situations which in turn influence the service level. The underestimation can be explained by the following:

- The stock level needs to be corrected for safety stock, which was not taken into account in the model. This would reduce the difference to a still significant -25%. The discrepancy is therefore still not justified;
- Out-of-stock situations in the model lead to a negative stock. This assumption is made since the historical demand data is leading and rescheduling the requirements is thus not possible. This negative stock leads to a lower average stock level, but also to a lower service level.

Since the safety stock factor and the factor of negative stock are part of both the traditional and VMI simulation model, comparison between both is possible.

The results of the validation of the VMI model are presented in *Table 2*. The validation focused on assessing the number of productions in the actual situation (for which a pilot in the real production environment was initiated) and the model. Results show that the number of productions at the supplier is represented by the model rather accurately. Inaccuracies do occur when very stringent constraints are used, but this is due to the fact that in reality not all materials are required every week.

Table 2: VMI validation results (SCS=Supply Chain Stock)

VMI constraints [weeks]		Supplier productions per year		
SCS_{min}	SCS_{max}	Expected	Model	Actual
2	3	52	46	...
2	7	7	8	...
2	13	5	5	5

With the information presented in this section it is concluded that the model is suitable for comparing between processes, although the stock level is underestimated due to the assumption that in out-of-stock situations, the stock level can become negative.

EXPERIMENTS AND RESULTS

In order to assess the performance of VMI and determine the minimal required constraints, multiple experiments were carried out. The following input parameters were varied:

- Production size – this value represents the production requirement at the customer. For each day of the year, 10 different samples were taken. An exponential distribution was used here to simulate erratic demand behaviour;
- Production seasonality – the seasonality determines the possibility of a demand occurring at a specific day. As with the production size, 10 different samples were taken for each day of the year;
- Forecast accuracy – based on the production size the forecast accuracy was sampled 10 times for the 13 weeks of every forecast (in total 53 in a year). The average forecast accuracy was assumed to decrease with increasing week number.
- Minimum supply chain stock – for each sample of the above three parameters the minimum supply chain stock is varied from 1 up to 13 weeks. Dependent of course on the maximum supply chain stock, which it should not exceed;
- Maximum supply chain stock – same as minimum supply chain stock.

On closer inspection of the above one will see the extent of the data involved in these simulations. This is one of the strengths of the simulation model. It is capable of handling a very large amount of data and process the information quickly. In fact the input parameters mentioned above imply a total of more than

4500 simulation runs. Which resulted in 8100 data points, with a total simulation run time of approximately 35 minutes. Running an analysis for the company's 1400 specific materials even led to a much larger value: 85000 simulation runs, amounting to more than 1.5 million data points.
The results of the experiments with varying input data were divided into two separate analyses. One for the performance of VMI and the other for the determination of VMI constraints.

The results of the performance analysis of VMI are presented in *Table 3*.

Table 3: Performance analysis results

	Traditional	VMI	Difference
Average Supply chain stock	5440	19074	251%
Average productions	22	8	-64%
Average deliveries	22	27	20%
Average SL	98%	99%	1%

From the results it becomes clear that the total supply chain stock under the proposed form of VMI will increase significantly. This is due to the fact that the number of production runs at the supplier is reduced. Although it should be noted that this is not a desirable situation for every material, for most of the materials that the soft drink manufacturer uses, it provides a significant cost advantage. On top of that the service level is increased marginally. The number of deliveries however may increase under VMI. Cost calculations with the actual data of the manufacturer however showed that the influence of this factor is small. In fact an overall cost saving of approximately 17% was possible for several suppliers when moving to VMI. The previously mentioned pilot study confirmed this value, with a cost saving of more than 18%.

The results of the analysis of VMI constraints are presented in *Table 4*. These results can be read as follows: For instance if a customer would agree with its supplier to a minimum supply chain stock of 1 week (row 1) and a maximum supply chain stock of 7 weeks (column 7), the theoretical service level will be 98% under VMI. This implies in this analysis that for 98% of the deliveries no corrective action is required. Increasing the maximum supply chain stock will further increase this number to 100%.

Table 4: VMI constraints analysis results

Service level behaviour under VMI

Maximum supply chain stock (in weeks) →

Minimum supply chain stock (in weeks) ↓	1	2	3	4	5	6	7	8	9	10	11	12	13
1	52%	70%	84%	85%	94%	94%	98%	100%	100%	100%	100%	100%	100%
2	-	70%	84%	85%	94%	94%	97%	100%	100%	100%	100%	100%	100%
3	-	-	84%	85%	94%	94%	97%	100%	100%	100%	100%	100%	100%
4	-	-	-	85%	94%	94%	97%	100%	100%	100%	100%	100%	100%
5	-	-	-	-	95%	94%	98%	100%	100%	100%	100%	100%	100%
6	-	-	-	-	-	98%	100%	100%	100%	100%	100%	100%	100%
7	-	-	-	-	-	-	100%	100%	100%	100%	100%	100%	100%
8	-	-	-	-	-	-	-	100%	100%	100%	100%	100%	100%
9	-	-	-	-	-	-	-	-	100%	100%	100%	100%	100%
10	-	-	-	-	-	-	-	-	-	100%	100%	100%	100%
11	-	-	-	-	-	-	-	-	-	-	100%	100%	100%
12	-	-	-	-	-	-	-	-	-	-	-	100%	100%
13	-	-	-	-	-	-	-	-	-	-	-	-	100%

The results in Table 4 show that, for a maximum service level, a supply chain with a minimum of one week and maximum of eight weeks can be adhered to. A higher maximum supply chain stock reduces the probability of the supplier being unable to deliver, since low stock levels occur less frequently in a year. This leads to less out-of-stock situations.

With this in mind it is interesting to notice that increasing the minimum supply chain stock has less effect on the service level and only when that level reaches values of seven weeks and above the maximum service level can be attained. This is the result of the erratic demand behaviour of the material in the stochastic model. It can thus occur that the demand in a week increases to more than seven weeks. The minimum supply chain stock is then no longer sufficient.
On further close inspection of Table 4, one can see that in one case, minimum 1, maximum 7 weeks, the theoretical service level is actually higher than the case for a minimum of 2 weeks at the same maximum. The cause for this is identical to the one mentioned above, here the erratic demand behaviour is somewhat more unfavourable for the 2-7 weeks agreement.

CONCLUSIONS AND RECOMMENDATIONS

The investigation of the implementation of VMI with help of a simulation model leads to the following conclusions:

- The largest cost reduction is likely to occur in the production process at the supplier as was also concluded in the VMI pilot that was carried out;
- The service level generally increases for most articles since VMI is more robust to demand changes and forecast accuracy fluctuations because of the following reasons:

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  - The delivery lead time under VMI is one week, which is shorter than usual for most articles. The delivery size is consequently determined on the forecast one week advance, instead of the less inaccurate forecasts for longer periods. This leads to a more accurate match between delivery size and actual demand;
  - Since the number of productions of the supplier decreases under VMI, the number of moments that only the minimal supply chain stock is present is also reduced. This in turn decreases the probability that the supply chain stock is insufficient to adhere to the customer's requirements;
- The stock level at the customer is likely to reduce, that of the supplier will in most occasions increase;
  - The latter should not be seen as an issue since the increase of stock at the supplier facilitates the freedom of production planning of the supplier and for most materials this will lead to a cost reduction;
- Under VMI the number of deliveries may increase;
  - This is due to the fact that the delivery size will better match the actual demand and situations of overstocking will occur less frequently. It however implies that the stock at the customer has to be replenished more often;
  - Suppliers that deliver from remote locations are therefore less suitable for VMI, although this issue can of course be covered in an agreement.

The simulation model that has been used for this analysis is fairly simple to facilitate fast calculation. For future research is recommended that the model is further developed to analyse specific cases in more detail. The model currently did not take perishable goods into account, which is an issue for several materials. If such an extension were to be implemented, the model can be used for other businesses as well. Finally it is advised that more detailed cost calculations are carried out for specific situations, in order to assess the overall benefit of implementing VMI at a company.

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