Vendor Managed Inventory in Wood Processing Industries – a Case Study

Manfred Gronalt and Peter Rauch

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Solid structure timber (SST) is an important building material in the wood construction business, in which its production volume is largely related to that respective business. Due to the large variability in the demand and seasonal factors, SST producers' inventories are likely to be simultaneously overstocked for one type of timber and out of stock of another. An inventory policy that ensures a high service level and relatively low stocks is required. In the present paper, we propose the vendor managed inventory (VMI) approach for controlling the stock of deals that are produced at a sawmill and delivered as raw material for SST-production. We evaluate two VMI implementations against the actual inventory management for three different market scenarios. Furthermore, we layout the necessities for reconfiguring the business processes, and subsequently set up an organisational framework within VMI, which is indeed applicable in this segment of the woodworking industry. In our application background, VMI as an inventory control system is able to reduce the overall raw material stock by more than 37% by simultaneously increasing the SST service level.

Keywords building materials, service level, solid structure timber, SST, wood construction
Addresses BOKU – University of Natural Resources and Applied Life Sciences, Feistmantelstr. 4, 1180 Vienna, Austria
E-mail peter.rauch@boku.ac.at
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1 Introduction

The European forest products industry is currently facing strong competition. There is an ongoing concentration process in the wood-processing industry. New markets and arising competitors in Eastern Europe are supporting the need for substantial cost reductions in the forest-wood supply chain. Solid structure timber (SST) producers are faced with a situation where customer's orders need to be supplied within a few days' time, and each order that consists of several SST dimensions must be fulfilled in whole or is thereby lost. Even slow seller products have to be stocked continuously. In the present paper, we describe a stepwise vendor managed inventory (VMI) implementation by two wood processing companies. The vendor produces lumber at a specific sawmill site and the customer (buyer) manufactures solid wood and glued beams for the construction industry. In order to sustain the market position, managing the order-delivery process between the companies in turn becomes an important issue.

For many companies, collaboration along the supply chain is seen as a key task. However, as there are a number of well-known opportunities, new challenges result from reorganising the order-delivery process and the perception of planning responsibilities. Disney and Towill (2003) define a supply chain as a system consisting of material suppliers, production facilities, distribution services, and customers who are all linked together via the downstream feed-forward of materials (deliveries) and the upstream feedback of information (orders). In a traditional supply chain, each actor is responsible for their own inventory control and production, or distribution ordering activities.

Especially when reducing chain inventories, new co-operation issues such as vendor managed inventory (VMI) are applied. VMI is a supply chain strategy wherein the vendor or supplier is given the responsibility of managing the customer's stock. The fundamental change is that the ordering phase of the process is saved, and the supplier is handed the authority and responsibility to take care of the entire replenishment process. Reduced delivery and administration costs for the buyer as well as lower delivery costs for the vendor are reported by Holmström (1998). Fig. 1 shows the information and material flow of the order-delivery process in a two stage supply chain with VMI control.

Simulation studies of two level supply chains conducted by Disney and Towill (2003) show that using VMI typically halves the bullwhip effect. A further result of implementing VMI is an improvement in customer service levels coupled with a significant improvement in inventory turnover (Achabal et al. 2000). In the short term, VMI usually reduces inventory-related costs mostly through optimising shipment quantities. Throughout a longer period, when the buyer and seller adjusts their production and distribution as well as marketing activities to VMI, the sales volume is likely to increase (Dong and Xu 2002). As the ordering responsibility is shifted to the vendor, people that were formerly involved in the ordering process can then adapt their activities to customer services and special order treatments.

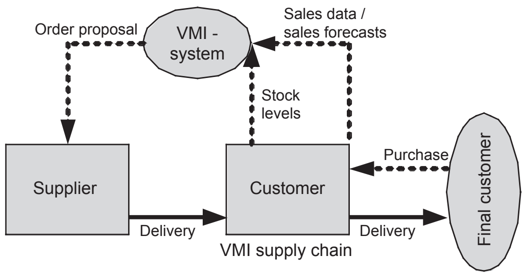

Fig. 1. Information and material flow in a two stage VMI supply chain.

Småros et al. (2003) also use a simulation approach in order to discover the impact of increased demand visibility on the production and inventory control by defining different portions of VMI based vendor-buyer relations. They show that a vendor can even benefit from a partial increase in visibility. Furthermore, they show that the planning cycle length is an important element for smoothing a vendor's production in a VMI approach.

However, alongside the success stories of VMI implementations, failures are also reported. A major barrier to the success of VMI is establishing trust among supply chain partners (Kuk 2003). Acceptance problems result from the high transparency of the buyer's business as well as from the shifted inventory responsibility. Increasing the producer's responsibility, frequency of the deliveries of stocks, as well as expensive advanced technology is required. Therefore, increased expenses for the producers are the most common disadvantages of VMI (Simchi Levi et al. 1999). In our case, one company is the shareholder of the other, so the transparency of the business as well as trust in each other already exists as a good starting basis for VMI.

In recent research, (Boute et al. 2007) an integrated production and inventory analysis of order smoothing in a two echelon supply chain where the retailer's order decision has a direct impact on the manufacturer's production is considered. With their order pattern smoothing they can bring advantages for both parties in the supply chain.

VMI was enriched according to the principle of postponement in order to flatten demand deviations. Van Hoek (2001) defines postponement as “delaying activities in the supply chain until the customer’s orders are received with the intention of customising products, as opposed to performing those activities in the anticipation of future orders”. Postponement effects depend on the product variety. The more varied the manufactured products are, the larger the effect of postponement will be (Silver et Minner 2005).

The applicability of VMI and redesigning the entire procurement process as a prerequisite for VMI in forest based industries are investigated in detail in the present paper. We analyse the VMI approach for controlling the stock of deals that are being produced at a sawmill and delivered as raw material for SST-production. Two VMI implementations are evaluated against the actual inventory management under three different market scenarios. By conducting this case study we will show that VMI is an appropriate management approach for the forest based industry in order to save inventory costs and to improve the service level.

The present paper is organised as follows. In Section 2, the production process of the SST and VMI approaches are explained. Section 3 shows the structure of the simulation experiments that we will conduct for testing several inventory policies and VMI. The results and a comprehensive discussion are provided in Sections 4 and 5, respectively.

2 Material and Methods

2.1 The Production of Solid Structure Timber

Our utilised supply chain consists of a sawmill that delivers the main part of its deals directly to a Solid Structure Timber (SST) production line. The simplest product of the SST production line is called a single SST, which is both an end product and a preliminary product for further processing in order to produce glued beams, namely Duo and Trio SST. The stocks of both factories are actually managed separately, and according to long lead times, expeditiously needed deals are often unavailable in due time. Large orders from SST customers are faced with a lead time that is given by the total of the sawmill’s and SST producer’s order to delivery time. Delivery problems can occur if insufficient raw materials are available with the required dimensions at the sawmill’s round wood stock.

Production planning at the SST producer is performed according to the customer’s orders, finished products stock, and raw material stock. If the SST booker thinks it is useful to replenish the raw material stock, an order is sent to the sawmill. No explicit demand forecasting techniques are used. Production lot sizes at the sawmill are constrained by the technical criteria of wood drying to the size of a wood kilning chamber. The SST producer runs a traditional buyer managed inventory. Applying VMI necessitates real-time data from the buyer, which is to be provided to the vendor as well as a commitment that the vendor shall trigger orders to establish an agreed service level.

Due to the need for fulfilling customer orders (retailers or mainly construction companies) within two days, the SST producer always has on hand a large finished goods stock. The production time within the SST producers is approximately one to two days if the appropriate raw material is in stock. The order lead time for a raw material order from the SST producer to the sawmill ranges from 9 to 14 days depending on the product’s dimensions, where most of this allotted time is utilised for drying the sawmill products. Usually a SST customer orders several different dimensions and accepts only entirely fulfilled orders. Therefore, even the dimensions that would normally be treated as make to order articles have to be held in the finished products stock.

The considered supply chain map (see Fig. 2) is displayed with arbitrary figures. Horizontal cycle time (lead indicator) is the time of activities, such as production planning, procurement, production, order processing, transport, etc. The vertical cycle time is the time that an item spends in stock, keeping working capital and not yet generating income. In the sawmill, production planning is performed only according to the SST orders and round wood stock possibilities. The sawmill production manager uses optimisation software for examining the optimal round wood dimensions to be used for the ordered SST raw material dimension. The software optimises the value of the main product (SST raw material) and of the by-products. Depending on the available round wood dimensions and sales potentials of the by-products, the production manager decides as to which round wood dimension is to be used for a given order.

Depending on the round wood diameter, different deal dimensions can be produced at the sawmill. SST is made out of dried, visually graded softwood deals. Parts of deals with material defects are lopped. Subsequently, deals are friction-type finger jointed lengthwise to lamellae and planed. The resulting product is called a single SST, which is, on the one hand, an end product, but on the other hand, also a preliminary product for Duo and Trio SST. A Duo SST consists of two single SSTs that are glued together with their flat side and then planed, and a Trio SST consists of three. The last step of SST production is to cut SSTs into lengths according to the customer's requests. The production process is shown in Fig. 3. The missing arrows indicate that some portion of timber was not used for the production of the actual cut deal dimension.

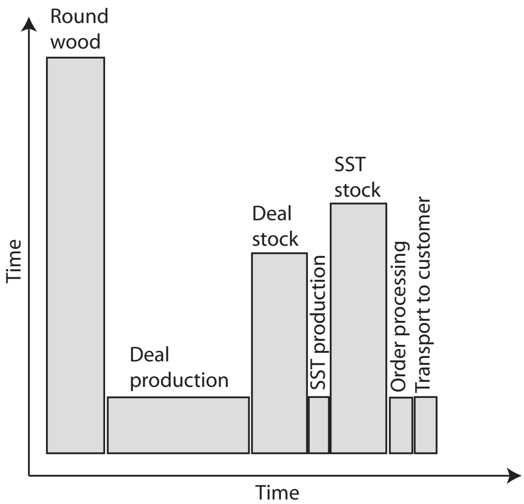

Fig. 2. Supply chain map of SST.

2.2 The VMI Approach for SST Production

Due to crowding out in the SST market as well as to the expansion strategy of the SST producer, management was looking for more efficient ways of linking their processes and inventories with the supplying sawmill. The sawmill is completely, and the SST producer is partly, owned by the same company. Therefore, a good basis for a strategic alliance between both of the production sites is given. VMI is known as a promising possibility for minimising system wide stock costs while satisfying the required service levels. Therefore, a prototype for a simultaneously planning deal and SST stocks has been set up to verify the impact of VMI for the described supply chain. The prototype has been programmed in MS Excel.

Using the sales figures of the SST-producer, a prototype of the inventory management system

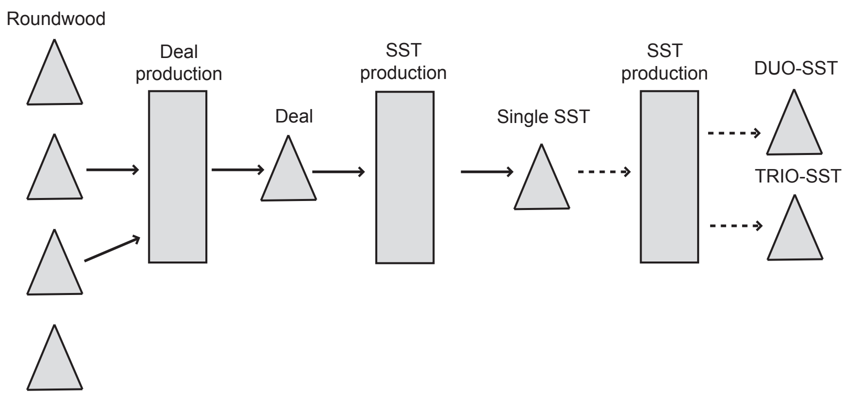

Fig. 3. Material Flow for SST production.

consisting of a forecasting procedure and order replenishment policy was established by the vendor. Stock parameters such as safety stock and reorder points were set dynamically in order to support a quick adaptation to market disturbances, and static to verify the effects of the dynamic setting. Additionally, a policy to order and forecast raw material on an aggregated basis for end products with the same basic deal dimension was applied by combining the demand patterns for solid construction timber with duo and trio laminated beams to a single basic SST demand. By combining products for joint disposition, volatility decreases because of a lower standard deviation of the aggregated products compared to specific end products. As a consequence, lower volatility also enables the lumber producer to smoothen its production. The VMI system was set up as a simulation prototype that is carried out in Excel.

Implementing VMI takes several project steps that can be concisely explained as follows: 1) top management commitment, 2) process redesign, 3) developing inventory management systems, 4) develop a prototype, 5) test the prototype, and 6) implementation.

Top management of both companies recognised the implementation of VMI as a rather important project and communicated that message to the lower management levels. Furthermore, they stayed in touch with the ongoing project and signalled their will to realise the system. Technically important questions such as the passage of title, use of storage, exception rules, and relevant decision variables were all fixed in the process redesign. Developing inventory management systems such as VMI meant a radical change in the ordering processes of the buyer and vendor. Traditional replenishment processes, where actors of different companies operate independently had to be changed into an inter-organisational replenishment process using real-time stock and sales data.

Stock parameters, such as safety stock and reorder points, are set dynamically (dynamic VMI) to support a quick adaptation of inventory control parameters to market disturbances, and static (static VMI) to analyse the effects of these different settings. As a third stock keeping policy, the one actually implemented is also calculated (booker's policy). In our application we do not consider each specific SST-type but rather we control the aggregated SST-stocks. The impact of the respective SST-types (single, DUO, TRIO) is estimated by their relative sales portion. Each specific SST can be manufactured within the guaranteed order-delivery time.

The simulation prototype was used to test the system and to find strategies for some pitfalls (holidays, 5 day work week, 7 day work week, major order, and promotions). Various scenarios and different inventory policies were tested to ensure that the set up inventory management system works smoothly under real world conditions. The results of a numeric study illustrate the effects of the suggested method due to various market and product sales scenarios.

2.3 The Order Replenishment Process

One element in VMI is to reorganise the order replenishment process. In Fig. 4 we show the developed order fulfilment process model including the activities at the vendor's and producer's units. The model also explains how the replenishment activities are organised. The process starts with the acceptance of a customer's order. Next, the SST stock is checked as to whether or not the ordered unit(s) is (are) in stock. If the ordered deal is not in stock, at first, the basic deal stock that needed to produced is checked. If it is not there, the drying chamber, and lastly, the sawmill's planned deal delivery date are checked. Knowing at which stage the needed SSTs or basic deals are, the delivery date can then be calculated. If the customer accepts the scheduled delivery date, the order is confirmed and the ordered units are booked. Once daily forecasts are calculated at the sawmill, the inventory position is compared with the reorder point. If the inventory position is below the reorder point, deals are ordered and produced. With the transport of the ordered SSTs to the customer, the process model ends. For dynamic VMI, safety stock and reorder points are also calculated anew once daily.

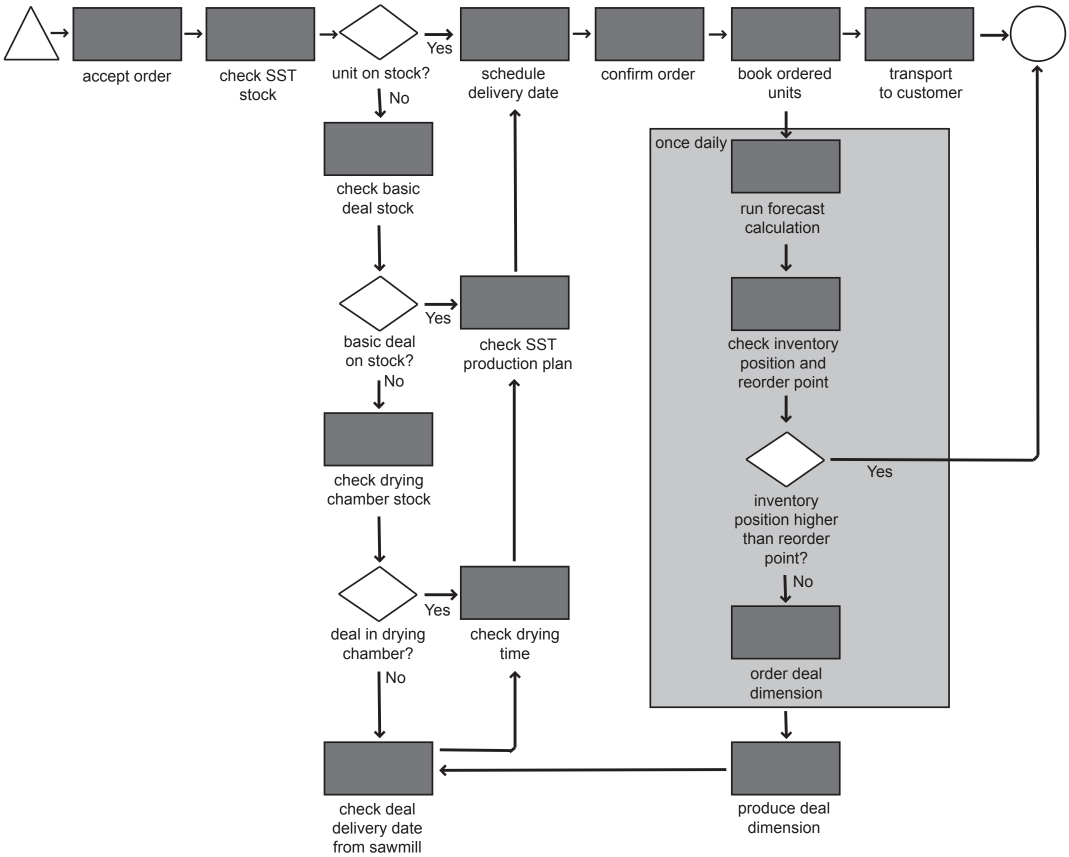

Fig. 4. Order replenishment process.

2.4 Inventory Management System

Out of one deal dimension, at least three different SST dimensions can be produced. Applying a postponement strategy here means summing up the demand forecasts of the individual SST dimensions and putting forth the decision as to what SST dimension will be made out of the deal during the very last processing step. The following data were used in the inventory management system: sales per period and inventory position, which is the sum of the stock keeping unit (SKU) of a basic deal in the production and kilning chambers at the sawmill, deal stock, and SST stock at the SST producer.

The calculated figures are the forecast, safety stock, reorder point, reorder quantity, and physical stock of deals. The reorder quantity is related to the capacity of the used drying kiln. The production lead time at the sawmill is assumed to be 12 days. The service rate was set at 98%. When the echelon stock inventory position drops below the reorder point, a new production quantity is initialised. During the same period, the inventory position is increased by this order and after the lead time, the physical inventory also increases.

The inventory management is based on the following principles:

- Exponential smoothing is used to forecast the aggregate demand for each period, e.g. one day, and for each deal dimension. The method is adapted according to the proposals of Gudehus (2002) in order to cope with demand variations.
- The forecasting method adapts the smoothing parameter for different products according to the expected values as shown in Fig. 5. A nervous volatile system works with a longer smoothing period, and vice versa.

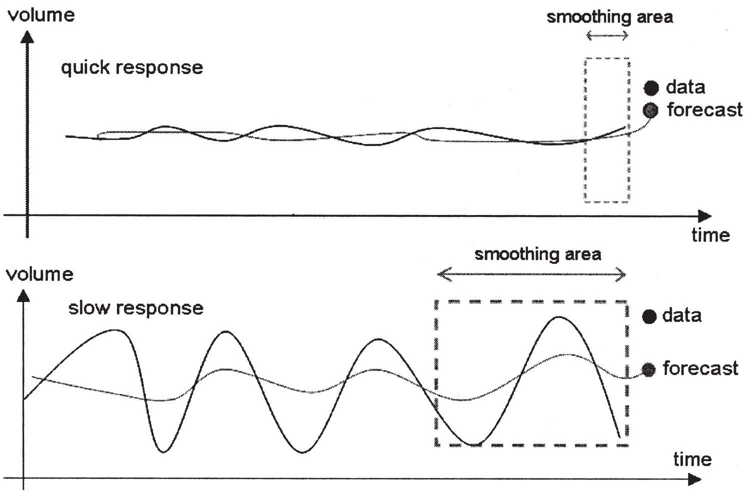

Fig. 5. Smoothing parameter and shape of the sales development.

The calculation of safety stock, reorder point, and reorder quantity is performed for a given production lead time and service rate. We denote *LT* as the production lead time, σ as the standard deviation of the forecasted sales, and *k* as the safety factor of the standard normal distribution. The safety stock *ss* is calculated with the standard formula: $k\sigma\sqrt{LT}$. The reorder point *s* is the sum of the safety stock plus the expected demand during the lead time. Whenever the inventory position drops below the value of the reorder point, a new order is placed that will be delivered after the lead time.

2.5 Inventory Development Example

For all the stock policies we apply the same base stock control as shown for one particular deal dimension in Table 1. We consider 20 Periods, in which a period in this case is equivalent to one workday. The sales column provides the sum of the sold SSTs made of the same basic deal. By applying a postponement strategy, different SSTs are put together here. The inventory position reflects the echelon stock of a basic deal, which is the sum of the stock in the production and kilning chambers at the sawmill as well as the deal stock and SST stock at the SST producer. The order quantity is fixed at 40500 m^3 i.e. the capacity of the kiln drying chamber. In Period 3, an order is posted and will lead to an inventory increase in period 15, which is merely one period after a new order was generated. In periods 13 and 14 we are faced with stock-outs.

3 Simulation Experiments

Three different inventory policies are tested under various scenarios. The actual inventory policy of the booker as the status quo is described as a simple algorithm that takes the week's sales as a forecast and checks if the future sales during the lead time can be fulfilled by the actual stock. In the case of the calculated stock out, the booker will place an order. The second policy is static VMI, wherein the safety stock and reorder point are calculated at the beginning of the year with the previous year's data. A dynamic VMI policy is introduced where the safety stock and reorder point are calculated anew for each period, i.e. daily. Although this work was motivated by a real life case, in evaluating our approach, we used a simulation test bed to generate various sales curves. 20 sales series, each covering 250 periods, were generated where the number and amount of orders are randomised, in which both seasonality and disturbances can be modelled (Gudehus

Table 1. Order quantity calculation and inventory development for dynamic VMI.

Period	Sales	Forecast	Variance of sales forecast	Safety stock	Reorder point	Order quantity	Inventory position	Inventory increase	Physical inventory
1	900	2012	873	6208	30735	0	38306	0	38306
2	6310	1981	880	6261	30403	0	31996	0	31996
3	768	2095	1116	7941	31713	40500	31228	0	31228
4	3034	2061	1122	7982	33116	0	68694	0	28194
5	1038	2078	1119	7964	32701	0	67656	0	27156
6	1787	2061	1118	7955	32895	0	65869	0	25369
7	3196	2056	1109	7891	32622	0	62673	0	22173
8	5102	2075	1110	7895	32570	0	57571	0	17071
9	2898	2127	1169	8316	33222	0	54673	0	14173
10	5321	2140	1163	8276	33800	0	49352	0	8852
11	500	2193	1224	8705	34389	0	48852	0	8352
12	5246	2164	1233	8771	35082	0	43606	0	3106
13	6084	2213	1283	9130	35101	0	37522	0	–2978
14	3018	2272	1360	9679	36238	40500	34504	0	–5996
15	1347	2283	1353	9629	36898	0	73657	40500	33157
16	2105	2270	1349	9594	36996	0	71552	0	31052
17	2676	2268	1339	9527	36773	0	68876	0	28376
18	576	2274	1331	9466	36684	0	68300	0	27800
19	1625	2250	1336	9508	36795	0	66675	0	26175
20	606	2241	1329	9454	36451	0	66069	0	25569

2002). Seasonality and disturbance parameters were held constant within the 20 sales series to design three different sales figures.

We denote the different sales figures as scenarios. The scenarios were modelled according to the real sales data from the past. Scenario 1 describes a standard year, which has in the SST business, a seasonal trend with a peak in the summertime when the building industry is running most of its yearly projects. However, according to the economic situation within the normal cycle, disturbances may occur at times with volatile increases of sales. One disturbance is modelled that starts in period 80 and ends in period 100 (see Fig. 6A). Scenario 2 stands for a more turbulent year with a higher deviation in the number of orders as well as the order quantity. Included in Scenario 2 is a simulated disturbance between period 80 and 100 (see Fig. 6B). Scenario 3 contains one major sale that is approximately 16 times the average period sales quantity. This large sale is handled like all other sales (see Fig. 6C).

For all inventory policies, under all three scenarios, the stock out costs and inventory holding costs are calculated. The stock out costs for unsatisfied demand per unit (m^3) are estimated as lost sales volume and valued with an average SST price of 300 Euro/m^3. Inventory holding costs are assumed as 10% of the sales price for the average inventory level of a year. During the experiments, the service level is set at 98% and the smoothing parameter a is adapted in the range of 2.0 and 0.01.

4 Results

In order to figure out the most advantageous policy, the above-mentioned scenarios are used to check the rationality of the described inventory policies to different trends of sales. Depending on the underlying sales scenarios, the inventory development is shown in Figs. 7A–C, respectively, for the sales data series 1 in a total of 20 different series.

If only a single SST dimension out of a customer's complete order, which usually consists of several dimensions, is not available within a few days, the order is lost and can be assessed as stock out cost. Otherwise, having SST on stock is connected with inventory holding costs. As another

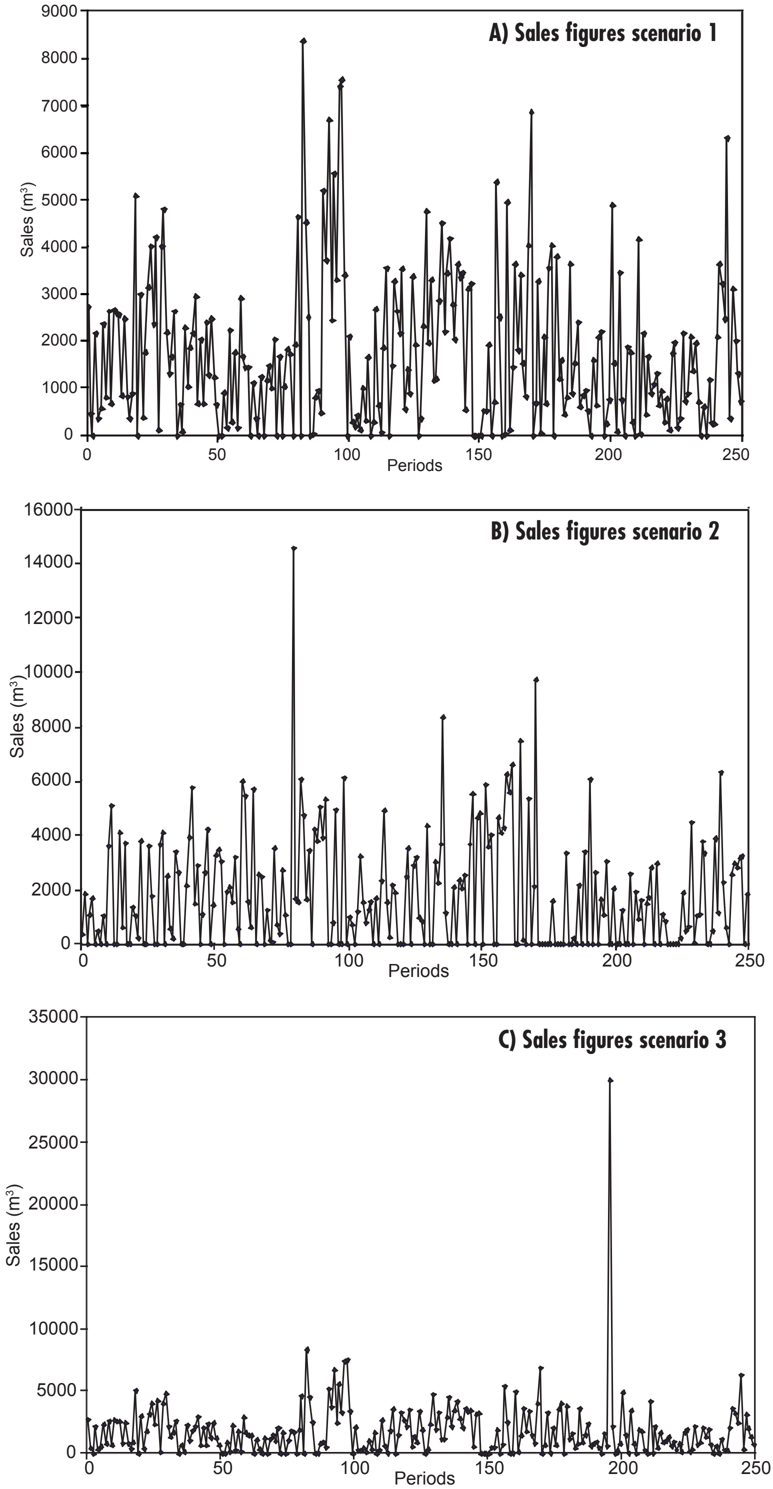

Fig. 6. Sales figures scenarios 1–3, sales data series 1.

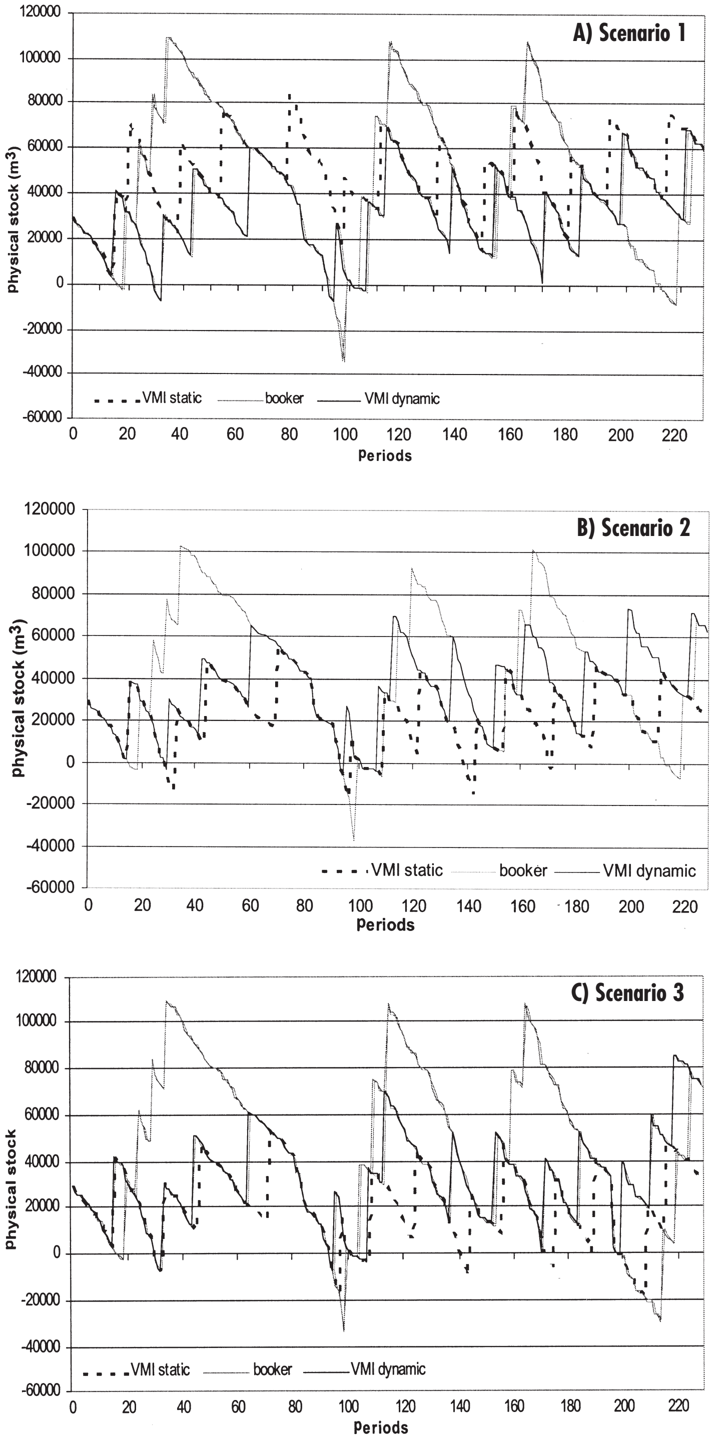

Fig. 7. Scenarios 1–3, results of sales data series 1: physical stock for static VMI, booker and dynamic VMI.

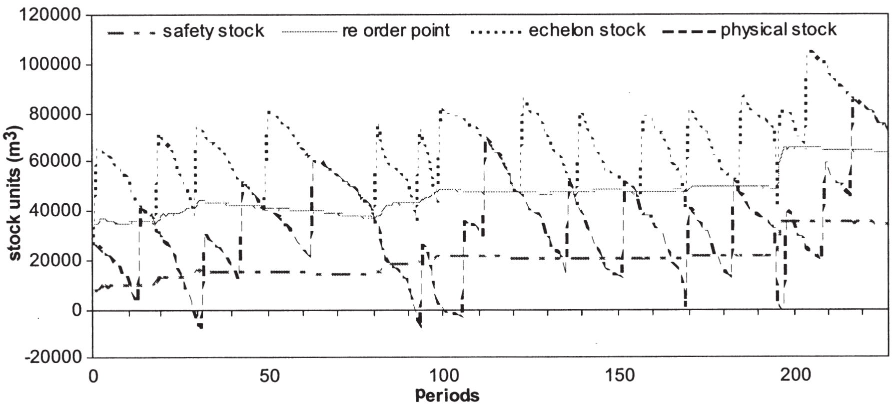

Fig. 8. Influence of a major order on the stocks and reorder point of dynamic VMI.

Table 2. Comparison of Inventory policies for 20 sales data series per Scenario.

	Scenario 1	Scenario 2	Scenario 3	Sum	Average
Lost sales' value in M Euro					
Booker	9.4	9.2	10.2	28.8	9.6
VMI static	0.4	15.2	19.2	34.8	11.6
VMI dynamic	6.2	6.2	7.7	20.1	6.7
Inventory holding costs in M Euro					
Booker	1.7	1.6	1.6	4.9	1.6
VMI static	1.5	0.9	0.8	3.2	1.06
VMI dynamic	1.0	1.0	1.0	3.0	1.0
Inventory turnover (turns per year)					
Booker	9	9	10		9.3
VMI static	10	19	22		17
VMI dynamic	16	15	17		16

important inventory measure, inventory turnover is given, which is calculated as the quotient of the year's total sales and the year's average inventory level (Table 2).

In Fig. 8, a major sale is included in period 195 in order to figure out the effects in the forecasts of the dynamic VMI's safety stock as well as on the reorder point.

5 Discussion

In Scenario 1, the sales data series 1, the booker policy is out of stock twice, first for 6 periods, and when after two periods of having stock again, for another three periods (see Fig. 7A). Dynamic VMI records 5 periods out of stock during the simulated disturbance of sales. Static VMI is the only inventory that ever has stock, but only because the standard deviations from last year's sales data, on which the calculation of the safety stock and reorder points are based, were higher than in a mean year.

Under Scenario 2, the sales data series 1, booker's inventory performance (Fig. 7B) worsens more than can be expected. The main difference occurs while the simulated disturbance, where the booker runs out of stock for six periods, has stock again for two periods and is out of stock for eight more periods. Static VMI records are four periods out of stock, again in stock for four periods, and then another eight periods out of stock. For dynamic VMI the values are six periods, two periods, and six periods. During the rest of the year, booker and static VMI have no stock for ten days, when applying the dynamic VMI policy, however, only one such day occurs.

The major order (Scenario 3, sales data series 1) enables all of the inventory policies to run out of stock, the booker for 17 days, static VMI for 11 periods, and dynamic VMI for 2 periods (see Fig. 7C). Additionally, the reaction time varies when the next new order takes place after the major order. Dynamic VMI orders immediately in the same period, static VMI reorders after 5 periods, and the booker after 4. All three policies have sufficient stock to serve the major order, but are then immediately out of stock one or two days after doing so. For the average of the 20 sales data series, the static VMI is the inventory policy that is the least out of stock in the normal year scenario, for the other scenarios, this is the case for the dynamic VMI (Table 3).

If a major sale is included (herein at period 195) in the forecast of the dynamic VMI, both the safety stock and reorder point increase immediately and decrease very slowly (Fig. 8), leading to higher inventory costs. In the SST business, a large order occurs when a customer puts up a superior large building, which is rather seldom, and does not reflect a trend. Therefore, this order should be eliminated from the sales data, which are used for the forecast. In the implemented dynamic VMI, the booker is informed by the system if a large order executed. The booker in most cases only knows if a single building is behind this order, and decides then whether to skip this order from the forecast data or not. The advantage of a dynamic VMI is that it adopts the smoothing forecasting period and the safety stock according to demand and appears in an average lower safety stock.

Service levels, as one important parameter for customer satisfaction and the average physical stock (inventory level), are shown in Fig. 9 for the three inventory policies to figure out their performance under 3 different scenarios, each being tested with 20 sales data series. The inventory level usually drops after VMI implementation, as is the case according to the findings of Tyan and Wee (2003).

Table 3. Periods out of stock as a result of all the sales data series.

	VMI Static	Booker	VMI Dynamic
Scenario 1			
Mean	0.35	12.3	7.45
Standard deviation	1.3	5.3	4.2
Scenario 2			
Mean	20.1	11.3	6.2
Standard deviation	8.3	6.0	4.4
Scenario 3			
Mean	25.0	13.6	9.5
Standard deviation	7.5	6.8	4.7

Scenarios 1, 2, and 3 generate only small differences in the booker policy in both the average stock and service level. The booker has the highest average stock of all the stock policies in all the scenarios. Static VMI policy reaches, under Scenario 1, a high service level (99.8%) with approx. 10% less inventory than the booker. In Scenarios 2 and 3 it has nearly half the physical stock of the booker and reaches service levels of only 92 and 89%. However, the performance of static VMI strongly depends on the relationship of the sales of the past year(s) to the sales of the current year. If, e.g., the preceding year's sales data have a higher standard deviation, then the following year a high safety stock and a high reorder point are calculated for the current year in turn resulting in high average stock and service levels. Therefore, estimating the safety stock and reorder point for VMI only once a year leads to an uncertain performance of stocks and to a system that is insensitive to trend changes.

Under different conditions that are simulated in the three scenarios, management's target of a service level higher than 95% can only be reached with a dynamic VMI system. During a normal year, static VMI and dynamic VMI ensure the desired service level but later on needs 37% less SKU. Under Scenario 2, booker and dynamic VMI hit the service level target, but again dynamic VMI's average stock is approx. 38% less. For sales figures, as modelled in Scenario 3, only dynamic VMI is able to hold a service level of more than 95%.

The actual service level of the SST producer could not be estimated, but if we consider the booker's policy as the upper bound, it would

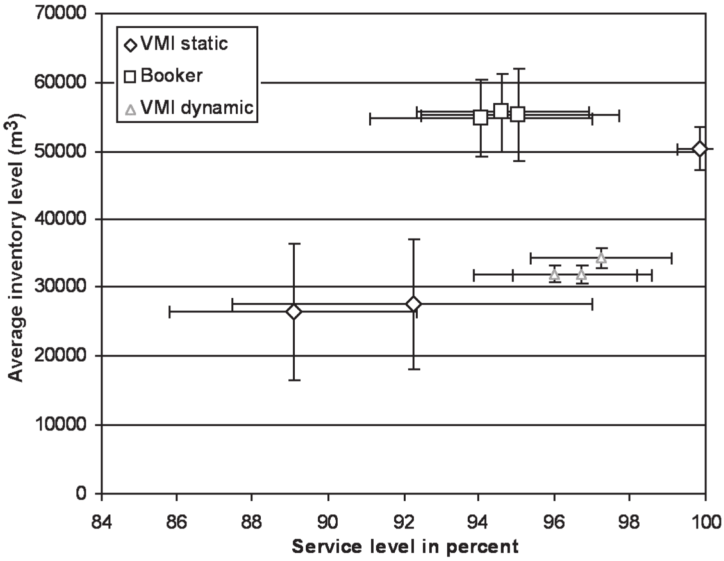

Fig. 9. Performance (mean and standard deviation) of the inventory policies in different scenarios.

be approx. 90%. Compared with the previous used (booker) inventory policy, lost sales can be reduced on average by at least 20% with dynamic VMI.

Inventory turnover is best for static VMI (in average 17) closely followed by dynamic VMI (16). However, due to the lack of sensitivity to sales disturbances, static VMI cannot achieve the high service level of dynamic VMI. Booker inventory policy has an inventory turnover from just 9. With dynamic VMI customer service levels, it could be improved, and in comparison with the earlier used stock, keeping strategy improvements in inventory turnover are made comparable to the results of Achabal et al. (2000) as well as of Tyan and Wee (2003) for other VMI implementations.

Furthermore, VMI is seen as a measure to lower inventory related costs (Dong and Xu 2002). It is here that it can be shown that inventory holding costs decrease from 1.6 M Euro under the booker's policy to approx. 1 million Euro under both VMI versions (Table 2).

Implementing VMI needs a top management agreement between the involved enterprises as well as the ongoing support of top management to overcome several typical pitfalls occurring when processes and manager's responsibilities should be newly defined (Hammer and Champy 1994). Kuk (2003, p. 653) widens this sight of implementation responsibilities to where: "Working towards VMI is not a single effort but rather a company-wide effort to reinvent and streamline business processes with supporting technology".

In our case, several changes in the old business processes were needed to implement VMI, which usually did not go off without a hitch. Middle management, which was affected most by implementing VMI, has to be won over for the new replenishment system. Process changes were introduced step by step, so that at first, all of the orders triggered by the sawmill had to be accepted by the SST producer. This was supposed to have the process owners to become used to the new system and to furthermore assure them that the system could do what the booker did previously. The Excel simulation prototype also provided the booker the opportunity to test the system running on his or her own personal computer in detail, in which he or she was convinced after arriving at the inability to blame the system.

VMI is a co-operation approach that aims at reducing stock levels in supply chains. Its advantages mainly result from new inter-organisational business processes and lower inventories caused by a reduction of information distortion. We present this concept within the wood processing industry and compare different inventory management policies. The results of the numeric study illustrate the positive effects of VMI due to the various market and product sales scenarios. Implementation for the successfully tested and adapted prototype was carried out by a software company. Different data formats of the computing systems were a major burden that had to be dealt with appropriately.

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