The potential benefits of advanced planning and scheduling systems in sales and operations planning

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Abstract
Purpose – The purpose of this paper is to explore what potential benefits may be achieved by using advanced planning and scheduling (APS) systems in the sales and operations planning (S&OP) process.
Design/methodology/approach – The paper investigates benefits at the S&OP process level by interviewing APS experts and APS users. Several methods have been used; literature review, Delphi study, and a case study at a company in the chemical industry which uses APS system support in the S&OP process.
Findings – Three types of potential benefits were found to be achieved when using APS systems in the S&OP process; benefits concerning decision support, planning efficiency and learning effects. The most common type was decision support benefits according to APS users and APS experts. The results from the case company showed that the benefits perceived in the different S&OP activities differed. In the activities concerning the preparation and generation of delivery plans, the perceived benefits mainly concerned learning effects. In the activities concerning the generation of a production plan, the benefits were foremost found in planning efficiency. In the S&OP meeting decision support benefits were highest valued. The reason for the different results can be explained by the aim of the activity, how APS was used in the activity, the user characteristics and the design of the model and access and quality of planning data.
Research limitations/implications – The focus of this paper is on potential benefits of APS systems in the S&OP process only, not the costs. It has established a typology of potential benefits. No validation in form of statistical analysis has been done. The empirical analysis is mainly based on findings from a single case study.
Practical implications – The findings about the types of APS potential will assist companies in understanding the benefits they can expect from its use in the S&OP process. The case study analysis gives further insight into how APS can be employed and what benefits different APS user categories can expect when it is used in an appropriate way.
Originality/value – The knowledge about which benefits that can be achieved when using APS in the S&OP process is quite unexplored. This paper fills some of these gaps.
Keywords Sales management, Operations management, Production scheduling, Decision support systems, Process planning

1. Introduction
Sales and operations planning (S&OP) is supposed to create a long-term balance between demand and supply by focusing on the right volumes to supply and sell (Olhager et al., 2001). An overall aim is to create consensus among several functions and actors, and to settle around one set of plans (Feng et al., 2008). Many benefits related to business performance can be associated with this process if managed in an appropriate way (Wallace, 2004).
However, the S&OP process can be quite difficult to handle without any software system support (Michel, 2007). This is why many companies have started to demand advanced system functionalities (Straube, 2006).

Advanced planning and scheduling (APS) systems normally include demand, supply and/or specific S&OP modules with the functionality needed for supporting the S&OP process. These systems should consequently be appropriate to apply as S&OP support (Stadtler and Kilger, 2005). Genin et al. (2007), for example, emphasize the great potential of APS systems since their capabilities of frequent rescheduling support modifications of S&OP decisions. Other functionalities usually included in APS systems, such as what-if simulation, finite scheduling and real time integrated S&OP workbench, have also been identified as important in the S&OP process (Grimson and Pyke, 2007; Michel, 2007). However, few studies have been made on how APS systems are used in practice (Wiers, 2009) and the benefits in which an APS approach results (Lin et al., 2007). APS vendors promise that after APS implementation there will be better throughput times, delivery times, inventory levels and utilization rates resulting in higher level of customer service and major reduction in costs (Van Eck, 2003). Still, these are the benefits one would expect from a well working planning process with or without advanced planning system support (Vollmann et al., 2005) and it would be interesting to increase the understanding for how APS support the planning process in question and which benefits APS give to the process. Most research concerning APS systems has focused on designing advanced algorithms to solve planning and scheduling problems (Wiers, 2002; Lin et al., 2007). The few studies made on how APS systems are used are of a descriptive nature, where benefits generated from the APS use are only of indirect interest. Besides, most studies describe how APS systems support the planning in general and do not look at a specific planning process.

Provided that the APS system is successfully adopted and implemented, there is great potential to receive value of the APS investment (Stadtler and Kilger, 2005). Still, if the APS system is not used it does not matter how well it was selected or implemented. The S&OP process is made up of several activities. Some examples are the generation of a final delivery plan, and the preparation of a preliminary production plan with several aims involving different actors and planning tasks (Feng et al., 2008). It is therefore reasonable to believe that APS systems are used differently in these activities and that the benefits one receives in one process differ from the other.

From an academically point of view, it would be interesting to understand what the APS approach really results in, considering the great amount of effort put into developing APS algorithms. Most of the literature in information system (IS) also focuses on the adoption and implementation of ISs (Zhu and Kraemer, 2005; Hakkinen and Hilmola, 2008) and there is a need for better understanding how the IS usage influences the benefits achieved. The potential value of knowing the APS systems benefits are important also for practitioners. Senior executives could for example use it as one of several tools to assess whether the potential benefits of APS support overall business objectives. Thereby they will be able to approve or reject APS implementations. Alternatively, it could be employed in the post-implementation phase as an evaluation mechanism to assess whether anticipated benefits were realized.

This study aims to fill some of the above mentioned gaps. The purpose of this paper is consequently to explore the potential benefits that will be achieved by using the APS system in the S&OP process. The study aims, in particular, to structure the different types
of benefits that have been reported in the literature, and to enlarge the list with experiences from practice. The study also aims to find out if the benefits perceived are different in the S&OP activities and how the use of APS influences the benefits perceived. The remainder of this paper is organized as follows: the first section presents the theoretical framework, where the APS system and S&OP process is defined. Previous literature in the area of ISs are also reviewed in order to propose the benefits achieved when using APS systems in the S&OP process. Thereafter the methodology section describes the research design and the data collection techniques used. The case company and the use of APS systems in the S&OP processes are thereafter described and the results from a questionnaire and interviews with APS users are presented. The analysis and discussion are integrated in one section. The paper ends with a conclusion, limitations and future research.

2. Theoretical framework
In the following section, a description of how S&OP is conducted is given and the APS modules supporting the S&OP process is presented. Thereafter, potential benefits of using APS system in planning processes and antecedents to benefits are described. The section ends by summing up the results in a table.

2.1 Sales and operations planning
S&OP is normally a monthly based tactical planning process performed to balance demand and all supply capabilities in order to ensure that the plans of all business functions are aligned to support the business strategic plan (Feng et al., 2008). Based on Wallace (2004), Grimson and Pyke (2007), and Jonsson and Mattsson (2009) we emphasize five main activities in the S&OP process:

- **Activity 1.** Normally the sales and marketing department produces a forecast of the coming planning period’s expected demand. This type of forecast refers to product groups and extends over a relatively long time in the future, at least corresponding to a full budget cycle.

- **Activity 2.** The sales and marketing department prepares a preliminary plan for future sales and delivery volumes (demand plan). Previous sales and delivery plans should be compared with volumes actually delivered. Goals are also established for inventory size or order backlog.

- **Activity 3.** The production departments and those departments responsible for the procurement of start-up materials for manufacturing, will prepare preliminary production plans (supply plans). These production plans relate to volumes to be produced and delivered from production for each period during the planning horizon.

- **Activities 4.** It involves a reconciliation meeting between the managers of the company’s marketing, production, procurement, financial and logistics departments. When consensus has been reached, a proposal is established. Thereafter a recommendation is made for a final delivery plan and production plan for the coming planning periods.

- **Activities 5.** the proposal for a delivery plan and production plan, including any other preliminary decisions taken as a result of plans drawn up, is put forward to the company’s top management group. Any remaining unresolved issues
are considered. When an agreement has been reached, the members of the management group meeting will settle the delivery plan and the production plan.

2.2 Advanced planning and scheduling (APS) system

According to The Association for Operations Management (APICS) (2007) APS is included in the group supply chain management (SCM) software and is defined as:

[...] any computer program that uses advanced mathematical algorithms or logic to perform optimization or simulation on finite capacity scheduling, sourcing, capital planning, resource planning, forecasting, demand management, and others. These techniques simultaneously consider a range of constraints and business rules to provide real-time planning and scheduling, decision support, available-to-promise, and capable-to-promise capabilities.

APS systems are either add-ons or direct integral components of enterprise resource planning (ERP) systems, which create the support mechanism for planning and decision making at the strategic, tactical, and operational planning level (Lin et al., 2007). One way to classify APS systems is by categorizing different modules depending on the length of the planning horizon on one end, and the supply chain process that the module supports on the other (Stadtler and Kilger, 2005). This paper focuses on S&OP, which relates to the tactical planning level where the multi-site master planning and demand planning should be of interest.

The demand planning module is used to support a market demand forecasting by using different forecasting methods. A common feature of APS demand planning tools is the possibility to integrate different departments/companies into the forecasting process, and to aggregate/disaggregate forecasts according to pyramid forecasting (Kreipl and Dickersbach, 2008). The multi-site master planning module[1] aims at synchronizing the flow of materials along the supply chain, and thereby balancing demand and capacity. It supports the mid-term decisions concerning efficient utilization of production, distribution and supply capabilities (Stadtler and Kilger, 2005). The multi-site master planning module not only balances demand with available capacities but also assigns demands (production and distribution amounts) to sites in order to avoid bottlenecks, wherefore it has to cover one full seasonal cycle, or at least 12 months in terms of weekly or monthly time buckets. Owing to the complexity and detail required in the model, only constrained (or near-constrained) resources are modeled in detail. To increase the solvability of the model, most vendors distinguish between hard and soft constraints in the linear programming (LP) or mixed integer programming model that is used (Entrup, 2005). While hard constraints have to be fulfilled, the violation of soft constraints only renders a penalty in the objective function.

2.3 Potential benefits of using APS

The literature reports some potential benefits, i.e. benefits that might be achieved when using APS systems in planning processes. Brown et al. (2001) present a large-scale LP optimization model used at Kellogg’s to support production and distribution decision-making at operational and tactical levels. The use of the model developed in-house at Kellogg’s has resulted in better decision-making and overall cost savings. Gupta et al. (2002) describe a decision support system that helps Pfizer plan its distribution network, with the model useful in strategic, tactical, and operational planning situations. The use of the decision support system has generated many benefits: improved transportation-scheduling support has led to savings in freight costs, elimination of customer deductions has amounted to several thousand dollars annually, and a strategic manufacturing plan has
saved millions of dollars each year. However, the greatest benefits identified were the intangible ones: it helped managers to understand the cost and service implications of proposed network alternatives and raised people’s awareness of and ability to act on supply chain issues. It also enhanced the firm’s ability to remediate supply chain problems, resulted in proactive improvements, and increased people’s confidence in the planning.

Dehning et al. (2007) examines the financial benefits of information technology (IT)-based SCM systems. They suggest that SCM systems add value to the inbound logistics through the availability of more current and accurate information regarding orders that is shared with suppliers. In addition SCM systems support operation processes by coordinating marketing forecasts, production schedules and inbound logistics. They also increase the firm’s ability to adapt to unplanned events. As a consequence, inventory levels and costs can be reduced and higher capacity utilization achieved. Fleischmann et al. (2006) explain the modeling of a decision support system used at Bayerische Motoren Werke AG (BMW) to support tactical and strategic planning. The model made the planning process more transparent and was accepted by the many departments concerned, which provided the necessary data. The model reduced the planning effort and allowed planners to investigate various scenarios more frequently than they could in the past. All in all, it greatly improved the decision support for BMW’s overall planning.

Jonsson et al. (2007) explored how APS systems can be used to solve planning problems at tactical and strategic levels, and the perceived effects of using APS systems. The perceived effects reported from the three case studies examined were: total cost reduction, decreased production cost, and less capital tied up in inventory, and positive effects on delivery performance. A reduction in overall planning time was also identified and the planning organization increased the control of material flow and cost structure, and increased the communication between different functions. Further, the visibility of demand and delivery promises increased and the process and demand uncertainties decreased. A greater understanding of supply-chain trade-offs and further developments of immediate importance were also found. Setia et al. (2008) developed a framework for organizational value creation from agile IT applications where APS systems were used as example. It was found that the APS facilitated the demand allocation process. It also provided divisional capability for instantaneous order commitment and timely communication with other organizational IT applications.

2.4 Antecedents to benefits
The benefit one receives in the end is influenced by a number of factors and a large number of studies have been conducted with the aim of explaining the antecedents of IS effectiveness (Zhang et al., 2005). In general, the results of the studies have been mixed due to among other things the many factors that may cloud the relationships between benefits and its causes (Grover et al., 1996).

Recent evidence suggests that IT investments such as APS systems are most likely to provide benefits when well targeted, well timed, well managed and accompanied with complementary investments and actions (Dehning et al., 2007; Setia et al., 2008). The characteristics of the IS implemented also seem to influence the benefits one receives from using the system. Schroeder et al. (1981) identified the material requirement planning (MRP) type (computerization, accuracy of data) as an important independent variable for MRP success. Similar findings have been identified in APS studies. Zoryk-Schalla et al. (2004), e.g. stress that a key success factor for implementation of an APS system concerns
consistent modeling. Wiers (2002) and Stadtler and Kilger (2005) highlight the importance of a strong integration with the APS system and the existing IT infrastructure as well as a strong coordination of APS modules. Jonsson et al. (2007) and APICS (2007) emphasize the need for access to planning data and insistence that planning data are up-to-date and accurate. The user acceptance is another factor that is of great importance for system success. According to Torkzadeh and Doll (1999) most IS failures result from a lack of user acceptance rather than poor quality of the system. Amoako-Gyampah (2004) stresses that user acceptance is not only influenced by variables such as gender, age and marital status but also by hierarchical levels. They suggest that “higher level personnel in an organization might have greater understanding of why a specific technology is being implemented. Because of their closeness to the decision making process they might buy into the innovation faster than end-users.” In their study it was found that different groups of organizational members have different perceptions of the benefits associated with an innovation.

Based on the literature review the aim of the S&OP activities, how APS system can support each activity, and the potential benefits of using APS system in the process, are proposed in Table I. In Activities 1 and 2, the demand planning module could supports the personnel developing a consensus forecast and a preliminary plan for future sales and delivery volume with help of statistical methods and demand planning tools. In Activity 3, the multi-site production planner supports the personnel creating a preliminary production plan by offering functionalities such as integration of certain entities and optimization models. APS modules can support Activities 4 and 5, adjust and settle the plans by making information visible for everyone and offer scenario analysis. The literature reports on a number of benefits that might be achieved when using APS systems in the strategic, tactical, and operational planning. Studies indicate that the use of APS systems allowed for coordination of business processes (Dehning et al., 2007), visibility of

<table>
<thead>
<tr>
<th>S&amp;OP activity</th>
<th>Aim of the activity</th>
<th>Potential APS support</th>
<th>Potential APS benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creating a consensus forecast</td>
<td>Statistical forecast methods, demand planning tools able to integrate different departments/companies</td>
<td>Improved decision support (Brown et al., 2001; Gupta et al., 2002; Fleischmann et al., 2006)</td>
</tr>
<tr>
<td>2</td>
<td>Creating a preliminary delivery plan</td>
<td></td>
<td>Reduced planning effort (Fleischmann et al., 2006; Jonsson et al., 2007)</td>
</tr>
<tr>
<td>3</td>
<td>Creating a preliminary production plan</td>
<td>Possibility to integrate several entities, coordination of different functions, possibility to use optimization models to find the most feasible solution</td>
<td>Availability of more current and accurate information (Dehning et al., 2007)</td>
</tr>
<tr>
<td>4</td>
<td>Adjusting delivery and production plan</td>
<td>Visibility of information, scenario analysis, for example what-if analyses of the impact in resource availability and customer demands</td>
<td>Increased confidence in planning (Gupta et al., 2002; Fleischmann et al., 2006; Jonsson et al., 2007)</td>
</tr>
<tr>
<td>5</td>
<td>Settle delivery and production plan</td>
<td></td>
<td>Costs savings (Brown et al., 2001; Gupta et al., 2002; Van Eck, 2003; Jonsson et al., 2007)</td>
</tr>
</tbody>
</table>

Table I. The aim of the S&OP activities, how APS systems can support each activity and potential benefits from using APS in the S&OP process.
demand and delivery promises (Jonsson et al., 2007), investigating various scenarios (Fleischmann et al., 2006), resulting in more feasible plans and realistic delivery promises (Jonsson et al., 2007). Managers and planners can therefore make proactive improvements (Gupta et al., 2002) and better decisions (Brown et al., 2001). The literature also reveals that the use of APS systems reduced the overall planning time (Gupta et al., 2002) and increased the focus on data quality (Fleischmann et al., 2006). Further, APS systems increased the understanding and confidence in planning (Gupta et al., 2002; Jonsson et al., 2007). All these benefits should have cost and delivery service implications. However, the focus of this paper is on how APS systems support the S&OP process, and as such the overall business performance related benefits (better throughput times, delivery times, lower inventory levels and utilization rates, reduced costs, etc.) are outside the present scope.

3. Methodology
When investigating in what benefits the use of an IS can result, there are several questions to be asked: What qualifies as a benefit? Benefits for whom? Unit of observation? (Seddon, 1997; DeLone and McLean, 2003). In accordance with Chau et al. (2007) we defined benefit as the positive consequences of system use. Benefits in this paper are considered from the point of view of APS experts and APS users. In the IS effectiveness literature, the consequence of use can be measured at different levels such as individual, group, organization, society (Miriani and Lederer, 1988). In this paper, we are studying the benefit for the S&OP process (Figure 1). As shown in Figure 1, we are not only interested in what benefits the APS usage gives the S&OP process as a whole, but also what benefits APS usage gives each activity in the S&OP process. Both focuses are taken in the analyses.

In order to pick up the potential benefits and understand how the APS system usage influences the perceived benefits, we used several different methods such as literature reviews, a Delphi study among APS experts, and case study research. Figure 2 shows the research design consisting of six phases. Phase 1 concerns the literature study. Phases 2-4 concern the Delphi study. Phases 5-6 concern the case study. The different phases are described below.

![Figure 1. The unit of analysis](image-url)
3.1 Literature study (Phase 1)
A literature review was conducted in order to describe the state-of-the-art understanding of how APS systems provide benefits to the S&OP process. As there is not much written about APS systems in production, logistics, and operation management, the review was complemented with literature on ISs.

3.2 Delphi study (Phases 2-4)
A list consisting of five potential benefits was developed with the help of the literature and previous knowledge we had from conducting case studies at companies using APS systems (The potential benefits in Table I except from costs savings). The list was tested in a Delphi type of study, with independent experts in order to validate single case findings and improve the generality of the findings. The objective of a Delphi study is to obtain the most reliable consensus of a group of experts and is a popular tool in IS research (Okoli and Pawlowski, 2004). About 15 industry and consulting representatives with experience from APS implementation and usage were selected and included in our study group. This group corresponds well with the recommendations of ten-18 experts given by literature (Okoli and Pawlowski, 2004). Ten of the 15 were APS users representing seven different manufacturing companies and five were consultants representing three APS software vendor companies and one application consultancy firm. The APS experts were identified from interviews with about ten major ERP and APS vendors and with our existing industry network. People with experiences from developing or implementing APS systems were defined as APS experts. They were asked to identify additional benefits of the list and rank the extent to which they perceived that APS usage results in the respective potential benefit, on a seven-point scale (ranging from very badly to very well) (Phase 2). The mean of the rankings and a revised list, consisting of nine potential benefits, were thereafter presented for the 15 experts in a workshop. During the workshop, the list was discussed and adjusted and a new list with 11 potential benefits based on the results from the workshop was developed (Phase 3). As all potential benefits were ranked high, the workshop participants were asked to mark the three potential benefits that APS foremost generates (Phase 4). The results of this second round survey are presented in Appendix 1, Table AI. The results were discussed with the expert group, who considered them to
represent relevant consensus rankings of the potential benefits. No further questionnaire round with the expert group was therefore considered necessary.

3.3 Case study
Case study research is considered preferable when the experience is rare and the contextual conditions are unknown (Voss et al., 2002). It is also a preferred method when “how” and “why” questions are addressed concerning contemporary set of events over which the researcher has little control (Yin, 1991). We wanted to explore how the APS usage influenced the perceived benefits in the different activities, which is why case study was considered the most appropriate research method. The case firm, a company in the chemical industry, was selected as it had a long and wide experience of using an APS system to support its S&OP process. The APS system was implemented to support the coordination of material flows and to keep away from sub-optimizations in an environment characterized by complex planning tasks. Since some of the main features of APS systems are to coordinate and integrate certain entities and produce feasible near optimal plans (Stadtler and Kilger, 2005) and it is argued that APS is an appropriate tool for supporting complex tasks environments (Setia et al., 2008), the use of APS in the case company was considered suitable. The APS system was well implemented and integrated with the existing organization and IT structure, and the APS users worked daily with the modules. It was therefore considered that the use of APS at the case company brought many benefits to the users.

In-depth interviews were carried out with over twenty people involved in the S&OP process (Table II) and lasted about 90 minutes each (Phase 5). The interviewed personnel were either direct users (working with the APS modules) or indirect users (using the output from the APS modules). They were asked about the consequences the use of APS system in the S&OP process has resulted in, and what factors those are important to consider for successful usage. In order to improve the reliability and validity, research protocols were designed and used in the interviews (Voss et al., 2002). The protocols were tested in initial interviews with key respondents. Respondents were frequently asked the same questions to enhance the reliability of the data and some informants were

<table>
<thead>
<tr>
<th>Position</th>
<th>Responsibility</th>
<th>Number of people at the position</th>
<th>Participated in an interviewed</th>
<th>Responded in the survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO</td>
<td>Management of Europe sub-division</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Operations manager</td>
<td>Operations planning</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Supply chain manager</td>
<td>Demand planning</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Supply planner</td>
<td>Supply planning</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Business managers</td>
<td>Head of market segments, marketing, and sales</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Sales managers</td>
<td>Sales forecast</td>
<td>40</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Production managers</td>
<td>Production planning</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Contract manufacturing representatives</td>
<td>Production planning</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Site schedulers</td>
<td>Production schedule</td>
<td>7</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

Table II. Actors in the S&OP process and information about interviews and surveys participation
interviewed several times. The notes from the interviews were sent to the interviewees for feedback and checking of the data.

In order to find out if there were any differences in perceived benefits among the S&OP activities, a questionnaire was developed based on the literature and the Delphi study (Phase 6). This questionnaire was modified in two ways: some words in the list were changed to fit the case company and some benefits were split into multiple benefits in order to be more detailed and not measure multiple issues. Before the questionnaire was sent to the respondents it was sent to three co-workers at the researchers’ department for feedback. This resulted in some adjustments to the questionnaire. The final questionnaire consisting of 18 benefits (Appendix 2, Table AII) was sent to all 63 actors involved in the S&OP process, out of which 29 answered the questionnaire (Table II). The questionnaire was sent via the supply chain manager at the company where she asked her co-workers to answer the questionnaire. An e-mail reminder was sent to those not answering the first round. Those not responding to the e-mail reminder were contacted by phone. The respondents were asked to rate how well the listed benefits correspond to their perception of using APS system in the S&OP process on a seven-point scale. It is worth noting that since the number of respondents was small no significant statistical analysis was possible to conduct in order to analyze the answers. Instead the results from the questionnaire were only used to identify tendencies of the benefits perceived in the S&OP activities.

Some of the people that did not answer the survey referred to that they had participated in the interview and had already told everything. Others told us that they did not have time to participate in the survey (mainly sales managers). Even though the response rate in the questionnaire only reached 46 per cent, there are enough answers to give some indications about the tendencies concerning the benefits perceived. The people answering the questionnaire are central actors in the S&OP process and represent all types of actors involved in the S&OP process. The fact that the questionnaire was conducted in parallel with interviews should also make the amount of responses feasible for our purpose.

The list, ranking and categorization of potential APS benefits are consequently developed through several phases in this research and presented in tables, figures, and appendixes, involving potential benefits generated from existing literature (Table I), expert panel ranking (Appendix 1, Table AI), 18 potential benefits based on literature, Delphi and interviews (Appendix 2, Table AII), ranking the benefits (Figures 3 and 4), and categorizing them (Table III).

4. The case company
In this section, the case company is presented. In order to understand the context, a short background to the case company is given. Thereafter the use of APS in the S&OP process is described.

4.1 Background
The case firm is a company in the chemical industry that manufactures, markets, sells and distributes chemicals used at the surface of other chemicals. The case firm employs 1,100 people divided into three regional organizations: America, Asia, and Europe, the latter of which is studied here. The European division has three production sites, each year producing 110,000 tons, or approximately 1,000 products. Many of the products are manufactured in more than one process step, often involving more than one production site, which means that there is a large flow of intermediate products between the three
Figure 3. Planning process, APS support, and actors

Figure 4. The users’ perceived benefits in their daily work

Notes: The y-axes represent the level of agreement that the respective benefit is received, is graded on a seven-point scale, where 1 = strongly disagree, and 7 = strongly agree. The 20 benefits are presented on the x-axes.
sites. Every month, the European division purchases a certain amount of products manufactured by sites in America and Asia as they do not have the technology in-house. The European division also has contract manufacturing at fifteen production sites. In case of capacity shortages, it is possible to use idle capacity at other sites or to purchase capacity from contract manufacturers and/or regional organizations. The customer can be found all over the world, in different market segments and with different commercial and strategic values. The European division has about 70-80 suppliers located in different countries.

In order to coordinate the material flows between the production sites and keep away from sub optimizations, a centralized planning organization and an S&OP process was established in 2000. Shortly after the process was introduced it was recognised that the centralized planning organization needed better control over the processes. Consequently, three APS modules were implemented in 2002 as the support tool for the planning process and has been used since then:

1. the sales module, which generates the statistical forecast using various forecast methods;
2. the demand planning module, where all forecast information, sales histories and outstanding orders are available; and
3. the multi-site master planning module, which calculates an optimized production plan (how much and which volumes each of the three sites should produce so that every demand and target level is fulfilled at the highest contribution margin) in a LP model for the three production sites.

The users involved in the S&OP process is divided into four user groups:

1. the central planning organization, consisting of one supply chain manager, and two supply planners;

### Table III.
The categorization of potential APS benefits

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Categorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Allows visualization of information</td>
<td>Decision support</td>
</tr>
<tr>
<td>2. Makes information easy to access</td>
<td></td>
</tr>
<tr>
<td>3. Makes it possible to identify unexpected future events</td>
<td></td>
</tr>
<tr>
<td>4. Makes it possible to analyze unexpected future events</td>
<td></td>
</tr>
<tr>
<td>5. Makes it possible to analyze the problem picture and solve the problem as a whole</td>
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<tr>
<td>6. Allows quantifiable what-if scenario analysis</td>
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<tr>
<td>7. Results in a reliable demand plan</td>
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<tr>
<td>8. Gives an optimal supply plan</td>
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<tr>
<td>9. Gives a common supply plan</td>
<td></td>
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<tr>
<td>10. Results in realistic and feasible delivery promises</td>
<td></td>
</tr>
<tr>
<td>11. Results in high data quality</td>
<td>Planning efficiency</td>
</tr>
<tr>
<td>12. Gives focus on data quality</td>
<td></td>
</tr>
<tr>
<td>13. Simplifies planning activities</td>
<td></td>
</tr>
<tr>
<td>14. Leads to less time spent on planning activities</td>
<td></td>
</tr>
<tr>
<td>15. Results in good knowledge about the planning processes</td>
<td>Learning effects</td>
</tr>
<tr>
<td>16. Results in good knowledge about the supply chain</td>
<td></td>
</tr>
<tr>
<td>17. Makes the planning activities important</td>
<td></td>
</tr>
<tr>
<td>18. Makes the planning activities enjoyable</td>
<td></td>
</tr>
</tbody>
</table>
(2) the demand side actors, consisting of four business managers and forty sales managers;
(3) the supply side actors consisting of three contract manufacturers, four production managers, and seven site schedulers[2]; and
(4) and the managerial group, consisting of the chief executive officer (CEO) and the operations manager.

The centralized planning organization is formally responsible for setting up and running the APS based planning. They also act as a centralized planning function. They work actively with the involved parts, they plan meetings and work with education and training. The sales managers work directly in the sales module whereas business managers use the demand planning module to view information. The supply side uses the multi-site master planning module to plan production and scheduling. The managerial group does not use the modules in their daily work but participate in various meetings supported by the demand planning module and the multi-site master planning module.

4.2 Use of APS in the S&OP process
S&OP consists of a demand planning sub-process and a supply planning sub-process. Figure 3 shows the use of the modules in the planning sub-processes and the actors involved. In the bottom of the figure the APS supported S&OP process is presented following the five steps identified in the literature:

- **Activity 1.** Forecast future demand. In the beginning of the month the sales managers put together a sales forecast. This is a combination of a statistical forecast produced by the sales module and the sales managers’ own forecast, based on experience for each stock keeping unit and customer for the coming 18 months.

- **Activity 2.** Prepare preliminary delivery plan. In the monthly demand meeting the business managers and the central planning organization meet to prepare the demand plan. During this meeting issues such as forecast accuracy, possible sales-increases, and specific customer profitability, are discussed with the help of the information in the demand planning module, visualized on screen. The central planning organization draws up the final demand plan after the demand meeting.

- **Activity 3.** Prepare preliminary production plan. The central planning organization is responsible for creating the preliminary production plan and this is done with the help of the multi-site production planner module. The delivery plan is automatically sent to the multi-site production planner module where it is converted into a preliminary production plan, taking the bill of materials, stocks, capacities, intermediates, production times, transportation times, and costs into account. Generally, the centralized planning organization runs several scenarios to analyze what happens if demand changes.

- **Activities 4 and 5.** Adjust and settle delivery plan and production plan. The central planning organization, the operation manager, the production managers and the contract manufacturing representatives meet in the monthly supply meeting to discuss capacity, bottlenecks, inventories and whether it is possible to meet the demand. The preliminary supply plan is the basis for this meeting. The centralized planning organization also has a telephone meeting with the American and Asian divisions to discuss common material flows. After the supply meeting and the
telephone meeting, the multi-site master planning module is updated with actual stock balances. A final production plan, made at stock keeping unit level and showing the volumes needed for the coming 18 months, is generated. Every second month an S&OP meeting is conducted where the CEO, the operation managers and the central planning organization meet to discuss remaining problems and to identify risks.

5. Results
In this section, the experiences of using the APS system in the S&OP process at the case company is presented. First the results from the questionnaire are presented, followed by the results from the interviews.

5.1 The ranking of the benefits
The S&OP process consisted of two sub-processes involving many different actors. In the first sub-process APS modules were used to support the demand side actors and central planning organization in the daily work and the demand planning meeting. In the second sub-process APS modules supported the supply side actors, the central planning organization in the daily work and the supply meeting. Every second month an APS module was also used to support the S&OP meeting where the CEO, the operation managers and the central planning organization met. Separate analyses were therefore conducted for the user group’s perceived benefits in their daily work and in meetings (demand planning meeting, supply planning meeting, S&OP meeting).

Figure 4 shows the answers of the user groups’ perceived benefits in the daily work. It is not possible to compare the significant differences between the user groups’ mean values as the number of actors, hence the number of answers, in each group are small and quite different. Still, some tendencies are found: two types of benefits are ranked highly by all user groups, namely that the APS system “allows visualization of information” and “makes the information easy to access.” The graph representing the ranking of the central planning organization shows that the benefits: “identify and analyse future events” and “what-if scenarios,” “common and optimal supply” stand out as high ranked. Whereas, “less time spent on planning,” “realistic delivery promises,” and “knowledge in supply chain and planning” are lower ranked. The demand side actors gave the highest ranking to “supply chain knowledge,” “enjoyable planning,” and “reliable demand plan” whereas “what-if scenario,” “simplifies planning activities,” and “less time spent on planning” stood out as lower ranked. The supply side actors ranked “analyze future events,” “optimal supply plan,” “common supply plan,” and “simplifies planning activities” high. The benefits standing out as lowest ranked were “analyze/solve problems as a whole,” “what-if scenarios,” and “realistic delivery promises.”

In Figure 5, the benefits perceived in the three meetings are given by the meeting participants. As can be seen in F the mean values are quite similar in the three meetings. In all meetings the benefits “make information easy to access” and “identify and analyze unexpected events” are ranked high. At the demand planning meeting “results in a reliable demand plan” stands out as highly ranked. Also the participants at the demand meeting see benefits in “planning knowledge,” and “important planning.” The actors participating at the supply meeting rank that “APS gives a common plan for the three sites” high. At the S&OP meeting the benefits that APS “makes it possible to analyze the problem picture and solve the problem as a whole” and that APS “gives a common plan for the three sites are ranked high.”
5.2 Experiences from the actors

In order to interpret the results from the questionnaire, interviews with the actors in the S&OP process have been conducted. The subjective experiences of the actors are presented by the user groups below:

- The central planning organization perceives that the organization has obtained a comprehensive view that was not there before. The production sites have started to communicate and the majority of the employees have understood that it is important to cooperate to reach the common goals and that they belong to the same company. The supply planners and the supply chain manager stress that APS modules have provided them with more and better information when decisions need to be made, which has made it easier to plan in advance. The actors in the central planning organization think that they could have used the functionalities in the APS modules to a larger extent and emphasize that the problem is not the system but the input to the system, i.e. the access and quality of the forecast, lead-time and capacity figures.

- The business and sales managers perceive that the APS system supported S&OP process has made the discussions at meetings and between different functions more sound since there are real facts to rely on. Consequently, it has become easier to create a realistic demand plan and replace ad hoc decisions with better supported decisions. Still, the output does not get better than the input and reaching a 100 per cent forecast accuracy is “to cry for the moon,” according to one business manager. Several sales managers also think that they put too much time in creating...
an accurate forecast for no use; “customers are guided by circumstances that are impossible to have control over.”

- The production manager, the contract manufacturing representative and the site schedulers pressure that they now have a tool that supports them to better understand what is happening in the future. This also helps them to stay one step ahead. The highest value with the APS modules is considered to be that all factories are in the same system and that it is possible to make centralized plans. The general view is improved. However, contract manufacturers are not included in the model, which according to contract manufacturing representatives is a pity as it is not possible to let the model decide from where (which contract manufacturer) it is beneficial to buy capacity. The production sites are no longer as dependent on the local knowledge as before year 2002 and they have a tool that supports them with the demand forecast and long-term planning. Because of this, the time to chase demand figures and to understand the situation has been reduced and more time can be put on problem solving at the sites. A problem noticed by many production managers is that they cannot always trust the plans.

- The managerial group stresses that it is important to have a decision support as a foundation for the meetings as the quality at the meetings gets much better when there are facts to rely on. The CEO means that APS is a support for the process to take place. It was a necessary condition for making the coordination and integration among the production site work. The operation manager thinks that it would be impossible to integrate all regional organizations in the same APS system as it would have torn the organization apart. There is more functionality in APS that Europe still has not utilized and the CEO and the operation manager see great potential of their APS investment. The CEO and the operation manager point out that one obstacle is to make the personnel understand the value of updating the data in the ERP system. It can easily become a vicious cycle if the system is not updated with the correct figures; the system gives odd figures which causes users to lose confidence in the system.

6. Discussion
The discussion is based on the literature review, the Delphi study and the case questionnaire and interviews. It consists of two parts:

1) different types of APS benefits; and
2) the use of APS and its perceived benefits.

6.1 Different types of APS benefits
Looking at the 18 potential benefits derived from the literature and experiences from APS experts and APS users it is possible to identify some main groups of benefits. The first group of benefits contains those with clear connection to the APS capabilities. An APS system is defined as any computer program that use advanced mathematical algorithms or logic to perform optimization and simulation (APICS, 2007). Therefore, benefits such as “optimal plans” and “quantifiable what-if scenario analysis” are two examples of such benefits. Out of the 18 identified potential benefits, ten represents so-called decision support benefits, i.e. benefits with close connection to the capabilities of the APS system. The other main group of benefits is concerned with planning efficiency as the use of APS
systems may result in reduced overall planning time and focus on data quality. Four of the 18 benefits belong to the planning efficiency group. The third, and last group of benefits concerns the so-called learning effects. When using APS systems in the S&OP process it seems as the users increase their understanding and confidence in planning. Table III shows the categorization of the potential APS benefits.

Using this categorization of potential APS benefits when comparing the results of the APS experts with the results of the APS users it seems as there are many similarities in how the benefits are ranked. Most of the perceived benefits were by APS experts and APS users lumped together at a medium place in the ranking and despite some small differences between each specific benefit there were benefits connected to decision support that stood out as the highest ranked. With respect to the similarities between the results of the APS users and APS experts and previous literature, it is reasonable to believe that the proposed list of the eighteen potential benefits (Table III) is relevant and should be possible to expect and to achieve when using APS in S&OP processes.

It was interesting to notice that the top one ranked benefit by the APS users was one of the lower ranked benefits by the APS experts. It was that APS “allows visualization of information.” The reason that visualization was not ranked high by the experts was that they did not consider visualization a unique APS benefit but instead a general software benefit, also available in, e.g. ERP systems. Nor was visualization as a benefit commonly mentioned in the literature when applying APS systems in the planning processes. This result may be unique to this case but it could also mean that visualization as an APS benefit has been underestimated by APS experts, and in previous literature. APS systems usually include user-friendly planning tools, such as interactive scorecards and drag-and-drop functionality (APICS, 2007). Indeed, one of the benefits derived from this could be that it makes it easier to visualize information.

The case study confirms that the gross list of perceived benefits derived from the literature and APS experts is reasonable to accept. It is possible to achieve different types of benefits connected to decision support, planning efficiency and learning effects when using APS system in the S&OP process. Decision support benefits were, according to APS experts and APS users, the type of benefits most likely to be achieved.

6.2 The use of APS and its perceived benefits
Table IV summarizes the aim of the S&OP activities, the use of APS, and the perceived benefits in each activity in the case company.

It was presumed that since the aim of the S&OP activities is different, the usage of APS would differ, resulting in different benefits perceived in each activity. The case results showed that this was true to some extent. In Activities 1 and 2, with the aim of generating a delivery plan, one of the highest ranked benefits was that the use of APS resulted in a reliable demand plan. In Activities 3-5 where the aim was to generate a production plan, one of the highest ranked benefits was that the use of APS resulted in a common and optimal supply plan. In the S&OP meeting, with the aim of identifying risk and solving problems, the benefits “make it possible to analyze the problem picture as a whole and identify future events” were ranked high. The result might seem obvious: if APS is used appropriately in the activities these are the benefits one would expect to perceive. Still there were other benefits perceived in the different activities that are not as obvious. Two benefits were ranked high in all S&OP activities; the use of APS makes information easy to access and APS allows visualization of information. The reason for
this can probably be explained by the history of the case company. Before the APS system was implemented the actors involved in the S&OP activities did not have any common tool where all information was collected and could be accessed. Therefore, the visibility at the company was consequently low.

The actors involved in the S&OP activities perceived different activities that were not connected to the aim of the activity. The benefits perceived in Activities 1 and 2 foremost concerned learning effects. The benefits in Activity 3 concerned decision support. The benefits in Activities 4 and 5 concerned planning efficiency and the benefits in the S&OP meeting foremost concerned decision support. The reasons for this can be explained by how the APS system was used in the different activities and the user characteristics. In Activities 1 and 2, the demand planning module was used which do not include so much decision support functionalities either than visibility and forecasting methods. This is why benefits derived from APS functionalities such as optimization and what-if scenario analysis is not found in the demand planning sub-process. One of the reasons why the planning efficiency benefits are not as highly ranked in these activities is that the sales managers and the business managers are responsible for creating the sales forecast. This was not the case.

<table>
<thead>
<tr>
<th>S&amp;OP activity</th>
<th>Aim of the activity</th>
<th>Potential APS system support</th>
<th>Potential benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1</td>
<td>Creating the sales forecast</td>
<td>Statistical forecast methods, demand planning tools able to integrate different departments/companies</td>
<td>Results in a reliable demand plan, visualization of information, makes information easy to access, resulting in good knowledge about the supply chain</td>
</tr>
<tr>
<td>Activity 2</td>
<td>Creating the delivery plan</td>
<td>Calculating an optimized production plan in a LP model for the three production sites, what-if analysis if demand is changing</td>
<td>Results in an optimal production plan, makes it possible to identify/analyze future events, allow quantifiable what-if analyses, visualization of information, makes information easy to access</td>
</tr>
<tr>
<td>Activity 3</td>
<td>Creating a preliminary production plan</td>
<td>Calculating an optimized production plan in a LP model for the three production sites</td>
<td>Results in an optimal production plan, makes it possible to identify/analyze future events, allow quantifiable what-if analyses, visualization of information, makes information easy to access</td>
</tr>
<tr>
<td>Activities 4 and 5</td>
<td>Adjust and settle the production plan</td>
<td>Calculating an optimized production plan in a LP model for the three production sites</td>
<td>Gives a common an optimal production plan, visualization of information, makes information easy to access, simplifies planning activities</td>
</tr>
<tr>
<td>S&amp;OP meeting</td>
<td>Identify risks and discuss reaming and unsolved issues</td>
<td>Visibility of information</td>
<td>Makes it possible to analyze the problem picture as a whole, makes it possible to identify/analyze future events, visualization of information, makes information easy to access</td>
</tr>
</tbody>
</table>

Table IV.
The S&OP activity, its aim, the APS supported used and perceived benefits in the case company.
before the APS supported S&OP process was implemented. The 40 sales managers involved in the demand planning sub-process have worked isolated from each other, and located in different geographical places. Since the APS supported S&OP process was implemented they have been forced to work closer to each other and to the production sites. This may be the reason for why learning effects were ranked highly in the demand planning sub-process.

The multi-site production planner, including functionalities such as optimization, integral planning and what-if scenario analysis, was used in Activities 3-5. In these activities, more decision support benefits are apparent than in activities concerning the demand planning sub-process. Still, some functionality could have been used to a larger extent, which probably would have influenced the perceived benefits. For example, the contract manufacturing representatives are disappointed that they are not included in the model and therefore are not able to support decisions in the model from where it is most optimal to buy capacity. The reason for not including contract manufacturers in the model is a lack of access to planning data. The findings from previous literature shows that the design of the system (Zoryk-Schalla et al., 2004) and access to planning data (Jonsson et al., 2007; APICS, 2007) influence the benefits one receives which is also evident in this study. The supply side actors have since APS was implemented reduced the amount of work as they do not have to chase sales figures, and the central planning organization now has a tool to support their planning. This, in turn, may explain why the actors involved in the supply planning sub-process see many benefits in the planning efficiency. The managerial group and the central planning organization, with a good knowledge and understanding of the S&OP process participate in the S&OP meeting. This may be the reason why learning effects were not as highly ranked here. Instead focus is on decision making and this is where the actors foremost see benefits. This corresponds well with the conclusions made by Amoako-Gyampah (2004) who found that different groups of organizational members have different perceptions of the benefits associated with an innovation.

The case study analysis shows that the benefits perceived in the S&OP activities are a bit different and that it depends on the aim of the activity, how the system is used, i.e. which functionality that is exploit and user characteristics. How the system is used is influenced by factors such as system design and access to planning data.

7. Conclusion and further research
The purpose of the paper was to explore what potential benefits could be achieved by using APS systems in the S&OP process. A gross list, consisting of 18 benefits divided into three types of benefits; decision support, planning efficiency, and learning effects, was derived from a literature review and in a Delphi type of study with independent APS experts. In order to understand if benefits were different in the S&OP activities the list was tested in a case study. The most common type of benefits was decision support benefits, according to APS users and APS experts. The case study indicated that the decision support benefit “visualization of information” has been underestimated in previous studies and by APS experts. The case study analyses showed that the benefits perceived in the different S&OP activities differed. In the demand planning sub-process, actors perceived that the use of APS resulted in a reliable demand plan, good knowledge about the supply chain and made the planning activities more enjoyable. In the supply planning sub-process, the actors perceived that the use of APS resulted in a common and optimal supply plan and simplified planning activities. In the S&OP meeting, the use
of APS made it possible to analyze the problem picture as a whole and to identify/analyze future events. The reason for the different results could be explained by the aim of the activity, how APS was used in the activity (which functionality that was exploited), the user characteristics (expectations, knowledge), the design of the model and access to and quality of planning data. The findings have several managerial implications. They could, e.g. assist companies in understanding the potential benefits they can expect from its use in the S&OP process. The case study analysis gives further insight into how APS can be employed and which benefits different APS user categories can expect when they are used in an appropriate way.

It is always difficult to identify potential benefits by using an IS since benefits are different depending on whom one asks and what level of analyses one applies. Besides, it is difficult to isolate the contribution of the IS functions from other contributions to performance. Indeed, one could argue that some benefits in the proposed list derived in this paper should be excluded or that some benefits are missing. The material written on this topic is comparatively small, therefore, study is relatively exploratory and should be followed up in order to verify and generalize the findings about APS usage and its benefits. Benefits were examined by individual users’ perceptions. However, a mix of surveys, interviews, and observations was used for the analysis. This should be sufficient in order to secure the reliability of the findings.

The study opens several opportunities for further research. Even though most of the perceived benefits and the lack of potential benefits could be explained by the case-unique usage, the cause and effect relationship between the potential benefits and its antecedents were not explored in detail. It would thus be valuable to further explore and explain how individual antecedents and different configurations of antecedents affect benefits. The focus here has been on benefits but there is also a cost side of APS which may constrain its usability. To understand the total APS performance, it is necessary to balance the costs and benefits of usage. These could be examined in further research. Finally, since the study only covers the S&OP process, it may be interesting to study the potential benefits in other planning processes in which APS system is used. An interesting extension of this study would also be to broaden the study to more cases and allowing for cross-case analyses and/or statistical significance tests of survey responses.

**Notes**

1. Notice that there are other names for this module, e.g. supply network planner, supply planner, and supply chain planner.

2. The site schedulers are not actually part of the S&OP process but as they use the input from the S&OP process to plan production their experiences are important.

**References**


van Eck, M. (2003), “Is logistics everything, a research on the use(fullness) of advanced planning and scheduling systems”, BWI paper, Faculty of Sciences, Vrije Universiteit, Amsterdam, April.


### Appendix 1

| Benefit | Corresponding benefit in Appendix 2 | Grade
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Allows information visualization and access</td>
<td>1, 2</td>
<td>2</td>
</tr>
<tr>
<td>2. Allows identification and analysis of unexpected events</td>
<td>3, 4</td>
<td>3</td>
</tr>
<tr>
<td>3. Makes it possible to analyze the problem picture and solve the problem as a whole</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>4. Allows quantifiable what-if scenario analysis</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>5. Gives reliable demand plan and delivery promises</td>
<td>7, 10</td>
<td>13</td>
</tr>
<tr>
<td>6. Gives a common supply plan</td>
<td>9</td>
<td>22</td>
</tr>
<tr>
<td>7. Gives a feasible and an optimal supply plan</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>8. Gives focus on and results in high data quality</td>
<td>13, 14</td>
<td>4</td>
</tr>
<tr>
<td>9. Results in simplification and less time spent on planning activities</td>
<td>15, 16</td>
<td>5</td>
</tr>
<tr>
<td>10. Gives learning effects about planning and supply chain</td>
<td>17, 18</td>
<td>4</td>
</tr>
<tr>
<td>11. Increases the focus on planning tasks and organization</td>
<td>19, 20</td>
<td>4</td>
</tr>
</tbody>
</table>

**Notes:** Each of the 15 experts was asked to mark the three specific benefits they considered that the use of APS first and foremost results in. The most important benefit was given three points, the second most important benefit was given two points, and the third most important benefit was given one point. The grades in the column represent the sum of points from all 15 experts.

### Appendix 2

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Corresponding benefit in Appendix 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Allows visualization of information</td>
<td>1</td>
</tr>
<tr>
<td>2. Makes information (e.g. customer, markets, capacity) easy to access</td>
<td>1</td>
</tr>
<tr>
<td>3. Makes it possible to identify unexpected future events</td>
<td>2</td>
</tr>
<tr>
<td>4. Makes it possible to analyze unexpected future events</td>
<td>2</td>
</tr>
<tr>
<td>5. Make it possible to analyze the problem picture and solve the problem as a whole</td>
<td>3</td>
</tr>
<tr>
<td>6. Allows quantifiable what-if scenario analysis</td>
<td>4</td>
</tr>
<tr>
<td>7. Results in reliable demand plan (low forecast error)</td>
<td>5</td>
</tr>
<tr>
<td>8. Give an optimal (consider capacity, lead times, etc.) supply plan</td>
<td>7</td>
</tr>
<tr>
<td>9. Gives a common supply plan for the three sites</td>
<td>9</td>
</tr>
<tr>
<td>10. Results in realistic and feasible delivery promises</td>
<td>5</td>
</tr>
<tr>
<td>11. Results in high data quality (e.g. capacity, lead times, safety stocks, customer data)</td>
<td>8</td>
</tr>
<tr>
<td>12. Gives focus on data quality</td>
<td>8</td>
</tr>
<tr>
<td>13. Simplifies planning activities</td>
<td>9</td>
</tr>
<tr>
<td>14. Lead to less time spend on planning activities</td>
<td>9</td>
</tr>
<tr>
<td>15. Results in good knowledge about the planning processes</td>
<td>10</td>
</tr>
<tr>
<td>16. Results in good knowledge about the supply chain</td>
<td>10</td>
</tr>
<tr>
<td>17. Makes the planning activities important</td>
<td>11</td>
</tr>
<tr>
<td>18. Makes the planning activities enjoyable</td>
<td>11</td>
</tr>
</tbody>
</table>

**Table A1.** Expert panel ranking of benefits

**Table AII.** The potential benefits derived from literature, a Delphi study and interviews at the case company.

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