The impact of improved supply chain planning on upstream operations

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ABSTRACT

This paper addresses the synchronization of a supply chain with two different production processes through improving the visibility to downstream plans. Dynamic demands and hard competitive situation make it increasingly necessary for companies in the food supply chain to seek for efficiencies and more responsive modes of operation. In this study it is studied how the different supply chain planning phases can be integrated to support the upstream dynamics of supply chains.

A case study involving a grocery manufacturer and a package material supplier was carried out. Three changes were recently implemented in the supply chain: a new forecasting process was launched, responsibility of the management for material inventories was shifted to the material supplier as vendor managed inventory, VMI, mode was adopted, and the manufacturer has set a target to reduce its finished goods inventory levels. The two first changes improve the planning quality and make integrated planning possible as the third requires more agility from the upstream operations.

To find out if it is possible and profitable to execute agile operations upstream in a supply chain, a three-month project concerning four stock-keeping units was piloted. The target of the pilot was to measure the impacts of the changes on production, production planning and inventories. In addition, the supplier was willing to test the scheduling of its production very close to need and producing smaller batches than before.

The case indicated that in addition to changes in demand, the upstream operations suffer from a number of other uncertainties, such as machine breaks, variable lead times, processing variations or price changes. Multiple sources of flexibility, such as those offered by production, inventories, and lead times, are required to manage the different sources of uncertainties in the chain. Shared good-quality planning data enable the supplier’s responsiveness. However, scheduling deliveries very close to need preclude the efficient use of shared VMI information.

Key Words: Supply Chain Planning, Information Sharing, Uncertainty, Flexibility, VMI, Upstream Operations
1. Introduction

Supply chain planning is the set of supply chain activities that focus on matching demand with material and production capacity availability and formulate plans and schedules based on meeting that demand and company goals. Each of these activities requires an accurate and reliable forecast in order to effectively balance demand requirements with supply chain capabilities. Supply chain planning addresses multiple functions: demand management and forecasting, inventory planning and sourcing, planning and scheduling and materials management (Williams 2002). To coordinate plans integration is needed across strategic, tactical and operational planning as well as across the supply chain. Supply chain planning is an integrated framework to capture the various synergies between functions and supply chain parties and to deal with trade-offs when preferences are conflicting.

The supply chain planning process may be highly complex, multistage and include multiple decision making points. Therefore many companies face difficulties in managing their planning process. This reflects in high safety stocks, problems in responding to volatile demand, low service level or long lead times. Lack of integrated planning or tracking processes prohibits the efficient use of supply chain information or the use of information to improve operational processes.

Supply chain uncertainty refers to planning and decision making situations in the supply chain. Due to uncertainties the decision maker does not know definitely what to decide as objectives may be unclear, lacks information about the supply chain or its environment, lacks information concerning processing capacities or is unable to create accurate volume plan or forecasts (Van der Vorst, Beulens 2002).

This research concerns planning processes and their role in synchronizing operations in the supply chain. Sharing information concerning the plans and the use of shared planning data in upstream operations is studied. In addition to different manufacturing processes, the companies in the case supply chain differ in their planning horizon. This paper addresses the synchronization of two different production processes through improving the visibility of downstream plans. The research studies how the supplier in a pilot project can support agile performance in the supply chain.

2. Literature survey

First in the literature survey is discussed the challenges the upstream suppliers face in a supply chain. Then supply chain planning and the state of integrated planning is treated. The third aspect is supply chain differentiating.

In many supply chain settings the availability of materials is tightly constrained due to long production or procurement lead times. The constrained supply needs to be matched with product demand, which fluctuates both in total volume and in product mix. These fluctuations tend to amplify towards the upstream part of a supply chain, as is proved by Lee, et al. (1997), who call the effect the bullwhip effect. Thus the uncertainties faced by companies concern both demand and supply (Lee, 2002). To successfully manage the chain companies have to adopt either demand-uncertainty reduction strategies to stabilize the bullwhip effect of the demand signal or they have to reduce supply uncertainty in order to balance the evolving supply process. Efficient information sharing is widely discussed and essential in both types of strategies. Traditionally, raw material and package material inventory buffers are used to level the impact of suppliers’ long lead times. However, fast reaction to
changes in demand is possible only if the whole supply chain, consisting of sourcing, manufacturing and deliveries, is sufficiently flexible (Prater et al. 2001).

When we consider the position of upstream players in a supply chain, it can be stated that, in addition to demand changes, the upstream operations face a number of uncertainties (Van der Vorst, Beulens, 2002). Short-term uncertainties causing volatility in upstream operations include processing variations, cancelled or rushing production batches, or equipment failure. Long-term uncertainties may take the form of changes in the price of materials, changes in the product itself or in package markings, and movements in the product portfolio.

Partnerships and collaboration practices with customers and suppliers are a means to reduce uncertainty in a supply chain (Van der Vorst, Beulens 2002). They provide more information for decision makers or reduce the need for decision-making. For example VMI eliminates one decision making phase in the supply chain and gives the supplier freedom to schedule deliveries according to its production process (Disney and Towill 2003, Kaipia et al 2002). Chain redesign strategies can be used to reduce uncertainty. To identify effective redesign strategies, the sources of uncertainties in the supply chain decision-making process should be identified and managed.

Integrated planning offers a way to manage the supply chain uncertainty. As supply chain planning takes place in strategic, tactical and operational level, the planning is, first, to be integrated across these levels. Second, functional integration of operations like purchasing, manufacturing, transportation and warehousing activities relates closely to integrated planning. The third aspect of integrated planning, and the part that has been gaining a lot of interest and grown in importance, is spatial planning across company boundaries in a supply chain (Shapiro 2001). Integrated supply chain planning is highly dependent upon the information, which flows between the supply chain partners to plan and effect the flow of materials and products. The purpose of the information is to provide better visibility of the physical goods, promote better communication between chain links and to reduce the need for warehousing and distribution.

Advances in information technology have made integrated planning in supply chains technically possible. Especially communication over the Internet and the adoption of enterprise resource planning systems has been rapid making communication of data accurate and fast. In addition collaborative initiatives, like efficient consumer response, ECR, and CPFR, collaborative planning, forecasting and replenishment, have supported the integration targets of supply chains. Recent case descriptions on successful supply chain planning have been published by for example Kumar (2004), De Kok et al. (2005) and Kumar et al. (2001).

However, findings indicate that the pace of which many European companies are moving towards a more integrated supply chain is slower than many leading writers suggest (Edwards et al. 2001). There have been barriers like lack of trust or guidelines how to start realise collaboration or internal processes are not integrated. Shapiro (2001) states that barriers to integrated supply chain management are organizational, not technical. Very few companies have departments to carry out end-to-end supply chain planning. Integrating planning process for the whole supply chain is essential to make even the weakest links work (Williams 2002).

Many companies face difficulties in managing their planning, which shows as inaccurate forecasts, high safety stocks, difficulties in managing seasonal demand pattern, lack of integrated end-to-end planning processes or order tracking process (Kumar 2004). A Swedish survey on the management of supply chains (Olhager, Selldin 2004) revealed that integration in supply chains concerns more
downstream actors as upstream. Integration activities focus on internal activities, or 1st tier suppliers or customers.

Fisher (1997) states that product characteristics and demand features are the primary determinant for deciding on the characteristics of the appropriate supply chain. The demand characteristics of products need to be matched with the right supply chain strategies. For products with unpredictable demand, companies should develop responsive operations, while for products with predictable demand they should develop efficient operations. The choice of a supply chain strategy also impacts the capacity usage: in lean operations, the main focus is on efficiency and fulfilling capacity. For responsive operations, the companies should reserve extra capacity and focus on flexible suppliers.

Fisher’s framework has similar features as developing supply chains into agile and lean, presented by Christopher et al. (2004). Agile performance requires the supply-chain ability to provide the customer with the products he needs and wants (Yusuf et al., 2003). Leanness means developing a value stream to eliminate all waste, including time and to ensure a level schedule. It is also stated that it is a too simplistic a view to consider lean and agile operations in isolation, they should be treated as complimentary within the correct supply chain strategy and correct part of a supply chain (Naylor et al 1999).

To reach agility the firms often have to adopt more complex practices, and this works against agility. Therefore firms have to do tradeoffs between agility on the other side, and complexity and uncertainty on the other (Prater et al 2001). However, differentiating supply chain according to product features has been proved very useful, for example by Wong et al. (in press) based on their studies in a toy supply chain. Similar results have been presented by Childerhouse et al (2002).

There can be pointed out three findings from the literature survey. First, there seem to be difficulties in integrating supply chains and supply chain planning. Second, supply chain planning should support supply chain differentiating. Third, the upstream players face many challenges, like multiple sources of uncertainty which have to be managed in supply chain planning.

3. Research setting

This empirical research involves synchronizing operations in the supply chain. The research question is: How can supplier use improved visibility to downstream plans to support agile performance in a supply chain? The question of whether agile operations are possible in an interface between package material supplier and a grocery manufacturer is investigated. Attention is paid to the planning processes and how they can be integrated to support upstream dynamics in supply chains.

More agility is required from the case supply chain, as the manufacturer’s competitive situation has become more difficult. European competitors with much bigger volumes are able to manufacture one product or product group in each factory and gain efficiencies in each supply chain phase. The case manufacturer produces 100-300 products at each plant. To manage in the competition requires good supply chain planning practices, efficient management of production in small batches, tight inventory control and accurate and fast reactions to changes.

The research is carried out as a case study. Recently in the case, changes that enable and require more agile operations have been taking place in the supply chain. First, the manufacturer has put in place a new forecasting process and during the use of it forecast accuracy has improved. Second, VMI operation mode was adopted. Third, the manufacturer has decided to reduce finished-goods
inventories. The case study was carried out to discover the impacts and possibilities these changes have in creating a more responsive supply chain.

A pilot project was set up involving four stock-keeping units (SKUs) with stable demand. The target of the three-month pilot project was to test how close to need, and in which quantities, the package material supplier can deliver needed materials. The second part of the case study takes the form of numerical analyses of the chosen pilot products. The goal in these analyses was to figure out how the changes in operations affected the performance of the supply chain. In the numerical analyses, the operational figures from the three-month pilot project are compared to those gained during a nine-month period before the pilot. The data for the analyses was accessed from the OEM data systems and from the supplier production planning systems. Production planners in both companies were interviewed.

The manufacturer produces groceries in a batch production system to inventory. The supplier’s production is of the process type and operates on customer orders. The supplier was chosen from among the best performing suppliers of the manufacturer, and results from an earlier research (Hellström 2003) were used in the selection process. The supplier is willing and capable of working with development actions, and has experience in operating in VMI mode with the manufacturer. The supplier offers ‘more than a box’ for its customers, offering customized package design, high-quality printing and innovative package solutions for customers.

The case study investigates how product size and different demand characteristics affect the supplier. The differences in the production processes are discussed. Also, the information needs of the upstream operations are considered. Last, the sources of uncertainty causing volatility are identified and solutions to the problems of how these sources can be managed are proposed.

4. Case description

The case handles a supply chain consisting of a supplier, who manufactures and delivers corrugated board, a confectionary manufacturer, called here the OEM (original equipment manufacturer), and customers, who are wholesalers delivering to retailers. The case treats the synchronizing of manufacturing processes different in nature. The case is based on a study project during the year 2004, where the OEM wanted to investigate the current state of its upstream operations. The OEM faces hard requirements from markets, characterized by intensive competition, strong seasonal sales, and pressure to introduce new products frequently and at the same time maintain existing strong brands to ensure shelf space in the retail store. The OEM wants to streamline its supply chain to ensure competitiveness. One part of the work is to develop the upstream operations of the OEMs supply chain.

4.1. Supplier

The supplier is a corrugated board manufacturer, whose production divides into two phases: corrugated board process and refining, which divides into cutting and printing. Production throughput time is 1 to 2 days. The supplier operates on customer order, and deliveries directly from production to customers. The supplier has 1700 customers, over 10000 product variants, each tailored to the customer and in many cases to the product. A medium delivery is 7000 packages. The supplier is
able to provide 49 different corrugated board types. The supplier has several VMI-customers, whose deliveries represent less than 10% of production volume.

Both delivery time and delivery quantity are flexible within certain limits. In the process the corrugated board is cut into sheets, and optimizing the use of processed corrugated board is the main challenge in production. This task becomes far easier, because delivery quantities are allowed to vary between +/-10 percent from the ordered quantity. Production planning takes place in two phases: first the deliveries are scheduled according to customer needs and production requirements. Planned delivery times are communicated to customers according to this plan. Typical delivery time for the customers varies between 2 to 3 weeks. The accurate scheduling of production may happen very close to execution, even only a couple of hours before production. The main factors that direct the production planning are capacity usage in both production phases, optimality in production, and customer needs.

The production planning system allows the supplier to take in express orders occasionally under certain conditions. These orders are delivered within a couple of days. The supplier takes in such orders if they match in the production schedule and can be added in planned production batches.

The target service level is 100% measured from the production needs of the customer company. The most important thing is that the customer company has got the right and proper materials available when needed, that is when the production starts. This requirement includes the ability to respond to VMI customers’ plan changes. These changes may cause additional planning rounds, and affect the production economics.

### 4.2. Manufacturer

The manufacturer, the OEM, is a Scandinavian chocolate and sugar confectionary producer. The company produces to stock in a batch production mode in five plants. Main customers are distributors and wholesalers in Scandinavia, who deliver the goods to retail stores and other customers. The manufacturer produces also special export products for tax-free sales and other export customers.

Production planning takes place at each plant. It is supported by enterprise resource planning (ERP) systems, but the final decisions and schedules are done manually. The production planner takes into account inventory levels, production optimality in the form of production order and batch size, use of personnel, and production breaks.

Finished goods inventory levels the gap between batch production and consumption. For seasonal products inventories are needed since production takes place before the season and only a fraction of consumption is manufactured during the season. In addition, production breaks during holidays or maintenance require keeping inventories.

The case manufacturer purchases represent about 2% of the corrugated board supplier’s production volume. The supplier provides about 250 different package materials for the OEM.

### 4.3. Recent changes in the process

There are several changes made in the process recently. The manufacturer has released a new monthly forecasting process. The responsibility of the process is distributed: each account manager makes forecasts concerning their own customers. Account managers are advised to make a stable
forecast and avoid nervousness in plans. The goal is to create a single set of numbers to be used in production planning and in supplier collaboration.

The supplier manages material inventories in a VMI mode. This is a new process model for the case materials, although the model has been in use for other materials and with other suppliers. The visibility to the supplier is provided through a supplier portal. The supplier can achieve information concerning material requirements based on production plans and package material inventories for the coming 52 weeks. The information is based on weekly production planning and material requirements planning processes, and each Thursday the freshest plans are available.

The third change concerns the OEM’s target to reduce finished goods’ inventory levels. The target of the change is to be more responsive to demand changes, to reduce costs and to ensure product freshness. This forces the OEM manufacturing produce goods in smaller batches and has impacts on the supplier requirements also.

4.4. Planning process in the chain

The planning process starts with demand forecasting at the OEM (Figure 4-1). This is a collaborative process, based on historical sales data, customer sales plans, campaigns, new product introductions and personal experience. Forecasts are made monthly for the coming 52 weeks. Production planning takes place weekly as well as materials requirements planning. The company ERP system suggests plans for the coming 52 weeks. Production planner creates a fixed plan in detailed planning for the coming two weeks. The material needs are communicated to suppliers via an automated supplier portal.

![Figure 4-1. Planning process in the case supply chain.](image)

The supplier uses the shared information efficiently. The person responsible for VMI customers can schedule production several weeks before and, more important, form the basis for efficient production batches by scheduling similar materials and rare printing colours for the same production week. It is essential that the supplier has access to production plans in addition to inventories. Those customers, who share only inventory information with their VMI-suppliers, do not offer advantages over orders, because the production planner can not anticipate the need according to production
plans, it only sees how inventory level reduced when the customer executed production. This is emphasized in batch production, when the consumption of materials is not even.

4.5. Pilot project

A pilot project was carried out during the three last months of the year 2004. The impacts of the three changes, described in chapter 4.3, are measured in production processes by the OEM and the supplier, and in the package material inventory. In addition, the impacts of the changes on planning processes are investigated.

The pilot project was carried out on a product level to ensure accurate information on the behavior of the chain. The project group wanted to choose products that contain product specific package materials to be able to follow the material flow throughout the chain. Also the products’ demand should be relatively stable, for making the test easier to realize and follow.

For the pilot project was chosen one product group, candy bars, which consists of four products. Three of the products are aimed at domestic markets (called Basic, Pepper and Lemon in the analyses) and they are delivered through distributors to retailers and other customers. These three products are packed first in wrapping, and then in corrugated board boxes from the case supplier. Minimum delivery batch size is one box containing 30 SKU, stock-keeping units. The boxes are uniform, with different printings for each product. The fourth product is an export product (called ‘Export’) and it is aimed at airport sales and tax-free shops. It is packed in a corrugated board box, which is the consumer package. This product is delivered to customers in batches of 16 boxes. In Figure 4-2 the production batches during the year 2004 as well as sales to distributors are illustrated.

![Figure 4-2. Production batches (nr of boxes) by the package material supplier, by the OEM and sales from the OEM to customers in 2004.](image)

The chosen pilot product group is very challenging for the supplier for several reasons. Even the biggest product is small in the senses of quantity and size. One pallet of this special package material contains 8000 boxes, which responds about two OEMs production batches (see Figure 4-2). When compared to the sales from the OEM, one pallet of this package material responds 3-13 weeks
sales depending on the product. In addition, the corrugated board type for these products is very rare, it represents less than 1% of the corrugated cardboard production volume.

The package material supplier was given the responsibility for replenishments concerning the pilot materials. This VMI mode of operation was new for these materials, although it was in place with other materials. The package material supplier was willing to demonstrate how well it can synchronize its production according to the OEM production plan.

The supplier decided to produce very close to the need and in minimum batches. The minimum batch size was set to one pallet. This is about half of the size of previous production batches.

The manufacturer continued reducing the finished goods inventories. For three products, the goal was already reached, but keeping the inventory level under the three-weeks consumption is a continuous challenge.

5. Results of the pilot project

5.1. Numerical analyses

The supplier succeeded in delivering very close to production, and in reducing package material inventory levels (Figure 5-1). For the two best selling products the inventory levels represented 19 days’ and 33 days’ consumption (Table 5-2). However, for the export product’s package material the inventory level is still high, representing about 130 days’ consumption.

Finished goods inventories for the three biggest products remained under the three weeks target. For the export product the target inventory level was not reached as inventory represents about 70 days of supply at the end of year.

A comparison of the realized production batches during the year 2004 (Table 5-1) revealed that during the pilot in addition to smaller batch sizes the supplier was able to produce in a more stable manner. By the candy manufacturer the production batches were bigger during the pilot period due to a coming break in production.

Table 5-1. Medium production batch sizes during the year 2004 and average deviation of production batches.
There occurred two minor availability problems during the year. Once the export product ran out. In package materials one out-of-stock situation threatened in the very beginning of the year 2005, but it could be managed by a small change in the OEM production planning.

The total throughput times were reduced for all products, which is mostly due to reduced package material inventory levels (Table 5-2). For the biggest product the total throughput time was reduced almost to half, from 85 days to 47 days. This throughput time describes the duration of the box’s life; it begins from the box manufacturing and ends up at the retail customer, where the box material is recycled to the producers. This throughput time measures the reaction time to implement a change in the package.

Table 5-2. Total throughput times (days) for the pilot products during the year 2004.

<table>
<thead>
<tr>
<th>Before pilot</th>
<th>Supplier’s production process</th>
<th>Package material inventory</th>
<th>OEM production</th>
<th>Finished goods inventory</th>
<th>Customer inventory</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pepper</td>
<td>2</td>
<td>67</td>
<td>5</td>
<td>21</td>
<td>8</td>
<td>103</td>
</tr>
<tr>
<td>Basic</td>
<td>2</td>
<td>52</td>
<td>5</td>
<td>22</td>
<td>4</td>
<td>85</td>
</tr>
<tr>
<td>Lemon</td>
<td>2</td>
<td>64</td>
<td>5</td>
<td>20</td>
<td>8</td>
<td>99</td>
</tr>
<tr>
<td>Export</td>
<td>2</td>
<td>178</td>
<td>5</td>
<td>48</td>
<td>10</td>
<td>243</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>During pilot</th>
<th>Supplier’s production process</th>
<th>Package material inventory</th>
<th>OEM production</th>
<th>Finished goods inventory</th>
<th>Customer inventory</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pepper</td>
<td>2</td>
<td>70</td>
<td>5</td>
<td>24</td>
<td>8</td>
<td>109</td>
</tr>
<tr>
<td>Basic</td>
<td>2</td>
<td>19</td>
<td>5</td>
<td>17</td>
<td>4</td>
<td>47</td>
</tr>
<tr>
<td>Lemon</td>
<td>2</td>
<td>33</td>
<td>5</td>
<td>18</td>
<td>8</td>
<td>66</td>
</tr>
<tr>
<td>Export</td>
<td>2</td>
<td>130</td>
<td>5</td>
<td>71</td>
<td>10</td>
<td>218</td>
</tr>
</tbody>
</table>

The operations model during the three-month period was noticed to be very tight. It was quite requiring for the supplier’s production process: it led to multiple changes as the batch size represents about 20 minutes production capacity. In general, the supplier decided to shift the production focus a bit and produce more rarely, in larger batches and to leave a safety time between delivery and need. This production philosophy was named ‘less frequently – more – earlier’. There are several reasons behind the decision:

1. As the supplier wanted to deliver very close to the need, the advantage of combined production batches was lost, which raised the number of changes and production costs as well.

2. The benefit that increased visibility offers to production planning was lost. The supplier needs orders several weeks in advance to be able to combine orders into an efficient production batch. VMI customers offer good advance information for production planners, but it can’t be fully utilized if the supplier is forced to obey certain production timetables.

3. The product quality is in danger, as in small batches the risk that corrugated board quality fails is bigger. This did not, however, occur during the period.
Planning became more complicated by the supplier. The impacts of forecast changes reflected in supplier production planning more clearly than before. The production scheduler had to more accurately and more often follow and react to changes in material needs.

5.2. Uncertainty factors faced by the supplier

To understand the supplier situation, we investigated possible uncertainty factors along the supply chain. In addition to demand changes, the supplier has to manage many other uncertainties that occur along the supply chain. Some of these factors require the adoption of agile practices in production, and others favor material buffers. In Table 5-3 there is listed the sources of uncertainty that may take place in the chain, and which impact the supplier position. During the year 2004, all these uncertainties, except one, occurred in the pilot product group. This was surprising, because selection criteria for the pilot products were stability and predictability. The source of uncertainty that did not take place was changes in the product itself.

<table>
<thead>
<tr>
<th>Source of uncertainty</th>
<th>How can be managed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material price change</td>
<td>Material buffers</td>
</tr>
<tr>
<td>Change in package markings</td>
<td>Low material buffers, agile production, short lead times</td>
</tr>
<tr>
<td>Change in package design</td>
<td>Low material buffers, agile production, short lead times</td>
</tr>
<tr>
<td>Process variations</td>
<td>Buffers for both finished goods and materials</td>
</tr>
<tr>
<td>Rushed/cancelled production batches</td>
<td>Material buffers</td>
</tr>
<tr>
<td>Machine breakage</td>
<td>Buffers for finished goods</td>
</tr>
<tr>
<td>Optional packages for the product</td>
<td>Improved planning</td>
</tr>
<tr>
<td>Demand changes</td>
<td>Reactive planning, shared information, buffers for finished goods, flexible production</td>
</tr>
<tr>
<td>Changes in product assortment</td>
<td>Shared information, improved planning quality</td>
</tr>
<tr>
<td>Changes in product itself (did not occur during the period)</td>
<td>Shared information, improved planning quality, shortened total throughput time</td>
</tr>
<tr>
<td>Plan quality: Inaccuracy of plans, planning nervousness, differences in planning horizons.</td>
<td>Shared information</td>
</tr>
</tbody>
</table>

Table 5-3. The uncertainty factors in the upstream operations

The differences in planning timetables add the uncertainty in the chain. The demand forecast is updated monthly although in between changes are allowed and encouraged. Because production plans are made weekly, the production planner may have to use three to four weeks old forecast information. Fixed period in OEM production plans is two weeks. However, the supplier needs accurate information concerning material requirements 8 to 12 weeks before execution. Therefore there may be a time gap of even 10 weeks, when the supplier has to rely on unfixed production plans.
When we consider the demand forecast accuracy figures (Figure 5-2), the impact of the different planning periods is emphasized. Demand plan accuracy measured as mean absolute percentage error (MAPE = \( \frac{1}{N} \sum \frac{|\text{forecast} - \text{actual}|}{\text{actual}} \times 100 \)) 8 weeks before execution is about 25% more inaccurate than the plan made 4 weeks before. In production plans the difference is even bigger.

![Figure 5-2. Pilot product’s forecast accuracy (MAPE and BIAS) 4, 8 and 16 weeks before execution during the year 2004.](image)

5.3. **Different features of export products require different operations**

One product among the studied four was difficult to manage. During the year 2004, both availability problems concerned this product. Package material inventory for this product was extremely high, due to overreactions in ordering during the package design process. One feature of the product is the minimum order quantity, which is 16 times larger for customers than for the other products. The products demand was lowest of the examined, and it declined a bit during the year 2004. Compared to the other three products the demand of the product is unstable. The total throughput time for the export product was longest, over 200 days.

In planning process the export product caused difficulties as well. Forecasting accuracy was on a low level (Figure 5-2). In production planning there seems to be a tendency to plan the case export product to be produced in larger production batches than other, more-selling products. Furthermore, most major changes in plans, like cancelled batches, concerned this product. The product did not reach the target inventory level during the pilot period.

The demand for the export product can be characterized by rarely placed large orders. One solution for these products is to produce on order. To enable this, the responsive features of supply should be adopted, as was suggested by M Fisher (1997). The case supplier is able to produce package materials in a lead time of a couple of days at the fastest. The required agility in manufacturer operations can be created through:

1. The planning horizon by the supplier should be shortened to two weeks, which is the fixed period of OEM production plans.
2. The materials should be chosen among those that are produced frequently, because then the supplier can add the new order to an existing production batch.
3. The printing colors of the package materials should be chosen to be easily available and executed.
4. Delays in process should be eliminated. In production, the total throughput time is one day, but currently in transportation there may be a one week delay.
5. Those materials that can’t be supplied in a required lead time should be kept in inventory to cover a typical production batch.

6. Standardized package materials should be favored.

6. Discussion

The case results and analysis on the uncertainties in the chain indicate that flexibility in the supplier operations can be achieved through:

Production – In production process flexibility can be created by reducing lead times and delays in product changes, and minimizing batch sizes. In the case supply chain, filling up the supplier’s production capacity, especially corrugated board machine, is essential because of the very high costs of inefficient production batches. Total production volume consists of multiple small customer orders, tailored products and several types of corrugated board. Therefore the supplier collects customer orders several weeks before to form optimal production batches. Production schedules and batch sizes rule the customer delivery timetables and the exact delivery sizes.

Inventories – By maintaining inventories, companies can reduce customer lead times and stabilize the supply chain (Baganha, Cohen 1998). The downsides in keeping inventories are costs associated with it and dependency on forecasts. If forecasts are wrong or inaccurate, for some products inventory levels rise and for some products the company loses sales as it does not have the right product available. In the case supply chain package materials inventories are needed to synchronize the different production requirements. However, there is a risk connected. If a change in package takes place, the company can either implement the change after the old material is consumed, or, if reaction time is too long, the old inventory becomes obsolete. Currently obsolescence costs are about 2 percent of the OEM total purchase costs.

Lead times – Some products are attractive enough that the customers accept to wait for them. Then a company can choose not to deliver instantly, but after it has processed the product. This approach could be considered for the OEMs export products. Another way to use lead times is to release service classes for customers: large orders are given a longer delivery time than normal orders. This aims at managing customer order habits, and leveling the production capacity use. In the case supply chain lead times are flexible for the package material supplier. In addition, the early reach of VMI information is used similarly to service classes. The information concerning inventory and production is used to plan optimal production batches according to the production schedule. The supplier is able to replace inventory with information.

Shared information – The key to balance the use of three above methods is in shared information. The solution to fulfill production capacity effectively is in visibility to the OEM production plans several weeks before execution. If the two companies shared only inventory information, the supplier would not benefit in production planning for the shared information, because it can’t anticipate the consumption. Neither would the supplier benefit, if it could use demand data further downstream, because the manufacturer serves the OEM production, not customers.

One issue that affects the benefits of shared information is the planning quality in the supply chain. Planning nervousness impacts directly supplier operations and may cause multiple planning rounds, rushed or cancelled orders, changes in production batch sizes and inefficient production batches.
7. Conclusions and further research

Finding the best balance in the supply chain planning and execution was the goal of this study. The suppliers have to respond to conflicting needs and requirements. Some sources of uncertainty require package material buffers to ensure material availability. However, responsiveness to changes favors lower inventories. The balance differs according to the product features.

The case showed us that agility in upstream operations is possible through the use of visibility to downstream plans. Even though the product group was very challenging for the package material supplier, it was able to plan and execute the production batches very close to need. However, as the capacity usage is extremely important for package material suppliers, using a combination of different sources of flexibility would be more profitable for the company.

Three conclusions can be drawn from the case. First, the full benefit of shared information can be realized if the supplier has the freedom to schedule deliveries. It was discovered that if the VMI-supplier wants to deliver very close to need, it is not able to efficiently use visibility in production planning and execution. Second, using buffer inventories and taking the risk of obsolescence is a profitable solution for relative inexpensive materials. However, the need for safety stocking is eliminated and replaced with information. Third, the responsive capacity of a supplier should be targeted towards those products that require agile operations. With respect to this case, the question of whether the products with unpredictable and relatively low demand benefit most from agility in upstream operations was discussed.

The main limitation of the study is that it is a single-case study. The case concerns planning processes and their role in increasing responsibility between two manufacturing companies located upstream in the supply chain. Customers’ planning processes were considered in the case, and therefore end-to-end planning was not treated. In future research it would be most interesting to be able to address the planning processes between downstream parties. Furthermore, as costs were not treated in this research, it would be beneficial to consider the costs of agility compared to the benefits. Also in future research a greater number of cases would give a more comprehensive picture of the impacts of integrated planning on upstream operations of supply chains.

References


