20 Demand Planning of Styrene Plastics

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The purpose of Demand Planning is to reduce uncertainty about what will be sold to the customer in the future. Improving forecast accuracy leads to economic benefits such as cost cutting by reducing safety stocks and increasing sales by avoiding stock out situations. The case presented describes a Demand Planning implementation using SAP SCM at an international company in the process industries.

The case study is structured as follows: first, we start with a description of the supply chain, then introduce the architecture of the planning system used. Subsequently, we focus on model building with the module Demand Planning of SAP's Advanced Planner and Optimizer (SAP APO DP) as a part of SAP's cross-industries solution SAP SCM. The process of the Demand Planning of styrene plastics shows the different tasks, responsibilities and dependencies. Finally, we finish with some concluding remarks about the benefits and lessons learned.

20.1 Description of the Supply Chain

This case study is about a project at one of the world's leading chemical companies. Here we focus on the Demand Planning of styrene plastics in the European plastics division.

Styrene plastics are all-purpose plastics and can be found in a multitude of different consumer products such as CD-DVD cases, packaging, computer chassis, monitors or printers. The main sectors for the products are electronics communication, consumer electronics and computer, packaging and film, medical technology etc.

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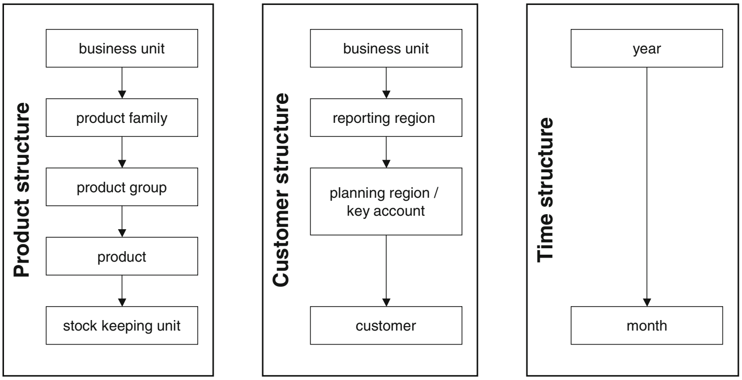

Fig. 20.1 Product, customer and time structures

The main raw material to produce styrene plastics is monostyrene, which originates from crude oil. The polymerization of monostyrene leads to "high impact" or "general purpose" polystyrenes—so-called product families—depending on whether further additives such as rubber are used. The assortment is made up of approximately 500 products, from commodities to specialities, including colored or fire-resistant granulates. The products are wrapped in different packaging leading to a total of 1,500 stock keeping units. From the logistic point of view the products can be combined into approximately 50 product groups (see Fig. 20.1).

The price is an important marketing instrument because a large amount of the quantities sold is made with commodity products. Furthermore, only a few large competitors are in the same market. Thus, changes in the quantities of one market player have noticeable effects on all others—a typical oligopoly situation. Because of the direct dependency on the rising price of crude oil on the one hand and the selling in consumer product markets with decreasing prices and quantities on the other hand, the margin has been under pressure. The sales activities are organized regionally. This means that one or more countries are combined to form planning regions, e.g. Germany, Switzerland and Austria are in the same planning region, while Portugal and Spain are in another one. A key account structure, which is made up of international business partners with a large portion of the sales volume, exists in parallel.
Further characteristics of the supply chain type can be taken from Table 20.1

Increasing the market share is at the expense of competitors and easily leads to price reductions and thus to decreasing margins. Because of the market situation, the economic benefits can only be obtained by decreasing costs. Precise forecasts are needed to achieve adequate inventories and balanced utilization rates throughout the supply chain. The main aims of this project have been to increase forecast accuracy and responsiveness by the effective use of all information in the system, and to secure the market share and gain a higher profitability in the organization.

Table 20.1 Typology for the styrene plastics supply chain

Functional attributes	
Attributes	Contents
Number and type of products procured	Few, standard (raw materials, packaging) Multitude (additives)
Sourcing type	Double/multiple
Supplier lead time and reliability	Short, reliable
Materials life cycle	Long
Organization of the production process	Flow line
Repetition of operations	Batch
Changeover characteristics	Weak sequence dep. setup times and costs
Bottlenecks in production	Known, shifting
Working time flexibility	Low, but high machine throughput flex.
Distribution structure	One stage, regionally organized
Pattern of delivery	Dynamic
Availability of future demands	Forecasted (3–24 months)
Demand curve	Almost stationary
Product's life cycle	Several years
Number of product types	Many
Degree of customization	Blending and packaging
Bill of materials (BOM)	Convergent (blending)/divergent (packaging)
Portion of service operations	Tangible goods
Structural attributes	
Attributes	Contents
Network structure	Mixture
Degree of globalization	International
Location of decoupling point(s)	Make-to-stock/make-to-order
Major constraints	Capacities of flow lines
Legal position	Intra-organizational
Balance of power	Customers, but oligopoly
Direction of coordination	Mixture
Type of information exchanged	Forecasts, orders and contracts

20.2 The Architecture of the Planning System

The demand planning of styrene plastics is embedded in a more complex planning architecture (see Fig. 20.2), which is implemented using SAP APO (see Sect. 18.5). This process consists of the following:

- Demand planning using SAP APO Demand Planning,
- Midterm production planning using SAP APO Supply Network Planning (SNP),
- Short-term production planning using SAP APO Production Planning and Detailed Scheduling (PP/DS), and additional optimization functionality of an IBM ILOG Cartridge,

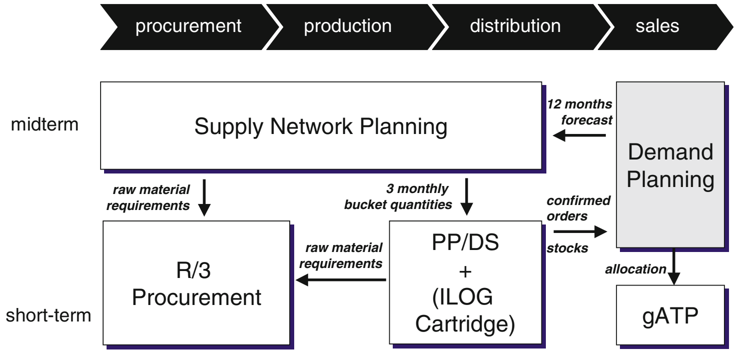

Fig. 20.2 The architecture of the planning system

- Demand fulfilment using SAP APO global Available-To-Promise (global ATP) and
- Procurement Planning using SAP R/3.

In the Demand Planning (DP) module, planned sales quantities—demands—are collected from customers (e.g. collaborative forecasting), forecasted by experienced planners or calculated by statistical models. The demand planning process consists of several dependent planning steps with different time horizons and aggregation levels.

The demands are the basis for midterm planning in SNP, where resource constraints and material availabilities in each time bucket are taken into consideration. Here, the planning horizon is 12 months with monthly time buckets.

PP/DS supports lot-sizing and the scheduling of production amounts per time bucket coming from SNP. Due to specific requirements in the process industries, an optimization extension with IBM ILOG Cartridge Technology has been implemented to improve the lot-sizing of PP/DS in the first 3 months of the planning horizon.

Demand fulfilment leads to promised delivery quantities that can be shipped to dedicated key accounts or regions. Global ATP supports checking allocated product quantities and the availability of materials, using search procedures or multilevel checks (see Chap. 9).

Procurement planning is done in the transactional system SAP R/3 based on the material requirements from planned orders.

20.3 Model Building with SAP APO Demand Planning

Modeling with SAP APO Demand Planning takes place in two different design areas (see Fig. 20.3):

- Historical data are provided by SAP's Business Warehouse.
- The planning environment is based on the *live*Cache (see Sect. 18.5).

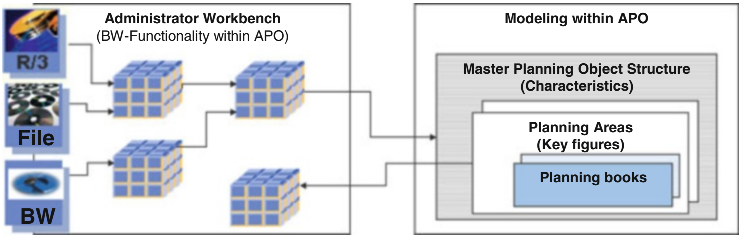

Fig. 20.3 The two design areas of the Demand Planning

The first step applies a typical data warehouse structure and uses the functionality of SAP's Business Warehouse (SAP BW). Thus, it supports the Extraction-Transformation-Loading (ETL) process to get data from different data sources, and cleanse and enrich them for further use. The data sources can be different transactional systems, e.g. R/3 systems of various affiliates, other data warehouses, data bases or even flat files. The structure of a data warehouse allows reporting large data sets along different dimensions on different aggregation levels (month or year, stock keeping unit or product family, customer or region, etc.). Also, selection of data and summations along hierarchies are performed very efficiently (see e.g. Berry and Linoff 1997 and Reuter 2004).

20.3.1 InfoProviders, Characteristics and Key Figures

The data model of a data warehouse is often represented by a "star scheme" as shown in Fig. 20.4, where the data values are stored in one "fact table" containing all data sets.

Each data set is identified by a unique key, which is a combination of characteristics, and consists of several key figures. The characteristics (see Fig. 20.4: customer C, product P, time T) are grouped in dimensions and might have several hierarchies (e.g. day, week, month, year; or see Fig. 20.1). The characteristic combinations span a multidimensional data space—the so-called InfoProvider (see Sect. 7.1).

The key figures are the quantities assigned to a dedicated characteristic combination such as actual sales, open orders, sales budget or forecast quantity (see Fig. 20.4). Key figures can be retrieved for every selection of one or more characteristics. For example, actual sales values can be displayed for one or more products for each region or each customer.

The interactive way to analyze the data is called online analytical processing (OLAP); it has the following functionalities:

- Slice and dice: get a subset of data, e.g. show the sales history of the region "Germany,"
- Drill down: get more detailed information from one hierarchy or dimension, e.g. show the sales history of all customers in the selected region

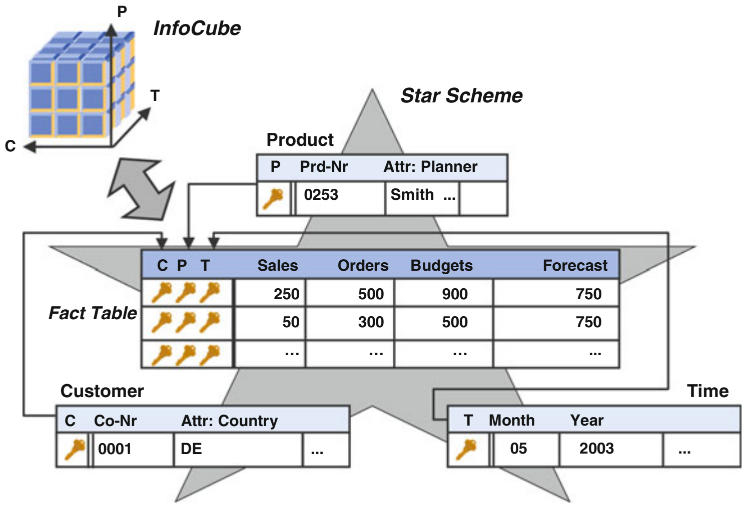

Fig. 20.4 InfoCube and star scheme

- Rotate: change the granularity of two characteristics, e.g. from showing the sales history of all products of the region "Germany" to showing to which region product "X" is sold.

Due to these functionalities, this structure is very appropriate for flexible Demand Planning purposes.

While a data warehouse supports reporting—retrieving data—the input of new planning data is done in the second design step. SAP provides several planning environments for Demand Planning outside the transactional system:

- Quantity-based plans: SAP APO Demand Planning
- Cost-, revenue- or quantity-based plans: SAP BPC.
- Combined quantity and value based approach: Sales and operations planning powered by SAP HANA

In this case study, the focus is on SAP APO Demand Planning.

The process starts based on the structures of historical data that describe the sales history. Usually, Demand Planning is done on quantities of several materials sold to several customers in dedicated periods. Long-term planning is performed at a more aggregate level, while short-term planning is performed at a more detailed level. First, the granularity of planning is defined by choosing aggregation levels of the characteristics. For example, Demand Planning of stock keeping units for each customer on a weekly basis is on a very detailed level and increases the number of data sets very quickly in contrast to a planning granularity of product groups, regions and months. Because of the vital impact on performance and workload the trade-off between detailed and aggregated data has to be investigated very carefully.

20.3.2 Master Planning Object Structure

Each characteristic to be planned on (e.g. region, customer, product group, product, business unit), needs to be included into the set of characteristics the so-called Master Planning Object Structure. Others, which are only for reporting or selection purposes, can be put into hierarchies or (navigation) attributes. In Fig. 20.4 the "planner" is an attribute of the characteristic "product". If the granularity-level of the characteristics is defined, a first estimate of the number of characteristics combinations can be done.

20.3.3 Planning Areas

As mentioned above, the key figures contain the quantities of a characteristic combination. The structure of SAP APO's Demand Planning allows for the creation of several "bundles" of key figures—the so-called Planning Areas—that can be assigned to one Master Planning Object Structure. Reasons for multiple Planning Areas can be different time granularities in different planning scenarios or avoiding data locking in simultaneous planning activities on the same characteristic combinations. SAP APO Demand Planning distinguishes three types of key figures:

- Persistent key figures: actual data with the origin of the data warehouse that should not be changed
- Planning key figures: open key figures to enter or manipulate data by the planner (data is saved to the liveCache)
- Temporarily created key figures: key figures that are used for intermediate calculations and are not saved.

Each key figure has its own aggregation rule. Thus, the selection of more than one characteristic combination displays the aggregation of the quantities of the key figure. For example, if the aggregation rule of actual sales is "adding up," then all the total sales quantities of all customers and all products in the selected region are displayed. From the planning point of view, the disaggregation rules are more important. If the planner enters a quantity for a key figure on an aggregate level, e.g. a region containing several customers, the disaggregation rule describes how the quantity is distributed to the different customers of the region. The most important rules are:

- Equally distributed: the quantity is distributed equally by the number of selected characteristic combinations.
- Pro rata: the distribution ratio is calculated by the portion of the key figure for a certain characteristic combination relative to the total of the key figure.
- Based on a key figure: the distribution ratio for the modified key figure is calculated by the portion of another reference key figure for a certain characteristic combination relative to the total of the reference key figure.

Figure 20.5 shows the aggregation of the forecast quantities (FCST) of three customers with 200, 400 and 600 units in Region 1 added up to 1,200 units. The

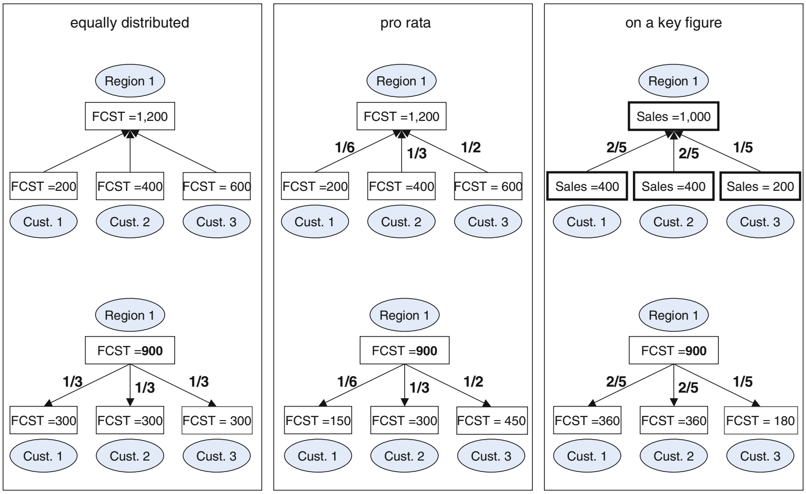

Fig. 20.5 Disaggregation rules

equally based disaggregation of 900 units of forecast planned on the region level leads to 300 units for each customer. The pro rata rule uses the current portions, e.g. $200/1,200 = 1/6$, to assign $1/6 \cdot 900 = 150$ units to Customer 1. In case of the disaggregation on another key figure, e.g. sales, the portions are taken from the sales quantities to Customer 1, divided by the total sales of Region 1 ($400/1,000 = 2/5$) and lead to a forecast assignment of $2/5 \cdot 900 = 360$ units to Customer 1. The example shows that the choice of the disaggregation rule has a large impact on the planning results.

20.3.4 Planning Books and Data Views

The access to the key figures is managed by planning books and their data views. Here data like actual sales or forecasts can be shown, checked and changed. They are the "planning front-end" to the planner. The planning book is a container providing the planning functionality, e.g. forecasting, the subset of characteristics of the Master Planning Object Structure shown to the planner for selection, a subset of key figures of the planning area and the temporarily created key figures. Based on these objects, a data view additionally defines the time horizons of past and future and the layout and format of the key figures (sequence of key figures, background color, number of decimals, etc.). Additional functionalities help the planner to create the forecast or to understand the data. The functionality (e.g. locking or highlighting data cells, calculating key figures, generating alerts) can be implemented with a programming language—the so-called macro-builder. Publishing a planning book in a web-based scenario supports collaborative demand planning (see Chap. 14).

20.3.5 Forecast Methods

SAP APO Demand Planning provides univariate and multivariate forecast methods and the combination of the two. They can be configured in a forecast profile. Here the type of model (e.g. constant, trend; see also Chap. 7) and the forecast methods (e.g. moving average, exponential smoothing, Winters' method, multiple-linear-regression) are also specified as the parameters of the method, the basis of historical data and the number of periods to be estimated (see Chaps. 7 and 29). As further topics, promotions planning and life-cycle models are provided to estimate singular or non-stationary effects of a time series.

The created demand forecast has to be released to production planning either to Supply Network Planning for finite capacity planning—as in our case—or directly to SAP R/3 for infinite capacity planning.

20.4 The Demand Planning Process of the Styrene Plastics Division

The goals of the Demand Planning in the Styrene Plastics Division are:

- Influence of the market behavior
- Using of sales departments' knowledge of customers' ordering behavior
- Coordination of decentralized regional sales departments
- Ability to react quickly to short-term market fluctuations
- Creation of a midrange demand plan in order to calculate a production and procurement plan.

To achieve these goals, input from marketing department, sales department and logistics department is needed. The marketing department adjusts market quantities and influences prices directly or indirectly. The sales department is responsible for customer relationships and the "recording" of demands and placing the orders. Sales and logistics negotiate sales budgets to support "management by objectives." The logistics department is responsible for the consolidation of the sales and marketing plans, the short-term adjustments and the creation of one single demand plan from the various plans.

The following plans are created:

- Sales budget
- Rolling business forecast
- Marketing plan
- Sales plan
- Short-term adjustments.

Referring to the structure of Chap. 7 (p. 125) only the sales plan is supported by a statistical forecasting method. The sales budget is the result of a negotiation process; the marketing plan is created in the marketing department and entered manually; the rolling business forecast is also entered manually and based on the experience of the planner. Starting from statistical forecasting, the sales plan is revised and can

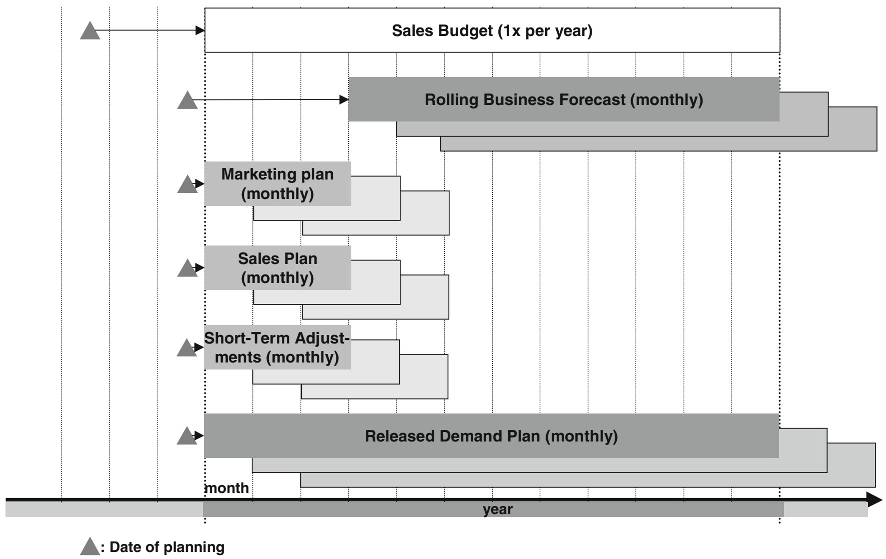

Fig. 20.6 Overview of the different demand plans

be modified (revised judgmental forecast). From the different plans, one consensus-based demand plan is calculated.
The monthly planning cycle consists of the following steps:

1. The sales plan is statistically forecasted and revised by the regional sales departments. The plan contains demands for each stock keeping unit and customer and determines the portions of each characteristic combination.
2. Marketing decides on the total quantities that should be sold to the market, neither to decrease the price by shipping too much nor to loose market share by selling too little.
3. The total of the sales plan quantities has to be adjusted to reach the total marketing quantity without changing the portions of the sales plan.
4. While the first three steps are related to months one through three, the aggregate rolling business forecast is made up for in months four through 12.
5. To release demands for 12 months to SNP (see Fig. 20.2), the first 3 months from the adjusted sales plan (step three) are combined with months four through 12 of the rolling business forecast.
6. Demands from the released demand plan are assigned to delivery locations for an interval of 12 months.
7. Short-term adjustments can be done prior to the release to SNP.

An overview of the existing demand plans is shown in Fig. 20.2. A more detailed description of the different plans is presented in Fig. 20.6.

20.4.1 Sales Budget

The sales budget is not a subject of the monthly planning cycle. The aim of the sales budgeting process is to negotiate the expected yearly quantities sold by a region or to a key account. The definition of the sales budget of the following calendar year takes place once a year in October and remains valid for 12 months. The result agreed upon is yearly quantities at the product group and region level. The negotiating partners are the logistics department of the business unit and the responsible regional managers of the sales department. The plan helps to keep track of the achievement of sales objectives and thus to shift priorities. It is also used to guide the promised product quantities—allocations—along the sales budgets. A special feature is an automated disaggregation procedure on the time structure that distributes the yearly quantity of the sales budget on monthly quantities. The distribution is based on the sales history of the previous year. This is done by the disaggregation rule of the sales budget based on the key figure “sales history.” Thus, seasonal effects are taken into account.

20.4.2 Rolling Business Forecast

In accordance to the midterm plans of the business unit, the logistics department enters the aggregate business forecast of the business unit manually. The definition or update of the business forecast for the next 12 months is performed each month in the so-called rolling business forecast. The result is a highly aggregated plan for the complete business unit on a monthly basis. The plan is needed to support 12 months production planning with SAP APO SNP. As the figures are highly aggregated on the product and customer structures, they have to be disaggregated for planning purposes. The sales budget is used as a reference key figure for the disaggregation.

20.4.3 Marketing Plan

The aim of the marketing plan is to influence prices in the oligopoly market by short-term adjustments of the expected sales quantities for the different product families. The plan is made up for 3 months on a monthly basis. Because of the global impact of the quantities sold to the market, a differentiation on regions or key accounts is not useful. The marketing department is responsible for the creation of a marketing plan. The quantities are used later in the adjustment process (see Short-term adjustments and plan consolidation).

20.4.4 Sales Plan

The sales plan is the central object of forecast collection and input of the sales department. It contains the forecast quantities for the next 3 months on a monthly basis for each stock keeping unit and each customer. The planning complexity is reduced by an ABC-classification of customers and stock keeping units; thus, only the most important items and customers are planned manually, all others are forecasted automatically. The forecast process can be classified as a revised judgmental forecast (see Sect. 7.3). The sales planner is supported by the historical sales quantities of the last 2 years as well as by forecasts calculated with a simple moving average method, whereby more than 6 months of historical sales quantities are averaged. Because of the absence of more complex regular patterns, the calculated forecast gives an impression of the expected quantities. The variations in the historical time series, e.g. reduced sales caused by vacation, are easily identified by the planner in a year-to-year comparison for each month and do not justify a more complex statistical model. Due to handling constraints, minimum delivery quantities have been taken into account for each combination of stock keeping unit and customer. Minimum quantities are automatically identified. If customer orders are already placed in a period, the forecasted quantities have to be at least as high as the ordered quantities, or else they are also identified.

20.4.5 Short-Term Adjustments and Plan Consolidation

Before the release of the demands to the finite capacity planning, various plans are consolidated and short-term adjustments are made.

One of the most important adjustments is matching the marketing plan with the sales plan. Here, the structure of the forecasted demand portions of the sales plan is combined with the quantities of the marketing plan. Consequently, the total quantity shipped to the market should not lead to an unwanted behavior, e.g. a decreasing price or loss of market share. Thus, quantities might change, but not portions. The calculation uses the disaggregation rule "based on a key figure," where the reference key figure is the sales plan.

Another important adjustment is the adding of the delivery location. As shown above the forecast is made on stock keeping units and customers, whereas the sourcing location is missing. In the case of multiple production sites, customer demands could be produced at and shipped from different sites. Subject to transportation and production costs, the choice of the assigned location has an impact on the cost structure. Of course, transfers between production sites are possible, but they cause transportation costs. Thus, the assignment of demands depends on the product (single production site or multiple production sites) and customer site. If the planning region of the customer could be supplied from multiple locations, the ZIP-Code of the customer is used for assignment to the location. Those rules are also used for a first allocation within global ATP checks.

In between a planning cycle, demand figures may change. An instant reaction is supported by a direct communication process with the logistics department and a separate key figure for short-term adjustments to allow for the monitoring of changes.

After the adding of the location to the demand data, the release to Supply Network Planning is performed and production planning can be started.

20.5 Results and Lessons Learned

The above demand planning application has been used since the beginning of 2002. The planning process and the functionalities are highly accepted. Currently, there are about 70 users in different European countries working with this system.

The planners not only use the Demand Planning application, but also profit from the reporting functionality of the Business Warehouse. SAP's Business Explorer (BEx), a Microsoft Excel front-end on the Business Warehouse, helps in analyzing forecast accuracy, printing formatted reports, checking master data and supporting online analytical processing.

Forecast accuracy is measured in different ways:

- Sales Budget fulfilment: The cumulated sales and the planned cumulated sales budget are compared on a monthly basis for each product group and region. If the sales go beyond the budget, the sales data are highlighted.
- Forecast development: Based on the historical sales data for each product group the mean value and the standard deviation sigma are calculated. Then the forecast of a product group is plotted in a graph with lines for the mean value and the mean value plus or minus one, two and three times sigma. If there is a demand forecast exceeding the one-sigma, two-sigma or three-sigma borders, a traffic-light function highlights the forecast and creates alerts of different severity.
- Sales—sales plan—marketing plan comparison: Because of the adjustments before the final release, the original forecast quantities can differ from the adjusted quantities. Thus, the actual sales are compared with the original sales plan and with the quantities after the marketing adjustments.

The following benefits have helped to stabilize the revenues of the Styrene Plastics Division in spite of the weak economic situation in Europe:

- Reduction of the planning cycle time, which led to a higher availability of the planners and to higher responsiveness
- Reduction of communication efforts by using a common data base with dedicated responsibilities for the different plans
- Increased forecast accuracy, through revised judgmental forecast and plausibility checks
- Better control of the decentralized sales regions by tracking the sales budget.

The lessons learned from the project are the following points:

- There is a vital impact of master data quality on the project efforts. The two main drivers are methods to identify master data inconsistencies, e.g. reports, and activities to repair them.
- The simplicity of building planning processes encourages a project team to create complex structures bearing the risk of increasing planning cycle times.

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