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Affecting parameters in the selection of Supply Chain Management software support

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Summary

Companies can today acquire Supply Chain Management (SCM) software support by developing it themselves or by purchasing it from a SCM provider. SCM support is today provided by both specialized SCM providers and Enterprise Resource Planning (ERP) providers. The purpose of this thesis is to formulate the basic SCM concepts and to formulate the parameters affecting companies in the choice of SCM support.

The study was conducted through a comprehensive literature study where SCM concepts were defined, a survey of market literature to obtain a vision of the SCM market in 2002, and a field study where 12 users of different types of SCM solutions were interviewed about the situation that led to their choice of SCM support.

It was found that when companies were about to purchase its SCM support, they have traditionally preferred a specialized SCM provider. Today, however, ERP providers have greatly developed their SCM suites and constitute an option even for demanding SCM users. 21 parameters were found affecting the selection with a varying influence.

These parameters are found to have absolute influence on the selection of the system.

- Demand Pattern
- Supply Situation
- Product Availability Requirement
- Forced Lead-Time
- Business Integration
- System Integration
- Integration Policy
- Business Activity
- Presence of SCM Options
- Documented success of the provider

The following parameters are found having some importance for the selection done.

- Level of Technical Complexity of Products
- Limited Product Durability
- Fast Moving Consumer Goods
- Manufacturing Complexity
- Business Dynamics
- Parallel Growth
- Legacy System Restrictions
- Amount of Time Given the Selection Process
- Personal Commitment

These parameters are found having an uncertain importance for the selection done.

- Dependency
- Underlying ERP provider

The report describes the basics of Supply Chain Management, it gives a profile of some of the SCM providers' solutions on the market, and describes the affecting parameters found influencing companies in the selection of SCM support.

Acknowledgement

I would like to thank supervisor and friend Ingvar Norelius at SchlumbergerSema, for his continuous support, his curiosity and his way of posing the essential questions.

Furthermore I want to thank every respondent participating in this study, for receiving me and my questions with a sincerity and interest that surpassed my expectations.

I also whish to thank supervisor and examiner Thomas Sjöland, at the Department of Microelectronics and Information Technology of the Royal Institute of Technology (KTH) and Mats Röberg for their support along the project.

Stockholm, December 2002
Andreas Röberg

Contents

1. Introduction

1.1. Background

There are today a variety of software solutions helping companies in managing their supply chain. Such software is normally defined as Supply Chain Management (SCM) software.

Certain SCM functionality is normally contained in Enterprise Resource Planning (ERP) systems, but occasionally this SCM support is not enough. A company in need of enhanced SCM support would have to implement specific SCM software.

A company in need of SCM software support has two options. It could develop its own SCM solutions, directly applied to the actual business situation of the company or purchase it from an exterior provider.

If the company decides to purchase the SCM support from an exterior provider it has the option of purchasing the support from an ERP provider or a provider specialized on SCM solutions.

The purpose of this thesis is to summarize the situation on the SCM support market and to suggest some of the most important parameters influencing companies when they opt for what type of SCM support to acquire.

1.2. Purpose

The main purpose of this thesis is to provide an introductory study of the situation of companies in need of supply chain management support. This is obtained through five separate objectives.

- The formulation of SCM concepts.
- Discernment between ERP and SCM systems.
- The study of available SCM solutions on the market.
- The study of trends on the SCM market.
- The formulation of elucidating decision variables, concerning factors like environment and business activity, which lead to the decision for or against specialized SCM solutions.

Principal for this thesis are SchlumbergerSema and KTH.

1.3. Limitations of the scope

Several delimitations have been made in order to increase the relevance of the problem and the method to this thesis.

1.3.1. Depth

The purpose of this thesis is not to present a complete survey over the existing parameters leading to the choice of specialized SCM solution or ERP-integrated solution. Therefore the reader should be aware that the synthesis presented in this report

is a suggestion of possible reasons to why a company may choose the one solution or the other. There may, of course, be others.

1.3.2. Defining the systems

The problem of this study would have been less ambiguous a few years ago when there was a more evident divider between specialized SCM support from ERP vendors and specialized SCM support from specialized providers. At that time a company with special requirements on the SCM functions in reality only had the option of specialized providers' solutions. The selection was for most companies a selection between specialized or non-specialized SCM support. Today a company not only has to decide whether it needs enhanced SCM support or not, it also has to decide what provider strategy to adopt: specialized provider or ERP provider.

This means that the situation of the companies and the SCM options available have been changing over the last decade. Consequently the options available for companies about to acquire SCM support has evolved along with their business situation and their requirements upon their supply chain. This, naturally, is a parameter that will be further explored in section 6, Affecting parameters in the selection of SCM support, however the reader is asked to keep this in mind throughout the thesis.

1.3.3. Choice of providers

Another limitation of the scope has had to be done considering which providers' solution to include in the study. This to delimit the field study and to obtain case studies that were comparable and within the focus of this research.

The criteria for choice of providers are:

- Availability — Those providers who did reply to the information requests sent out during this research are selected in preference to those who chose not to reply.
- Presence — The provider has to be present at the Swedish market.
- Size — The provider has to be active on the world market.
- Solution — The provider has to present a suite for supply chain planning. The system considered should also contain a solution for industrial manufacturing.

1.3.4. Choice of users

The amount of users to include has been limited for the feasibility of the field study. As each provider refers to a limited number of clients the choice of clients has been subordinated to those users fulfilling the following:

- Availability — Users interviewed presented an interest in participating in the study.
- Business — Users had to be participating in a supply chain. Consequently every company interviewed was familiar with SCM problems.
- Size — The users should be large companies connected to an international organization.

1.4. Method

The method formulated for this study is directly derived from its purpose. *SCM concepts*, *discernment between ERP and SCM systems*, *study of available SCM solutions* and *trends on the SCM market* were derived from a literature study based on publications, market research reports, books, and Internet sites. *The study of available SCM solutions* and *trends on the SCM market* were also backed up with interviews with various SCM providers. The *affecting parameters in the selection of SCM support* were derived from qualitative interviews with a selected group of users of different types of SCM support.

The work was conducted according to the following schedule:

Literature study

1. General background study and formulation of problem and method
2. Study of available solutions and SCM market
3. Selection of SCM providers
4. Study of selected SCM solutions
5. Selection of SCM users
6. Formulation of interview model

Field Study

7. Execution of interviews
8. Analysis of interviews

1.4.1. General background study and formulation of problem and method

Through an introductory literature study, the problem for this thesis was confirmed and formulated. The problem had been formulated in discussions with the principals at SchlumbergerSema and KTH but a more specific formulation was needed.

According to the problem and the purpose of the research a method was formulated defining steps to take in the study. The method was also verified with principals.

1.4.2. Study of available solutions and SCM market

Through market research a list of most common SCM and SCM related software providers was compiled. The list contained 43 names. Out of these 12 could be referred to as specialized SCM solutions and the rest were business system providers.

A view of the SCM market situation was obtained through market research from publications, market research vendors and Internet.

1.4.3. Selection of SCM providers

After some contact with certain SCM providers, 4 SCM providers and 7 ERP providers were chosen. These fulfilled the criteria described under the section 1.3.3 Choice of providers. A goal was to find an equal number of both types of provider.

The reader should be aware that there are other SCM and ERP providers able to provide fully functional SCM support. This selection was done primarily in order to obtain a list

of providers whose applications could be compared and who had users presented in Sweden.

1.4.4. Study of selected SCM solutions

Some vendors were contacted and interviewed about their solutions' abilities and their opinion about the SCM market. It was found that in order to gain a somewhat unprejudiced image of every SCM solution other sources of information were required. This was obtained through interviews with the users and independent market research.

The study of selected solutions resulted in the vendor presentation included in this report.

1.4.5. Selection of SCM users

From each SCM provider's direct referrals a few companies were selected. This implied a list of 53 users, 26 out of those using specialized SCM support. The rest were ERP clients and there was no information about how many out of those that were clients of the ERP providers' SCM solution or only their business system. The list was used during contact making. The actual selection of SCM users was done by the users themselves when deciding whether they wanted to participate in the study or not. The purpose was to obtain interviews with an equal amount of users using specialized SCM support as users not using specialized SCM support. Here the reader is asked to remember that the objective has derived slightly as a company's selection today is not only between specialized and non-specialized SCM support. This means that there is a variation in attention given to SCM questions among users referred to by ERP providers in this study.

It must be declared that the willingness of an SCM user to participate in the research was depending on whether the right person, concerned with the SCM problems within each company, was found. Once the appropriate person was found, he or she generally agreed on participating in the study.

1.4.6. Formulation of interview model

The purpose of the interviews has been to construct a case study of each company and its SCM solution. This implies dividing the interview into questions concerning:

- The company, products, market behavior, and general supply chain structure.
- The situation anterior to SCM support acquisition, problems experienced, and business system structure.
- The selection and implementation process of the system considered.
- The situation posterior to the implementation.

It was found that the interview model had to be adapted according to the type of system the selection concerned. That is, if the interview was concerning an ERP system acquisition the interview model had to be different from the one concerning a pure SCM acquisition.

The general interview model is to be found in Appendix B.

1.4.7. Execution of interviews

Each user was contacted independently from the provider. Some providers have been willing to communicate contacts with users. This has not been used however, as an interview contact in general has been quite possible to obtain without the aid of the provider.

Prior to each interview a short introductory study was made concerning the company, its market, its products and the systems in use. This resulted in an adaptation of the interview to each company and its case. The questions were sent to the respondents in order to permit some preparation and to verify that the respondent could answer the questions.

The interview was constructed to permit being executed within one hour. Time however, has in most cases not been a limiting factor and the interview has been let to sink deeper into details than originally previewed. The interviews were recorded when possible. On three occasions the interview had to be done over telephone. The telephone interviews were not recorded.

After each interview, a case study was written summing the general information about the company, the situation that was connected to the current supply chain solution, how the current solution was obtained and how the situation had changed after the implementation. This case study was sent to the user who had the opportunity to review, correct, cut out or add information.

In order to facilitate the participation of the users, they have been granted not to occur as detailed case study in the report. *No case will be given and referred to a specific company or person in this thesis*. This means that once interviews were conducted and case studies concluded, the information has been analyzed laterally and examples given in the report are constructed from several situations found on the field.

The objective was to carry out between 10 and 20 interviews with SCM users with an equal distribution between users of specialized SCM support and users of ERP based SCM support. When the field study had been carried out, 12 companies had been interviewed, 7 with a specialized SCM support an 5 with ERP based SCM support.

1.4.8. Analysis

Due to the qualitative approach of the interviews a rather broad view over the system acquisition was obtained from each company. The case studies were collected and observations were gathered. The observations were arranged into groups that later were transformed into parameter groups. These groups were divided according to the art of the parameter, being functional, structural or other. Some observations could not be defined as parameters and were removed. Others could be defined as parameters but only of uncertain importance, these parameters were collected in a last parameter group.

Most parameters are conclusions drawn by the author and not explicitly given by the users as factors concerning the selection of SCM solution. It has been an explicit wish from the employer of this research and a prerequisite for the analysis of the material,

that the author should have the right to draw conclusions from his proper experience gained during the work.

1.5. Sources of error

1.5.1. Selection of users

Users were selected from references given by the various SCM providers. This could imply a source of error, as providers are likely to advertise those users with a confirmed successful implementation, rather than those with unsuccessful implementation.

The ratio of satisfied users might have been different if randomly selecting companies without passing through vendors' references. Also the ratio of users of specialized SCM providers is not representative for the market. However the purpose has not been to give statistical foundation for the synthesis but to qualitatively elevate parameters affecting companies in the selection of SCM support.

1.5.2. Respondents

In some cases the people connected to the SCM selection and implementation were no longer working on the company and in some cases long time had passed since the implementation. This meant that facts were not clear on a few occasions, and only a general view could be obtained from the interview. Especially selection criteria and solutions considered during selection process could not be recalled.

1.5.3. Author's analysis

Conclusions drawn in this work are done from the authors experience from literature studies and field studies. Consequently the parameters and conclusions presented are based on private vision. This can of course provide a source of error.

1.6. Instructions to the reader

The area of SCM contains a wide range of technical terms and abbreviations. If the terms are considered of vital importance for the understanding they are explained in the thesis, otherwise they are to be found in the dictionary. The reader is urged to search the dictionary in Appendix A for further explanation of terms. Definitions given in the dictionary derive from the experiences done by the author during the literature study and the field research.

This thesis can be read differently depending on the purpose and the experience of the reader.

1.6.1. The comprehension of parameters

If the reader already is familiar with concepts and function of SCM support, but wants to gather a vision of the parameters leading to the implementation of specialized SCM support versus support provided from ERP vendors, he or she could go directly to section 6 Affecting parameters in the selection of SCM support, section 7 Conclusions,

and eventually study different providers solution in section 3 Presentation of SCM providers.

1.6.2. Comprehensive introduction to SCM

If the reader whishes to gain an introductory understanding of the concepts and function of SCM support and what factors urges companies to implement different sorts of SCM support, the reader should make use of the entire report.

1.7. Definitions

In order to conduct a comprehensible discussion some terms frequently reappearing in the thesis deserve to be given an unambiguous definition. The reader should observe that these definitions only concern the contents of this report.

The company – is the organization that is about to acquire, or already is using the system considered. The company may be a producing industry or a commercial organization delivering products to internal or external clients. The company may also be called the *enterprise* or the *user*.

The provider – is the selling organization of the system considered. The provider may also be called the *vendor*. The provider is either an ERP system vendor or a specialized SCM system vendor. A *specialized* SCM provider is also called a best of breed (BOB) provider.

The supplier – is the organization providing material required by the company to be able to deliver its products.

A parameter – is a fact concerning the company's situation or the status of the SCM market that affects the choice of system. The parameter is also called a *factor*.

An ERP system – is an Enterprise Resource Planning system in use at or to be acquired by the company. There can be several ERP systems in use within one company. An ERP system contains a certain amount of SCM functionality, such as production planning, inventory planning, and supply planning. The ERP system is further described in the Supply Chain Management section.

An SCM system – is a software support for Supply Chain Management in use at or to be acquired by the company. Several SCM systems may be used at the same time. The system can be constructed by the company itself or provided by a vendor. SCM systems can be divided according to the provider selling the system. The provider can be either an ERP vendor offering an SCM suite, or a specialized SCM provider whose main focus is within supply chain planning and execution. The SCM system is further described in the Supply Chain Management section.

2. Supply Chain Management

This section is dedicated to provide an understanding of Supply Chain Management and to describe how SCM software may improve the performance of a company's supply chain.

Furthermore will be described the differences and similarities between ERP and SCM. This is required since today several terms are common for both ERP and SCM. Often both types of systems are sold by the same vendor. Also a description of the historical development will be given. Having a historical view of the situation on today's SCM market gives an understanding of why the problem defined for this thesis is relevant. Finally some trends on the SCM market are given. These trends are syntheses from market analyzers' conclusions about today's SCM market and the SCM users description of their current and future situation.

When an enterprise software vendor is charged with implementing a business process package, the first thing done is a profound analysis of the situation of the enterprise. The company's assets, clients, suppliers, competitors, business processes etc. are thoroughly examined. Then there is normally a major adaptation of the processes with mainly two objectives in mind. The first one being assertion of the relevance of the business process and the second one being adaptation of the process to the system concerned. The latter has been subject of discussion as the logic in implementing a system, that requires the underlying process to be more or less perfectly fitted, can be questioned (Davenport, 1998). Nevertheless the function of the ERP/SCM solutions is closely linked to the situation of the user why the user's business situation will be described in connection to the function of the system.

It is recommended for the reader to verify unfamiliar terms in the dictionary in Appendix A in the end of the paper.

2.1. Supply Chain Management

In order to describe the field of SCM, it could be rewarding to start by analyzing the term Supply Chain Management.

Supply

The supplies are the materials used by the company when it is performing its business activity. Supplies can be either consumed during this activity or left intact, stored, packaged and shipped to clients. Supplies possess a value and therefore storing and consuming supplies implies direct and indirect costs. Supplies are provided by a supplier that is internal or external to the organization.

Supply Chain

The supply chain is the chain of processes that are required in order to bring the final goods to the final client or consumer. It is called a Supply Chain since it is constituted from actors passing supplies in a number of directions, mostly towards the final customer. The supply chain can be dynamic; new suppliers and new clients may occur and disappear. The supply chain can be static; contracts with suppliers and clients run on a long-term basis. The supply chain can be a mixture of both dynamic and static

parts. Also important to notice is that a supply chain can be defined within one single organization or as the cumulative of a multitude of organizations.

The supply chain has a few standard components:

- The stock, or the inventory, is a stationary depot where goods are stored between different units linked in the manufacturing or distribution of the goods. When talking about the inventory of an object one normally refers to the *quantity* or the total *value* of all such objects being stored.

- The production unit takes one or several supplies and through various activities puts them in a state that is closer to the final product.

- The transportation is the activity of physically making sure that each component is where it is supposed to be. Supplies are moved between different units of production and inventory.

Supply Chain Management
Theoretically SCM is the coordination of transportation, production and inventory throughout the supply chain in order to deliver the final product to the final client. Supply chain management has also been described as the art of making sure that the right supply is in the right place, at the right time, in the right quantity (at the right cost) anywhere along the chain, all the time. The goal of supply chain management activities is to increase the profitability of the business. This is normally achieved when the company manages to reduce inventory and transportation costs, to increase service level, to limit risks connected to the supply chain (e.g. unmarketable inventory etc.), to gain a vision of the supply chain and tools to control it, or to foresee future changes and to adapt to them.

More directly there are a few typical activities that need to be handled in order to have a well functioning supply chain. These activities can be divided into executive and planning functions on the analogy of the two main functions of SCM systems: Supply Chain Execution and Supply Chain Planning. These two categories will be further discussed in the 2.3.1 Modules of the SCM system section.

Normally the amount of data in need to be handled is enormous and SCM has flourished thanks to computer development. SCM can be supported through ERP systems or through more specialized SCM software packages that are developed by either the user itself, an ERP provider or a specialized SCM provider. SCM software suites on the market consist in several modules like demand planning, replenishment planning, manufacturing planning etc. A company in need of SCM software support might purchase a complete suite or just separate modules.

This rather theoretical, “general”, view of the supply chain and supply chain management will be somewhat concretized in the 2.3 Basics of the SCM system section.

2.2. Basics of the ERP system

To understand the function of an enterprise system it is instructive to start by the problem it is supposed to solve. In a big company every department collects, processes and generates huge quantities of data. Without a centralized system, the data is stored in different repositories depending on its origin. In large enterprises there can be as much as hundreds of separate systems, each belonging to an individual function, business unit, region, factory or office. Every single system may provide invaluable support for its proper unit, and when handled separately they may very well function in a satisfying way. Yet, when coordinating these systems, and the vast amount of data, continuously being stored, processed and transferred, the speed of the total system is slowing considerably. This is due to the inter-application connections being slow or non-existent. Another effect of many separate systems is large costs due to treatment of redundant data, reformatting of data between systems, keeping communication links between different systems to automate data transfer, maintenance of obsolete software code etc.

Maybe of even greater importance than the direct costs are the indirect ones. When a company's sales and ordering system cannot communicate with its production-scheduling system, then manufacturing performance and customer responsiveness suffer. Equally, if its sales and marketing systems are incompatible with its financial-reporting systems, the management risks not having the correct foundation for the decisions to make.

An ERP system is constituted by a comprehensive database. The database collects data from and distributes data to separate modules where all applications support every part of the company's business units. This is done across functions, across units and across the geography. If information is inserted in one end of the system, it is stored in the core database and passed on to other sections of the system concerned by the information.

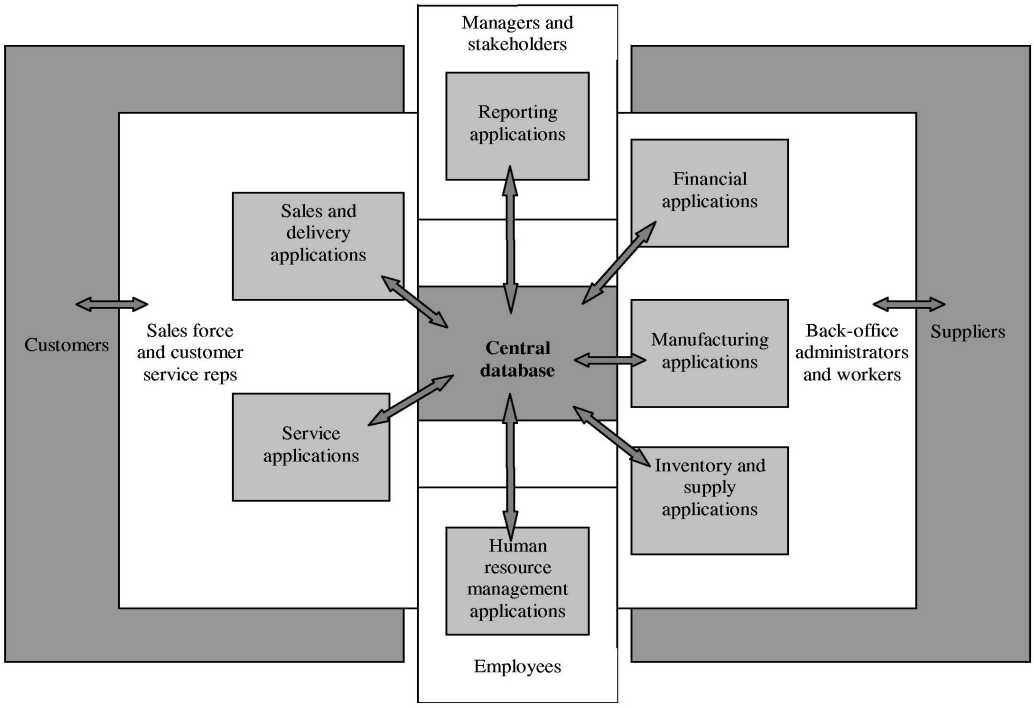


Figure 1. Structure of ERP system, (Davenport, 1998)

It can be clarifying to examine a simple example of the ERP function. Let's say that a Paris based sales representative for a U.S. computer manufacturer prepares a quote for a customer. The salesperson enters some basic information about the customer's requirements into his laptop computer, and the ERP automatically produces a formal contract, in French, specifying the product's configuration, price, and delivery date. When the customer accepts the quote, the system, after verifying the customer's credit limit, records the order. The system schedules the shipment; identifies the best routing, and then, working backward from the delivery date, reserves the necessary materials; and schedules assembly in the company's factory in Taiwan. The sales and production forecasts are immediately updated. The sales representative's payroll account is credited with the correct commission, and his travel account is credited with the expense of the sales call. The actual product cost and profitability are calculated, in U.S. dollars, and the divisional corporate balance sheets, the accounts-payable and accounts-receivable ledgers, the cost-center accounts, and the corporate cash levels are all automatically updated. The system performs nearly every information transaction resulting from the sale. (Davenport, 1998)

2.3. Basics of the SCM system

Similarly to the ERP case, it is a good idea to start the description of the SCM systems by the problem they are supposed to solve. Traditionally in a manufacturing business, moving and storing goods was done in a disparate way, under different managers. Transport from suppliers to plants was handled by suppliers themselves or by purchasing departments. Within the plant, transportation and storage was handled by the stores department (in stores) and by manufacturing operations (within the plant). Transport from plant to customer was handled by transport or distribution departments.

Buying was handled by purchasing; sales forecasts by marketing and communicated to manufacturing and procurement, generally in one-way information flow. Thus different functional departments were split into watertight compartments. (Boubekri, 2001)

A manufacturing company can be regarded according to its structural organization (production, distribution, storage, etc.) or according to its business process (the flow of supplies). When looking at the business as a flow it is easier to discover points in the production running in a less efficient way. For example a huge stock is clearly an interruption in the product flow. Then, when stating that each part or piece of material locked in the process is a running cost, it is obvious that, in order to reduce costs, the objective must be to accelerate each product's movement towards the final customer. In order to do so, the different compartments described above would have to cooperate, sharing order, production and sales data. Also high levels of products locked in inventory or production implies a risk. If the demand would diminish and the products at stock cannot be sold, the loss is linear to the amount of capital locked in the inventory. Information sharing between tiers in the supply chain may not only diminish inventory levels but also diminish the effect of changes in demand that occur further down in the supply chain.

Now consider a company manufacturing a product C out of component A and component B. The company consists of a purchase department, a manufacturing department, a sales department, a distribution department, and a financial department. When the sales department has received an order, it is sent to the distribution, which arrange the delivery by taking the correct amount of products from the stock of finished products. When inventory level has decreased below the order point, an order is sent to production to produce the order quantity, thus inventory will be refilled. In order to maintain this storage, order point is kept at a level so that stock-outs never (are very unlikely to) occur. Yet inventory of finished goods is kept at lowest level possible. The production takes the material from the storage of A's and B's, whose level is guaranteed by the purchase department. If demand is fluctuating the stock of finished products is required to be bigger due to lead-time in production. Consequently this stock will be varying more frequently, causing level of production to fluctuate over time. As a consequence introductory stocks of A's and B's will need to be even bigger. All this implies larger costs due to fluctuating demand. Today, in most cases, demand fluctuates. If maintaining the introductory stock at a level too low, the risk of shortage of A's and B's is higher, resulting in a higher rate of missed delivery dates for finished goods and goodwill loss. The company therefore experiences difficulties in balancing inventory levels and production level to demand.

The basic problem derives from the fact that one unit is not completely aware of the situation of other units, and the overall planning process lacks visibility of the process. This visibility is created through information about inventory levels, forecasted demand, and production capacity. The main purpose of the SCM system is to communicate the information required between separate units and deliver decision support tools. In other words break the isolation between tiers in the supply chain.

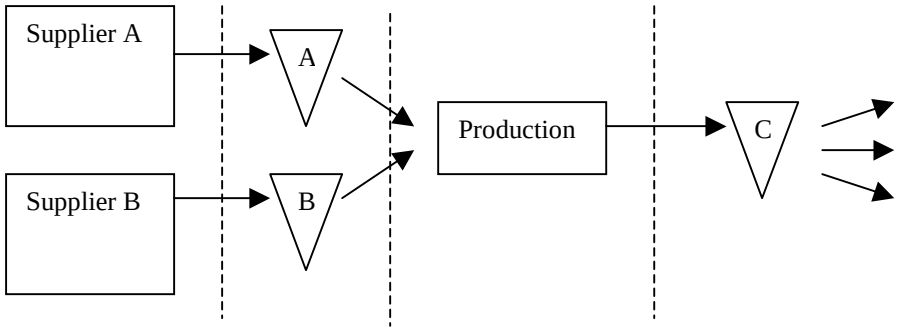


Figure 2. Schematic setup of a basic supply chain

When bearing in mind that the situation of the suppliers of As and Bs is the same. It becomes clear that, for the whole supply chain, lacking information exchange results in costs that should be avoided and a delivery quality that could be much higher.

In order to design and manage a well working supply chain it is useful to use a software package. This permits information to travel rapidly between different business units and to coordinate operations within a company as well as between companies. There are several definitions about what an SCM system should contain but in general the modules mentioned here are contained in today's SCM applications. (Exon-Taylor, 1996; Eds. Goletz, 2001)

Problems connected to badly functioning supply chain management are normally shown in the shape of excessive inventory cost and poor service level. The theory of how to handle the supply chain is a big subject within research, especially within Operations Research and Logistics.

2.3.1 Modules of the SCM system

Supply Chain Management normally includes two types of activities, Supply Chain Planning (SCP) and Supply Chain Execution (SCE). Typically Supply Chain Planning performs all kinds of planning activities within the supply chain regardless of level of detail (strategic, tactical or operational) while the Supply Chain Execution module is the connection between the planning system and the manufacturing system. SCE works in real-time, tracking materials, checking machine/process status, tracking labor, reporting events and alarming exceptions, managing stocks etc. The reader should notice that the following description of an SCM suite is a considerable simplification. Most vendors offer a complex SCM solution, sometimes mixing execution and planning function and often the vendor has repacked the modules into industry-specific solutions. An SCM suite contains both SCP and SCE modules.

SCP modules:

- Demand Forecasting
- Demand Allocation
- Replenishment Planning
- Manufacturing Scheduling
- Manufacturing Planning

Procurement

SCE modules:
- Stock Control and Distribution
- Production Tracking
- Inventory Management
- Transportation

Normally SCM solutions also contains modules for:
- Supply Chain Network Modeling
- Advanced Planning and Scheduling
- Supply Chain Event Management
- Supply Chain Collaboration

Demand Forecasting
When trying to anticipate future demand there is a variety of methods. Which one being used depends on the feature of the product, the market where the company is present or the culture of the business. Everything between personal judgment and sophisticated mathematical modeling is used. Needless to say, the accuracy is varying. Uncertainty in forecasts only increases the need for relevant planning.

Demand Allocation
This business process is only needed if the products can be manufactured in different factories within the supply chain and when these factories deliver to a number of different markets or regional depots. The purpose is to determine how demand should be distributed over the factories for the future period of e.g. 12 months. This allocation is then delivering demand input for each plant's planning process. Like manufacturing planning and scheduling, demand allocation is a question of optimizing assets to a number of constraints. Often forecasting, allocation and planning of future demand is carried out in one single module called Demand Planning. DP normally assemblies forecasts with incoming orders generating a plan of future demand.

Replenishment Planning
There is a need to plan the inventory levels from the plan over future demand derived from the demand planning activity. Inventories can be regional stock, central stock, and also stock of introductory supplies. Replenishment planning calculates optimal order quantity, security level and order point for the inventory of each product. Replenishment Planning is also called Supply Planning.

Manufacturing Scheduling
This might be the most evident business process within SCM. The manufacturing (or production) scheduling starts by defining what is to be manufactured and in what way. It then has to recognize the production constraints (e.g. which products can be made on which line and at what rate, retooling time, labor and material availability etc.). Scheduling also means pursuing a number of conflicting objectives such as optimizing batch size, achieve target stock levels or minimizing late orders. Manufacturing schedules must also be responsive to quick changes as demand normally changes and production deviates. The output of the scheduling activity is called a Master Production Schedule (MPS). A MPS only dictates the amount of each product to be produced in

each period of time. It does not verify whether the scheduled production fits the actual production capacity nor does it detail the amount of materials required in each period. Capacity scheduled is verified in the Rough Cut Capacity Planning (RCCP), which either accepts the schedule and passes it to the planning process or sends it back for rescheduling.

Manufacturing Planning
The scheduling activity works at an aggregated level and strives at fulfilling demand (real and forecasted) at a minimized production cost. However there is a need to render a more detailed plan of required materials and capacity utilization. This is done through Materials Requirements Planning (MRP). Input to the MRP is the schedule delivered by the MPS and confirmed by the Rough Cut Capacity Planning, structural information such as Bill-Of-Materials and Item info, and tactical information like placed sales orders, inventory levels and placed purchase orders. Contrarily to the scheduling activity, where the objective is to fulfill demand at lowest cost possible, the objective of the material planning activity is to render a plan for materials procurement, buying supplies as late as possible while maintaining the risk of stock-outs under a predetermined level. The production planning also plans the production activity over the planning points. A planning point is a specific production operation, e.g. a cutting machine, a coating machine or an assembly station. Normally a production point is connected to several products and switching between different products requires a period of time for retooling. Changing production implies a cost and consequently large batch sizes would be preferred. On the other hand large batch sizes make the production slow in reacting to changed production requirements and require higher inventory levels. There is a need to find a balance between sizes of batches and the agility of the production. A production line may contain several production points. A production plant may contain several production lines and a product may be produced at several plants. The planning activity becomes quickly a very complicated task of finding the overall cheapest and most efficient production setup for every planning point during a number of periods of time. The production plan derived from the MRP is again verified against actual capacity, this time at a more detailed level in the Capacity Requirements Planning module. If the production plan is feasible it is classed as fixed production plan and cannot be changed. If rejected a response is sent back to the Manufacturing scheduling, demanding the original schedule to be rescheduled.

Procurement
The outcome of the Materials Requirements Planning is a plan indicating the order quantities and dates to place the orders to suppliers. The Procurement process handles plans and executes the purchase orders. In some major systems this module is extended with collaborative supply planning, collaborative design and decision support for strategic sourcing. Normally this function is then named Supplier Relationship Management (SRM). Some vendors include Procurement in the Supply Planning.

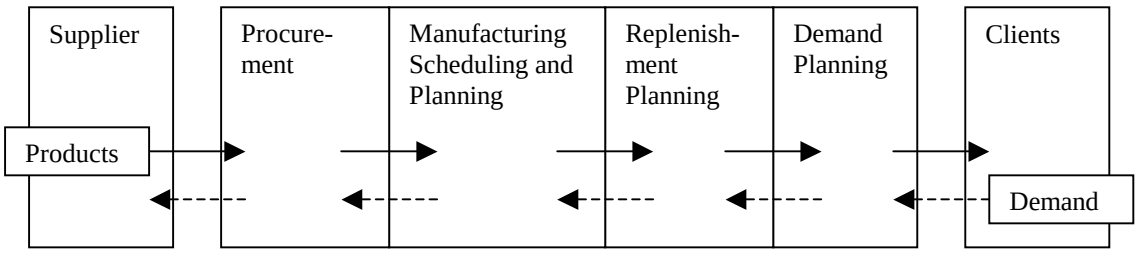


Figure 3. The basic SCP modules

Stock Control and Distribution
Once the products are ready for delivery, there are a number of problems to solve depending on the structure of the business. Enterprises with several regional depots, warehouses etc. need to optimize the distribution with stock control. Distribution is also about how to handle transports in an efficient way. This could imply choosing means of transport, purchasing of transportation services, optimizing lot size and transport frequency. Also the distribution has the objective of reducing cost with maintained delivery quality.

Production Tracking
This business process keeps an account, continually updated, of what has been made and when. The production tracking provides a feedback to the continuous re-scheduling.

Inventory Management
Inventory management is the ongoing handling of the inventory and identifying inventory requirements. It sets targets, provides replenishment techniques and reports actual and projected inventory status.

Transportation management
The transportation of goods is connected to several problems of how to best pack orders, plan co-shipments, confirm deliveries etc. Transportation management is a broad subject covering both performance and planning.

Supply Chain Network Modeling
Supply chain network modeling is a support tool for strategic and tactical decisions often providing a graphical view of the entire supply chain. It permits to compare the effect of different set-ups called “what-if” simulation. This simulation could be carried out both for strategic an tactical situations such as high level decisions about where to locate production units or low level decisions about which out of a few possible production plans to be the valid one.

Advanced Planning & Scheduling
APS is a tool that permits production to be simultaneously optimized to material, capacity and demand constraints. This optimization can also be applied to transportation and inventory planning. The benefit of APS is that the co-optimization to several constraints brings a more optimal solution than sequential optimization. If used

in real-time optimization of the supply chain, APS can deliver an order acceptance tool indicating profitability of potential orders.

Supply Chain Event Management
SCEM is an exception handling tool that assures that units concerned are informed about changes in capacity, order delivery dates, inventory exceptions etc.

Supply Chain Collaboration
Even though a single company can achieve cost savings through SCM, the real benefit comes when connecting several companies along the supply chain. The system works in the same way with the difference that instead of optimizing each single link in the chain, the optimization process focuses on the whole chain. Consequently the result is a higher point of resource utilization than the one rendered when focusing on each single company.

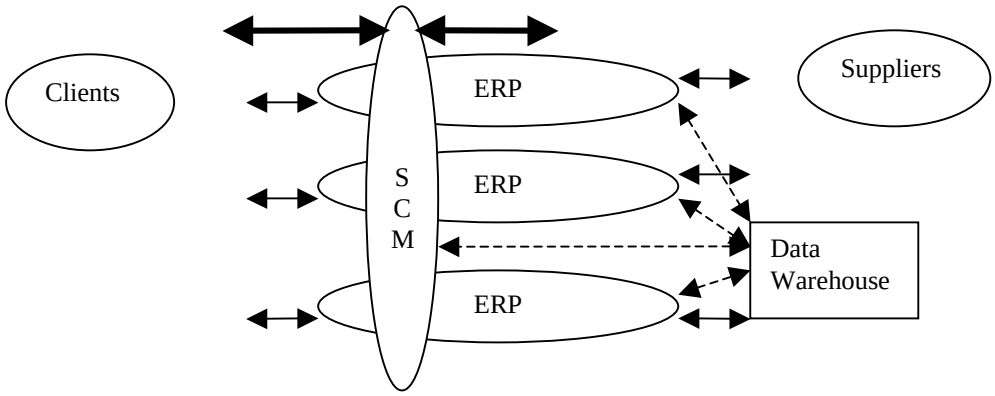


Figure 4.Example of collaborative function of SCM solution

2.3.2. Vertical solutions

A vertical solution is a business-specific software package. Since activities within different areas differ largely, there is a need to adapt packages to specific products, manufacturing process or company structure. A vertical solution is a package of the SCM modules required for the specific industry together with some special adaptations. An adaptation could concern something as basic as unity or something as complicated as adapting the production planning to process industry or assembly. Some verticals do not contain manufacturing at all, but focus on retail or wholesale. The importance of the existence of verticals in the SCM provider's product line has become vital for the competitiveness. Some typical verticals are automotive, pharmaceutical, process industry, electronics, consumer-packaged goods etc.

2.4. Differences and similarities between ERP and SCM:

What ERP systems traditionally have performed is management of administrative activities like payroll, financials, inventory and order processing. Practically this means the functionality to process an order, but it does not provide much information about the profitability of the order or the best ways to deliver it to the customer, it only processes the transaction. Traditionally when it comes to planning, an ERP system generated statistics about what already happened in the company. Reports from ERP

systems have been compared to snapshots of time, without delivering continuous planning support, whilst a supply chain planning system continuously refines and enhances the plan as changes occur. The task of optimizing a plan using ERP system has been compared (by SCM provider i2 Technologies) to steering a car by looking through the rear-view mirror.

Nevertheless when looking at the contents of an SCM system, there are many similarities to the contents of an ERP system. They both contain functions for planning and scheduling production, inventory allocation, tracking and distribution. They both communicate data between different business functions, be it continually or at intervals.

The main difference is that SCM systems try to speed up and optimize the complete process, covering as much as possible along the supply chain by connecting forecasting, planning, scheduling and other functions between different actors along the chain. This while the ERP system focuses on speeding up and coordinating the internal enterprise communication. Of course this permits optimization of the internal activities, but it does very little to optimize the entire process from raw material to finished product.

Normally an SCM suite aims at providing an agile real-time optimization where the production is optimized to inventory, production capacity and demand simultaneously. Thus the SCM suite can give a view of the optimal production and distribution continuously, permitting the direct effect of any changes to be measured. An ERP system working with MPS, MRP, RCCP and CRP in a loop optimizes the production to these constraints, but does so only with one constraint at a time. (Tarn, Yen and Beaumont, 2002)

Important to remember is that almost every major ERP provider today offers a specialized SCM suite through acquisition and in-house development within the providing company.

2.5. Historical perspective of ERP and SCM

2.5.1. ERP

Originally the problem to solve in a typical manufacturing environment was the one of specifying the quantity of each product required in each planning period. The master production schedule (MPS) was conceived for this purpose. MPS is a set of time-phased requirements for end items. The input of data for the MPS is forecast demand, sales order, inventory levels, production costs, inventory costs etc. and the output is a production plan detailing amounts to be produced, staffing levels etc. for each of a number of time periods. The production plan does *not* specify what parts to be used in the production, why this planning is sometimes called *aggregate planning*. The plan is cost driven, that is, the goal of the plan is to meet the specified requirements at minimum cost.

However a firm also needs time-phased requirements for components or raw materials that are required for each end item. In the 1970s a concept of Material Requirements Planning (MRP) was introduced by Orlicky (Orlicky, 1975). MRP is a production

planning and control technique in which the MPS is used to create production and purchase orders for lower-level components. It can be said that MRP translates (explodes) the *aggregate plan* from the MPS into an extremely detailed plan. Two types of information are required in MRP: structural and tactical. Structural information is information about the components that the enterprise uses and how different items are related to one another. This information changes relatively infrequently. Tactical information is about the company's current state, for example sales orders pending, the master production schedule, inventory levels and purchase orders. This information changes frequently. Thus the MRP delivers a detailed plan of when to place orders with external (or internal) suppliers, and the size of these orders so that production never stops due to lack of stock.

Important to notice is that MRP is not cost driven like the MPS. Instead it is stock-out driven, meaning it arranges orders as late as possible without attaining stock-outs.

At this time enterprises had vertical organization structures and optimization was focused on functions within each activity. Companies' relations with vendors were win-lose interactions where business partners many times were adversaries. (Chandra and Kumar, 2001)

MRP continued expanding to include more business functions. In the 1980's MRP expanded from a material planning and control system to a company-wide system that could plan and control basically all the firm's resources, combining planning and scheduling with production capacity verification. Consequently capacity restrictions are included in the planning process. This wider approach was so fundamentally different from the original MRP system that it, in 1984, was named Manufacturing Resource Planning (MRP II) by Wight. (Chen, 2001)

Often the MRP II works in a loop where the scheduled production is verified in a first capacity control called Rough Cut Capacity Planning. If the scheduled production differs too much from actual capacity it is sent back to the MPS for rescheduling. Not until the production schedule is accepted is it sent to the MRP. After the production plan has been generated is it sent for another capacity check in the Capacity Requirements Planning (CRP) where the detailed production is verified. If the production plan differs too much from production capacity it is sent back to the MPS for rescheduling. When the production plan is accepted it is fixed. The scheduling and planning covers a horizon which is continuously being re-planned and re-scheduled and only fixed when it is sufficiently close in time. (Chung and Snyder, 2000)

In the 1990s the development continued and the new concept was termed ERP by Gartner Group. The scope did not cover production planning only, but financial systems, human resources systems, project planning systems, marketing systems etc. One key difference between MRP II and ERP is that while MRP II traditionally treated the planning and scheduling of *internal* resources, ERP strives to use the dynamic customer demands and schedules to plan and schedule the supplier resources as well. (Chen, 2001)

The ERP market grew enormously in the late 1990's and companies started to invest enormous amounts of money in ERP systems like SAP R/3, Baan, Oracle or JD Edwards.

2.5.2. SCM

When considering how the view of the inter-enterprise relationship has evolved, it is clear that the development is parallel to the one of ERP systems. The main propellant is the same: increasing the profitability of the business, mainly by reducing cost, by shortening the time-to-market and improving delivery accuracy.

The SCM business philosophy has evolved out of the field of logistics. During the 1960s, the focus was on physical distribution rather than on business-to-business (B2B) relationships. Optimization was limited to internal functions.

This emphasis shifted in the 1980s towards total quality management (TQM), where the primary mean of competition was the quality of the actual product. Still the supplier-customer relationship was on an adversarial level.

During late 1980s and early 1990s, the trend was process engineering. An increasing international competition put pressure on business processes to be streamlined along the value chain. Organization structures started to align with processes. Manufacturing systems in organizations were enhanced with information technology tools such as enterprise resource planning, distribution requirements planning, electronic commerce, product data management, collaborative engineering etc. (Chandra and Kumar, 2001). US enterprises started to incorporate Japanese business practices that involved supplier relationships. A supplier partnership, *Keiretsu*, involving partial ownership of the suppliers themselves, was observed to be an effective method of improving quality and reducing cost. The B2B relationship has been formulated by the SCM evolution in recent years. Continually systems for better B2B interaction, improved production and simultaneous forecasting have been developed. (Tarn, Yen and Beaumont, 2002)

2.6. The ERP/SCM Market

In general companies in need of software SCM support have the option of either constructing their own solution or adopting a vendor's solution. If choosing to adopt a vendor's solution they normally consider solutions from both ERP based vendors and SCM-only vendors since most ERP based SCM solutions are possible to integrate into any other ERP system. The question of integration will be further discussed in section 6 Affecting parameters in the selection of SCM support. Some SCM providers, both ERP based and best of breed, and their solutions will be presented in section 3 Presentation of SCM providers.

2.6.1. ERP

The world's five biggest ERP system providers are SAP, JD Edwards, Baan, Oracle and PeopleSoft. They offer a set of standardized business processes for enterprise management, and sell a packaged ERP solution to improve business performance.

The ERP market is in a mature phase. According to a study of 63 different ERP implementations, a negative value of $1.5 million was found when quantifiable cost savings and revenue gains were balanced against the cost for software, hardware, consulting and support (Stedman, 1999). According a field survey by Interface GmbH, where 644 users of MRP- or ERP-systems were interviewed, 90% were not satisfied by their MRP/ERP systems, indicating significant weak points in these systems. Most companies having adopted a MRP/ERP system use less than 25% of the system (Eds. Goletz, 2001). In order to enhance the value adding ability of the ERP systems, major ERP vendors are attempting to extend beyond the original functionality of the ERP products. One such extension might be incorporation of SCM and CRM (customer relationship management) modules into the ERP package. Yet, the cost of adopting an ERP system increases as the range of ERP implementations becomes wider. This can seriously limit the ERP market, why top ERP vendors are developing packaged products rather than full ERP implementations. These packaged solutions are essentially component-based solutions and lack some of the breadth of full ERP implementations. On the other hand, customized solutions imply delivery and installation at lower cost platform. Consequently, even small- and mid-sized companies can benefit from the ERP systems earlier limited to large companies. (Tarn, Yen and Beaumont, 2002)

2.6.2. SCM

While the ERP market has entered a mature phase, the SCM market is showing strong and robust growth. In the Interface GmbH study mentioned above, 79% of the respondents believed that they would be making SCM improvements in each of the next three years. As ERP systems being used today focus rather on internal than external processes, their emphasis is essentially on control and not on collaboration. They mainly sustain non-value-added activities. In comparison to this, SCM systems let the companies react quickly to external changes by maintaining a pertinent view of their supply chain. Another important difference is the real-time optimizing ability of SCM systems, permitting them to simultaneously execute core activities such as manufacturing planning and scheduling, demand planning, distribution planning and transportation planning. And maybe most importantly: doing this in a synchronized way all along the supply chain. It is obvious that a well functioning SCM system implies a foundation for cost savings and improved supply chain performance. It is no wonder companies are expected to increase their spending in SCM systems (Perez, 2002). The European market for SCM will increase its turnover from $485 million in 2000, to $2,78 billion in 2007 according to Frost & Sullivan (Wallström, 2001). Some major SCM providers present on the Swedish market are the best of breed providers such as i2Technologies, Manugistics, Logility and Syncron, and the ERP providers Intentia, IBS, IFS, SAP, Oracle, Baan, and J.D. Edwards.

2.7. Trends on the SCM market

One major trend is the development of ERP into a new broader enterprise system extended with sales-force automation, data warehousing, document management, after sales services and SCM. Market analyst Gartner refers to this new extended enterprise system as ERP II. Incorporation of complete SCM solutions into the ERP packages also implies a major shift in the market about to take place. Many ERP vendors have been

struggling with insecure ROI to their customers, prolonged implementation periods and unexpected implementation costs. The new enterprise systems might be a solution to these problems, much thanks to increased profitability with support for proper handling of the supply chain. Also many ERP vendors and ERP consultants have learnt how to implement the systems properly while keeping track of hidden costs. (Birnbaum and Grackin, 2002; Tarn, Yen and Beaumont, 2002)

This is predicted to cause a more crowded market for SCM. Best of breed providers like i2 Technologies and Manugistics have been cornered into a position where their main market is being invaded by ERP vendors looking for a new strength for their applications, thus delivering higher return of investment to their customers.

Another trend is the adaptation to the Internet. SCM providers develop web-interfaces for customer facing sites and collaboration over the net. The intention is to create easily accessed suites adapted for and used by any tier in the SCM network. (Davydrov, 2000)

Most ERP vendors claim today that their SCM solutions can provide what specialized SCM vendors deliver, and that they can do it at a lower price. SCM providers however claim that there is a big difference between ERP-based SCM solutions and their specialized SCM solutions, stating the real-time optimization abilities as an example. Traditionally this has been a fact, but the implementation of ERP providers' SCM solutions is becoming a more frequent case and the differences in functionality is decreasing.

3. Presentation of SCM providers

Following will be a short presentation of some of the most reputed providers of SCM. Both specialized SCM providers and ERP providers are presented. The ERP providers are only presented by their SCM solution since it is still quite an entangling task just to present the SCM suites available.

SCM modules and suites are presented by the provider's name, which implies that definitions vary. The more diffuse software modules are given a short explanation.

3.1. Limitations

It is an overwhelming task to present in an objective way solutions provided by the vendors present on the SCM market today since the software suites are highly complex. Most vendors' solutions are the result of more than decades of development, add-ons, restructuring, adaptation to business areas and so on. Consequently the contents are synthesized according to the objective of this paper. In order to obtain a more comprehensive view of each provider's solution the reader is urged to directly contact the provider.

Vendors presented here are the ones selected for the study. For a description of the selection of SCM providers the reader should refer to the section Limitations of the Scope.

3.2. Baan

In 1978 Baan started as a financial and administrative company founded by Jan Baan. The company released its first MRP software in 1987, and since then the company has grown to cover more than 35 countries. Today Baan is included in the top five ERP vendors. As late as in April 1998 did the company create a separate SCM business. The SCM modules being integrated with their ERP software can also be used together with other ERP systems. Today the SCM suite is named iBaan for Supply Chain Management.

SCM product line includes:

- Demand Management
- Strategic Supply Chain Network Design
- Logistics Management
- Production Planning and Order Fulfillment
- Supply Chain Event Management

iBaan Demand Management lets companies establish close relationships with customers and sharing demand information and forecasting. Through Strategic Supply Chain Network Design the user can evaluate location of production and inventory in relation to remaining supply chain and develop strategies for which site to serve which clients. Logistics Management provides an operational tool for logistics operations such as order management.

The Baan planning engine is a constraint-based APS solution to optimize production and transport in order to construct an ever-profitable situation for the user.

Vertical solutions include Aerospace and Defense, Automotive, Industrial Machinery and Equipment, Electronics, Telecommunications, Logistics, and Process Solutions.

3.3. i2 Technologies

Founded in 1988, best of breed SCM provider i2 has presented a strong growth up till now. i2 started and became a leader in manufacturing scheduling, through various acquisitions more functions have been added to the package. The original idea was to implement mathematical methods for supply chain optimization into software. These mathematical methods were progressively extended to apply to other parts of the supply chain than just manufacturing.

The latest i2 release Value Chain Management Five.Two (5.2) includes supply chain management, demand chain management and supplier relationship management. By this i2 continues its development from a set of advanced planning and optimization products for manufacturing. The Value Chain Management suite supports collaborative-based planning and execution functions, such as design, source, negotiate, buy, make, move, store, service, fulfill, market and sell. Today relatively few i2 customers are live with i2's collaboration features.

i2's Network Services extends i2's software to public and private marketplaces, enabling supply chain participants to collaborate over the Web.

SCM product line includes:

- Procurement
- Network Design
- Demand Planner
- Supply Chain Planner
- Inventory Collaboration
- Factory Planning and Scheduling
- Replenishment Planner
- Transportation and Distribution Planning

Latest release 5.2 is a development towards a more quickly implemented solution with lower cost of ownership.

The factory-planner considers material and capacity constraints and generates an optimized production plan and a schedule for the factory. The Supply chain planning function considers material and capacity when matching supply to demand. Replenishment planning evaluates constraints in the supply chain such as lead-times, material availability and storage capacity to keep inventory levels at a minimum.

Vertical Solutions include Aerospace and Defense, Automotive and Industrial, Consumer Packaged Goods, Energy and Chemicals, Consumer Electronics, Electronics

Manufacturing Services, Original Equipment Manufacturers, Semiconductor, Metals, Pharmaceutical, Retail, Softgoods, Telecommunications, and Utilities

3.4. IBS

Swedish ERP provider International Business Systems offers a system called Application SoftWare (ASW) aimed for wholesale distribution and supply chain execution for mid-sized and large enterprises. ASW is based on the platform AS/400. The company was founded in 1969. Through partnering with i2 Technologies IBS now provides a complete SCM collaboration suite combined by the Virtual Enterprise and ASW suite. IBS also works in close development with IBM.

IBS focuses on customers with demanding requirements in terms of advanced inventory and warehouse management, short response times and large transaction volumes. Consequently, IBS customers are mainly medium-sized and large distributors and manufacturers.

SCM product line includes:
Within the ASW system:

- Distribution (sales, inventory and replenishment)
- Distribution Requirements Planning
- Inventory Control
- Industrial Manufacturing
- Warehouse Management

Within the Virtual Enterprise suite:

- Collaborative Demand Planning (i2)
- Collaborative Supply Chain Planning (i2)
- Collaborative Procurement
- Collaborative Sales

The Distribution Requirements Planning is a tool for organizing replenishment throughout a warehouse network, with a proactive approach. Inventory Control is an enhanced replenishment function, product values are periodically updated and include forecast demand, economic order quantity, reorder point and safety stock level. The Warehouse management solution provides functions for warehouse operations and management. It is a tool for reducing operational and capital costs, to improve space utilization and customer service.

Virtual Enterprise is a collaboration software integrating different ERP software and enabling supply chain coordination and synchronization. The purpose of the Virtual Enterprise suite is to link different companies into a united company through sharing of information and functions. The collaborative demand planning and supply chain planning functions are provided by BOB provider i2 Technologies.

IBS focuses primarily on customers within electronics, chemicals, pharmaceuticals, medical supplies, durable consumer goods, industrial components and spare parts.

3.5. IFS

Swedish ERP vendor Industrial and Financial Systems was founded in 1983 and has seen a strong growth since. The IFS ERP system, IFS Applications, is focused on large and mid-sized manufacturing companies. The company provides its business solutions in a strongly component-focused approach where each solution is built on a foundation of open architecture, and with modules attached according to the specific client situation.

SCM product line includes:

- Supply Chain Management
- Demand Planning
- Inventory
- IFS Manufacturing
- IFS Distribution

IFS' SCM supports supply chain visibility and collaboration via portals with forecasting, demand planning, and supply chain event management functionality. Demand Planning supports forecasting and collaborative demand planning. IFS Distribution and IFS Manufacturing are functional suites containing several modules.

Vertical Solutions include: Aviation and Rail, Defense, Energy and Utilities, Engineering and Project delivery, Forest Segments, Repetitive/Automotive, Service Management, and Telecommunications.

3.6. Intentia

Intentia was founded in 1984 in Linköping, Sweden. The company vision was to offer software and services that would help companies in logistics, production and finance. In 1999 the company launched the first Java version of its software Movex. Today Intentia has approximately 3400 employees and 3500 customers in 40 countries.

Some of the SCP and SCE functions are provided through partnerships with Mercia and Manhattan Associates. Most clients are mid-sized manufacturing companies.

SCM product line includes:

- Demand Planner
- Supply Chain Planner
- Multisite Planner
- Global Capable to Promise
- Transportation Management
- Warehouse Management
- Master Production Scheduling
- Material Planning
- APP Advanced Production Planner
- e-Collaborator

Movex SCM suite supports constraint-based supply chain planning and execution. It also supports planning functions for demand, supply and production. APP is an enhanced planning tool considering finite capacity constraints and material flow throughout the entire supply chain. The e-Collaborator provides a foundation for business collaboration.

Vertical ERP solutions include: Automotive, Distribution, Fashion, Food and Beverage, Furniture, Maintenance Repair and Overhaul, Paper, Steel, Service and Rental.

3.7. J.D. Edwards

J.D. Edwards provides an SCM suite within its ERP II suite. The JDE SCM solution is considered having some development to do before being able to meet with best of breed SCM providers. However J.D. Edwards is continuously improving its solution One World, adding CTP functionality by 2001.

SCM product line includes:

- Demand Planning
- Production and Distribution Planning
- Production Scheduling
- Order Promising

JDE is providing a wide solution for SCM for large and medium enterprises. Manufacturing and network planning functionality, ERP integration and acquisition price are the solution's strengths.

Vertical ERP solutions include: Automotive, Chemicals, Consumer Products, Construction, Energy, Field Service, Financial Services, High Tech and Electronics, Homebuilders, Industrial Manufacturing, Life Sciences, Mining, Paper, Professional Services, Public Sector, Real Estate, Telecomm, Utilities, and Wholesale Distribution.

3.8. Logility

The core competency of Logility, being a best of breed SCM provider, is within demand planning and supply planning. Software solutions are delivered under the Voyager suite, covering both supply chain planning and execution. Logility also provides a Web based collaboration solution for information sharing between enterprises, retailers, customers and suppliers. In addition to core competencies Logility also offers event management and strategic support such as network design and strategic sourcing.

Primarily Logility targets enterprises within distribution-intensive domains, such as consumer goods, retail, chemicals and pharmaceuticals, food and beverage, and associated distributors and suppliers within these markets.

SCM product line includes:

- Value Chain Designer
- Demand Planning

- Inventory Planning
- Life-Cycle Planning
- Supply Planning
- Replenishment Planning
- Manufacturing Planning
- Transportation Planning
- Voyager Collaborate
- Voyager Navigate

The Logility SCP suite is considered to be relatively easy to implement. Manufacturing Planning and Supply Planning are powered by constraint-based planning engines. Life-Cycle Planning is a tool to plan each phase of a product's life cycle. Voyager Collaborate is a web-based B2B application for collaborate planning, forecasting and replenishment. Voyager Navigate is an event management tool.

Logility has a horizontal approach, implementing its solutions across many industries. The vendor claims that its software does not need to be tailored for each implementation, only one set of source code that can be implemented anywhere through configuration files.

3.9. Manugistics

Founded in 1969, best of breed SCM provider Manugistics was originally called Scientific Time sharing Corporation. In 1980 the company developed and marketed its first supply chain management software and twelve years later it changed name to Manugistics. In a continuous ongoing process the vendor has added more functionality to their SCM products, and today it has one of the most complete product lines on the market.

The suite NetWORKS is developed to support strategic, tactical and operational management of the supply chain. NetWORKS Supplier Relationship Management adds support for managing processes within the material life cycle, through collaborate design, strategic sourcing, supply planning, procurement and analysis. The SCM component provides material planning, demand management, inventory management/replenishment, order fulfillment and transportation management capabilities. By integrating its three main application suites the vendor offers what it calls an Enterprise Profit Optimization solution (EPO). The purpose of EPO is to simultaneously optimize demand and supply within an enterprise while considering pricing strategies derived from its Pricing and Revenue Optimization (PRO) support. This type of analysis and software in the SCM market remains relatively unproven.

SCM product line includes:

- Network Design and Optimization
- Manufacturing Planning and Scheduling
- Sales and Operations Planning
- Fulfillment Management
- Collaborative VMI & Collaborative Planning, Forecasting and Replenishment
- Service and Parts Management

- Order Management
- Logistics Management
- Profitable Order Management
- Profitable Demand Management

Manugistics, as a best of breed SCP software provider, offers depth in its supply chain optimization products and can target specific industry verticals, which differentiates, according to Gartner, this vendor from large ERP vendors trying to cover the entire spectrum of an enterprise's technology needs. Manugistics' SCP modules are suited for complex BOM collaboration, distribution-intensive industries and processes, although some large ERP vendors can prove tighter application integration in their product suites.

Vertical solutions included: Aerospace and Defense, Apparel, Footwear and Textiles, Automotive, Chemicals, Consumer Packaged Goods, Communications and High Tech, Energy, Financial Services, Food and Agriculture, Government Sector, Industrial Sector, Life Sciences, Retail, Transportation, and Utilities.

3.10. Oracle Applications

Oracle was an established database vendor before moving into the ERP market in 1989. As an ERP II provider Oracle provides an SCM suite with constraint-based advanced planning applications, SCP and SCE.

Oracle Applications SCM provides advanced planning and scheduling (APS) that supports planning for demand, supply, inventory, manufacturing production (process, discrete and flow) and procurement.

SCM product line includes:

- Demand Planning
- Supply Chain Planning
- Manufacturing Planning and Scheduling
- Inventory Planning and Optimization
- Global Order Promising ATP, CTP

Oracle is also currently developing its supply chain execution suite. The APS software is still regarded as relatively untried, with a lack of live customers. Gartner recommends SCM clients with more complex SCP requirements to also look at more practiced solutions.

Vertical ERP solutions include: Aerospace and Defense, Automotive, Chemicals, Communications, Construction, Consumer Packaged Goods, Energy, Engineering, Financial Services, Government, Healthcare, High Tech, Life Sciences, Metals, Retail, Travel and Transportation, and Utilities.

3.11. SAP

SAP is by far the biggest ERP provider on the market with its product R/3. SAP was founded in 1972 by five former IBM systems engineers. Today SAP employs 27800 people. The company has 17500 client organizations through120 countries.

The planning applications of mySAP SCM support both strategic and tactical planning requirements. The strategic planning, Supply Chain Design, helps organizations identify and select strategic elements of the supply chain, such as manufacturing locations, and map out the supply chain to accommodate evolving market conditions.

SAP's Advanced Planner and Optimizer (APO) is a major component of the mySAP SCM solution and provides tactical and operational planning functions. It combines the enterprise resource planning (ERP) execution capabilities of the R/3 system with SCM tools, a library of advanced optimization routines for an extended supply chain. APO offers integrated applications supporting demand and supply planning, production planning and scheduling transportation and vehicle scheduling, collaborative procurement planning, and vendor managed inventory (VMI).

SCM product line includes:

- Collaborative Planning, Forecasting and Replenishment (CPFR)
- VMI
- Supply Network Planning & Deployment
- Production Planning and Detailed Scheduling
- Demand Planning
- Global ATP
- Supply Chain Event Management
- Transportation Management

SAP offers an SCM solution containing both advanced planning capabilities in APO and execution capabilities. These functions have been greatly improved by SAP and the solution is seriously competing with the specialized SCP solutions. Even though SCM is not considered the core competency of SAP there is no doubt SAP is gaining momentum in SCM and has reached a high level of license revenue on its SCM products.

SAP APO is continuously developing and has started to gain interest even among high requirements users. Yet the SAP APO industry-specific functionality is left to mature according to Gartner.

Vertical ERP solutions include: Aerospace and Defense, Automotive, Banking, Chemicals, Consumer Products, Engineering and Construction, Financial Service Provider, Healthcare, High Tech, Insurance, Media, Mill Products, Mining, Oil and Gas, Pharmaceuticals, Public Sector, Retail, Service Providers, Telecommunications, and Utilities.

3.12. Syncron Supply International

Syncron is a Swedish supply chain management and collaboration company providing best of breed logistics and B2B solutions since 1988. Main focus is within supply chain planning activities and collaboration.

SCM product line includes:

- Demand Forecasting
- Replenishment Planning
- Planning & Scheduling
- ERP Connector
- The Supply Chain Planner

One of Syncron's major strengths lies in its forecasting solution, which has an enhanced support for demand pattern classification. Then inventories and replenishment is handled according to each type of demand pattern. The ERP Connector application provides interface between a wide range of ERP systems.

Like Logility, Syncron does not see any need for providing industry specific solutions as their solutions are equally fit to be implemented into any industry, under any circumstances.

4. Foundation for the field studies: the SCM users

During this research several case studies were carried out, investigating the circumstances for SCM support implementations. The objective of each interview was to gain a general view of the situation of the company and its supply chain at the time of the SCM acquisition, the selection and implementation process, and the situation after implementation was carried out.

This objective had to be somewhat changed during the research since not all companies have a single point of time when support was acquired but have been developing their supply chain support during time either on their own or together with an external provider. In these cases focus was on the development process and the situation that forced the development.

Companies interviewed have selected or are currently using SCM support provided by i2 Technologies, Logility, Manugistics, Movex, Syncron, IBS, SAP, J.D. Edwards or a solution created by the user itself. This is not the complete range of providers considered from the start. Limiting to this factor was the companies' possibilities to contribute to the study and the time previewed for field studies. Yet, the spread of providers was found sufficiently wide in order to elevate a general view of the factors affecting companies in their choice of SCM solution in 2002.

The users are distributed accordingly over system type:

- 7 users of SCM best of breed solution
- 5 users of ERP providers' solution, occasionally enhanced

The users are medium or large sized companies with international organizations.

4.1. Different implementation projects

Common for all users is that they have conducted or are continuously conducting major SCM implementation projects. These projects vary largely both in depth and range. Some concern globally the whole enterprise in one or several domains, while others only concern a limited part of the business, but then in a more profound aspect.

4.2. The problems solved by SCM

Every user indicated several reasons for their SCM selection. Among those, two major groups could be discerned. Some companies had acquired the SCM support because the systems already in use were not able to deliver some functions. Those companies generally only implemented specific functions from specialized SCM providers. Other companies experienced structural problems concerning primarily organization integration or system integration.

5. The system selection process

During the research there has been a pattern of how the selection of an SCM system has been conducted. In the following section is presented a short description of a typical process. The author has chosen only to present the selection of the system and not to describe the implementation process since the implementation processes seem to vary more from case to case and since it has been difficult to obtain a detailed description of these processes.

5.1. Process mapping

Almost exclusively the selection process starts with an investigation of the company's own business processes. The mapping of these processes aims at generating knowledge about exactly *what* is being done *when* by *whom* and *how* it is done. A mapping activity is always required when there is a major restructuring about to take place. The mapping of the processes results in a description of the company and a list of what parts of the business processes that need to be changed. In SCM selection processes the typical need can be:

- Ability to range products into valid product categories.
- Ability to measure service rate to final customers.
- More accurate demand forecasting.
- Visibility throughout the supply chain.
- Scalability of planning process and possibility to work at different levels of detail (days, weeks, months)

5.2. Formulation of criteria

This need of change is then transformed into a more formal sheet of demands of the new system. Normally the criteria are categorized into:

- Functional criteria (Is the module really solving the problem?)
- User criteria (Is the module easy to use? is it logic? How fast is it?)
- Integration (How difficult will it be to integrate the solution with the business systems being used? What will implementation cost in time and money? Future systems?)
- Provider criteria (Will the provider still be present in ten years from today? Will our company be an important client to this provider? What's the accessibility of this provider? What do we generally think of this provider?)

Each of these categories contains a multitude of criteria where each one is given a grade of importance.

5.3. Listing of providers

A list of providers and the capabilities of each system is constructed, sometimes with help from independent consultants who might propose appropriate providers. The depth of this list can vary, throughout the research it has been found that this list can

sometimes be incomplete. Many SCM clients are poorly aware of the presence of the SCM providers on the market, and complaining about lack of information.

Each solution is then tested against the criteria and evaluated through a graded system.

5.4. Business case or demonstration

In order to do a more profound study of each provider's solution, one or several business cases may be constructed posing some of the problems that the solution should be able to handle. The case could concern an operational activity like handling of order/stock at a regional store or could be a more strategic problem of locations of inventory. The providers then present their solution to the problem and how each system would handle the situation.

Often the provider is asked to demonstrate a real business case by referring to a client.

5.5. Summary and selection

Finally the results are collected and weighted into a final judgment about each provider and its solution. Not to be underestimated are the personal preferences about the solutions in competition. The final judgment is taken into account when the buying company considers the offers, license cost, implementation cost etc. After the selection is done the implementation normally starts. Sometimes the decision taken in the selection process needs to be confirmed with other units or the results from parallel projects within the company have to be awaited before starting the implementation. Sometimes the purpose of the selection process is just to give advice to executive units.

6. Affecting parameters in the selection of SCM support

The contents of this paragraph are entirely obtained from the user interviews undertaken throughout this research. It is therefore necessary to bear in mind that the source of information is a limited number of case studies. The following sections should be read as examples and not as a complete mapping of underlying parameters. Nevertheless it could be argued that complete answers to the questions "What parameters affect companies in their selection of SCM support? And how do they affect?" do not exist. Every enterprise has its own process of selection and in the end there will be a personal judgment deciding which system to adopt. Consequently two different companies in a similar situation might very well opt for two different systems. However this does not diminish the interest for the problem. By studying some situations leading to a choice of system we can learn about the situation on the SCM software market, about the situation of many companies in need of them and what they expect from the future.

The first objective of this field study has been to locate the parameters affecting companies in the selection of SCM support. Secondly the importance of the parameters is estimated. This is done based on the qualitative discussions carried out with the users/potential users of SCM systems. The importance of the parameters is more difficult to analyze. Consequently the parameters are arranged into Parameters of absolute importance, Parameter of some importance and Parameters of uncertain importance. Thirdly the direction in which each parameter affects the selection is given in those cases where a direction has been possible to detect. It must be understood that there is a risk in defining the importance of parameters and their direction of impact as every company's situation is specific and parameters often work in conjunction. Yet there is a need to define the effect of a parameter since 1) without effect it is not a parameter and 2) defining the influence of each parameter gives further understanding of the situations leading to SCM decisions.

When a company implements an SCM support there are normally several factors affecting the choice of system. It must be assumed that when taking these factors out of their context, studying them as isolated parameters, there is a certain loss of pertinence. Parameters should be regarded as weights, influencing the choice of system in one direction or the other.

In order to understand the parameters affecting the selection of the SCM system it is important to understand the purpose or the goal of the implementation. Even though the situation urging an enterprise to acquire SCM support varies greatly from case to case the goals of the implementation remain surprisingly similar. Therefore this section will start by defining the goals as they have appeared in this research.

The most important parameter affecting the selection is the type of system being bought. During this research, SCM support was acquired through two different acquisitions. The first one being when an enterprise is buying a new complete ERP system. In these cases the company already has an SCM function, and the supply chain requirements are only a part of all requirements of the new system. The second case is when the system acquired is an SCM system and the selection is then more focused SCM questions. Still integration ability with other systems, especially ERP systems

remains an important issue. These two cases will be described under the section “Two types of implementation”.

6.1. The Goal

It is surprisingly easy to define the goals for SCM implementation. A company is in need of saving money, reducing risk, improving service quality or gaining control over the business processes. Often several of these are the goals of an SCM implementation. The goals will here be shortly presented together with some examples of how SCM support help achieving them. They will reappear under each parameter section and explain how they are affected by each parameter.

6.1.1. Reduce cost

Costs connected to production and distribution may be decreased using SCM support. It may decrease costs for resources locked in production, stock or transportation, it may also decrease costs due to wasted production. Thus a common goal is to reduce stock quantities or to reduce lead-times.

Costs connected to IT infrastructure can be decreased. Sometimes a big organization is using several different systems on several locations for functions that can be contained in one single system. Thus taking all forecasting and replenishment planning functionality into one system might reduce license and maintenance costs. Naturally this can be done through integrated ERP solutions as well, where the solution integrates with the legacy system.

6.1.2. Improve service level

Service level may be defined as the extent to which a supplier satisfies customer requirements, it may be measured as resource availability, error rate or the rate of incoming orders that can be delivered on requested date. An important factor to maintain service level is availability, for example availability of products or spare parts. Sufficient would then be to maintain a large stock of spare parts. Only this is directly contradicted to the urge to cut costs. Increasing service level and reducing costs would consequently be hard to do at the same time. Best solution is to keep in stock only what’s needed. This is a typical SCM function. Also SCM solutions may provide a measurement of the actual level of service.

6.1.3. Reduce inventory risk

There is a risk connected to large inventory. If products on stock are fast moving consumer goods or food products there is a certain risk of products becoming obsolete or expired. The larger quantities on stock the larger the capital at stake. To reduce the inventory risk, shortening lead-times decreases risk of products turning obsolete and decreasing inventory quantities reduces capital at stake.

6.1.4. Control of the business processes

By providing a better visibility of the company’s different processes the SCM system can serve as a tool for control. This is done by having updated information about the production, inventory, orders, scheduled deliveries etc. Control over the supply chain

can also be obtained by special decision support functions such as the zoom function where the production planner can, from an overview, select a period of time or a certain production point to investigate at a more detailed level. Another way of using SCM tools to gain control over the supply chain is the ability to work with several versions of a production plan or a delivery plan before fixing it to production or distribution. This means an ability to test several scenarios or a "what-if" simulation. The planner can directly get the result of a change in schedule before undertaking the change. Better control of the supply chain may also be obtained through "manageability". If e.g. a production plan can be updated twice a week instead of once a month the production planner can be more in control of the current situation.

6.2. Two types of SCM acquisition

The first and most important parameter found is the underlying purpose of the implementation. There are mainly two types of selection processes when an enterprise is about to buy an SCM support entirely affecting the choice finally made. Either the SCM system is a part of a complete ERP implementation where the SCM selection process cannot be isolated from the total implementation project, or it is only an SCM system being purchased consequently giving more focus to pure SCM functionality. In the research conducted most cases were pure SCM implementations, nevertheless it could be clearly seen that one of the major parameters affecting the choice of system is whether it is being purchased as an SCM system solely or as a part of a company wide ERP implementation. Before treating each parameter the importance of the implementation type will be explained. The type of implementation is a parameter of absolute importance.

6.2.1. Included in an ERP acquisition

If the company is buying a new ERP-system the selection of SCM support is subordinated to that process. In most cases this means that the SCM solution is not the only objective. Thus the company will most likely opt for an ERP integrated solution. However, if the present ERP solutions lack important features required by the company's treatment of the supply chain the SCM function may be left to be incorporated from an external provider. Today this is a rare case due to ERP providers' efforts to improve their SCM suites. Another cause for separating the SCM selection process is if no ERP system has been found able to cover the company's business processes or not being able to treat the quantities of products, shipments, storage, providers etc. In these cases the implementation process is divided up according to separate functions; Finance, Human Resources, SCM etc. Splitting up the ERP functions for implementation might also be a way of splitting up immense implementation projects.

6.2.2. Independent SCM acquisition

When the selection process is just concerning SCM functions the selection process is still not disconnected from the ERP issue. Following will be a walkthrough of the different parameters affecting the company in the selection of the system. One difficulty of structuring the parameters is the multitude of their characteristics. Factors can be divided into internal factors deriving from the company's situation, structure or

culture and external factors deriving from the SCM market, economical market situation, etc.

Factors can be arranged according to relevancy or purpose of the implementation, i.e. functional, structural or other purposes. The arrangement of the parameters will be further described in the next section.

6.3. The parameters

In the following the affecting parameters are divided into the following groups; Functional parameters, Structural parameters, Other parameters, and Parameters of uncertain importance. This structure is chosen since it reflects the problem the company intends to solve by the implementation, which in general can be divided into function or structure. Functional or structural parameters also constitute a divider between the companies opting for an ERP provider and a specialized SCM solution. Companies that need to add specific functions have here been found to opt primarily for best of breed SCM support.

Important to notice is that during the research these parameters has not been studied isolated from each other as every company has stated several parameters affecting their selection.

It is also to be noticed that the topic of SCM implementation strategies is very broad, in some cases the implementation concerns replenishment functions for every regional inventory, in other cases it concerns a major centralization of production and inventory. This is to alert the reader of the heterogeneous nature of the topic. A more pertinent comparison of different SCM cases might be obtained from dividing the SCM support into separate functions such as demand planning, production planning and supply chain collaboration. Yet SCM deserves to be handled in its complete form in one and the same research if the aim of the research is to gather an overview of the SCM solutions in use today.

6.3.1. Order of selection

The view upon the difference between ERP, specialized, or in-house developed SCM is definitely not the same within every organization. This means that while some companies make a distinction between the different types of providers, some companies don not. This means that *some* companies opt for ERP based SCM versus best of breed SCM before making the decision of *which* system to choose, while other companies include solutions available from both provider types without profound distinction, and weights ERP/SCM provider qualities in the final decision. It is not the purpose of this thesis to declare which approach that is to be preferred. But the reader should be aware that the order of selection varies.

6.3.2. What is a parameter?

A parameter is here regarded as a certain circumstance considering the situation of the company in question that has a possible influence on the decision of which solution is selected for handling the company's supply chain. The situation circumstance can be concerning the interior of the company, like its products and structure of supply chain

or the exterior situation such as the market on which the company is active or the availability of solutions when deciding how the supply chain should be managed.

6.3.3. Importance of the parameters

The parameters have been arranged into groups according to the rate of influence they are found having on the selection of the type of SCM solution.

Parameters of absolute importance

If a parameter is found having a direct influence on the requirements upon the system acquired it is considered having an absolute importance. For example a user has chosen the system type A since that would solve the problem X, consequently X is related to or is itself a parameter of absolute importance.

Parameters of some importance

Circumstances that have a more diffuse influence on the requirements upon the system acquired but still clearly concern the selection of SCM solution in some way are considered as parameters of some importance. Typically this could be parameters that work indirectly on the selection of the system or parameters that have an influence that's noticeable only when combined with other parameters. It is not the purpose of this thesis to map which parameters that work in conjuncture. The main idea is that parameters of some importance have an influence but less obviously than parameters of absolute importance.

Parameters of uncertain importance

On some occasions the users have stated that a parameter has no influence even if it seemingly should. If these parameters are suspected having an importance those are given the status of parameters of uncertain importance. Parameters of uncertain importance could be such that they require further study before revealing whether they have an influence or not. Circumstances subscribed to uncertain importance are collected under the section 6.7 Parameters of uncertain importance. This is partially so since they should not be discarded but be given more attention in continued studies.

6.3.4. Cases

In order to clarify some circumstances considered as affecting parameters short examples are given describing the situation that has influenced a company in its choice of system. These cases are fiction. They are inspired by situations encountered during the research but normally they are a mixture of situations and business areas or simplifications of situations encountered. No conclusions about the enterprises participating in this research should be drawn from these cases. Only those parameters where exemplification can be clarifying are complemented by a case.

6.4. Functional Parameters

The following parameters reflect a problem that the user tries to solve by implementing an enhanced support. The user wants to add *functionality* to the system already in use, why the following parameters are grouped as Functional Parameters. In these cases the user is generally satisfied by the overall system performance but experiences a few exceptional shortcomings. It is consequently not a question of implementing a new ERP

system. However ERP providers are still highly interesting by their specialized SCM suites. The decision of best of breed, ERP or in-house developed SCM is still to be made.

The first parameters described are concerning the market characteristics of the company. If the market is highly irregular and future demand is difficult to forecast the company experiences a need for SCM support, this parameter is called *Demand Pattern*.

In comparison with demand forecasting difficulties are the supply planning difficulties, normally in the form of irregular capacity of the suppliers or difficulties for the suppliers in delivering orders due to irregular demand from the company. This is connected to the *Supply Situation* parameter.

Some parameters are directly connected to the products' characteristics such as *Product Availability Requirements, Level of Technical Complexity of Products, Forced Lead-Time, Limited Product Durability*, and *Fast Moving Consumer Goods*.

The last parameter in this section is due to productions characteristics and is called *Complex Manufacturing*.

6.4.1. Demand Pattern

One major conclusion reached during the research is that almost every user experiences difficulties or high difficulties in predicting future demand. This is one of the most central reasons for implementing an SCM support. There are two major actions that can be undertaken, either the company tries to improve its forecasting methods or it tries to reduce the impact of unpredicted demand.

Forecasting

There are two main ways of producing a forecast; using historical analysis such as exponential smoothing and the moving average method or using sales estimations collected from sales units. Normally both methods are used simultaneously. Mathematical forecasting might often need to be changed to take into account exterior circumstances not considered by the forecast model and sales estimations might need to be backed up with underlying data. One problem with sales estimation is that they are founded on personal interpretation of a situation and different sales units might work differently and the amount of attention given to forecasting might vary greatly.

Some demand patterns being hard to forecast are lumpy, new and slow. "Lumpy" demand is when orders tend to arrive in clusters, and between demand peaks incoming order frequency is relatively low. The demand pattern of "new" products arriving at a market is represented by an introductory weak demand, followed by a quick increase and then stagnation at a mature market. In the "slow" demand pattern the frequency of incoming orders is low as is the level of demand. These demand patterns can be seen in figure 5.

The demand forecasting function is quite specific and normally a company in need of enhancing this function would contract a specialized provider with confirmed success, preferably within the business area concerned.

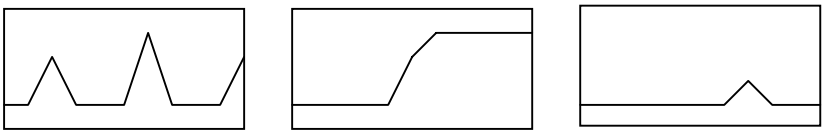


Figure 5. Lumpy, new and slow demand patterns

Reducing demand impact
Actions to reduce impact of unpredicted demand normally aims at making the supply chain able to respond quickly to changed circumstances at low cost. This could be shortening lead-times and a close tracking of incoming orders at sales level in order to quickly detect changes in demand. Maintaining a large stock also reduces impact of changes in demand. If the production plan can be updated frequently production will be easier to change to new circumstances.

One way of reducing demand impact is also to arrange the products into groups depending on the demand pattern. Normally only a restraint number of products are really difficult to forecast. If arranging the products into groups according to demand pattern, those products with irregular demand can be given more attention, for example through special agreements with suppliers. The supplier could for example accept a much shorter lead-time for those products if a more regular supply rate is accepted on other supplies.

Case 1:
A company constructs equipment of high technical complexity, called a system. Each system contains 300 different components and has a lifetime of about ten years. The price of a system is around 10K Euros. The product range counts 100 product ids due to development and merger. Spare parts has to be available within 24 hours otherwise no client will be interested in a deal. The company is present in Europe and North America. The SCM problem concerns the spare parts. Out of 20 000 spare parts 20% are regularly being sold, the rest just need to be available. Those parts being sold present a lumpy demand. This obliges the company to maintain a major stock at high cost even though the sales are low. The company has a poor image of the demand pattern of the spare parts.

Solution:
Forecasting support and enhanced replenishment planning. The company invests in a specialized solution for spare parts where products are categorized according to price and frequency of sales. Each product category is given the most suitable forecast model and replenishment is done according to sales frequency and forecast. The higher the price and the lower the sales frequency of a product the lower amount of it stored on regional depot, keeping the major inventory on central stock.

The purpose of implementing forecasting and replenishment support is normally to decrease inventory cost and to increase service level.

Problems in forecasting the demand is one of the major causes for implementing an SCM support. Many companies sense that they have ways of handling the business processes within the company but very little expertise when it comes to predicting future demand, using demand models and estimate the preciseness of the forecasts, and incorporating predictions in a production plan. Consequently a company experiencing forecast failures and the costs of not predicting demand is easily convinced about the need of an effective demand planning tool. However, promising successful forecasting is hazardous and there are examples of companies who find that the biggest benefit of the implementation was the demand planning knowledge acquired by the employees and not the software implemented.

Synthesis
Demand pattern is a parameter of absolute importance, which points towards a specialized solution.

6.4.2. Supply Situation

Common for all companies present in this research is that they all belong to a supply chain. That is, their business activity requires supplies, which are either raw material collected by the company itself or products delivered by the company's suppliers. If the company experiences problems with its supplies this implies problems in carrying out the business activity. Frequently problems in receiving supplies aggravate the problems of forecasting the demand, and vice versa. A company squeezed between unpredicted demand and poor delivery security of supplies is in a situation that is very difficult to handle, and normally results in lost orders and market share.

There can be many problems connected to supplies. During this research however, only a few situations were encountered. It must be suspected that other situations concerning supply problems have an effect on the SCM support selected. But here will only be described the situations and selections discovered during the field study.

Supplier production strategy
In a supply chain companies and their suppliers are sometimes rigidly attached to each other. Market strategy can be one reason for rigid attachment, where a close relationship permits a closer cooperation. Another factor is geographical access; sometimes there is only one supplier available in the area. There can also be a more technical reason for close relationship between supplier and companies if there is only one supplier able to deliver the product needed by the company. When the company is highly dependent on its supplier, it is also largely concerned by delivery problems since it has little possibility to change to another supplier in short time. The question of supplier dependency will be further treated under the 6.7.1 Dependency section.

If the supplier has a production strategy conflicting with the needs of the company, this can mean serious problems in obtaining the right products in right quantities at the right time. A simple example of this is a supplier giving priority to production quantity instead on focusing on delivering the most delayed orders. Increased pressure from the

company on the supplier only results in increased debit of supplies from the supplier, and a more strained situation, if the production strategy is not changed.

This situation is aggravated by high dependency between the company and its supplier, but can occur even if the rate of dependency is lower.

Supply market behavior
If supplies are obtained from a dynamic market where variations occur, like the electronic component market where lack of components may occur, the company may quickly encounter supply problems. Normally variations in supply accessibility result in variations in price, which results in changed profitability for the company and may cause price variations of the company's products. Effects of a strongly varying supply market are hard to avoid, the company may maintain a high level of safety stock on supplies or try to connect suppliers closer to the company. SCM support is used for close collaboration between companies and their suppliers, so it can be concluded that the behavior of the supply market indirectly is a parameter for SCM implementation.

External market drivers
Supplies can also be products sensitive to external factors such as draughts or war. The effect of these causes resembles the effect of complex supply market behavior and it is equally hard to avoid their influence. Companies are left trying to build safety stock, but predicting causes like monetary politics, war or draught is difficult.

Case 2:
A *company* delivers chemical equipment. Each product is composed by approximately 40 components. The only activity carried out by the company is a quick assembly and installation at the client site. Deliveries are linked, (in order to deliver the product all of the 40 components need to be delivered by suppliers). A *supplier* that is closely connected to the company delivers 80% of the components. The *company* experiences a lumpy demand on its products. The *supplier* experiences difficulties in obtaining supplies. The *supplier* prioritizes output rate instead of giving the most attention to the most delayed orders. This means that frequently the *company* can't deliver an order because a few of the components are missing. Lead-time increases and delivery accuracy decreases.

Solution:
Supply Planning. The solution has to be found by both the *company* and the *supplier*. Ranging components into groups in relevance to demand pattern. Prioritizing missing components. The *company* must share the information about incoming orders and forecasts to let the *supplier* plan purchase and production.

Having supply problems does not explicitly imply that external SCM support is needed. In fact, during this research were found examples of companies that were able to

resolve severe supplier problems without any external SCM support, claiming that supply problems still have to be resolved first through direct agreement between company and supplier before software solutions are implemented. This would be especially true for closely related suppliers. It must be thought however that an SCM solution would be equally able to deliver a supply solution. Furthermore supply problems deriving from situations where suppliers are less attached or problems deriving from supply market behavior or external market drivers might require more general solutions like enhanced supply planning in order to facilitate changes in sourcing strategy.

Other examples were found during this research were SCM was used by companies in order to "smooth" the supply plan, in order to facilitate the suppliers situation. By smoothing the supply plan, suppliers can more easily fulfill delivery requirements and are not struck by high variations in demand. Consequently planning is easier for the suppliers and a more leveled demand lowers the product price, which is beneficial for the company buying the products.

Synthesis
The Supply Situation parameter has to be given the status of absolute importance since supplier problems are directly affecting the company and its supply chain. The relations with suppliers and the planning of supplies is one of the most basic SCM functions. However the need of external support depends on the structure of suppliers and the supply chain. It is hard to give an unambiguous direction of influence of the parameter.

6.4.3. Product Availability Requirements

Some products have high requirements on availability and delivery accuracy. This can be spare parts to medical equipment or equipment to process industry where a stop is very costly. In those cases clients might not be interested in buying a product from a company that cannot provide a supply guarantee or even provide spare parts on stock in the geographical vicinity. In these cases a well functioning supply chain is a mean of competition and even a *requirement* to be present at a certain market.

Case 3:
A company manufactures and sells clinical equipment to hospitals located in Europe, America and East Asia. The equipment consists of computer terminals, mechanical equipment and expendable materials. By contract the company is obliged to serve the client with spare parts within 24 hours should vital parts be needed. This is market standard. There is no risk of not fulfilling this thanks to efficient but costly instant delivery services. Total stock of spare parts is 19 000 parts. There is a requirement to keep vital parts on regional stock with a safety stock about 3 WOSS, Weeks of Sales in Stock. Demand is lumpy. Focus is to keep right amount of the right component on stock.

Solution:
Regional stocks are maintained with demand forecasting and replenishment planning. The company can prove that deliveries are granted. Stock value is kept as low as possible.

Companies experiencing high requirements on the efficiency of their supply chain have been found selecting a specialized SCM solution. It cannot be excluded that these implementations also serve a marketing purpose. Indicating the firm's eagerness to meet with market requirements and preferably surpass them.

Synthesis
Product Availability Requirements is a parameter of absolute importance, mostly implying a best of breed support containing enhanced forecasting and replenishment functions.

6.4.4. Level of Technical Complexity of Products

If the company manufactures a product which is composed from a high number of components and where technical development is a major mean of competition the product is considered being technically complex.

The influence of the technical level of complexity has been quite difficult to analyze. On one hand the technical level of complexity has been an indirect cause for SCM support implementation, e.g. the amount of spare parts needed to be kept on stock is directly dependent on the number of components in each product, consequently high level of technical complexity implies a large number of spare parts to keep on stock especially if product development frequently delivers new models. The automotive industry is a good example of this. On the other hand, examples were found of companies with products of high technical complexity and a large amount of components that claimed no need for specialized SCM support beyond some adaptations of the business processes carried out within the company and towards its supplier.

Synthesis

It will have to be concluded that the level of technical complexity of products is a parameter of some importance and that further studies should yield its influence upon SCM requirements.

6.4.5. Forced Lead-Time

On some occasions there is a limit to how time-efficient production can be. For example if the product has to be left to mature for a fixed period of time or if clinical tests of the product are required in order to be permitted to sell it. In this thesis this is defined as *forced lead-time*. The consequence is that the company is forced to have capital locked in stock or production. No matter what improvements of the production process are undertaken the forced lead-time will always be there.

The effect of forced lead-time can be enormous. First the task of forecasting becomes even more difficult as miscalculations in demand take a longer time to repair. Changed circumstances are difficult to meet. Secondly the huge inventory required implies high inventory cost. Furthermore, if a part of the stock should be of bad quality the consequences are aggravated since lost inventory is hard to replace.

Examples of industries affected by this situation are food and pharmaceutical industry. In some situations the forced lead-time occur together with limited product durability.

If the company is bound to long lead-times due to long transportation times, e.g. naval shipments, this has the same effects as Forced Lead-Times. It might for example not be possible to transport the products faster for economical reasons.

> Case 4:
> A whisky distiller in western Scotland manufactures 10-year-old single malt Islay whisky. The distillery has been in the family for 110 years. Every year 40 barrels are tapped on bottles and sold and some 10 more are delivered to whisky blenders. The demand has been the same as long as anyone on the distillery can remember. This implies 500 barrels in stock due to forced lead-time. One year the whisky appears in a James Bond sequence and as a consequence demand is up 150 %. Yet no more than 40 barrels per year can be bottled and sold for another 10 years to come.
>
> Solution:
> The situation above has been somewhat brought to a head. In reality a stock with finished goods, bottled whisky in this case, is kept with some safety level to meet with unexpected demand. There is no harm in letting the whisky rest in bottles for a few more years. However, the situation implicates a large inventory cost.

The forced lead-time cannot be removed; instead actions have to be taken to reduce its impact. To be able to meet variations in demand, the stock of finished products normally needs to be kept at a high level. Since forced lead-time also implies large product quantities to be locked in production the total amount of resources locked in production and inventory is very high. As a consequence it becomes even more

important to maintain in stock what is actually needed, right quantities of the right products. Consequently forecasting is an essential tool.

Synthesis
These companies search a specialized forecasting solution, preferably from an experienced SCM provider. Since forced lead-time is a most essential problem for manufacturers concerned by it this parameter has been considered having an absolute importance upon the selection of SCM support.

6.4.6. Limited Product Durability

A product with limited durability has to be delivered and sold within a certain time limit otherwise it cannot be sold. When the goods handled have a limitation to its durability this puts emphasis on increasing delivery frequency and limiting inventory. A typical example is perishable goods that also have high transportation and inventory requirements when it comes to temperature and cleanness. Limitations in durability have been found to have an effect on the distribution structure, limiting the producer-client distance. Economic benefit decreases with transportation time, especially for heavy perishable goods. Durability limitations oppose in this case to the single-sourcing strategy.

The effect of limited product durability works indirectly on the choice of system. If, for example, sourcing has to be done at a regional level this implies for a big company a decentralized structure. The opposite would be a highly centralized organization with a few central distribution sites and products delivered from single sources. A decentralized organization has an increased need for functions like replenishment planning to refill shortages and long term, short term sourcing. These needs are very much due to stock spread out on several sites and thus inventory levels can easily grow too high.

Accumulative to this, limited product durability puts pressure on more frequent deliveries, which require a more agile supply execution system in terms of packaging, order confirmation, billing etc.

Synthesis
Limited product durability is in this research defined as a parameter of some importance, since it requires a supply chain structure that is more demanding in terms of transportation and inventory planning and execution. Yet it has not been described as a major concern for companies included in this research why the parameter is not to be regarded as a parameter of absolute importance.

6.4.7. Fast Moving Consumer Goods

When speed of product development is high. Products available for sale are only active during a relatively short period of time before a new generation of products enters the market, making the old generation less coveted. Typical products are home electronics and fashion. Consequently there is a high risk connected to large stock quantities and the main aim is to reduce inventory and lead-time.

To reduce inventory risk, stock has to be kept at a low level. One way of keeping a limited stock is to centralize inventory as much as possible. When inventory is

centralized, possibilities to distribute and redirect products is greater than when inventory is decentralized.

Case 5:
A major retail company is selling fast moving consumer goods on several outlets. The product line is composed of approximately 1500 product numbers. Of these 30% (60% of stock value) has a market presence of less than 10 months. Outlet inventory is refilled from one major distribution center every 12 days. Forecasts are made by both historical forecasting and estimation. The company can see few ways to improve forecasting. In the case of unsuccessful forecasting unmarketable products have to be sold at very low profit or even loss.

Solution:
Reducing lead-times through more frequent deliveries reduces required safety levels of outlet stock. This implies maintaining less products on outlet level and thus the total inventory level can be reduced. More frequent deliveries from supplier to central inventory further reduces inventory level. Inventory management can optimize stock level and categorize products according to demand pattern.

Synthesis
There is a confirmed need of SCM support for reducing inventory. Yet no clear indication of which type of SCM support preferred has not been given. Both ERP integrated SCM support and specialized SCM support is used. This is considered a parameter of some importance.

6.4.8. Manufacturing Complexity

An interesting factor is whether the need for SCM support increases the more complex the production carried out within the company. During the research some companies even though considering their production to have a low level of complexity expressed a need for enhanced production planning and production modeling. Simultaneously companies having one or several complex lines of production were declaring production not to be the cause for the SCM implementation. The question of production planning support is largely connected to the question about underlying ERP systems. Manufacturing Complexity is separated from the parameter Level of Technical Complexity of Products since production can be complex even though the products are simple. Also the handling of technically complex products may occur even if the company has no manufacturing at all.

When manufacturing is complex the planning function is consequently being more complex.

In many cases this function is included in the company's ERP system. However some times the company's legacy systems lack overview functions and are too slow when it comes to production planning but fulfils other functions perfectly. Then implementing

an exterior production planning support might be a simple way of enhancing the planning function.

Production complexity has been found to be the cause for SCM integration in rare cases during this research, and then in combination with lacking production planning functionality of the old ERP system.

> Case 6:
> A company has 12 production sites, each one with up to 6 different lines of production. Manufacturing is done batch-wise, each production site has the ability to manufacture different products but production has to be "set up" and it is normally not changed more frequently than once in a few weeks. Products are single-sourced. Existing planning tools are slow and production plan can't be updated more than once a month. This is insufficient due to changing order situations and the batch production.
>
> Solution:
> The company implements an enhanced production planning support in addition to the old ERP system provided by a best of breed provider. By this the company can update production plans twice a week and has obtained a production-wide visibility.

Complex manufacturing is defined in the glossary.

Synthesis
Manufacturing complexity is a parameter of some importance. A company in need of manufacturing planning support has the option of implementing an ERP based production planning module or one provided from a specialized SCM provider. In most cases the production planning operations are closely connected to the general resource planning activities, planning of human resources, transportation planning, supply planning and manufacturing execution systems. Consequently it is often considered as a logical solution to integrate the production planning function in an ERP system. The question of internal or external production planning becomes a question about the agility of the old system. Most companies in use of a functioning ERP system would be reluctant to let an exterior provider, be it specialized on supply chain matters, make changes in the existing production planning function if no planning problems are evident. This is a serious cause for skepticism about SCM vendors' vision of the whole integrated supply chain.

Yet obsolete legacy systems might influence in the direction of specialized production planning support. Consider a company that is running a group-wide ERP system, and experiences a lack in production planning support for one single unit. Still the system functions perfectly well for the rest of the group, why there is no option of implementing a new ERP system. In this case the very fact of an existing group decision about the system, causes the implementation of specialized support enhancing

the lacking function. The effect of legacy systems will be further treated in section 6.5.5 Legacy Systems Restrictions.

6.5. Structural Parameters

When a company grows, its surrounding situation changes. Volumes produced or sold increase, inventory levels increase, product lines widen, manufacturing lines grow in complexity, and distribution has to cover a larger area of clients both in geography and shipment-size. To this comes a growing organization with functions distributed over several units, an increasing amount of employees connected to the supply chain. If the company has been restructured or merged with other companies the supply chain has to suffer even more complicated rearrangements. Natural results from these changes are changed needs for supply chain management support.

First, the changed business structure normally requires changed system support. A newly regrouped organization would for a start continue with the original system architecture but changed circumstances might quickly reveal new system requirements. Sometimes reorganization might need to be backed up by new systems. A company might also discover that it, through several mergers or reorganizations, has lost control over its supply chain. Also the new physical structure of the company might require enhanced SCM support, e.g. new inventory locations have been added or production can be spread on new production units. On some occasions the benefits of a company merger or overtake require the business activities to be integrated through supply chain management tools. This need to integrate is here defined as the *Business Integration* parameter.

Secondly, the problem of system integration is a natural result of merging organizations with separate system cultures. Different approaches are possible in system integration; to build interfaces between relevant functions, to replace several systems with one single system, or to isolate the functions laterally and incorporate them into separate but company wide systems. This situation is here called *System Integration*.

Furthermore the issue of company structure and reorganization has a few more ways of implicating the system in use. If new reorganizations, new systems are about to be acquired in a related part of the enterprise or if new IT policies are expected this affects the selection process and the decision to implement a new support. This is called *Business Dynamics*.

In contrast to the volatile changing system structure, there can be an effect from having a steady relationship with the system provider, where the system is developed through a mutual long-term engagement. This is defined as *Parallel Growth*.

Sometimes underlying systems are restricting the options possible for SCM support. This situation is described under *Legacy System Restrictions*.

Finally parameters concerning the company's *Integration Policy* and its actual *Business Activity* are discussed.

6.5.1. Business Integration

A common situation in big organizations today is that they've grown, over a period of time, both through natural growth and acquisition. This results in growing pains that derive from a multitude of factors that will be discussed in the following.

Insufficient communication

When a large enterprise is constituted by several smaller companies, each one with their own original business processes, the big organization often ends up in a situation that is hard to overview. Several units could handle one and the same function in disparate ways or handle it similarly but without communicating the information to other units eventually concerned. This problem is connected to the legacy systems in use.

Inefficient use of resources

Often different divisions of one and the same organization have its own clients, product line, production sites, channels of distribution, marketing organization, sales units etc. Yet the product line could be partially common with other divisions, the market strategy is normally the same and so on. This means that there can be several units within an organization carrying out the same functions. The result is that resources are inefficiently used and it is hard to get a company overview.

One example might be handling of order and stock, if separate production units handle interchangeable products they may both be able to refill a common inventory. But if they have separate inventory and separate systems for stock and distribution it is difficult to plan production over both sites. A bigger stock would have to be kept as a result of the lack of visibility.

This situation finally leads to a main restructuring of the enterprise; integrating sales, marketing, purchase and production planning laterally over the organization. Information systems have to communicate with each other.

There are two strategies to take. One strategy is to implement a company-wide system, replacing the old systems. This means a large implementation project where there is a risk of loosing some of the original functionality but instead it implies fewer problems with interfaces between separate systems. Sometimes specific functions are left in separate systems when they are poorly handled by the ERP system. The other strategy to take is to connect different systems according to functionality. In this case one financial system is implemented for the entire organization, one order/stock system is implemented, one marketing system is implemented and so on. These systems *can* be provided by separate providers.

Synthesis

Business integration is a parameter of absolute importance since there are obvious examples found of how SCM support may provide means of integration between separate units and businesses.

6.5.2. System Integration

This situation is similar to the business integration situation, and normally they occur together when companies are merging. Nevertheless they deserve to be separated since

there exist cases where one and the same enterprise has had an undefined IS strategy. As a result, even though separate units have had similar processes, they have acquired different systems through in-house development or purchase. Separate systems communicate badly, cost more in maintaining than one single system and do not provide the visibility normally gained when separate units use the same system and the same database. Another problem with separate systems is that even though they communicate through an interface, they generally become very slow to use. This is a problem for example if one system is a production planning support, and when updating a production schedule takes too long. It will be hard to update the schedule or the plan as frequently as should be desired. The result is that production runs on obsolete production plans and cannot adapt to changing order or stock situations.

The question of integrating separate systems is a reality for many companies today and the problem is not exclusively connected to manufacturing or supply chain systems. During this research heterogeneous system architecture was commonly found, and in some cases this was the very cause for the system implementation.

In the situation of bad system architecture similarly to the business integration case, there are in general two possible approaches. One is to implement a new company-wide ERP system, taking over every legacy system function. The advantages are that this guarantees better inter-communicational functions of the system, a more structured fauna of systems, one single provider and the possibility to have only one single internal system support group. One disadvantage is that implementation-time normally is higher than when single external systems are “glued” to the existing system, even though new interfaces need to be made. Another problem is that a provider of a complete integrated suite normally is not as skilled in every function as each specialized provider. Thus some functionality is lost, and sometimes ERP providers have a hard time proving successful cases in specialized business areas. One example might be process industry where many companies are reserved against ERP solutions normally aimed for assembly production, electronics or consumer goods.

The other approach is implementing an external best of breed system for every function that needs to be integrated (e.g. demand forecasting, supply planning or multi site production planning). The advantages are that these systems normally are easier to implement and often provide a better functionality in each area. The major disadvantage is that this might not really solve the situation of poorly communicating systems. Certainly, underlying ERP systems are allowed to communicate in each area but more system interfaces are needed and the system structure does not become less complex.

Case 7:
A company uses SAP's financial system, Movex production planning combined with Excel-sheets, Movex demand planning and in-house developed inventory management system. Some smaller production sites also use Baan and J.D. Edwards for order management, inventory management and production planning. This implies that production planning has great difficulties in coordinating production between different production sites and in deriving production demand from inventory and incoming orders. Visibility is poor as is the possibility to frequently update production plans. Consequently demand is lost even though final stock safety levels are high. License and maintenance costs are high. Service level is low.

Solution:
The company investigates the solution of either implementing a supply chain planning support while keeping the old systems as a foundation (SCP option) or implementing an integrated solution covering all activities on every site (ERP option). No ERP provider is found with a sufficiently developed industry-specific solution for the company's business and the company does not want to risk an expensive implementation and uncertain functional performance of the final system. SCP solutions available would be able to handle the supply chain requirements but would not imply a permanent solution since some underlying systems would have to be retired within five years. The company decides to implement a demand forecasting and replenishment planning support from a best of breed provider and reevaluate options in two years from now.

Synthesis
System integration is a parameter of absolute importance that has been found being a reason for several users to implement SCM support. Especially since the SCM functions normally need information from several separate systems in order to work properly.

6.5.3. Business Dynamics
Continuous merger and restructuring of enterprises implies an ongoing change of both system architecture and company priorities. This has an effect on the selection of the system since implementing a system means trying to find an enduring solution that the company can grow into. If business structure is suspected to change again within the close future this may postpone the implementation.

To pause implementation
Example has been found during the research where one unit of the entire company had finished its selection of SCM support. A provider had been chosen. Yet the implementation had to be postponed since a larger restructuring project was started within the group during the selection process. The result of the bigger project had to be awaited and should the decision of the group be contradicted to the minor units SCM

selection would the selection probably have to be revised. This proves that the dynamic changes within or between companies affect the implementation process. In this case the effect was indirect.

To urge implementation
Other examples indicate that a dynamic, continuously changing business structure has rendered legacy systems obsolete. This is an obstacle in the continuous growth and development of the company. If new units are docked to the enterprise and the legacy system obstructs the integration of new businesses there is a specific need to adapt the systems to the new situation. Consequently business dynamics can have an accelerating effect on the implementation of new systems.

Dynamic solution
It must be suspected that dynamic business structure puts emphasis on the adaptability of the new system implemented. Users have stated that one of the major concerns when selecting the SCM solution is that it should be valid within a long future horizon, reorganizations and changed business circumstances included. Yet IT strategy varies largely from the most reserved one, postponing investments as far as possible, to the most proactive one, investing in solutions to prepare the company's future growth.

Synthesis
This is a parameter of some importance. Companies apprehend the importance of having systems that will survive future changes, but it is hard to estimate the influence of this upon the choice of SCM solution. There is no clear directive of which type of SCM support that is most apt to adapt to changing conditions.

6.5.4. Parallel Growth

A situation that deserves to be described is when there has been a long-term relationship between the system provider and the user. During the research evidence of the importance of co-development was found. Characteristic for this situation was that the business of the user to a large extent was dependent on well functioning SCM support and its integration with remaining processes such as financial systems and customer relationship management systems. In this case the user had been a client of the very same provider for decades.

One result from joint development was a common spin-off business implementing knowledge from the development of the user's business.

Naturally when an organization is so closely linked to its system provider the tendency is to remain with the same provider and to push for improvements of the system already in use.

Synthesis
This is estimated to be a parameter of some importance. It obviously affects companies that have chosen to have a long-term relationship with the system provider. Yet some users have explicitly claimed that they do not want to be too dependent upon one provider. If there is a divider between these two visions of long-term vendor relationship it has not been detected during this research, very likely the differences are due to business culture and personal commitment. Long term relationship was only

found between an ERP provider and its user (using both the ERP system and the SCM support).

6.5.5. Legacy Systems Restrictions

In parallel to the situation where a company acquires SCM support to provide a common function for separate business units, the new SCM support could require functionality that underlying systems cannot provide. For example if an SCM system requires updated inventory and order data once an hour and the legacy system cannot permit to be updated more than once a day the SCM system will not deliver the functions it was intended for. Consequently it is an important issue to verify the requirements on the underlying system. If the legacy system is unable to deliver the function the process of implementing SCM support tend to become a question of enhancing the existing system or acquiring a new one.

Synthesis

Normally the limitations of the legacy system are already known and SCM functionality might be incorporated in the question of acquiring a new ERP system. The situation of restricting underlying systems has the opposite effect of the functional parameters where insufficient system functionality was a cause for implementing SCM support. This is a parameter of some importance.

6.5.6. Integration Policy

In some situations companies find themselves in the situation of having to change to systems that they do not need or that lack functionality compared to what they have been using so far. This is due to a group decision, where a contract has been put up with a major provider giving him the exclusive right to provide a particular suite of solutions to the whole group. Of course this can result in awkward situations for some units within the group that can see a loss of functionality when changing into the new system. Yet this makes sense from a top point of view where integration abilities between different units is important or if system support organization can be reduced thanks to homogenized information system structure.

In some cases there might be a decision to let units continue with their existing system but when in need to upgrade they are bound to follow group decisions.

This strategy of homogenization of the group's system architecture is no rule however. Different enterprises have different strategies and normally the information system strategy is comparable to general policy on regimentation. This parameter is linked to the culture of the company.

Some companies have a strong regulation policy of business processes used by the units within the company. High pressure is put on newly acquired units to adapt to the culture, logos, procedures, organization structure etc. of the parent company. Companies with strong integration policy might not accept smaller units to use the separate systems if there is a group decision about a specific solution or provider to use.

Synthesis

This is a parameter of absolute importance. It directly affects the company's choice of system. The direction can be towards either ERP provided or best of breed SCM support.

6.5.7. Business Activity

A factor affecting the selection of system is naturally the focus of the provider's solution vis-à-vis the business activity of the user. In general every SCM provider has a line of vertical solutions specially adapted for the actual circumstances within the specific industry or business.

In some selection processes the users have been fully aware of the lacks and shortcomings of some vendors' SCM solutions. This is especially true for industries with special requirements on production and distribution planning such as process or chemical industry. When a company with special requirements searches an SCM support it therefore limits the selection to vendors experienced within the specific area preferably with proved successful implementations.

Some best of breed SCM providers do not offer a vertical solution, claiming that their software is easily adapted to any industry and only refers to successful implementations within the specific industry.

From a vendor point of view, it can be hard to start providing solutions for a new business area since there most likely exists reputed industry/specific solutions for that area. Adapting a general ERP or SCM solution to a new area is connected to the risk of introductory diseases, and users are aware of this risk.

Synthesis

Business activity is a parameter of absolute importance, since it is vital that the vendor provides a solution that can handle the activities within the company.

6.6. Other Parameters

A few parameters could not be arranged into neither functional parameter nor structural parameters. Nevertheless they affect the selection of SCM support.

Primarily the *Presence of SCM options* has an influence upon the selection of SCM support. The options available depend on several circumstances described under this section.

Documented Success of the Provider, *Amount of Time Given to the Selection Process* and *Personal Commitment* are other parameters described in this section.

6.6.1. Presence of SCM Options

When a company has detected its need to implement SCM support an important factor is what solutions are selected for the study. This selection depends on a few parameters: When the selection is done, where providers are geographically located, how important the user is to the provider, and how selection is done. These factors are gathered under

the same parameter Presence of SCM options since that is what concerns the user; what options do I have in this selection?

Point of Time
There is a continuous development of the SCM suites available on the market. Solutions today aim at web integrated collaborative solutions as solutions seven years ago were still aiming at integrating functions between separate units or sites within the manufacturing company. Many SCM clients still face the problem of function integration. So there is a gap between the vision of the providers and the reality as it appears among most users. Today there are vertical solutions available for many different industries. ERP providers are seriously competing with best of breed SCM providers. Time is a factor that affects the options available to the potential user. In general it can be said that the amount of available options is today larger than ever and it is assumed to decrease, as the SCM market is believed to be saturated.

Time also poses a threat on SCM users since an important factor when selecting a solution is the longevity of the provider. No one wants to invest in a system whose developer might not be around in five years.

Location
In some cases the vendor of a solution considered has been located abroad. This has been regarded as a disadvantage for the solution since implementation efforts are believed to require presence of vendor consultants. Furthermore the presence of the provider reflects the importance of the geographical region to the provider. No company wants to be treated as a peripheral client.

Vendor attention to the client
Even though every client is important to an SCM provider, some areas are considered as their “specialty”, consequently such a client might be given more attention than one who the provider suspects from the start not being a future client. On the other hand, when a provider desires to enter a new solution area or a new market it is apt to make an even bigger effort to gain new clients within that area. Those clients are given more attention and more beneficial deals than a normal client.

Way of selecting SCM options
An interesting observation during this research was that many clients are poorly aware of which providers are available and the solutions they offer. On several occasions the system acquired was one that a company executive “happened to discover“ at an IT fair or in an article. One company consulted a market research and advisory firm and was given two providers (both best of breed), evaluated the providers against each other and finally opted for one of them. Obtaining a general view of the options on the SCM market is difficult and different providers are hard to compare. This is largely so due to the complexity of the contemporary SCM suite. Nevertheless it must be seen as a restriction in the implementation process if not all feasible solutions have been considered.

During this research SCM executives have presented complaints about the anonymity of the SCM providers.

Synthesis
The presence of options available for the company is highly influencing the selection and is therefore a parameter of absolute importance. The trend up till now has been that more options have been visible.

6.6.2. Documented Success of the Provider

Naturally the business of the company is a major player when selecting which SCM option to adopt. One part of selection process is always a case study and demonstration of the providers abilities in the specific field of activity of the company. These studies have an obvious importance to the decision outcome and it is highly important that the vendor is able to prove successful implementation and use of its solution to be at all present as one of the final options. This could be a reason for the difficulties to enter a new area of functions or business vertical. Basically every SCM provider offers business-specific solutions today and widening the line of vertical solutions is one major mean of competition at the SCM market.

When a company active in a certain business area is implementing SCM support one major parameter is then the presence of business-specific solutions in the vendor's product line. Some typical verticals are automotive, aerospace, consumer packaged goods, foods, medical industry, process, retail, and so on.

Synthesis
This is a parameter of absolute importance. A provider who cannot show a successful customer case will have a hard time convincing the potential client of the functionality of the system.

6.6.3. Amount of Time Given to the Selection Process

A fact discovered throughout this research is that time given the selection and implementation process always is a shortage. Inventory is an excessive running cost, orders are missed due to insufficient supply planning, delivery dates are missed and goodwill is lost. This is the most probable cause for companies' tendency to limit the amount of systems considered during selection. The lack of time also puts emphasis on the providers' ability to present short implementation time and short time to ROI.

Synthesis
This is a parameter of some importance. It affects the selection, but only indirectly and not necessarily in a unanimous direction.

6.6.4. Personal Commitment

A parameter that is difficult to measure but must be included in the general picture of the company's selection of SCM support is the commitment of the employees connected to the implementation. There is a perceptibly different approach if the requirements on the SCM solution derive from people connected to the every-day SCM operations than if requirements derive from above, such as group decisions or IS executives. SCM requirements tend to be more focused on function if they come from SCM committed people who have, through everyday work, generated a list of requests concerning enhanced SCM support. The focus of such requests is normally on improving the business processes and the system functionality. This is to compare with

the case of SCM decisions derived from tactical or strategic goals and resulting in an implementation process which has to start by mapping the business and discover the way operations actually *are* carried out within the company.

Synthesis
Personal commitment has been considered a parameter of some importance. Certainly the personal preferences of the employees conducting the selection and implementation process are a major factor affecting the selection process. Nevertheless the professionalism of employees attached to the selection must be assumed. It is therefore difficult to indicate how personal commitment affects the selection.

6.7. Parameters of Uncertain Importance.

A few parameters whose influence have been difficult to analyze are here gathered and described. It must be assumed that it would require more investigation to conclude which importance they have upon a company's choice of SCM support.

6.7.1. Dependency

In some cases the supplier is strongly dependent on its client. The supplier might in some cases just have one client. This can result in a difficult situation for the supplier, especially if demand from the client is showing a very irregular demand pattern. Such a varying demand complicates production planning for the supplier who risks ending up with irregular production capacity employment. In the end the irregularities in incoming orders will result in higher production costs that, due to the close dependency, will strike back on the client in the form of higher prices and poor delivery accuracy.

Synthesis
The dependency situation increases the need to generate smooth supply plans in order to facilitate the suppliers planning process. Both specialized and integrated planning support is being used. This parameter is estimated to be of uncertain importance since it is a relatively rare situation. Also examples of smoothing of the supply plan have been found both with and without external support.

6.7.2. Underlying ERP provider

Few companies appeared to be bound to opt for an SCM solution from an ERP provider already contracted for the mere reason of this being the existing provider. Some companies even stated that they intentionally try not to be too closely connected to one and the same provider. This however should be regarded in comparison with the Parallel Growth parameter that has been detected on obvious cases.

Synthesis
It appears that there are different approaches to whether it is judicious to stay faithful to the same provider. The difference could be a reflection of culture and personal commitment.

7. Conclusions

7.1. The SCM market

A normal ERP system contains today some SCM functions such as production planning and scheduling, inventory management, and transportation planning. Under some circumstances a company experiences a need for enhanced SCM support. The company can then obtain SCM support by developing it itself, or acquiring it from an exterior provider. This provider can be an ERP provider with a separate SCM suite or a specialized SCM provider.

The European SCM market is expected to increase its turnover from $485 million in 2000 to the multiple in 2007. This since SCM can prove a safe and quick return of investment, there is also a major need for SCM improvements among European companies.

The ERP market is mature and providers are struggling in rendering a return of investment to their clients. Consequently the growing SCM market constitutes a tempting possibility for many ERP providers. Furthermore the business collaboration practices are a natural extension of the ERP system. All major ERP providers have developed or purchased SCM suites that have gained functionality and are today approaching the specialized SCM providers' solutions. This means that the SCM market, which certainly is growing, is about to be overcrowded. A major elimination of several providers on the ERP/SCM market is expected.

7.2. Affecting parameters in the selection of SCM support

The first and most important parameter is the type of implementation. If the company is acquiring a new ERP system, it normally incorporates the SCM purchase in the same buying process. In that situation the solution chosen is often an ERP system and the SCM functions delivered by the same provider. However the company may have specific SCM requirements not met by the ERP provider's solutions, in those cases the user is likely to separate the SCM purchase process from the ERP implementation.

If the SCM purchase is handled as a separate acquisition there are several parameters affecting the company in the selection of SCM support. In this research 21 different parameters were found.

The most important ones are either concerning lacking functionality of the company's existing system or problems concerning the company structure. If the company has problems in predicting demand or experiences difficulties in assuring the supplies this also is a major driver for external SCM support. Somewhat confusing is the fact that during the research examples were found where the company in question did not at all see its supply problem as an incentive to implement SCM support, however examples were found where supply problems highly represented a cause for SCM acquisitions.

Some parameters concern the product characteristics such as requirements on the products availability on the market, or if there was an inevitably long lead-time, or if the durability of the product was limited, or if the product had a high level of technical

complexity, or if the products are of a category that's quickly developing. These parameters all pose requirements on the supply chain and have been found giving reason for SCM support. Other parameters concern the structure of the supply chain. Often the SCM support can be used to permit different business systems to integrate, which implies it can be used to let organizations integrate. A volatile, quickly changing business organization might find itself in need of systems that can support the business dynamics.

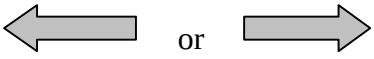
Apart from the factors mentioned above, there are also some circumstances that affect the selection of the system yet not being problems that need to be solved. First of all, a potential user can only make a selection from the SCM solutions that are available. Consequently when, where, and how the selection is done matters greatly to the final selection. The company is likely to opt for a solution, which is confirmed suitable for the specific business activity of the company. If the vendor also can prove successful implementations from similar situations this affects in favor of that specific provider. When time previewed for the selection and implementation process is scarce this tends to limit the selection process drastically. Sometimes the user and the vendor have been conducting a long-term relationship why the user most likely will employ the same provider when new requirements occur. It must also be concluded that the private preferences of people responsible for the selection has an influence on the system finally chosen.

7.3. Direction of influence of the parameters (ERP or BOB?)

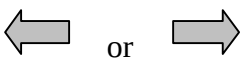
In order to give the direction of the influence of each parameter all cases were reviewed and every parameter was analyzed to the decision of implementing SCM support from either an ERP provider or a best of breed provider. This gave a first hint of how each parameter work. It could be concluded that many parameters do not work in the sense ERP- or BOB provider at all, e.g. the parameter "Amount of time given to the selection process" works towards well-known providers or "big names" and available SCM options depends largely on the point of time for the selection. These parameters were excluded. Some parameters where only one observation had been made and the direction could not logically be explained were also excluded.

The result of this analysis is given in picture 5 where the direction of influence of each parameter is given and the specific circumstances that make the given parameter to work the way it does.

If the given parameter was regarded as a strong incentive it is pictured as a long arrow:

 or

If the incentive was less strong or subordinated it is pictured as a short arrow:

 or

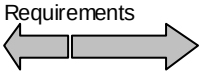
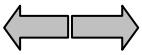
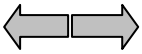
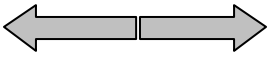
ERP based solution (circumstances)	Parameter	BOB based solution (circumstances)
(In combination with Business Integration and System Integration)	Demand Pattern 	(High forecasting requirements)
	Supply Situation 	(Strong Dependency between the company and its suppliers, several suppliers)
(If appearing with business- or system integration goals)	Product Availability Requirements 	(In combination with Demand Pattern, Forced Lead-Time, Level of Technical complexity of Products or Limited Product Durability)
	Level of Technical Complexity of Products 	(Spare part inventories of technically complex products are normally high. In combination with Demand Pattern and Product Availability Requirements)
(If appearing with business- or system integration goals)	Forced Lead-Time 	(In combination with Demand Pattern, Product Availability Requirements, Level of Technical complexity of Products and Limited Product Durability)
(If appearing with business- or system integration goals)	Limited Product Durability 	(In combination with Demand Pattern and Forced Lead-Time)
	Manufacturing Complexity 	(If underlying ERP system is insufficient in manufacturing planning)
(If Business Integration is the major goal of the system implementation)	Business Integration 	(Only separate business functions need to be integrated, time is limited, changing requirements in the future)
(Most cases of system integration. If system integration is a major issue the user would primarily opt for an ERP-provided SCM solution)	System Integration 	(If integration through ERP system not possible, time is limited, SCM requirements are high)
(A solution that can be continuously developed is sought. When apperaing together with business- or system integration goals)	Business Dynamics 	(A solution that can be continuously developed is sought)
(If the user has been using the same ERP provider for a long time, it might like to implement SCM functions from the same, trusted provider)	Parallel Growth 	
(If underlying ERP system requires SCM support but cannot sustain the functions of such a support, a completely new ERP system should be acquired)	Legacy Systems Restrictions 	(If lacking functionality can be acquired through specialized SCM support, equals the different functional parameters)
(Normally a company's Integration Policy aims at integrating all functions (SCM included) into one ERP system)	Integration Policy 	(If group-wide ERP system lacks required functions. If group has signed contract with BOB provider)

Figure 6. Parameters influencing towards SCM support by either ERP provider or best of breed provider.

The reader is asked to remember that these parameters are the result from case studies performed. If no arrow is given this implies that the given parameter has not showed any influence in the specific direction.

A tendency that can be clearly seen is that structural parameters primarily point towards an ERP provided SCM solution and that functional parameters primarily point towards a solution from a best of breed provider. This has a natural cause; when the company's business structure is a major issue this is closely connected to the ERP issue in general and on the other hand when a limited number of specific functions are needed it is natural to opt for a provider who is more specialized on the specific task.

When a system is chosen there are many factors that cannot be evaluated, particularly the personal preferences of the people conducting the selection and the relation that occur between the buying organization and the provider. Many users have mentioned reasons such as "we estimated that the provider X was not experienced enough in our type of problem", "provider Y was speaking our language and seemed to understand out problems", or "the Z system just seemed more comfortable to work with, all options were valid for our SCM needs". This implies that the analysis had to be somewhat "cleaned" from personal preferences in order to make the influence of each parameter to come out clearly.

These were the most important parameters found during the field study of 12 companies in use of either the SCM support provided in by an ERP provider, of the SCM support provided from a specialized SCM provider or of their own developed SCM support.

7.4. Other conclusions

There is a major difference between the visions of SCM providers, both ERP and best of breed, and the reality as it appears among the user companies. The vendors see a completely integrated supply chain, where production and inventory is continuously leveled with demand on every stage and where supply chain executives have perfect control of every step, on every level of planning, on every horizon. In contrast to this, users focus on improving forecast accuracy or making inventory refill only the parts needed. Some users have problems with suppliers and need SCM support just to create smooth supply plans so the suppliers are able to handle demand. Other users realize that the production planning system they created a decade ago requires days to update a production plan; consequently production plans can only be updated once a month. This means that in general there is a big difference in the providers' visions and the users' reality.

8. Suggestions of further study

Several questions have occurred during this study that would deserve a closer investigation and will here be presented in short.

8.1. Forecasting strategy

Demand planning remains one of the major key factors to successful supply chain planning. Forecasts are mainly constructed from estimated demand and historical forecasting. Many forecasting methods are relatively simple yet improving forecasting models is very difficult. Several companies put effort to improve forecasting results, efforts with varying result. The objective of such a thesis would be to develop an introductory forecasting strategy depending of market behavior and products.

8.2. Develop SCM strategy

Many companies are badly prepared when it comes to selecting support for SCM. Availability of independent, unprejudiced information is limited and information base of successful / unsuccessful implementations are kept within provider and user organizations. Out of this study and continued user studies develop a strategy of how companies with different business situations should select the SCM support to adopt. Synthesizing a model for SCM selection and implementation would be a valuable support for both future users and implementation consultants.

8.3. The strengths and weaknesses of Customer Relationship Management

CRM support is today provided by a multitude of vendors. CRM systems combine sales, marketing, contact management, and support activities in managing customer interaction. They provide tools to analyze customer/product sales history and profitability, campaign tracking and management, contact and call center management, order status information, and returns and service tracking.

- What parameters urge users in opting for a specialized CRM support?
- What do CRM really bring to its users?
- What are the trends on the CRM market?
- Which are the participants?

8.4. Level of order promising

Available to promise (ATP) indicates the verification of material availability when orders are taken. Capable to promise (CTP) verifies both material availability and production capacity in order to be able to precise delivery dates when taking an order. Profitable to promise (PTP) is the relatively unpracticed process of checking up material availability, production capacity and profitability of an order before it is taken.

- How do these concepts work?
- Which companies are in need of them?

- What company requirements are conjoined with each level of order promising (none/ATP/CTP/PTP)?
- Which solutions are available on the market?

8.5. Business integration strategies

SCM software support is sometimes used to integrate various business functions laterally over the company. This is done function by function and the company only integrates certain functions (e.g. demand planning, replenishment planning, or manufacturing planning).

- How is the selection of which functions to integrate laterally done?
- Which functions are the most common ones?
- How does the selection depend on the company structure and the business activity?
- Develop a business integration strategy according to company's structure and business activity and SCM solutions available on the market.

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9.3. Vendor Contacts

i2 Technologies, July 17, 2002
Erik Wedell

Manugistics, August 6, 2002
Anders Sundberg

Frontec, August 6, 2002
Jörgen Persson

Agile, August 7, 2002
Martin Rosell

SAP, August 9, 2002
Anders Segerfelt

IFS Data AB, August 20, 2002
Ronny Ideskär

Syncron, August 21, 2002
Hans Montelius

Logility, August 21, 2002
Mathew Lloyd

Baan Nordic AB, August 22, 2002
Per Lönn

9.4. SCM user interviews

Gambro Renal Products, September 11, 2002
Zlatko Rihter, Implementation Project Manager
System: SAP, i2 Technologies

Duni, September 13, 2002
Christer Alerstam, Process Development
System: various ERP, i2 Technologies

Carlsberg Sverige, September 18, 2002

Peter Jibrandt, Movex Production Planning
System: Movex ERP + SCM.

Cambrex Karlskoga, September 19, 2002
Tommy Hjalmarsson, Production Planning
System: Renaissance, Logility

Ikea, September 23, 2002
Örjan Jonsson, Global Sourcing
System: various ERP, Manugistics

Kraft Foods Sverige, September 25, 2002
Tyrone Andersson, IS Executive
System: SAP, Manugistics

ABB Automation Technologies, September 26, 2002
Anders Carlsson, Supply Chain Development Manager
System: SAP + enhancement

Alfa Laval, October 7, 2002
Klas Hilding, Project Manager, Operations Development
System: various ERP, Syncron

Volvo Construction Equipment, October 10, 2002
Jan Paulsson, Manager Dealer Stock Management MMI
System: SPIS, Syncron

Amersham Biosciences, October 11, 2002
Carina Bremler, Senior Business Analyst
System: Movex, J.D. Edwards + enhancement

Expert Sverige, October 16, 2002
Håkan Egerborn, Manager, Logistics
System: IBS

Arla Foods, October 25, 2002
Sofia Bårman, Project Manager, Logistics
System: Movex, SAP

9.5. Other Contacts

Interface GmbH, July 9, 2002
Jörg Goletz

Market-Visio, July 5, 2002
Björn Roting

Gartner, October 30, 2002
Jonas Rosén

Gartner, October 31, 2002
Maria Eriksson

Gartner, November 1, 2002
Marcus Lindstrup

Appendix A

ERP/SCM dictionary

ERP/SCM dictionary

The ERP/SCM dictionary is a result of the most essential terms occurred during this thesis. Explanations given here are based on the author's experiences from literature study and field research and should be regarded as such. Other definitions may exist.

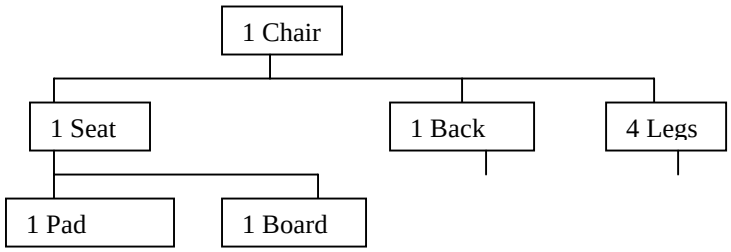
Advanced Planning and Scheduling (APS)
Tool aimed at optimizing production to several criteria simultaneously. Normally the objectives are minimizing production cost, maximizing use of capacity and maximizing employment of material. The idea is to continuously carry out the APS activity to verify the impact of small changes. For example it should be possible to verify the profitability of adding a new order to the order stack. APS is the foundation of the Profitable To Promise (PTP) concept.

Available To Promise (ATP)
Before taking an order, it is verified that the business unit's inventory holds the ingoing components required to deliver the order. Thus delivery of the order can be promised and dated even though production capacity is not taken into account.

Batch Production
Production is done in a determined quantity that is processed at the same time with the same process parameters. A batch may include several item numbers but all items are considered to have the same characteristics, this to simplify tracing.

Best Of Breed (BOB)
Systems that provides the highest level of performance in their class. This normally means a narrow field of function since integrated systems tend to loose some functionality.

Bill Of Material (BOM)
The bill of material is a structured multilevel list of components required to manufacture a certain item. It reflects the relation of the items and quantities needed. The BOMs are used by the MRP process to calculate component requirements.



Business Plan
Financial and operational plan at strategic level whose aim is to fulfill the goals stated in the Strategic Plan. Among other things the company's market strategy, product range, production structure (allocation of units or resources) are defined here.

Business to Business (B2B)
Communication and transactions between different businesses. What in the old days was done over the phone and by post is today handled over EDI and Internet.

Capable To Promise (CTP)
A system combining ATP inventory availability with capacity status when calculating customer order delivery dates. This means a higher degree of verification than ATP.

Capacity Requirements Planning (CRP)
Verifies that production plans don't deviate excessively from production capacity.

Input data:
- MRP order
- Open production orders
- Capacity data

Output data:
A status report over the current capacity situation. If the planned production deviates too much from what can be produced (over or under capacity) a so-called rescheduling is proposed, sending the plan back to the MPS or the production is geographically moved.

The objective is to obtain the smoothest possible use of resources.

Complex Manufacturing
Manufacturing is considered to be complex when production uses multiple production departments and facilities, BOM is deep and contains many component items and design/production cycles are long.

Constraint-based planning
A method of obtaining a plan or a schedule by *simultaneously* considering the constraints connected to the production. The computational method is called constraint programming and it includes two different approaches, constraint satisfaction and constraint solving. Constraint satisfaction problems start by defining a finite set of variables that describe the problem and a function that maps every variable to a finite domain. To this a finite set of constraints is assigned. The task is to find one or all solutions. The constraint satisfaction problem is a combinatorial problem that can be solved through search. A solving algorithm generates all possible combinations of values and tests whether each given combination satisfies the constraints (this algorithm is called *generate and test*). The algorithm is very time consuming and research in this

area concentrates on finding more efficient algorithms. Constraint solving problems use variables with infinite domains and whose constraints can be more complicated such as nonlinear equalities. As a result constraint solving algorithms use algebraic and numeric methods instead of search combinations. The point of constraint-based planning is that it finds a feasible plan while considering several constraints at the same time.

Customer Relationship Management (CRM)
Sales, marketing, contact management and support activities in managing customer interactions are gathered in the CRM function. There are systems specialized on CRM, providing tools to analyze customer and product sales history and profitability, to manage campaigns, to continuously provide order status information to clients etc.

Demand Planning
The purpose is to generate a valid forecast. Normally this is done through aggregation of several sales forecasts from different sales organizations or mathematical forecasting methods such as exponential smoothing or the moving average method. The result of the Demand Planning activity is a pace for the production to follow.

Electronic Data Interchange (EDI)
EDI is electronic transfer of trading documents (orders, stock data, invoices, etc.) for e-commerce. EDI was first carried out over separate net but is gradually moving over to Internet.

Electronic Data Interchange For Administration, Commerce and Transportation (EDIFACT)
EDIFACT is a universal standard for a total approach to EDI including syntax, data elements and messages. Defined by United Nations.

Enterprise Resource Planning (ERP)
A business strategy that aims at connecting a company's every function through a common architecture. Functions included are manufacturing, finance, human resources and distribution. The purpose is to continuously balance the resources being used by the enterprise. Normally the ERP functions are carried out in company wide software.

Event Management
If a new situation comes up at a certain point in the supply chain the information can be spread to other concerned units in the chain. Event management is a tool to handle exceptions, and especially to spread the news about them.

Exponential Smoothing forecasting method
A forecasting technique where the rate of importance is given to past periods can be varied. If a moving average technique uses the last X periods of time. The exponential smoothing multiplies a factor alpha to demand from the last period (e.g. 0.15) and

multiplies 1-alpha (e.g. 0.85) to the average demand. Mathematically this is easily defined as follows. Let S_t be the smoothed observation for period t.

$$S_t = \alpha y_{t-1} + (1-\alpha)S_{t-1} \qquad 0 < \alpha \le 1 \qquad t \ge 3$$

then S_{t-1} can be developed again:

$$S_t = \alpha y_{t-1} + \alpha(1-\alpha)y_{t-2} + (1-\alpha)^2 S_{t-2}$$

if continued till starting point $S_2 = y_1$ reached:

$$S_t = \alpha y_{t-1} + \alpha(1-\alpha)y_{t-2} + \cdots + \alpha(1-\alpha)^{i-1} y_{t-i} + \cdots + \alpha(1-\alpha)^{t-2} y_2 + (1-\alpha)^{t-2} S_2, t \ge 2$$

it can be seen that the weights $\alpha(1-\alpha)^i$ decrease exponentially as i approaches $t-2$.

Interface

The interface is a connection between two different equipments or systems that would normally not be able to communicate with each other. Signals that pass are carefully defined. The interface can be both hardware and software equipment.

Lead-time

The time passed between the registration of an order and it's delivery. If products are manufactured against forecast demand and orders are delivered from stock the production-time is normally not included in the lead-time. A part of the lead-time may derive from production requirements or transportation circumstances and can't be reduced by supply chain improvements. Long lead-times normally imply high costs, poor adaptation possibilities and high inventory risk.

Maintenance Repair and Overhaul (MRO)

Common name for the industry segment of companies providing service within these three segments. MRO companies are specialized in a sector, such as aviation or nautical equipment.

Master Production Schedule (MPS)

Future production is planned in an aggregated form. An MPS is created through so-called scheduling. The MPS is continuously updated, e.g. once a week.

Input data:

- Demand Planning output
- Open Sales orders
- Production cost data (Set up cost, working capacity per employee, regular working time cost, over-time capacity, over-time cost, backlog cost etc.)
- Stock costs
- Stock info (Initial stock and rest orders)

Goal:

The goal is to (by linear programming) render the production schedule generating the lowest production cost possible.

Output data:

A schedule stating quantities to be produced per time period with the horizon. Typical for the MPS is that it only states the planned production quantity in completed units, also called aggregated planning. The horizon may vary from tactical to operational.

Manufacturing Resource Planning (MRP II)
The MRP II is an extension of Materials Requirements Planning, taking manufacturing capacity into account when generating a production plan. This is done through a loop where the scheduled production is verified by the Rough Cut Capacity Planning. If acknowledged the schedule is sent to the MRP, if not it's sent back to MPS for rescheduling. The MRP derives the production plan from the schedule and Bill Of Materials. This plan is sent for closer capacity verification by the Capacity Requirements Planning.

A MRP II system normally consists of:
- Demand Planning
- MPS
- Rough Cut Capacity Planning
- MRP
- Capacity Requirements Planning

The database is the heart of the system, yet the MRP II is not an enterprise wide system since it only focuses on manufacturing planning.

Materials Requirements Planning (MRP)
The MRP translates the scheduled production into a detailed work plan. It breaks down the production schedule and together with BOM and lead-times for each component it calculates the quantities that need to be purchased and the latest dates to place the purchase orders.

Input data:
- Bill Of Material
- Product information, lead-time for each component, unity definitions (entity, kg, 1000pack etc.)
- Stock Levels
- Placed Purchase Orders
- Placed Sell Orders
- MPS

Objective:
The goal is to decide quantity and time for purchase, placing purchase orders as late as possible, while maintaining the risk of stock-outs as low as possible. Assemblies are planned.

Time horizon varies from operational to tactical.

Output data:

A plan over when and how much to purchase (internally or externally) of each component and when to assembly.

Note that no concern is given to the actual production capacity. Capacity has to be included for in the MPS and in CRP and RCCP.

Moving Average forecasting method
Future demand is calculated by calculating the average demand from past X periods of time.

Multi Sourcing
Opposite of the single sourcing strategy is the multi sourcing strategy where the same product may be produced at several sites.

Planning, operational level
Horizon: from daily planning to a few months
Short time planning of supplies, production, deliveries to meet short-horizon forecasts and open orders. This planning is carried out within the separate business units and occasionally over the whole supply chain. Information treatment is done continuously updating orders, production capacity and unpredicted events in order to obtain an updated view of the process and plan the activity consequently.

Planning, strategic level
Horizon: several years (5, 10...)
Decisions considering supply chain structure, location of production and stock facilities, markets to attend, etc.

Planning, tactical level
Horizon: from monthly to a few years
Long term planning of supplies to meet trends and demand forecasts. Decisions concern long-term supplier contracts, location of stock, etc.

Profitable To Promise (PTP)
Term defining that the potential profitability of an order is calculated before the actual order is taken. This requires a real-time calculation of the current and future production plan. In some cases not every order is profitable to take, in some cases the manufacturer should chose which orders to take. PTP is still a new concept in order promising and requires APS.

Replenishment Planning
Calculation of order quantities, safety stock and order point with the purpose of maintaining the lowest stock possible without the occurrence of stock outs.

Replenishment Planning is normally connected to a forecasting function when future demand is unknown.

Return Of Investment (ROI)
The ratio of income produced by an asset divided by its investment cost.

Rough Cut Capacity Planning (RCCP)
The fixed production schedule is verified against actual capacity. If scheduled production derivates too much from capacity, the production schedule is returned to the MPS for rescheduling.

Sales and Operations Plan (SOP)
Strategic level. Defines goals for production, stocks and sales according to the Business Plan. Rough Cut Capacity Planning refers to the SOP.

Single Sourcing
The product is produced in only one production site and then transported to inventory and sales units.

Strategic Plan
Strategic level. The highest plan of activity in the company. States which markets to attend, what strategic resources are available and defines the enterprise weaknesses and strengths in relation to competition.

Supply Chain Execution (SCE)
Activities transforming production plans to production. In a wide context systems included are Manufacturing Execution Systems (MES), inventory systems, manufacturing operations, shipments to customers and connectors between MES systems and ERP/SCM systems.

Supply Chain Management (SCM)
The never-ending search for best handling of the flow of goods within and between organizations. SCM contains the concepts Supply Chain Planning (SCP) and Supply Chain Execution (SCE).

Supply Chain Planning (SCP)
Collective name of all planning activities aimed at improving flow of goods within an organization. The planning activities aim at keeping down costs while maintaining a certain service level, reducing risks connected to inventory and obtaining measures and control of production and distribution.

Functions included are:

- Forecasting
- Replenishment Planning
- Master Production Scheduling
- Rough Cut Capacity Planning
- Materials Resource Planning
- Capacity Requirements Planning
- Distribution Resource Planning
- Advanced Planning and Scheduling

Vendor Managed Inventory (VMI)

VMI is the process of letting the vendor or the supplier being responsible for a company's inventory. Thus the company cedes control over its incoming stock but delivers orders and forecast data to the vendor who will assure stock levels.

Appendix B

Interview Model

Interview model

The following interview model was adapted to the specific company's situation and its selection of SCM support. Interviews were recorded and a summary was sent to the respondent to permit verification and changes of the summary contents. Telephone interviews were not recorded but written down directly.

General introduction and background of the study

The situation of the company prior to the implementation

What is the business activity of the company?
What is the structure of the supply chain?
What ERP system/s is/are the company using?
For how long has this system been in use?
What functions are supported by the system?
How well is the ERP system adapted to the company's business?
What were the underlying needs that led to the implementation of the SCM support?
From which parts of the activity did these needs origin?
Why was the ERP system incapable of fulfilling these needs?
When was the SCM support implemented?

The selection

What people were involved in the investigation and the decision to implement SCM support?
Were other solutions considered than implementing SCM support? Which?
What SCM support solutions were considered during the selection?
Was any SCM support solution provided from the present ERP provider at that time?
How was the selection process carried out?
What were the criteria for the new system?
What factors led to the selection finally made?

The implementation

Was it possible to select what functions to implement from the SCM solution?
In that case; what functions were selected?
How was the implementation process carried out?
What people were involved in the implementation process?
What changes were required of the business organization and its activity?
How long did the implementation take?
Is the SCM support being continuously upgraded?

The situation of the company posterior to the implementation

Were the original needs satisfied by the SCM support?
How is the company's supply chain performing today? Is it satisfactory?
If not satisfactory, what are today's problems?

Summary and further discussions