Supply Chain Management in the Life Science Sector: Does Trust Play a Role?

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Abstract

Supply chain management has emerged as cross functional, cross company concept to improve coordination of entire value chains through coordinated actions of all companies in the value chain. It has received a major push from the availability of Internet-based information and communication technologies. The conditions in certain sectors are favorable for a realization of chain wide supply chain management. In other sectors, however, conditions are more complex and companies and value chains still struggle to exploit the potentials from supply chain management, in particular when it comes to cross enterprise coordination. This paper takes a complex supply network as example and discusses improvement potentials from supply chain management and developments in their implementation as well as barriers to the realization of chain wide supply chain management.

Keywords: *supply chain management, trust, life science sector*

1 Introduction

Supply chain management (SCM) has emerged as cross functional, cross company concept to improve coordination of entire value chains through coordinated actions of all companies in the value chain. It has received a major push from the availability of Internet-based information and communication technologies. The conditions in certain sectors are favorable for a realization of chain wide supply chain management. The automotive sector is an example where relatively short supply chains prevail and forecasting the demand for cars is reliable. Car manufacturers are very powerful in these supply chains and therefore could initiate a chain wide supply chain management to generate efficiency advantages throughout the supply chain.

In other sectors, however, conditions are more complex and companies and value chains still struggle to exploit the potentials from supply chain management, in particular when it comes to cross enterprise coordination. This paper takes a complex supply network as example and discusses improvement potentials from supply chain management and developments in their implementation as well as barriers to the realization of chain wide supply chain management. The case supply network regarded deals with the production of crop such as grain or produce. It is a complex multi echelon network with four tiers and spans from production of crop protection to crop production in agriculture to be further processed in the food industry. This supply network is characterized by, a. o., unforeseeable demand changes, very long lead times for input production, a fragmented tree structure for the coordination and disaggregation of the material flow, and system breaks causing inefficient material and information flows. After a discussion of general objectives and potentials from supply chain management, the paper analyzes the case of the complex crop production supply network with its characteristics, issues, and problems regarding the supply chains. Potentials from supply chain management are discussed together with barriers to their realization and further implementation.

2 Potentials from supply chain management

Supply chain management regards the holistic, process-oriented, cross company management and coordination of processes regarding material and product flows as well as complementary, initiating and accompanying information flows (Waters, 2003a). The principles of supply chain management build on logistics and its key issues, the reduction of cycle times and the improvement of the supply flexibility to reduce working capital (Wildemann, 2001).

Supply chain management is a relatively new function with different focal areas, both strategic and operative. Supply chain management should be used as a value driver and cross functional or even cross enterprise operation for the management and optimization of the flow of goods (Simchi-Levy *et al.,* 2003). Cross functional supply chain management intends to orchestrate all major areas of a company’s internal value chain as well as the entire value chain including suppliers and customers. It intends to find a global optimum of all functions, which is often better than the sum of local optima of single functions. Regarding a company’s internal functions, it affects procurement, operations, marketing and sales, logistics, or product development to act like one function towards the customer. The local optimum of a warehousing department that tries to cut down expenses by reducing stock levels can result in operations disruptions, loss of sales, etc. To achieve a reduction of working capital by reducing stock levels, only a cross functional perspective leads to a global optimum of the company’s entire internal supply chain. This not only results in reduced safety stocks in a warehouse, but also allows for reducing inventory buffers in the production chain. With a broader cross enterprise scope, supply chain management spans beyond a company’s interfaces with first-tier suppliers and customers and goes all the way up and down the chain to create coordinated actions of all value chain players. In this way, supply chain management is not a single company’s operational function, but a concerted action between multiple stages of cooperating companies, with the flexible use of functions like collaborative planning, forecasting and replenishment throughout the whole value chain.

Triggers for the improvement of logistic processes in supply chains comprise inefficiencies of the logistic system, a high complexity of the logistic system, or cost pressure (Wildemann, 2001). Various logistic levers, which are often interdependent, exist to improve the efficiency of the logistic system. An important lever in supply chain management is the reduction or elimination of interfaces between logistical processes and companies or an improved coordination between these interfaces. This involves a reorganization of supplier-buyer relationships and respective processes. An important enabler for the redesign of processes is information technology (IT) (Helbig, 2003). IT supports the reorganization of communication and coordination processes by enhancing information distribution, availability, presentation, and processing. In supply chain management, IT can support and improve the coordination of activities and communication within a company and across supply chain members to raise efficiency and reduce costs. The IT-based networking of in-house information systems and the streamlining of information processes like decision making and planning is the fundament required for a cross functional supply chain management. Networked in-house information systems can be connected with suppliers and customers to cross-link the supply chain network to achieve an information flow along the chain and an optimized networking of all functions in the entire supply chain, and as a result lead to a networked market. One of the major IT-enabled potentials for the improvement of supply chain management are e-marketplaces or trade platforms on the Internet (Hausen, 2005), which especially support the cross functional and cross enterprise aspect with the vision of supply chains going beyond procurement, production and distribution activities of a single company.

Prerequisites for the achievement of a networked supply chain are the optimization of a company’s single functions and the optimization of its internal processes. The next step is the integration of external functions from suppliers and buyers across the value chain, which can then lead to a total networking of the entire chain. The improvement of supply chain processes across companies requires not only the availability of appropriate information infrastructures (real-time information), but also close collaboration and cooperation as well as the integration of all participating companies. Supply chain management across companies is supported by advances in IT-based tools such as advanced planning and scheduling (APS) systems, or concepts such as collaborative planning, forecasting, and replenishment (CPFR), efficient consumer response (ECR) or vendor managed inventories (VMI) and improvements in mathematical optimization of supply chains.

3 Case study supply network crop production

The regarded case supply network produces crops such as grain or produce. It is a complex multi echelon network with four tiers and spans from production of crop protection to crop production in agriculture to be further processed in the food industry. The case study analyzes in detail from a supply chain management perspective the network between crop protection production and ag production (see fig. 1) as this supply network is characterized by, a. o., unforeseeable demand changes, very long lead times for input production, a fragmented tree structure for the coordination and disaggregation of the material flow, and system breaks causing inefficient material and information flows. Supply network levels ranging from agricultural producers to the retail level were only considered on a more aggregated viewpoint. The case study is based on a literature analysis and discussions with senior executives of supply chain management in the crop protection sector from different chain levels as experts in the field. Main dimensions of the case analysis are the configuration of the supply network including general external conditions like legislation, the products and the relevant supply chain processes.

3.1 Configuration of the supply network

The supply network (see fig. 1) starts with companies from the process industry followed by agrochemical producers. These two stages are often multinational companies, being complex networks themselves. Agrochemical producers are often vertically integrated with their suppliers or follow a single sourcing strategy for raw materials with selected suppliers. The further distribution of manufactured agrochemicals includes central warehouses, wholesalers, traders, and agricultural producers (farmers), which apply them in their food production process as end customers. Farmers, which are mostly small or micro enterprises, are at the end of the general lot disaggregation process. This distribution network between agrochemical producers and farmers is characterized by either one-tier or two-tier distribution with an increasing number of interfaces towards the ag-producer due to rising market fragmentation visible in small and medium sized and micro enterprises on the distribution and ag production levels. The large number of companies to coordinate and therefore interfaces between companies creates high complexity and raises coordination efforts for information and material flows, resulting in often inefficient supply chain processes. Relationships between companies in the distribution network vary from spot market relationships to long term contracting. Larger buyers in the network show a higher price sensibility. Often, agricultural producers have only one or two regular regional suppliers.

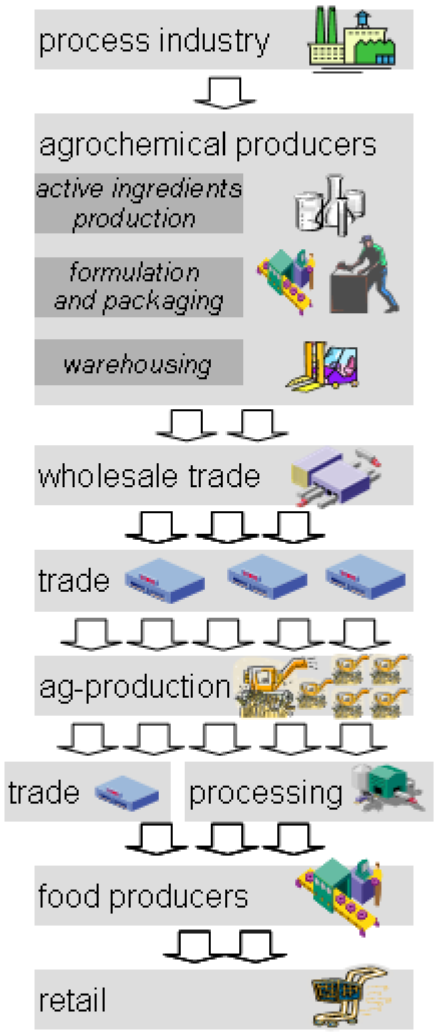

Figure 1. Supply network for crop production and processed food products

3.2 Products and processes in the crop production supply network

The crop production supply network is involved in the production of food. Its output – food products – highly impacts human health and quality of life. As a consequence, agrochemicals are subject to strict approval and licensing procedures and strict regulations exist for production, transport, storing, and application. This situation is mirrored by demands from food industry and retailers and their quality signs regarding the reasonable and limited application of plant protection (see Levidow, Bijman, 2002; Krieger, Schiefer, 2006) and traceability requests (Poignée *et al.*, 2004).

The production of agrochemicals involves high working capital and is prone to risks and uncertainties from long and cost-intensive research and development for new product development, including target discovery, screening, and a tedious regulatory approval. It requires raw materials from the process industry where various petrochemicals are processed to raw materials (Shah, 2005). Agrochemical producers synthesize raw materials to active ingredients required for plant protection. Active ingredients are produced either continuously or in campaign production for the entire season to avoid seasonal stock outs. This results in high inventory costs for internal distributing and warehousing. The synthesis of active ingredients is commonly realized in a central plant. From several months up to two years are required for the synthesis of active ingredients causing a very high replenishment lead time for the further production of agrochemicals (Shah, 2004). Therefore, it is difficult to ensure agility and responsiveness in the production stage for active ingredients. In formulation, the final agrochemical is realized by formulating active ingredients with various formulation ingredients to bulk products, either solid such as granulate or liquid such as suspensions or emulsions. Procurement of formulation ingredients and package material is reliable and allows changes on short notice. Packaging concludes the agrochemical production of plant protection products, which are then ready to distribute to the next levels of the network. In some cases bulk products (e.g. liquids) are moved directly form the formulation site or bulk terminals to traders and placed into the traders' bulk tank under consignment in the off-season. Formulation and packaging is realized either centrally for distribution on a local or national level (assemble-to-order) with warehouses to cover specific regions or decentralized and internationally for distribution in the respective region of the world (deliver-to-order). E.g., active ingredients may be synthesized in Germany and formulation as well as packaging is realized in South America. Decentralized formulation and packaging is carried out due to specific legislation requirements in different countries regarding formulation, to move the decoupling point closer to the final consumer, to be more flexible on dynamic changes in supply demand, and a lower shipping volume of active ingredients as opposed to packaged agrochemicals. Packaged goods are shipped to either internal or third-party warehouses, using own or third-party transportation.

Forecasting of future demands for agrochemicals in ag production is highly insecure and needs to take into account the low responsiveness in the active ingredients synthesis as well as unforeseeable demand changes. In principle, the demand for agrochemicals is linked to the consumption of food by consumers determining as supply demand of operating input by ag-producers. However, seasonality and therefore inflexibility in ag production does not allow to flexibly link the quantity of ag production to food consumption quantities, as well as output maximizing practices by farmers driven by legislation and subsidies. The demand for agrochemicals is discontinuous and seasonal and varies strongly according to unforeseeable natural conditions like weather (see Bassermann, 1999). As a consequence, agrochemicals can be characterized as typical z-goods with varying demand and therefore requesting high safety stocks throughout the supply chain (Wildemann, 2001). Despite of the unforeseeable demand situation, agrochemical producers traditionally realize top-down forecasting in headquarters for a whole sales season, made several months in advance of the actual sale. Bottom-up forecasting by sales departments is generally on the rise on product type or stock keeping unit (SKU) level, allowing companies a higher certainty in demand. However, forecasts remain unreliable due to the dependency of the demand on natural conditions bringing a high uncertainty in the supply chain. In addition, agrochemical producers have only rough estimates on total or remaining stocks in the distribution stages of the network to include in the forecasting. As a consequence, due to loss of inventory information for agrochemical producers, the distribution levels are often considered by agrochemical producers as levels adding costs to the final product for ag-producers. Due to the difficult forecast situation, redistribution of agrochemicals between sites or countries is regularly necessary to balance unforeseen demand fluctuation. For agrochemical producers, redistribution is favored as opposed to lost sales as transport costs are acceptable due to the favorable weight-value-ratio of agrochemicals.

Agrochemical producers traditionally have higher margins as opposed to the further distribution. The further distribution of agrochemical products down the chain towards agricultural producers across wholesalers and traders is determined by the demand situation and the characteristics of agrochemicals. In general, complex information and material flows exist in the distribution part of the network, with a large variety of processes and interfaces as well as different corporate structures and behaviors (e.g. culture, size, IT, strategy). On each distribution level, due to the increasing number of interfaces between suppliers and buyers an increasing number of small scale orders exist to coordinate the material flow. These factors create inefficiencies and, as a consequence, this part of the network can be considered as bottleneck limiting the efficiency of the entire supply network. This bottleneck character together with the inflexible production of agrochemical producers determines the supply chain problem situation in the crop production network.

Highly qualified and specialized consultants are needed to advise trade levels and ag-producers in the selection of suitable crop protection products. Agrochemicals have a limited shelf life and their transport and stocking are under strict legislation. High costs for warehouses and transport makes distribution capital intensive. Due to conditions of agricultural production, ag-producers request high flexibility and a high service level in their supply with crop protection and consider delivery flexibility in logistics as an important element of logistics quality (Schulze-Düllo, 1995). As a consequence from requested high service levels, wholesalers and traders often hold high inventories and safety stocks to prevent lost sales. The market for agrochemicals is characterized by frequent new product launches and product differentiation over the life cycle in addition to a large number of substitutes from same producers or competitors. For most agrochemicals, ag-producers as customers can select among various products and price is increasingly becoming an important decision criterion. Stock outs at the wholesale and trade level can lead to lost sales for the crop protection producer when substituting products from competitors are available for ag-producers.

A more detailed analysis on the process level shows that the core process on the distribution levels is order processing and the related sub processes. Order processing is seen as a critical success factor for wholesalers and traders (Schulze-Düllo, 1995) and highly influences the distribution service. Process efficiency of order processing is considered as essential. Order processing consists of the sub processes order reception, processing, fulfillment, documentation, and customer communication – including specialists' advice in sales – and related processes coordinated by order processing such as storage and transportation. It is essential as tool for customer relationship management as it includes the product-related consulting. Especially the order processing for sales of plant protection products in the high season is time-critical. Processes are error prone, mainly in high season at demand peaks. Process breaks at some point of the process flow are the consequence. Main errors in order processing are mistakes in order reception; appropriate specialist advice may not be possible and inefficient route planning and mistakes in commissioning can arise.

4 Improvement options and barriers

Supply chain management concepts and technologies offer different improvement options for the situation in the complex crop production network. In particular, improvements need to take into account the coordination of material and information flows in the network including information exchange to improve forecasts. This chapter discusses improvement options together with experiences and insights from the case study expert interviews regarding their implementation and barriers to their implementation. Figure 2 shows an overview of SCM concepts and already used IT systems.

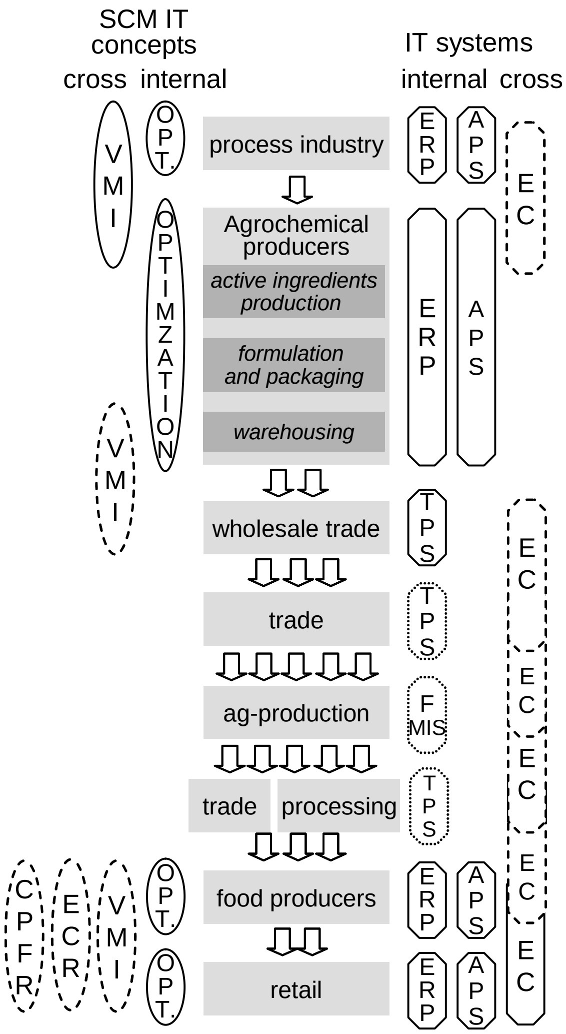

Figure 2. SCM concepts and IT systems in the supply network

4.1 Options and developments in subnetwork agrochemical producers

Agrochemical production companies being complex networks of material and information flows themselves face large internal supply chain challenges. To improve coordination and efficiency, agrochemical producers are realizing real time information and real time planning with advanced planning and scheduling (APS) systems. The implementation of APS systems requires a streamlined IT infrastructure as a basis. During recent years, agrochemical producers have worked on the creation of this basis. Continuous mergers and acquisitions among agrochemical producers, however, are often opposed to the process of streamlining the IT and supply chain structures and processes (see Buchta *et al*., 2004). An example for APS is SAP's APO system (advanced planner and optimizer) with functions such as the demand planner (sales forecast), production planner (with capacity restrictions, coordination or resources, etc.), supply network planner (simulation of cross enterprise tactical planning), supply chain cockpit (e.g. specific querying, performance measurement), and global availability check (availability-to-promise) (see Bartsch, Bickenbach, 2000). Data for these systems are data from the internal logistic network of the agrochemical producer, mostly provided by ERP (enterprise resource planning) systems or legacy systems.

However, the overall implementation of supply chain management at agrochemical producers is still functional oriented and resides within classical functions like transport or production. Departments in of agrochemical producers have different objectives and targets, e.g. the buying departments procures large amounts of bundled products to reach lower prices, production wants smooth and stable processes without change for large batches, sales wants customized products and flexibility to react on the market, personal objectives versus company objectives. In addition, most agrochemical producers are companies with long traditions and structures organized by experience with behaviors, habits and processes not easy to overcome.

4.2 Improvement options for bottleneck subnetwork distribution levels and ag-producers

For an improved coordination of the material and information flows in the bottleneck of the network where low IT infrastructures are common, web-based coordination platforms for the entire distribution network offer low cost access to support options. Coordination functionalities to overcome the problems in the bottleneck can be automation of order reception processes, group buying, targeted offers or virtual warehouses provide support options. Each of these functionalities is a lever focusing certain inefficiencies of the bottlenecked distribution network (see Hausen *et al.*, 2006).

An automation of the order reception process of wholesalers and traders enhances efficiency of their order processing for distribution to the more fragmented chain levels. In addition, automation reduces process errors and process breaks in high season and opens time for customer communication and advising. The automation can be set-up as shop based system with an electronic catalogue providing information on available products, prices, amounts, possible delivery dates and varieties of trading units to reduce communication errors. Bundling or group buying reduces information interfaces by bundling the customers' information flows towards suppliers in the bottleneck. The group buying mechanism horizontally bundles product demand lines from a common chain level as it bundles buyers according to region, product, and delivery day. It builds on the automated order process, creating synergies. In addition, transport pooling for groups' loads with flexible delivery dates to optimize similar routes transportation raises logistic quality. Targeted offers are an immediate solution for the purposeful reduction of inventories by offering and selling products to specific, interested customers. In particular, targeted offers are interesting for remainders of stock, e.g., from the previous season. Targeted offers can be used as tool for customer relationship management as it allows for targeting specific customers with specific information or product offers.

4.3 Overall crop production network

An optimization of material flows in the entire crop production network with the help of mathematical optimization is not feasible as most optimization models tend to picture only single staged chains or tree like formations. Networked structures with two branched endings are more complex and therefore hard to model. Often, picturing network relations is achieved by decomposition to limit the nodes around a central perspective to 1-tier suppliers and 1-tier customers (De Kok, Graves, 2003; Waters, 2003b). An improvement line traditionally used by agrochemical producers are optimization procedures on problems like facility location and design, inventory and distribution planning, capacity and production planning or detailed scheduling (Kallrath, 2000). Major efforts have been undertaken to optimize these supply chain management problems (Van der Vorst, 2000). However, the general problem in the suitability of mathematical optimization is the fact that every facility faces external, hard to control variables like the demand of its successors with different variations, varying lead times with uncertainties and a usually committed service level, and also internal variables, like costs or capacities and that optimizations depend on a given, narrow scenario with a large number of existing constraints so that an optimization is often restricted towards these constraints that can not be optimized (see Simchi-Levy *et al.*, 2004). The procedure to focus on single nodes of the supply chain contradicts “true” supply chain management in a way but reduces complexity. The limitations of optimization modeling prevent them from being used in a cross company way across an entire supply chain and not only company internal. In addition, cross company optimization requires information exchange across companies, which is a barrier as most input information for models is highly competitive and willingness to share this information is low.

Several key coordination problems of the network including the forecasting problem require improved communication and information exchange between network participants. However, information exchange between companies and across chain levels requires collaboration and collaboration requires trust (see Wildemann, 2001; Beth *et al*. 2003). Collaborative exchange of real time information supported by IT advances is an enabler for collaborative actions throughout the crop production network. It can support collaborative planning to coordinate on forecast and delivery schedules, or collaborative order management to communicate real-time with partners to coordinate on production or demand planning and foresee actual changes, both to achieve optimal resource allocation. Options for collaboration and cooperation can be facilitated by online supply chain communities, enabling daily work with flexible service components that allow adaptability and scalability on different levels of integration and customizability. An option to decrease the information intransparency throughout the distribution network is a virtual warehouse for the exchange of information on inventories and available products on stock between suppliers and buyers. The virtual warehouse enables information exchange on available quantities of products and an exchange of detailed information on qualities. It has the objective to improve the planning and efficiency of supply chain management processes like production, procurement, inventories, or sales through a reduction of safety stocks and traceability. It therefore can contribute to streamline the material flow throughout the distribution network as well as to the improvement of the forecasting problem of the agrochemical producers with vendor managed inventories (VMI). Information on qualities is particularly important for the levels of the agrifood production network on the output side of agricultural production. However, as the results for the case of the crop production network show, willingness to cooperate is low. Agrochemical producers have high margins and are therefore not willing to exchange information with distributors.

In essence it can be said that barriers toward an IT based network wide supply chain management to improve efficiency in the crop production network include several technical issues, but more people related issues. Technical barriers arise by the need to streamline IT applications. Prerequisites are common exchange formats for data to facilitate planning and transactions between chain levels. A more difficult problem with regard to information exchange is the lack of trust between the companies and their willingness to share certain data to achieve a global optimum throughout the entire network (Narayanan, Raman, 2004). Barriers to change are often related to culture and complexity. Change is cumbersome; a positive outcome is not evident (Garvin, 2006). Organizations and market culture expresses very much in the mind set of single managers, the amount of trust and the fear for vulnerability for opportunistic behavior on a company, department and personal level (Goleman, 1998; Gosling, Mintzberg, 2003). The last decision is taken by a manager (Hammond, 1998). Trust is a key ingredient for cooperation and cross functional and cross enterprise supply chain management largely depends on trust.

The current situation pictures general two lines of supply chain improvements. Improvements are realized on the stages of input production. The situation on stages of the distribution network of the trade levels including farmers. This reflects the traditional view on this network that focused either only on agrochemical producers or the distribution network of traders and ag-producers. The low cooperation of a network mainly caused by the lack of trust and lack of information sharing is a common barrier of supply chain management. Another barrier is the varying importance of the need to change, in times of prospering growth companies carry out their value generation and remain on their path. Pressures for change exist in times of declining growth and exploding costs, when budgets for required changes are tight. Future impulses forcing companies to leave their path (see Theuvsen, 2004) are decreasing margins due to higher competition, but also increasing power of better informed customers who can be less willing to accept higher product prices resulting from inefficient supply chain management.

5 Conclusions

Supply chain management has emerged as cross functional, cross company concept to improve coordination of entire value chains through coordinated actions of all companies in the value chain and has received a major push from the availability of Internet-based information and communication technologies. This paper has taken a complex supply network as example for analysis and discussed improvement potentials from supply chain management and developments in their implementation as well as barriers to the realization of chain wide supply chain management. The case supply network regarded deals with the production of crop such as grain or produce. It is a complex multi echelon network with four tiers and spans from production of crop protection to crop production in agriculture to be further processed in the food industry. This supply network is characterized by, a. o., unforeseeable demand changes, very long lead times for input production, a fragmented tree structure for the coordination and disaggregation of the material flow, and system breaks causing inefficient material and information flows. After a discussion of general objectives and potentials from supply chain management, the paper has analyzed the case of the complex crop production supply network with its characteristics, issues, and problems regarding the supply chains. The case shows the high complexity of the crop production network. As the analysis indicated, several key areas of the network are in need for better communication and collaboration between network participants. Collaboration offers huge potential for supply chain management in complex networks. The supply network might be improved by more reliable and more exact forecasts (working capital, remainder of stocks, safety stocks). Besides the problem of environmental conditions like weather, better collaboration and information sharing can improve forecasts within the supply chain. For network wide supply chain management the willingness to cooperate is therefore a prerequisite. Concepts like collaborative planning, forecast and replenishment (CPFR) offer potentials and are already in place on the downstream side of the chain toward the food processing industry and retailers (see Fritz *et al.*, 2004).

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