2 Supply Chain Management and Collaborative Planning

Content

This first chapter intends to give an overview of Supply Chain Management (SCM) and an introduction to Collaborative Planning. In particular, it shall be clarified how Collaborative Planning relates to SCM and why it can be considered an important component of implementing SCM.

The concept and understanding of supply chains is introduced in section 2.1, followed by a brief overview of SCM in section 2.2. The remainder of the chapter is dedicated to operations planning in supply chains. The traditional concept of successive and segregated planning is shortly outlined, the focus is however set on two alternate approaches to coordinating operations along the supply chain: hierarchical planning one the one hand and collaborative planning as the theme of this work on the other.

Key points

- Supply Chain Management (SCM) can be regarded as cross-functional, inter-company business process management which tries to integrate and coordinate all the activities required to fulfill ultimate customer demand
- Planning of operations (i.e. production, inventories, logistics activities) across the supply chain is a major component of SCM
- Whereas operations planning traditionally happens in a segregated and successive way, a hierarchical approach is proposed within SCM. Here, centralized planning tasks (especially the medium-term master planning) coordinate and synchronize operations across the entire supply chain
- Centralized planning in practice is however limited to parts of the overall supply chain (e.g. individual companies). Therefore, the idea of Collaborative Planning is to connect and coordinate planning tasks pertaining to indivudal SC members without the installation of a centralized, all-embracing decision making unit

2.1 The Concept of Supply Chains

Based on the often cited definition by Christopher (2005) a supply chain (SC) is defined as

G. Dudek, *Collaborative Planning in Supply Chains*, 2nd edn.,
DOI 10.1007/978-3-540-92176-9_2,

"the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the eyes of the ultimate consumer".[3]

The recognition of supply chains makes apparent that no single company or business unit fully controls manufacturing and distribution of its products. Instead, it also depends on the contribution of others and, just as important, the interactions between the various parties involved in the total process.

Although the concept of SCs is well established and often referred to in the literature on marketing, logistics, operations management and other disciplines,[4] its application to real-world businesses is not straight forward. First, it should be noted that the SC looks different from each party's subjective perspective. For example, the SC of a manufacturer with several suppliers is not equivalent to the SC of one of the suppliers. This is because the supplier likely serves other customers, too, but has no direct business relations with the remaining suppliers. This is visualized in Fig. 1. Part a) represents the manufacturer's SC and part b) the supplier's one. The framed sections are common to both SCs.

Second, trying to map a company's SC raises at least two questions, namely: how many tiers of suppliers and customers should be regarded and at which level of detail. Principally, the SC might start at the stage of raw materials such as agricultural or mining products and go through to retail outlets of consumable products. However, with such as broad understanding one obtains highly complex, unmanageable networks. To better focus on activities that are of real relevance, Lambert et al. (1998) propose to differentiate between primary and supportive SC members.[5] In analogy to Porter's (1985) value chain model,[6] primary members directly add value to the final products through their operations or services (e.g. component suppliers, logistical service providers), while supportive members provide resources that are consumed (e.g. equipment suppliers).

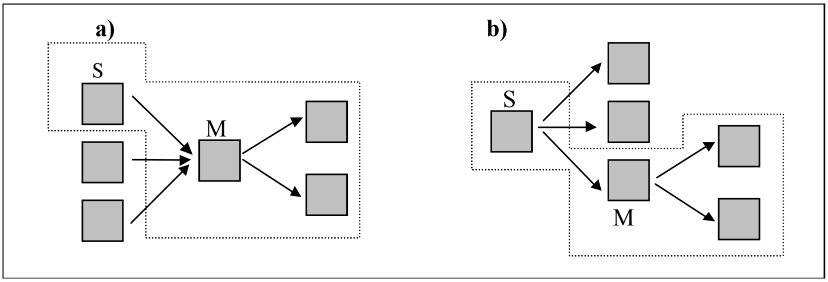

Fig. 1. Supply chains of a manufacturer and one of his suppliers

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3 Christopher (2005), p. 17.

4 See Croom et al. (2000) for an overview of subject areas dealing with SCs.

5 C.f. Lambert et al. (1998), p. 5.

6 See Porter (1985), pp. 36.

If only primary members are considered, the SC's point of origin falls to where there are no direct suppliers and the point of consumption is where the product is no direct input but a consumed resource (e.g. an industrial machinery).[7] Since the resulting network can still be large, a further limitation might be useful. Some authors therefore propose to consider only two tiers in the up- and downstream direction (the suppliers' suppliers and the customers' customers).[8] Alternatively, one might try to evaluate which business partners are critical for and/or generally under the influence of the company of interest, and only consider these players in the SC.

The appropriate level of detail to sketch a SC depends on the business context and managerial level. For example, when dealing with strategic relationships to business partners, the company itself and each supplier and customer might represent a single node of the network as depicted in Fig. 1. However, when logistical material flows are planned for, the various facilities of the company and its business partners usually each form a network node.

Finally, it should be noted that SCs are sometimes regarded as a type of network organization, considered having characteristics that fall between vertically-integrated systems and pure arms length market relationships.[9]

This view is not generally taken here. While the SC or a part of it might very well be managed like a network organization once Supply Chain Management techniques are applied, this is not per se the case. In fact, many of the deficiencies observed in SCs result from purely market-oriented interactions between their members.[10]

2.2 Overview of Supply Chain Management

The term Supply Chain Management was initially proposed to link logistics issues with strategic management.[11] Early publications stress the growing importance of well-designed logistics processes in increasingly challenging business environments of the 1980's. They propose intra-company integration of the purchasing, material handling, manufacturing and distribution functions and a reduction of inventory buffers.[12] A similar understanding is expressed in many contemporary textbooks where SCM is often regarded as a synonymous term for integrated logistics management.[13] However, a major difference concerns the scope attributed nowadays to SCM. Whereas initially an intra-firm perspective was predominant,

7 C.f. Lambert et al. (1998), p. 6.

8 C.f. Stadtler (2005), p. 9.

9 C.f. Cooper / Ellram (1993), pp. 13, Stadtler (2005), p. 15.

10 For example the well-known bullwhip effect (see e.g. Lee et al. (1997), pp. 93).

11 See e.g. Oliver / Webber (1992), p. 63, Houlihan (1985), p. 23.

12 C.f. Houlihan (1985), pp. 26, Jones / Riley (1985), pp. 19.

13 See e.g. Bowersox / Closs (1996), p. 34, Gattorna / Walters (1996), p. 12, Copacino (1997), p. 7, Simchi-Levi et al. (2004), p. 2.

today the idea is to consider and manage the entire SC including external business partners as described above.

From this perspective, SCM is primarily concerned with establishing a seamless flow of material and information through the entire logistics channel. Stadtler (2005), for example, defines SCM as

"the task of integrating organizational units along the supply chain and coordinating material, information, and financial flows in order to fulfil (ultimate) customer demands".[14]

The viewpoint that SCM is essentially equivalent to integrated logistics management on an inter-firm level is in part supported in scientific discourses on the nature of SCM. Kotzab (2000) compares the two management concepts and concludes that the difference is very small, if not negligible.[15] However, practices and methods proposed within the context of SCM by academia as well as practitioners, often include elements that go beyond what is usually regarded as logistics management. Prominent examples are joint product development between SC partners[16] or aligned promotion activities.[17]

Building on these observations, some authors differentiate between integrated logistics and SCM. They argue that SCM is a broader management concept, for that it is potentially concerned with the integration of all business processes between SC partners, not just logistics activities.[18] In the words of Cooper et al. (1997)

"SCM ideally embraces all business processes cutting across all organizations within the supply chain".[19]

Due to the emphasis of business processes, SCM can also be considered as cross-functional, inter-company business process management.[20] An overview of the business processes which can be integrated along the SC is shown in Table 1.

Irrespective of its precise definition, the objective of SCM can be summarized by

- increasing final customer service,
- lowering the amount of resources involved in servicing customers,
- and ultimately improving the competitiveness of the entire SC.[21]

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14 Stadtler (2005), p. 11.

15 C.f. Kotzab (2000), p. 33.

16 Considered a key issue of SCM by e.g. Simchi-Levi et al. (2004), p. 15.

17 Marketing issues are mainly treated in initiatives between consumer goods manufacturers and retail chains, such as Efficient Consumer Response (see e.g. Kotzab (2001), pp. 29).

18 C.f. Buscher (1999), p. 449, Pfohl (2000), pp. 7, Zijm (2000), p. 323.

19 Cooper et al. (1997), p. 5.

20 C.f. Hewitt (2001), p. 30.

21 See e.g. Cooper / Ellram (1993), p. 14.

Table 1. Supply chain business processes

Business processes along the supply chain
Customer relationship management
Customer service management
Demand management
Order fulfillment
Manufacturing flow management
Procurement
Product development and commercialization

Source: Cooper et al. (1997), p. 10[22]

Of course the improved competitive standing of the SC should translate to competitive advantage to all SC members. However, this is not necessarily guaranteed, and must be fostered by appropriate agreements between SC partners (e.g. savings sharing).

The major theme to realize the objectives lies, as implied above, in the integration and coordination of the SC and its processes.[23] A major question hence is how to actually realize a tighter integration and improved coordination. Noteworthy contributions to this issue are made by Hewitt (1994), Lee (2000), and Bowersox et al. (2000). These authors (independently) propose frameworks for the integration and coordination of business processes along the SC.

Based on an empirical study of SC initiatives in practice, Hewitt identifies three dimensions relevant for SC process redesign: work structure, information flow, and decision authority.[24] Work structure relates to rearranging and aligning tasks carried out by various parties in a SC. For example, suppliers can take over responsibility for replenishment of the items they deliver. Information flow deals with the availability of data. For one, the speed or timeliness of available information can be increased. In addition, new, formerly unavailable data can be made accessible. Decision authority finally relates to changing decision rights and redesigning decision support systems. Hewitt stresses that truly successful SC initiatives simultaneously address work structure, information, and decision authority which, in summation, results in radically new process design.[25]

Lee (2000) deals with the question of what constitutes SC integration. As an answer he proposes three dimensions of SC integration: information integration, coordination and resource sharing, and organizational linkage. Informational inte-

22 A similar compilation of business processes is presented by Buscher (1999), p. 455.

23 See e.g. Stevens (1989), p. 3, Bechtel / Jayaram (1997), pp. 19, Copacino (1997), p. 5, Lee (2000), pp. 31, Stadtler (2005), p. 11.

24 C.f. Hewitt (1994), p. 6.

25 C.f. Hewitt (1994), p. 5.

gration is viewed as the "foundation of broader supply chain integration".[26] It comprises the exchange of mere data in a first step and knowledge in a second. The latter obviously requires a deeper, trustful relationship. Coordination refers to decision rights, work activities, and resources. The first two aspects are equivalent to the framework by Hewitt, while the last means pooling and sharing of resources by SC partners (e.g. warehouses and other facilities). The organizational linkage dimension deals with the alignment of performance measures and incentives, such as costs, risks, and reward structures.

Bowersox et al. develop a so-called "Supply Chain 2000" framework for SC integration.[27] It consists of three contexts or components that serve to integrate organizational structures and functional activities: operational, planning and control, and behavioral. The operational context is concerned with the integration of activities within an organization as well as with external business partners. Planning and control embraces sharing of appropriate information, integrated decision making, and alignment of performance measures. The behavioral context deals with the underlying management of relationships to partners.

The three frameworks share major characteristics as can be seen from the summarizing overview in Table 2. In result, they make apparent that the integration of business processes along the SC needs to tackle

- the work structure (how and by whom processes are operated),
- information flows (how and to whom data is communicated),
- decision authorities (how and by whom decisions are drawn),
- and the underlying relationships between SC partners.

Table 2. Dimensions of supply chain integration

Hewitt (1994)	Lee (2000)	Bowersox et al. (2000)
Work structure	Coordination and resource sharing	Operational
Decision authority		Planning and control
Information flow	Information integration	
	Organizational linkage	Relational

Source: Hewitt (1994), p. 6, Lee (2000), p. 32, Bowersox et al. (2000), p. 72

These principles or dimensions can be used to evaluate and redesign any business process that cuts across the SC. In consequence, a myriad of different change and improvement opportunities can potentially be identified. Nonetheless, common principles or recipes for the integration and coordination of SC processes can

26 Lee (2000), p. 33.

27 C.f. Bowersox et al. (2000), pp. 71. The framework was first introduced in the form of a case study in Bowersox et al. (1999), and is also discussed in detail by Stank et al. (2001).

be drawn from SCM literature. For that purpose, Otto / Kotzab (2001) have analyzed contributions to SCM with respect to underlying (common) principles. The results of their study are presented in Table 3. They are not discussed in detail at this point. Instead they shall give an overview of the common approaches to SC integration as developed in the literature.

It should however be noted that SCM does not necessarily aim at a holistic integration of all business processes along the entire SC. Much rather, the appropriate level of integration has to be chosen based upon the specific situation of the SC and its environment.[28]

Table 3. Principles of Supply Chain Management

Principle	Explanation
Compression	Reducing the SC structure (e.g. no. of suppliers)
Acceleration	Reducing time lags (e.g. lead times)
Cooperation	Enhancing cooperation in planning, control, and operations
Integration	Reducing time, cost or performance loss at the transition between two processes (e.g. eliminating buffers)
Optimization	Applying quantitative modeling in planning and control
Differentiation / individualization	Increasing the specification of products / services
Modularization	Reducing time, cost or performance loss of replacing a part of the SC by another (e.g. changing suppliers)
Leveling	Reducing the variation of process parameters (e.g. production volumes)
Postponement	Moving the order penetration point towards the customers

Source: Otto / Kotzab (2001), p. 166

[28] C.f. Lambert / Cooper (2000), p. 74, Bask / Juga (2001), p. 139.

2.3 Operations Planning in Supply Chains

In the following we turn our attention towards one of the SC business processes as shown in Table 1, namely the manufacturing flow management process. Regardless whether SCM is understood as inter-firm logistics management or a broader management discipline on its own, the flow of material and related information, as well as associated planning and control activities are seen as a core component of SCM.[29] This is because operational activities underlying the manufacturing flow directly form the SC's final output and incur a large portion of total costs and capital needs. Effective and efficient management of operational activities is hence imperative for a SC's success.

The focus herein is not only on manufacturing in a strict sense, but on all processes related to the flow of material, i.e. production, transport / distribution, and storage, altogether subsumed by the general term of *operations*.[30]

The coordination of operations along the SC requires well-structured planning processes. In general, planning is defined as a rational, structured decision making process which aims to find the best choice of objectives and measures to a decision situation and its environmental setting.[31] The importance of well-planned operations results among others from two characteristics of operational processes. First, they interrelate one with another in many ways. For example, several operations consume identical resources such as production capacity or some processes require the output of others such as component parts needed in final product assembly. Second, operations ultimately serve to cover final customers' demand. However, as it is usually not possible to initiate all processes upon individual customer orders, expected demands have to be forecasted and anticipated at all tiers of the SC well in time.

According to Kansky / Weingarten (1999), the overall task of operations planning in the SC can be seen in deciding on:

- when to produce, transport, or store
- which quantities of final products, components and raw materials
- at which locations in the SC

such that customer demand can be met efficiently.[32]

Of course, this overall problem statement is usually of a daunting complexity and can hardly be tackled by a single, large decision making model that reveals all results on a detailed, implementable level. To make the overall problem yet tracta-

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29 C.f. Simchi-Levi et al. (2004), pp. 2, Chopra / Meindl (2001), pp. 6.

30 C.f. Nahmias (1996), p. 1.

31 C.f. Berens / Delfmann (1995), p. 12, Scholl (2001), p. 9.

32 C.f. Kansky / Weingarten (1999), p. 87. See also e.g. Chopra / Meindl (2001), pp. 6.

ble, several thrusts on how to deal with it are known in literature and practice and are introduced in the following.

The first approach is the typical way of how operations are planned and controlled without much integration of the SC. It is therefore considered only as a benchmark situation prior to the use of SCM techniques. The two approaches presented thereafter are those suggested within the debate of SCM. They are referred to as hierarchical and collaborative planning within the SC. As noted earlier, the latter is the particular subject matter of this work.

2.3.1 Successive and segregated planning

Until recently, the predominant approach to operations planning was the concept of manufacturing resources planning (MRP II). It is implemented in traditional production planning and control systems as well as in more modern enterprise resources planning (ERP) software.

Conceptually, MRP II grounds on the logic of successive planning. That is, the overall decision problem is sub-divided into several planning tasks that are executed successively in a hierarchical order. Results from super-ordinate planning levels form given input to succeeding tasks.

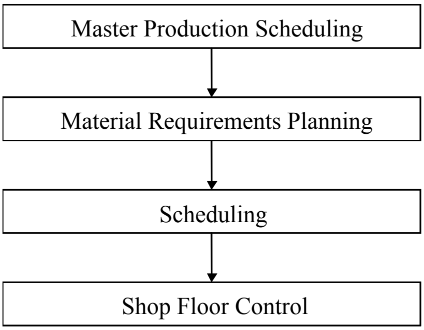

Fig. 2. MRP II planning tasks

The major planning tasks and the corresponding hierarchy are depicted in Fig. 2 and outlined in the following. It should be noted that from a conceptual perspective, the framework can include further planning activities such as medium-term aggregate planning or demand planning.[33] However, computerized decision support is usually restricted to the tasks as shown in the figure.[34]

Master production scheduling serves as the driver within the planning framework. Its purpose is to generate master schedules, i.e. planned production quanti-

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33 See e.g. Vollmann et al. (1984), pp. 12.

34 C.f. Drexl et al. (1994), p. 1023.

ties by period, for final products. Master schedules are obtained by netting demand forecasts and on-hand inventory at the beginning of the planning interval.

Material requirements planning (MRP) is the original core element within the concept. Requirements of components and parts are derived from master schedules by a bill-of-material explosion, and lot-sizes are generated based upon some predefined rules such as the EOQ-formula. Initially, only MRP was proposed as a novel, output- or program-oriented planning philosophy in contrast to thus far known inventory control policies.[35] The basic idea is to derive dependent demand for parts from final product forecasts rather than from replenishment orders faced at the corresponding stage of the production system. Subsequently, the MRP logic was supplemented by other planning tasks to form the planning framework of MRP II.[36]

Scheduling serves to generate the order in which individual items are processed on resources such as work centers. Quantities and due dates obtained by MRP are to be obeyed. However, as limited resources availability is accounted for here, capacity shortages can occur, in which case resolutions by plan shifts need to be made.

The shop floor control task finally represents the link to plan execution. It includes the release of production orders and subsequent follow-up on progress.

MRP II allows a computerized, integrated planning and control of manufacturing processes. As such it was and is widely used in practice since the advent of material requirements planning in the 1960's. Compared to control concepts known until that time, it brought a new philosophy to plan based on final demand and an increase in shop floor transparency.[37] Nonetheless, the concept suffers from considerable shortcomings, especially when it comes to planning with tight capacities and on a SC level. Deficiencies originate for one in its planning logic itself, and second in its limited scope with respect to all operations and planning activities of relevance from a SC perspective.

Four major conceptual weaknesses inherent in the planning logic are identified by Drexl et al. (1994). The authors put forward that in MRP II based planning systems

- there is no sufficient support of company wide planning embracing various facilities as well as the distribution and sales functions,
- plant orders are generated with an isolated view of the item in question, i.e. without taking account of the interdependencies with other items,
- average lead times, which include waiting time, are input to the system rather than a result of planning,

35 C.f. Voß / Woodruff (2000), pp. 180.
36 C.f. Hopp / Spearman (1996), p. 135.
37 C.f. Hopp / Spearman (1996), pp. 105, Kuhn / Hellingrath (2001), p. 121.

- and, above all, resource capacities are not systematically considered at all as limiting constraints, except for rough, ex-post capacity checks at the scheduling level.[38]

The last, major point is amplified by the successive, top-down execution of the planning tasks as indicated in Fig. 2. The approach lacks any anticipative "look forward" or feedback mechanisms that would incorporate consequences of planning decisions on subsequent tasks.

The second shortcoming of MRP II, that is its too narrow scope, is already implied by the first point made by Drexl et al. The problem here is that the concept lacks decision support on transport and distribution of intermediate and finished goods as well as on the links between various manufacturing facilities of one company, let alone the entire SC.

In result, MRP II like systems are independently operated at various facilities based on locally available data, leading to segregated planning processes along the SC. Coordination can in that way neither be achieved within a single (large) enterprise nor across company borders. As pointed out by Stevens (1989), based on the MRP II concept manufacturing and distribution are effectively decoupled in most companies due to the lack of a coherent integration of planning systems.[39]

In consequence, it is of little surprise that other, novel approaches to operations planning are proposed within the discussion of SCM. They are the subject of the following sections.

2.3.2 Hierarchical planning

An improved methodology to operations planning in SCs proposed by Drexl et al. (1994), Shapiro (1999), Miller (2002), and many other authors is the concept of hierarchical planning.[40] It is also the conceptual framework underlying Advanced Planning Systems (APS), new planning software packages which try to overcome the major flaws known from MRP II. In particular, the objective is to

- consider the entire SC,
- obey system constraints (e.g. incorporate resource capacities),
- and account for the interrelations between distinct processes.[41]

Hierarchical production planning was first introduced by Hax and Meal (1975) in the form of a case study.[42] Since then it received considerable attention in the

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[38] C.f. Drexl et al. (1994), p. 1025. Similar conclusions are given e.g. by Hopp / Spearman (1996), pp. 175, Zijm (2000), pp. 317.

[39] C.f. Stevens (1989), p. 7.

[40] C.f. Drexl et al. (1994), pp. 1028, Shapiro (1999), pp. 741, Miller (2002), p. 1.

[41] C.f. Kansky / Weingarten (1999), pp. 91.

[42] C.f. Hax / Meal (1975), pp. 53.

literature on production planning and scheduling.[43] Its basic idea is in fact similar to successive planning, in that the overall planning problem is decomposed into sub-tasks which interrelate in a hierarchical way. That is, higher level decisions form a given frame for decision making at subordinate levels. This is visualized in Fig. 3 for a hierarchical planning system with two levels.

The novelty of hierarchical planning however stems from the fact that the decomposition is regarded as a key aspect in creating a coherent planning system and therefore is based on a careful analysis of the overall decision or planning problem.

First, sub-tasks are usually defined such that decisions with similar time horizons and many interdependencies between one and another are combined at one planning level.[44] Also, the design of planning levels is oriented on the structure of the organization the planning system belongs to. For example, the number of levels can correspond to the number of layers of managerial decision makers.[45]

Second, distinct degrees of aggregation are used at the different planning levels. They are chosen in a way to best support the respective decision making processes. For example highly aggregated data is used in long-term, top-level planning, whereas detailed information is used for day-to-day short-term decisions.

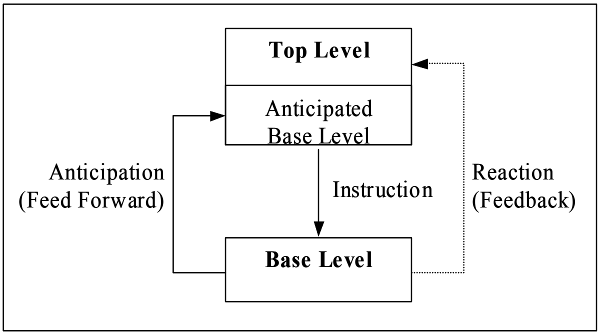

Fig. 3. Hierarchical planning system (source: Schneeweiss (1999), p. 19)

Finally, the coupling or interaction of decisions at various levels receives particular attention.[46] This is important in order to limit the sub-optimality of the total solution which naturally results from the decomposition of the overall planning problem into smaller chunks. Two concepts can be used to improve the quality of total solutions: anticipation and feedback.[47]

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[43] See e.g. Stadtler (1988), pp. 36, for a comparative study of various hierarchical production planning systems proposed in the literature.

[44] C.f. Kistner (1992), p. 1127.

[45] C.f. Scholl (2001), p. 37.

[46] C.f. Stadtler (1988), p. 31, Kistner / Switalski (1989), p. 498.

[47] C.f. Schneeweiss (1999), pp. 18.

Anticipation aims at drawing top-level decisions that do not overly hamper base-level decision making. According to Schneeweiss (1999) it can be defined as "choosing an anticipated base-level and taking into account its impact on the top-decision".[48] This is indicated in Fig. 3 by the "anticipated base level" which becomes a part of the top-level decision situation. To keep the resulting complexity manageable, the anticipated base-level model is usually limited to a rough, strongly simplified representation of the actual base-level objective and decision space.[49] Still, even a simplified base-level model is often sufficient to guide top-level decision making in a beneficial direction.

Whereas base-level circumstances directly influence top-level decision making through anticipation, feedback is realized by reporting the consequences of top-level decisions once they were incorporated into the base-level problem. Feedback communication is indicated in Fig. 3 by the dashed arrow. It can result in a re-evaluation of top-level decisions even before the plan is actually put into practice. Alternatively, it may only be used to improve top-level decision making in later, subsequent planning cycles.[50]

In contrast to the simplified visualization in Fig. 3, hierarchical planning systems usually include more than two levels and comprise more than one separate planning task at a given level. Since there usually are interdependencies between the various planning tasks at one level, coordination among them is required. It is established by the upper level, in that the interrelations are anticipated by the upper level problem. In consequence, instructions received by the various planning tasks are hoped to be coherent one with another.[51] This concept, i.e. that coordination is achieved by establishing an all-embracing upper-level, is another key characteristic of hierarchical planning.

Nonetheless inconsistencies can arise due to aggregation and coordination problems.[52] Aggregation flaws result from the changing level of detail used at different planning levels. Since aggregation usually incurs a simplification of the actual problem structure, it might not be possible to properly disaggregate top-level instructions at the base level. Similarly, coordination defects can occur, since well-coordinated, aggregate instructions do not necessarily enforce consistency at the detailed, disaggregated level. For example, while weekly production quantities for components and final products are synchronized, they can still become inconsistent on a daily basis after disaggregation in separate planning modules.

In order to organize SC operations planning in terms of a hierarchical system, it is useful to consider the various operational activities on the one hand, and differing time frames of decisions on the other as two distinct dimensions. The resulting

48 Schneeweiss (1999), p. 18.
49 C.f. Homburg (1996), p. 21.
50 C.f. Stadtler (1988), p. 139.
51 C.f. Kistner / Switalski (1989), p. 480.
52 C.f. Corsten / Gössinger (2001), pp. 34.

hierarchical planning system embedded in that framework is shown in Fig. 4, it is the so-called "supply chain planning matrix".[53]

Demand planning and fulfillment are the major drivers of all planning decisions, as forecasts and known orders of the SC's final demand are determined here. Strategic network planning and master planning are two central planning tasks which consider the entire SC, and serve to decide on how expected demand can be effectively satisfied. Herein, strategic network planning is concerned with long-range decisions on the SC's configuration such as the selection of locations and their capacities. Master planning in contrast operates within the frame defined by strategic decisions, and establishes target quantities, e.g. for production or procurement, on a medium-term, aggregate level for the entire SC such that corresponding demand forecasts can be satisfied. On a short-term level, individual planning tasks are proposed for the different operational processes. Planning decisions comprise order generation for procured material (procurement), lot-sizing, scheduling and shop-floor control (production), and detailed planning of transport flows, tours and truck loads (distribution).[54] In fact, multiple instances of these tasks are usually in place dedicated to specific locations or facilities, e.g. individual scheduling systems for each shop floor. A good example of how the various planning tasks look like and interact with each other in practical applications is described by Meyr (2004) for the automotive industry.[55]

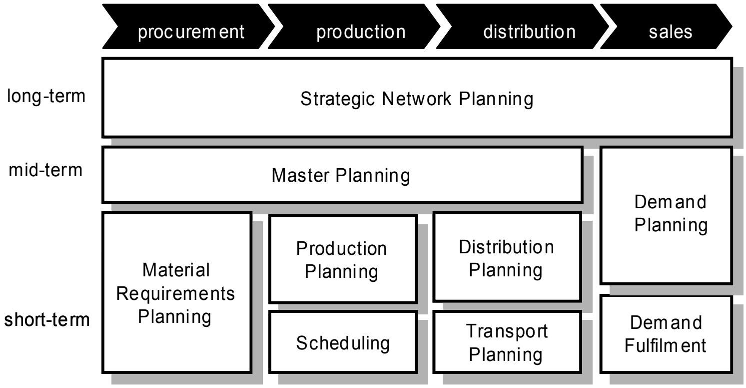

Fig. 4. Supply chain planning matrix (source: Rohde et al. (2000), p. 10)

As discussed above, upper level planning results define the frame for subordinate levels. In particular, the coordination of the various planning modules at the short-term level is established through instructions from their top-level. Therefore, the mid-term master planning plays a crucial role within the framework. It bal-

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53 Rohde et al. (2000), p. 10. Alternative, but similar frameworks are proposed e.g. by Zeier (2001), p. 36, Shapiro (2001), p. 41, Kuhn / Hellingrath (2002), p. 143.

54 For a more in-depth overview of the planning matrix see Meyr et al. (2005), pp. 109.

55 See Meyr (2004), pp. 447.

ances supply with expected demand and synchronizes the operational processes across the SC.[56] In order to achieve this purpose, it is commonly agreed that it should be organized as a single, centralized planning task embracing the entire SC.[57]

However given the nature of SCs, centralized decision making is a questionable aspect of the hierarchical planning concept. Concerning strategic network planning one may argue that chances exist to implement it as a single, centralized process, e.g. owned by the most powerful member of the SC, since the planning frequency is low, data is highly aggregate and can even be gathered manually.[58]

At the master planning level however barriers are higher to centralized decision making across business units or company borders. From a technical perspective, it requires for one a high level of systems integration, as accurate and steadily updated data on all processes must be available. Secondly, the computational complexity grows with an increasing number of facilities and processes covered.

Even more important, from an organizational perspective, independent entities in the SC will often resist to open all information to a central planning unit and accept to receive instructions in the form of plan targets. This is further complicated by the fact that individual entities can be involved in SC relationships to several, independent partners as indicated by the example of Fig. 1 above.[59] In such a situation it is doubtful, whether an entity can be integrated into centralized planning with one of the SC partners.

In result, hierarchical planning can regularly be realized only for a part of the overall SC, e.g. for all processes within one company or business unit. Therefore, the question arises, if there are alternative approaches to coordinate planning of adjacent operational processes without centralized decision making. Such an alternative approach is offered by collaborative planning.

2.3.3 Collaborative planning

Coordination can principally be established in two ways: by a hierarchical (also called vertical) approach or in a non-hierarchical (horizontal) way.[60] As we have seen above, hierarchical coordination is achieved through a common top-level decision process which generates synchronized instructions for interrelated subordinate levels from a central perspective. This is a common way to achieve coor-

56 C.f. Rohde / Wagner (2005), p. 159.

57 C.f. Corsten / Gössinger (2001), 33, Rohde / Wagner (2005), p. 159, Kuhn / Hellingrath (2002), p. 145.

58 In fact, various successful implementations of SC-wide strategic planning are reported in the literature, e.g. by Lee / Billington (1995), pp. 42, Camm et al. (1997), pp. 128.

59 C.f. Zijm (2000), p. 323.

60 C.f. Brockhoff / Hauschildt (1993), p. 400, Wildemann (1997), pp. 423, Steven (2001), p. 969.

dination within companies.[61] However, it comes to an end when a joint top-level embracing all interrelating units and their decision processes does not exist and the parties involved cannot agree to establish a central decision maker.

In contrast, heterarchical coordination grounds on consensus-like agreements on objectives, measures, and rules between parties with (relatively) equal decision rights. It is usually achieved through communicative, negotiation-like processes.[62] In the context of SCM heterarchical coordination of planning tasks is referred to as collaborative planning.[63]

The term collaborative planning gained popularity due to the industry initiative "Collaborative Planning, Forecasting, and Replenishment" (CPFR). CPFR represents a standardized process for implementing cooperative SC relationships between retailers and manufacturers in the packaged consumer goods industry.[64] As implied by its name, the original CPRF model consists of three phases: planning, forecasting, and replenishment.[65] Planning here refers to the definition of a cooperation's mission statement including goals, tasks, and resources, and the development of a joint business plan. The latter specifies the items involved in the cooperation, how they should be marketed, and how their supply should be organized.[66] Hence, in this context collaborative planning is understood as *business planning*, that is as a broad task which specifies how SC partners intend to cooperate.

The meaning attributed to collaborative planning throughout this work is different. Here, it is understood as collaborative *operations planning*, i.e. as a non-hierarchical, cooperative approach to the coordination of operations planning tasks across the SC.

To further specify the definition, it is helpful to introduce the concept of planning domains. A planning domain is a part of the SC (including corresponding planning processes) under the control and in the responsibility of one planning organization.[67] Examples of planning domains may be the distribution stage of a SC, a regional subsidiary of a large corporation, or the part of the SC which pertains to one company.

Planning processes can usually be well-structured and hierarchically coordinated within a planning domain, but are disconnected at the interfaces towards other, adjacent domains. This means, that only rough and uncertain information is available on other domains in the form of demand forecasts (in case of customers)

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61 C.f. Brockhoff / Hauschildt (1993), p. 400.

62 C.f. Steven (2001), p. 969, Zäpfel (2001), p. 13.

63 C.f. Zäpfel (2001), p. 13, Kilger / Reuter (2005), p.259.

64 C.f. Ireland / Bruce (2000), p. 83. C.f. Feuerstake (2002), p. 22.

65 See VICS (2002), p. 4, for an overview of the original CPFR model which comprises a total of nine process steps. The model was redefined and partly rephrased by the VICS CPFR committee in 2004; the initial phase is since then called „strategy & planning", but essentially still consists of the activities described above (see VICS (2004)).

66 C.f. Lohse / Ranch (2001), pp. 58, Seifert (2002), pp. 15.

67 C.f. Kilger / Reuter (2005), p. 259.

or supply capabilities (in case of suppliers). Now, collaborative planning is a means to link several such domains and their respective planning processes. Along the lines of Kilger / Reuter (2005) it is defined as follows:

"The idea is to directly connect planning processes that are local to their planning domain in order to exchange relevant data between the planning domains. The planning domains collaborate in order to create a common and mutually agreed upon plan."[68]

Similarly, Stadtler (2007) defines collaborative planning as "*a joint decision making process for aligning plans of individual SC members with the aim of achieving coordination in light of information asymmetry*."[69]

This is visualized in Fig. 5 for two planning domains. Within each domain hierarchical coordination of planning processes can be realized. Collaborative planning however serves to establish coordination between the domains. The lowest-level planning task which covers all operational processes within a domain is usually the mid-term synchronization by master planning. Hence, collaborative linkage of domain-specific master planning tasks is of particular interest.

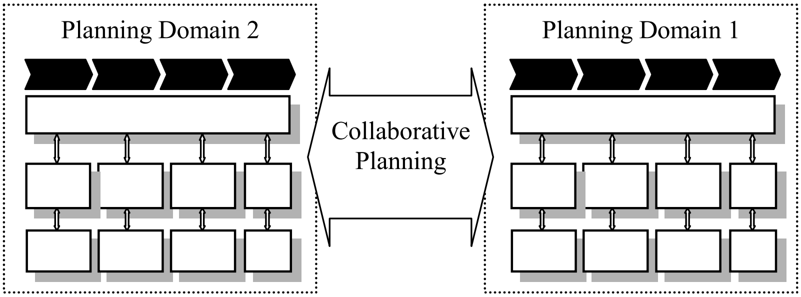

Fig. 5. Collaborative planning visualized (source: Kilger / Reuter (2005), p. 259)

A generic collaborative planning process comprises the phases as shown in Fig. 6. Once the cooperative relationship is defined, typical activities follow a cyclical process. Initially, intra-domain plans are generated and relevant data is exchanged between the domains. The crucial phase is then to adjust the internal planning results in an agreed upon way such that a consistent overall plan is obtained and committed to ("negotiation & exception handling"). Thereafter, final results can be executed and resulting performance be measured. The process starts over after a pre-defined re-planning interval.

Systems support of collaborative planning, that is support by Advanced Planning Systems (APS), is available for all phases as shown in Fig. 6. Naturally, APS support the generation of intra-domain plans. Regarding data exchange, APS offer

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68 Kilger / Reuter (2005), p. 259.

69 Stadtler (2007), p. 2.

web-interfaces for data visualization and entry by external partners. Also, automatic transmission via XML or e-mail in conjunction with Excel spreadsheets or flat files is available. For example, inventory levels, supply or transport requirements can be transmitted by e-mail to planning partners or accessed through webpages in SAP APO or the SAP Inventory Collaboration Hub.[70] Various rules can be defined concerning exception handling. The basic idea here is to monitor some performance indicators such as capacity utilization, order quantities, or service levels. Alerts can then be provided in case predefined value corridors are violated. Workflows specifying how to deal with such violations can be defined, e.g. in the SAP APO Macro Builder.[71]

In the execution phase, plans are put into practice. It is insofar supported by APS as production, transport, or purchasing orders are created and possibly automatically directed to transactional systems (e.g. a company's ERP system).

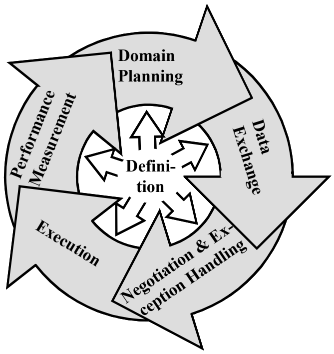

Fig. 6. Collaborative planning cycle (source: Kilger / Reuter (2005), p. 271)

Finally, performance measurement is too facilitated by APS in that key performance indicators can be defined and kept track of in so-called plan monitors. Performance measurement can relate to plan figures, actual data from past periods, or comparisons of plan and actual figures.

Despite these extensive support functionalities, a shortcoming to date is that only little decision aid is provided with respect to the negotiation process itself. Here, the question of which tools to utilize and how to embed their use in the entire collaborative planning process as depicted above is largely unanswered, and it is left to the individual user or implementer to define the workflows associated with alerts or violations as explained above. It is therefore the purpose of this work to develop a negotiation-based collaborative planning scheme that goes beyond mere data exchange and to demonstrate which improvements in SC performance can result from its application.

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70 C.f. Bartsch / Bickenbach (2002), pp. 361, Kilger / Reuter (2005), p. 276.

71 C.f. Kilger / Reuter (2005), p. 277.

A final note is in place on the applicability of collaborative planning in SC relationships. As described above in 2.1, SCs usually are complex networks comprising a number of companies, facilities, and often thousands of stock-keeping units. As collaborative planning requires substantial investments in hard (e.g. IT systems) and soft matters (e.g. team building across companies), it is clear, that it cannot realistically be implemented between all planning domains of a SC. Following Williamson's (1985) classification of transactions by frequency and degree of asset specificity, Skjoett-Larsen et al. (2003) suggest that so-called developed or advanced CPFR (i.e. a close collaboration) should be used where transactions recur frequently and require at least some specific investments by the trading partners,[72] which "lock" the SC members into a supply relationship and create barriers to switch suppliers or customers easily. Products or components requiring such dedicated investments are usually the major items dealt with in a SC (by volume and / or contribution to the value / functionality of the end-product). Specific investments around such items are often joint R&D and development actitivities which e.g. ensure, that parts fit together appropriately, can be processed in the desired way, or provide customized end-customer functionality.

Even when only key items and their corresponding planning domains are regarded as candidates for collaborative planning, additional factors can come into play, which foster or inhibit the applicability of collaborative planning. Based on a survey by Barratt (2004), these mainly go back to the relationship and cultural fit between the respective SC members. Enablers of collaborative planning are personal relations across various levels and functions of the companies, mutual interdependence, openness, and (at the base) the right individual chemistry. Inhibitors on the other hand are mechanistic behavior, functional (silo-oriented) management styles, and a lack of honesty, trust and process visibility.[73] Only when sufficient "enablers" are in place, collaborative planning will likely be implemented successfully.

Finally, as in any SC integration project, expected benefits of collaborative planning have to be compared with the cost of initial implementation and ongoing operation of the process.[74] McLaren et al. (2002) and Kilger (2005) give indications on the potential benefits (e.g. financials, service levels, as well as qualitiative factors such as improved market knowledge) and costs (system implementation and integration, process coordination costs, data translation and integration, switching costs, etc.).[75] Only when expected benefits of developing and implementing a collaborative planning process exceed associated costs, an implementation can be recommended.

72 C.f. Skjoett-Larsen (2003), p. 538.
73 See Barratt (2004), pp. 81, for a full overview.
74 C.f. Kilger (2005), pp. 281.
75 C.f. McLaren et al. (2002), pp. 355, Kilger (2005), pp. 291.

Recommended readings

- Simchi-Levi, D. / Kaminsky, P. / Simchi-Levi, E. (2004): Managing the Supply Chain – The Definitive Guide for the Business Professional, 2nd edition, Boston et al. 2004 (especially chapter 1 "Introduction").
- Meyr, H. / Wagner, M. / Rohde, J. (2005): "Structure of Advanced Planning Systems", in: Stadtler, H. / Kilger, C.: Supply Chain Management and Advanced Planning – Concepts, Models, Software and Case Studies, 3rd edition, Berlin et al. 2005, 109-115.
- Kilger, C. / Reuter, B. (2005): "Collaborative Planning", in: Stadtler, H. / Kilger, C.: Supply Chain Management and Advanced Planning – Concepts, Models, Software and Case Studies, 3rd edition, Berlin et al. 2005, 259-278.

Springer
http://www.springer.com/978-3-540-92175-2

Collaborative Planning in Supply Chains
A Negotiation-Based Approach
Dudek, G.
2009, XIV, 234 p. 45 illus., Hardcover
ISBN: 978-3-540-92175-2