A Methodology for the Segmentation of Supply Chains

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Abstract

Supply chains increasingly have to cope with heterogeneous customer needs related to the performance areas of supply chain management (SCM), e.g. delivery reliability, delivery time, and availability. ‘One-size-fits-all’ supply chains that are predominant in reality are often not very effective and efficient. In order to better meet customer needs, supply chains can be segmented so that they have different priorities, objectives, and means. A methodology will be elaborated for developing segmented supply chain strategies, which first identifies segments, then sets strategic priorities to be operationalized and allows to concretized supply chain designs accordingly. Furthermore, the methodology comprises a value-based system of objectives and means of SCM for the operationalization of strategic priorities in order to align the segmented supply chain strategy with the corporate and competitive strategy and customer needs. Based on the identification of different supply chain segments with specific objectives, appropriate best practices and measures can be selected.

Keywords: Supply Chain Management, Supply Chain Segmentation, Supply Chain Strategy, Axiomatic Design

1. Introduction

Supply chain management (SCM) has become a successful concept for the management of inter-company logistics processes in value-added supply chains and networks in industry. SCM connects, aligns, and coordinates processes in supply chains as well as flows of material and information between suppliers and customers. SCM is “the coordination of a strategic and long-term cooperation among co-makers in the global logistics network for the development and production of products, both in production and procurement and in product and process innovation” (Schönsleben, 2003). Companies hope to achieve more efficient logistics processes, better customer service, and cost reduction by employing SCM in order to gain competitive advantages. Surveys of European companies show that SCM has a decisive influence on business success and it is increasingly a top management issue (ELA/Bearingpoint, 2002; Nienhaus et al., 2003).

Companies are forced to seek after business benefits of SCM and to capitalize on them due to increased customer and market orientation, ever more intensive competition, globalization of procurement and sales markets, increasing complexity of products and regulations, risk and dynamics of the markets and demands as well as advances in information and communication technologies. As a consequence, supply chains increasingly have to cope with heterogeneous customer needs related to the performance areas of SCM, e.g. delivery reliability, delivery time and availability. ‘One-size-fits-all’ supply chains that are predominant in practice or supply chains segmented using market criteria such as market size, location, products etc. are often not very effective and efficient since they are poorly adapted to customer needs regarding SCM and often incur high costs (ATKearney, 2004). Heterogeneous requirements may raise risks due to augmented complexity of processes, higher costs, little synergies or organizational impediments. Companies can cope with these issues by segmenting their supply chains according to different requirements in an adequate way by striking the balance between customization to specific requirements and complexity: “Each supply chain should be brought enough to have sufficient scale and narrow enough to avoid loss of focus” (ATKearney, 2004: 3). Thus, the number of distinctive supply chains depends on products, customers, and the market.
The objective of this paper is to develop a methodology for the systematic development of a segmented supply chain strategy for segmented supply chains that reflect specific requirements.

The research methodology incorporates the principles of action research according to Greenwood and Levin (1998): structured research process, participation of industrial partners by involving them in the research process, and ‘action’ by transferring the results into practice. The research process consists of four steps. In a first step, the requirements and issues in theory and practice of SCM related to supply chain segmentation are identified using literature review and surveys. In a second step, the method of Axiomatic Design is applied to SCM, yielding a decomposition of SCM that was validated together with industrial partners during the ProdChain project (see below). This result serves in the third step as a basis to elaborate a methodology for the development of a segmented supply chain strategy. Then, the methodology is applied in a case study.

Accordingly, the remaining part of the paper is organized as follows: In the next section, an overview of the research background (state of the art) is given. In sec. 3, a systematically structured system of objectives and means of SCM (Supply Chain Design Decomposition SCDD) is presented. This decomposition can be used for the segmentation of supply chains as shown in the fourth section. A brief case study illustrates the application of the methodology in the fifth section. Subsequently, some implications are drawn in sec. 6. In the concluding section, lessons learnt, benefits, and limitations are discussed.

The research described here is a part of a large-scale international research project, ProdChain (IST-2000-61205), funded by the European Commission. The main objective of ProdChain was to develop a decision support methodology to improve the logistics performance of globally acting production networks. In addition to the three academic partners ten industrial partners participated in the consortium.

2. Research Background: Supply Chain Segmentation and Supply Chain Design

In this section, some essential terms are defined and relevant literature is discussed.

2.1 Supply Chain Management (SCM)

Various definitions of SCM can be found in literature. Additionally to the aforementioned definition of SCM as the co-ordination of a co-operation, SCM can be defined as the integration of processes from suppliers to customers in order to add value to customers (Lambert et al., 1998). In another market-oriented view, Ross (2000) stresses that SCM has to create unique sources of customer value by synchronizing the flow of products and information. Seen from a broader management perspective, SCM can be understood as the long-term and collaborative design (configuration, definition of collaboration, co-ordination), control (guidance towards the objectives by means of supply chain strategies) and development (long-term adaptation to trends through flexibility in collaboration and capabilities) of supply chains and value-added networks (Schnetzler et al., 2004). Despite extensive advances in the last decade, there are still major gaps in theory and practice of SCM remaining, in particular related to the holistic view of the supply chain and the inter-organizational level instead of focusing on one or a few elements of supply chains and related to the incorporation of theories of other disciplines, as reviews of SCM research by Chen and Paulraj (2004) as well as Sachan and Datta (2005) show.

2.2 Supply Chain Segmentation

As mentioned in the introduction, supply chains have increasingly to cope with heterogeneous customer needs and to serve a wide range of products, customers, and markets (Lovell
Segmentation originates from marketing (Smith, 1956) and is an approach to improve customer orientation and to handle a diversity of customer needs by dividing a market as a whole into segments according to the parameter values of the requirements. For example, the market for computers can be segmented into the segments of laptop and desktop computers, respectively, since the corresponding customers have different requirements, e.g., weight, battery time, display size etc. The idea of supply chain segmentation is to adapt this approach to supply chains: “Supply chain segmentation works on the assumption that customers buy products in different ways, have different expectations of service and are prepared to pay different prices based on their service requirements” (Barratt, 2004: 33). As a consequence, one single supply chain (design), i.e. strategy, structure, processes, resources, is often not very effective and efficient to meet different customer needs (Christopher and Towill, 2002). If, for instance, customers want high availability, this implies short lead times and/or high inventory levels; but if customers require high punctuality of delivery, this means primarily reliable processes. Therefore, the supply chains have to be configured in terms of partners, processes, and resources accordingly. Even when products are the same, customers may have different requirements (AT Kearney, 2004). For example, a producer of a product sold as a component to an OEM has primarily to guarantee punctuality of delivery, while end-customers buying the product as a spare part require availability first of all. Segmentation does not imply that the supply chains have to be physically separated, they may use the same infrastructure (warehouses etc.), but may differ in strategy, objectives, and processes.

The issue of supply chain segmentation has long been recognized and evolved from marketing. Gilmore et al. (1977) claim that customer service (delivery time, quality, order accuracy, availability etc.) should take into account variations of requirements according to customer type. Likewise, Sharma and Lambert (1990) propose a market segmentation based on customer service requirements. Fuller et al. (1993) suggest that logistics has to be tailored to specific requirements resulting from characteristics of product, customer interaction, delivery and order, handling, inventory and possible defection. As a consequence, a company can differentiate logistically distinct businesses and set up customer oriented supply chains (Otto and Kotzab, 2003).

2.3 Supply Chain Design

Fisher (1997) argues that innovative and functional products should be treated differently in separate supply chains, i.e. an efficient and a responsive supply chain design, respectively. Thus, the supply chains should be designed according to product characteristics. The idea of different supply chain designs has been developed further into lean, agile and ‘leagile’ or hybrid supply chain design (Mason-Jones et al., 2000a, 2000b; Christopher and Towill, 2001 and 2002; Vonderembse et al., 2006). The focus of a lean supply chain for commodities and standard products is cost reduction and flexibility, while for an agile supply chain for innovative products objectives are high availability and short lead times (responsiveness). Hybrid or ‘leagile’ supply chains combine the capabilities of both designs for complex products.

Hill’s (1989) framework of order qualifier (minimum requirements in order to be competitive) and order winner (requirements differentiating from competitors) can be used for the selection of the most appropriate supply chain design (Mason-Jones et al., 2000b), see Table 1. An agile supply chain design is related to the order winner availability (service level) and the order qualifiers quality, cost and lead time, while a lean supply chain design is suitable for cost as order winner and quality, lead time and availability as order qualifiers.

The answer to ‘which supply chain design is suitable for which products?’ is dependent on the product lifecycle as well (Aitken et al., 2003; Vonderembse et al., 2006). Thus, a hybrid or lean supply chain should be used for innovative products that are in their maturity or decline phase (Vonderembse et al., 2006).
According to Lovell et al. (2005), there are many more factors that influence the selection of the most appropriate supply chain design. The authors group them into factors related to the product, market as well as factors related to the geographic and commercial environment, see Table 1. As the key drivers in the segmentation process, they identify demand level (throughput), demand variability-service (availability) and product value-density (combining product value, size and weight). Since these factors drive the major cost of a supply chain, i.e., cost of manufacturing, transportation, facilities, and inventories, they influence decisions about decentralized or centralized inventory holding and the speed of transport options in particular.

2.4 Conclusion

Based on the current status of research in the field of supply chain segmentation and supply chain design, the conclusion is that there is a fundamental need for the segmentation of supply chains and that there exist several 'generic' supply chain designs, such as lean, agile, and hybrid supply chain design, which define the focus of the supply chain. For the determination of suitable supply chain segment, several factors are described in literature.

Nevertheless, there is a lack of segmentation methodology that adapts the supply chain design to specific requirements and makes it realizable. Beyond, there is a need for a procedure guiding practitioners in developing a supply chain strategy for segmented supply chains.

Consequently, in the next section, a decomposition of supply chain design is presented that will be used later in a methodology for the segmentation of supply chains.

3. Supply Chain Design Decomposition (SCDD)

3.1 Axiomatic Design

Axiomatic Design (AD) is a scientific approach developed at the Massachusetts Institute of Technology (MIT) for the development and selection of good design solutions for products, processes and systems (Suh, 1990, 2001). It focuses on the identification of functional requirements (FRs) (objectives: what to achieve), and the selection of means for achieving them, i.e., design parameters (DPs) (how to achieve). By decomposing a design into several

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<tr>
<th>Order qualifiers, order winners (Hill, 1989)</th>
<th>Price related to operational costs (FR-C)</th>
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<tr>
<td>Order qualifiers, order winners (Hill, 1989)</td>
<td>related to operational costs (FR-C)</td>
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<td>Quality</td>
<td>= quality (FR-Q)</td>
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<td>Delivery reliability</td>
<td>= delivery reliability (FR-R)</td>
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<td>Delivery speed</td>
<td>= delivery lead time (FR-L)</td>
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<td>Demand increase others</td>
<td>= flexibility (FR-F)</td>
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<td>others e.g. support, product range etc.</td>
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<td>Product</td>
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<td>(key drivers in italics)</td>
<td>Life cycle, variety, product type, handling characteristics, shelf life, physical size and weight, value, product value density</td>
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<td>Product life cycle, variety, product type, handling characteristics, shelf life, physical size and weight, value, product value density</td>
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<tr>
<td>demand location, demand level (throughput), demand variability (availability), service expectations</td>
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<td>existing infrastructure, transport mode availability, customs/duty/trade areas, legislation</td>
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<th>SCM target areas (Schnetzler, 2005)</th>
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<td>SCM target areas (Schnetzler, 2005)</td>
<td>= quality of product, process, and organization</td>
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<td>SCM target areas (Schnetzler, 2005)</td>
<td>= punctuality</td>
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<td>SCM target areas (Schnetzler, 2005)</td>
<td>= time to delivery, availability</td>
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<td>SCM target areas (Schnetzler, 2005)</td>
<td>= order patterns, demand uncertainties</td>
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<td>SCM target areas (Schnetzler, 2005)</td>
<td>= inventories, work in process, infrastructure etc.</td>
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<tr>
<td>SCM target areas (Schnetzler, 2005)</td>
<td>= costs related to flows of materials and information, management, and warehousing</td>
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FR = functional requirement (objective), see sec. 3.
levels of objectives-means-combinations, a hierarchical causal model is created that shows the connections of an objective and the corresponding solution, i.e. means. In doing so iteratively, high level objectives and means are decomposed. This systematic approach has two main benefits (Duda, 2000):

- The separation of objectives and solutions clarifies the logic and enables to focus on what to be achieved prior to thinking about solutions.
- The systematic decomposition enables to concretize high-level objectives systematically as more tactical objectives and means on lower levels.

Axiomatic design has been successfully applied to the design of many products, systems, and software as well as to the development of manufacturing systems (Suh, 2001).

3.2 Set-up of the SCDD

The result of applying AD to SCM is the so-called Supply Chain Design Decomposition (SCDD) (Schnetzler, 2005). The SCDD is structured in a systematic way (see Figure 1): The value-based management concept of Economic Value Added (EVA) is the root of the decomposition as a representative for company success (Ehrbar, 1998). Simplified, EVA is net operating profit after taxes minus a capital charge, which depends on the total invested capital and the capital costs. Next, the target areas of SCM are covered: quality, delivery reliability (punctuality), delivery lead time (availability, time to delivery), flexibility, assets (capital investments in current capital, e.g. inventory, and fixed assets, e.g. infrastructure) and operational costs, see Table 1. Subsequently, ‘source’, ‘make’ and ‘deliver’ processes are differentiated according to the Supply Chain Operations Reference (SCOR) model (SCOR, 2005). Subsequently, production resources are considered (capacities, information, materials). Appropriate means are identified according to the state of the art of SCM and the principles of lean manufacturing, i.e. elimination of waste (over production, unsuitable production methods, excess inventories) (Ohno, 1988) as well as reduction of fluctuations and inflexibility.

![Figure 1. Set-up of the Supply Chain Design Decomposition (SCDD).](image-url)
The rationale behind is the following: When optimizing reliability and lead times, compromising quality would induce serious problems. If a certain degree of reliability is established, then lead times can be optimized and subsequently flexibility (it is inefficient to optimize processes, which are not well controlled, towards speed and flexibility). This is the prerequisite for reducing assets and costs. Reducing them first can cause serious problems regarding quality, reliability, and availability. Thus, this sequence reflects better the logical order of decisions and implementation order of measures.

The SCDD consists of more than 250 objectives and means of SCM and is described in detail by Schnetzler (2005). Figure 3 shows a small excerpt of the SCDD. A remark regarding the notation: Functional requirements and design parameters are noted as FR-xyz and DP-xyz, respectively, with x = Q, R, L, F, A or C for the target areas quality, delivery reliability, delivery lead time, flexibility, assets, and operational costs, y = S, M or D for ‘source’, ‘make’ or ‘deliver’ in the corresponding target area, z = hierarchical number for the further decomposition. (Due to taxonomy reasons, the high level objectives and means FR/DP-1 and FR/DP-11 (EVA, logistics excellence) are noted differently).

![Figure 2. Sequence of target areas and ‘sandcone’ model of Ferdows and De Meyer (1990).](image)

![Figure 3. Strategic SCM in the SCDD (excerpt).](image)
The target of a high EVA (FR-1) is achieved by means of the optimization of its value drivers in terms of logistics (DP-1). Therefore, DP-1 is decomposed into the value drivers high sales revenue (FR-11), low assets (FR-A), and low operational costs (FR-C). As means for FR-11, increasing customer satisfaction (DP-11) is identified, which is further decomposed into the objectives of high quality (FR-Q), high delivery reliability (FR-R), short delivery lead times (FR-L) and high delivery flexibility (FR-F). For each of these objectives, appropriate means are identified, following the state of the art of SCM and lean manufacturing principles, as mentioned above.

These elements are further decomposed into objectives and means over several levels. By doing so, the level of operational SCM is reached and corresponding best practices (e.g., vendor managed inventory) can be assigned. The same principle applies for the sub-branch of assets (FR-A), i.e. investments in current and fixed assets (e.g. inventory, infrastructure), and for the sub-branch of operational costs (FR-C).

High quality (FR-Q) is achieved by reducing deviations from quality requirements from customer side. Only a small over-achievement is allowed (otherwise, it is waste). When quality is ensured, delivery reliability (FR-R), i.e., punctuality, can be optimized by minimizing time deviations and delays of source, make, and deliver processes. In particular, supply chain risk management and process control can be employed as well as supply techniques such as continuous replenishment. Next, with a high reliability as a prerequisite, delivery lead time (FR-L), i.e. availability and time to delivery, can be optimized by reducing any kind of time waste, for example, avoidable waiting times. Measures are, for instance, just in time techniques, better synchronization, co-ordination and harmonization of processes, seamless flows of materials and information, set-up time reduction and optimization of capacity utilization. Processing time may be reduced by elimination, parallelization, integration or acceleration of process steps or change in sequences. Furthermore, information technology can help accelerating the flow of information (order processing etc.). High flexibility (FR-F) relates to the capability to cope with changes of order patterns and order due dates as well as uncertainties of demand. General means are scalable and adaptable capacities.

When these prerequisites are fulfilled, assets (FR-A) can be optimized by reducing investments in non value-adding current (inventories, work in process etc.) and fixed assets (infrastructure), as far as possible. This can be achieved, for instance, by means of optimizing lot sizes and order cycles, smoothing of demand variations, inventory management, reduction of inventory levels, outsourcing, and the reduction of added value profile. Beyond, it is essential to optimize safety stock and to prevent the bullwhip effect (Lee et al., 1997) that describes the phenomenon that demand variance is amplified upwards the supply chain resulting in inefficiencies such as surplus and fluctuating stocks as well as long lead times. This can be reduced through sharing of information on end-customer demand and on forecasts throughout the supply chain, as well as inventory control. Furthermore, measures for short lead times (DP-L) have a positive impact on low assets. Fixed assets can be reduced, for example, by outsourcing of non-core processes, e.g., warehousing. Since costs are influenced by all target areas discussed so far, cost reduction (FR-C) are not sustainable unless all prerequisites are met. Any kind of waste in processes related to the flow of material and information, related to management and warehousing has to be eliminated systematically. In particular, information technology can facilitate this objective by automating exchange and processing of information exchange and by employing, e.g., barcoding, track & trace, radio frequency identification (RFID), electronic procurement etc.

Usually, a means for achieving an objective has a positive or negative impact on the achievement of other objectives (shown in the SCDD in Figure 3 by means of dotted lines). For example, many measures influence costs. Hence, there are trade-offs and a supply chain strategy can lead to conflicts between objectives as well as to synergistic effects. Thus, inter-
dependencies of measures, practices, and objective must be analyzed carefully in the specific company context.

The main benefits of SCDD are the separation of objectives and solutions—which helps clarifying the inner logic of SCM and focusing on what is to achieve prior to thinking about solutions—and the systematic decomposition, which enables to concretize high level objectives stepwise, down to operational objectives and means. The SCDD was successfully applied in several case studies (Schnetzler, 2005).

4. Methodology for the Segmentation of Supply Chains

4.1 Segmented Supply Chain Strategies

Since the SCDD relates objectives and means of SCM in a systematic way, it can be used for the development of a supply chain strategy. We define supply chain strategy as a set of prioritized SCM objectives (strategic priorities) and a way to operationalize them, i.e. to determine appropriate measures, in order to build up and capitalize on specific capabilities and resources that can potentially result in successful business performance. A segmented supply chain strategy deals with supply chain segments and defines objectives for each segment and operationalizes them.

The objectives are related to the SCM target areas quality, delivery reliability, delivery lead time, flexibility, assets, and operational costs. A supply chain strategy can be developed by starting in the SCDD at the predefined strategic priorities and following the SCDD top-down. In doing so, objectives and means can be operationalized. The SCDD shows adequate means (DP) that can be employed in order to achieve a specific objective (FR). Since each means relates to two or more sub-objectives (as a rule), there are possibilities for decisions or prioritization, i.e. one or more sub-objectives can be selected or prioritized in order to operationalize it or them further. This selection or prioritization depends on specific situation of the supply chain in question: Which sub-objective does better enable the achievement of the higher objective? Where are improvement potentials? Are there prerequisites to be achieved prior? What are the requirements from customer side (order winners, order qualifiers)? What are the factors influencing segmentation (see sec. 2.3)? In the SCDD, the supply chain strategy can be interpreted as a ‘path of operationalization’, possibly with ramifications.

These possible ramifications enable to develop segmented supply chain strategies: By making decisions on the prioritization or selection of appropriate sub-objectives, different requirements related to customer and product as well as the factors, which influence segmentation, can be taken into account. Therefore, in the SCDD, a segmented supply chain strategy represents a ramified path of operationalization with different branches for different segments of the supply chain (see Figure 4).

If a company has the same strategic priorities for all products and markets, ramifications of the path of operationalization of the segmented supply chain strategy are possible at a lower, more detailed level of the SCDD. For example, if a high availability is defined as a strategic priority, for some products short sourcing lead times may be essential to ensure a high availability, and for others production time. Accordingly, the segmented supply chain strategy can take this difference into account: in one segment, sourcing lead times have to be reduced, while in the other production lead times have to be optimized. Correspondingly, different measures, which are indicated in the SCDD, have to be taken, e.g., modular sourcing and supplier management in the first case and optimization of utilization or set-up time reduction in the second case.
For example, a company pursuing different strategic priorities, due to the competitive strategies in different markets, consequently develops a segmented supply chain strategy by starting at the respective strategic priorities and operationalize them by means of the SCDD. If, for instance, a company supplies mature and new products, the strategic priority for mature products can be low costs. This part of the segmented supply chain strategy is located in the FR-C-branch of the SCDD. The strategic priority for an innovative, new product can be high delivery reliability and short delivery lead time, thus the second part of the segmented supply chain strategy is located in the branches FR-R and FR-L of the SCDD. Therefore, the two segments of the segmented supply chain strategy represent two separated paths of operationalization in the SCDD (see Figure 5).
4.2 Procedure for Segmentation

In order to support the systematic development of segmented supply chain strategies, the principles discussed above are embedded into a procedural model that guides the application of the SCDD and the principles step-by-step. The procedure presented here takes up on approaches for strategy development (see, for example, Stevens, 1989; Ross, 2000; Rumelt, 2003) and follows the decision-making process described by Simon (1997) with four phases subdivided into individual steps, see Table 2.

| Intelligence phase | Analysis of order qualifiers and order winners  
|                    | Analysis of strengths, weaknesses, opportunities, and threats  
|                    | Identification of relevant segmentation variables  
|                    | Analysis of the impact of such differences on SCM and the supply chain  
|                    | Definition of supply chain segments  
| Design phase       | Setting of strategic priorities for each defined supply chain segment and matching to order qualifiers and order winners as well as to ‘generic’ supply chain designs  
|                    | Operationalization of strategic priorities, identification of sub-objectives and means  
| Choice phase       | Analysis of potential conflicts of objectives and synergistic effects  
|                    | Analysis of fulfillment of prerequisites according to the ‘sandcone’ model  
|                    | Analysis of the economic value added (EVA) of the segments  
|                    | Evaluation of consistency, agreement, competitive advantages, and feasibility  
| Implementation/  
|                   | review phase  
|                    | Preparation of implementation (project management, change management)  
|                    | Reconfiguration of supply chains  
|                    | Monitoring and controlling  

Table 2. Procedure for the segmentation of supply chains.

In the ‘intelligence phase’, customer needs are analyzed according to order qualifiers and order winners (compare sec. 2.3). Furthermore, analysis of strengths and weaknesses investigates the fulfillment of order qualifiers and order winners, results from performance indicators etc. Opportunities and threats can emerge particularly from bargaining power of suppliers and customers, through supply-side risks or demand-side risks. By carrying out this analysis, the main emphasis is put on the identification of differences associated with products, markets, and customers. For example, order winners may vary with customers or markets, or risks may be different for products, namely due to different suppliers. Beyond, the impact of such differences on SCM has to be analyzed: What does it mean for SCM and the supply chain in terms of objectives and means? Segmentation variables (i.e. factors that influence segmentation) for the determination of segments of a supply chain strategy are (compare Table 1):

- According to the order qualifiers and order winners (Hill, 1989) and the corresponding SCM target areas: quality, delivery reliability, delivery lead time (time to delivery, availability), flexibility, price (or costs).
- Demand level, demand-variability, product value-density (Lovell, et al. 2005).

If there are major differences that have an impact on SCM and the supply chain, there is a need for a segmented supply chain strategy that is tailored to these specific requirements. In a first step, this is done by defining distinct supply chain segments accordingly.

In general, there is an inherent trade-off between a most uniform supply chain (in order to capitalize on economies of scale) and several most differentiated and focused supply chains in order to better meet specific requirements (we will come back to this issue later on).

During the ‘design phase’, the segmented supply chain strategy is being developed by first setting strategic priorities for each defined supply chain segment. The strategic priorities are derived from corporate and competitive strategy of the enterprise as well as from the results of the preceding phase. In particular, strategic priorities have to match order qualifiers and order winners. For example, if reliability is an order winner and availability an order qualifier, the strategic priorities should be delivery reliability (FR-R) and delivery lead time (FR-L).
Moreover, an appropriate ‘generic’ supply chain design, e.g., lean, agile, or hybrid supply chain design (see sec. 2.3), can be selected for the different segments. In view of that, suitable strategic priorities can be defined as well. For instance, low assets (FR-A), low operational costs (FR-C), and short delivery lead times (FR-L) are typical strategic priorities in lean supply chains. In an agile supply chain, high delivery reliability (FR-R), high flexibility (FR-F), and short delivery lead time (and, thus, high availability) (FR-L) are characteristic strategic priorities. Hybrid supply chains combine strategic priorities from lean and agile supply chains.

The strategic priorities are the starting points (FRs) in the SCDD for the segmented supply chain strategy. They can be the same for all segments defined in the ‘intelligence phase’ or can be different for each segment (see sec. 4.1). Now, strategic priorities are operationalized as described in sec. 4.1 using the ramifications of the SCDD as possibilities to prioritize or select specific sub-objectives for different segments and a segmented supply chain strategy is being developed. When determining appropriate measures for different segments, synergistic potentials have to be taken into account. The result of this phase is a segmented supply chain strategy that defines objectives for each segment and operationalizes the objectives.

In the subsequent ‘choice phase’, the segmented supply chain strategy is examined as to potential conflicts among objectives and as to synergistic effects. Beyond, it is analyzed whether, in the sense of the implementation sequence according to the ‘sandcone model’ (see sec. 3.2), prerequisites for all objectives and sub-objectives are fulfilled. In the SCDD, this means analyzing closely if objectives of the left part of the SCDD are met in an adequate manner. In order to balance one uniform supply chain and several focused supply chains, i.e. the appropriate number of distinct supply chains, the economic value added (EVA) of a supply chain segment can be assessed.

Using the EVA concept incorporated into the SCDD (see sec. 3.2) it can be determined if a specific supply chain segment can generate or lose value, i.e., generate more sales revenue (FR-11) or reduce assets (FR-A) or costs (FR-C). If, for instance, the differentiation between two supply chain segments generates more EVA than one single supply chain, the segmentation makes economically sense. Hence, the optimal number of distinctive supply chains is determined by the highest EVA. In practice, it is mostly difficult to estimate the exact amount of EVA of a supply chain segment, nevertheless, for several solutions, the positive impact on sales revenue, assets, and costs can be compared to the costs of the measures (set-up and operation) as well as the investments. Again, synergistic effects have to be considered. If it turns out that the segmentation does not add value or a further segmentation would add more value, the design of the segmented supply chain strategy has to be overhauled by repeating the ‘design phase’). In addition, the objectives and means of the segmented supply chain strategy have to be formally evaluated according to the criteria consistency (conflict-free, connected objectives), agreement (consonant with the company context, corporate and competitive strategy), competitive advantages, and feasibility (resources and capacities needed) (Rumlet, 2003).

In the ‘implementation/review phase’, the implementation of the appropriate measures is prepared by setting up project management and change management. In particular, the structure of the supply chain (partners, locations etc.), the organization (processes, tasks etc.), and information technology (Schönleben, 2003) that supports the segmented supply chain may have to be adapted. The implementation has to be monitored and controlled in order to ensure that the defined objectives are achieved.
5. Case Study

In the following, a case study is presented in order to show the application of the methodology. The case study was carried out in the context of the ProdChain project mentioned at the end of sec. 1.

A leading company for sophisticated packaging machines competes in a market where delivery reliability and short lead times are important since the machines are often a part of a new plant of a customer who wants to introduce his products as fast as possible. Therefore in general, delivery reliability and delivery lead time are order winners for new products that are made to order. Thus, high delivery reliability (FR-R) and short delivery lead time (FR-L) are strategic priorities to be pursued by the segmented supply chain strategy.

In order to guarantee high availability and a long product life cycle of the machines, spare parts are an important business, too. Apart from preventive maintenance, availability and short delivery lead time of spare parts are crucial since customers want immediate replacement for minimum downtime. Consequently, at a first sight in the ‘intelligence phase’, two segments can be identified: the supply chain for new products and the one for spare parts.

In order to ensure a high delivery reliability (FR-R) for the new product supply chain segment, several measures are identified during the ‘design phase’ using the SCDD (see Figure 6). Further analysis showed, that there is in particular improvement potential in ‘source’ since a large share of value added is generated by suppliers. Therefore, it is vital to ensure the reliability of suppliers (FR-RS).

![Figure 6. Segmented supply chain strategy (case study example).](image-url)
As a measure, a software-supported tool for monitoring and controlling suppliers was defined and implemented (later, during the ‘implementation/review’ phase). It aimed at monitoring and controlling quality and punctuality of orders as well as capacity and utilization of frame contracts. This tool has several benefits: First, by illustrating punctuality, it facilitates an awareness of reliable planning and cost efficiency; second, the tool can help identifying appropriate suppliers with free capacities for operational sourcing; third, regarding strategic purchasing, requirements and supplier capacities can be balanced, and, moreover, supplier evaluation and contracting are assisted. The results of the implementation were a change of mind of purchasing managers, more reliable and cost-effective planning, balancing, and decision making (FR-RS), and finally, significantly lower purchasing costs (FR-CS).

A high reliability on supply-side facilitates a high delivery reliability. In addition, a short delivery lead time (FR-L), the second strategic priority, has to be ensured for the new product segment as well as for spare parts, although customer needs in terms of delivery lead time are very different. Often, customers are willing to pay more for a shorter delivery lead time, but other customers are willing to accept longer lead times in favor of lower costs. Hence, the combination of costs and delivery lead time is decisive. Again, a significant part of the lead time is determined by suppliers (FR-LS) that produce components to order. The idea was to define three ‘outsourcing platforms’ as further three different supply chain segments (subsegments) with a specific combination of costs and delivery lead time. Each component can be sourced through each supply chain segment. The suppliers are located inhouse, in Switzerland, and in low wage countries in Middle and Eastern Europe. The inhouse suppliers are the most expensive, but with the shortest lead time (few days). The suppliers in the low wage countries are the cheapest, but the lead time is some weeks. Swiss suppliers are in between. In particular for spare parts that are not on stock, inhouse production is used if the demand can not be foreseen. For preventive maintenance, which can be planned, the low cost segment is used primarily.

During the ‘choice phase’, the emphasis was put particularly on analyzing the interdependencies between availability and inventory levels. The availability of spare parts should not to be enabled by high inventory levels (FR-AD). In order to optimize spare parts availability and inventory, a software-supported spare part management tool was defined and implemented (‘implementation/review phase’) that determines and monitors the appropriate materials management techniques based on demand patterns, product life cycle phase, and other parameters. Here, again a further supply chain segmentation can be elaborated, namely on a detailed level of the SCDD: the segmentation according to the way of sourcing the spare parts or making them available, i.e. Kanban, make-to-stock, inventory, and make-to-order. As a result, availability and delivery lead time (FR-LD) of spare parts could be improved with reduced inventories (FR-AD) and obsolescence costs (FR-CD).

6. Managerial Implications

In view of the methodology presented above, the need for a supply chain segmentation in order to cope with heterogeneous customer requirements has several implications for the management of supply chains:

- First of all, customer needs as well as the whole supply chain have to be analyzed carefully. Relevant supply chain variables that distinguish different supply chain segments have to be identified. Correspondingly, the distinct supply chain segments are defined.
- The key questions to be answered are: ‘What are relevant differences?’ and ‘What is the impact of such differences on the supply chain and on SCM?’.
• Developing a segmented supply chain strategy means defining strategic priorities for the supply chain segments and operationalizing them in order to adapt to specific requirements. Generic supply chain designs such as ‘lean’ or ‘agile’, or ‘hybrid’, should be adapted to the specific supply chain segments. The result is a tailored set of sub-objectives and appropriate measures for each supply chain segment.

• It is essential to analyze and exploit synergistic effects in order to have sufficient scale and not too much focus. In addition, an analysis of the economic value added of the supply chain segments is advised to ensure that the segmentation makes economically sense.

• In order to implement the segmented supply chain strategy, the supply chain has to be reconfigured in terms of organization, processes, and information technology. Moreover, the implementation sequence of measures is very important in order to ensure the sustainability of measures: First, quality has to be ensured, then, delivery reliability has to be optimized, followed by delivery lead time and flexibility; finally, assets and costs can be reduced.

By taking this into consideration, a segmented supply chain strategy can be developed in order to segment the supply chain and to align systematically all measures and activities of SCM with corporate as well as competitive strategy and customer needs.

7. Conclusion

‘One-size-fits-all’ supply chains are often not very effective and efficient in meeting heterogeneous customer needs. A supply chain strategy can be adapted to different requirements by segmentation. The methodology of Supply Chain Design Decomposition (SCDD) can be used for the identification and definition of supply chain segments and for the development of a segmented supply chain strategy. Segmentation variables for the definition of supply chain segments have to encompass SCM target areas as well. Appropriate objectives and measures for distinctive supply chain segments can be identified and operationalized systematically. By rethinking and reconfiguring the supply chain, companies can improve their customer orientation and reduce inventories and costs. Moreover, the SCDD facilitates the understanding of interdependencies among measures and practices of SCM and makes them transparent.

Some limitations of the methodology should be mentioned. The SCDD always has to be interpreted in the specific context of the company and the supply chain. In general, the interdependencies in the SCDD are hard to be quantified due to the high degree of dependencies and the context sensitivity.

As an outlook for further research, there is the opportunity to validate the methodology further and to supplement it with empirical research on specific supply chain designs and segments from industrial practice. Many empirical questions are left unanswered, however, and await further research.

References


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