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| Abstract Title: | Best Practices for Supply Chain Management Techniques and Concepts across Industries |


Authors Information: 1st author: Felix Friemann

ETH Zurich, BWI Center for Industrial Management, Zurich 8032, Switzerland

Email: ffriemann@ethz.ch

Phone: +41 44 63 20 534

2nd author: Stephan Verhasselt

ETH Zurich, BWI Center for Industrial Management, Zurich 8032, Switzerland

Email: sverhasselt@ethz.ch

Phone: +41 44 63 20 527



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**Abstract.** Due to diverse boundary conditions and requirements across industries, structures and processes of supply chains vary considerably between different industries. This paper summarizes the results of an interview-based survey with supply chain management experts from different industry sectors indicating best practices for supply chain management techniques and concepts across industries.

Key Words: Best Practice, Supply Chain Performance, Supply Chain Design

## 1 INTRODUCTION

In today's global markets the competition is more and more between supply chains rather than single companies competing against each other. That is why supply chain management has become a key factor for managerial success in many industries and gained tremendous attention within the last decades. Supply chain management (SCM) is defined by the Council of Supply Chain Management Professionals (CSCMP) as an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model (CSCMP 2012). These business models vary between different industry sectors. This is caused by the various challenges a specific supply chain has to face regarding its product characteristics, flexibility, market speed etc. Because of that, the success models for different supply chains mostly evolved separate from each other. The target of this study conducted by the ETH-BWI is to analyze the models within three selected industry sectors. This serves as a basis for a successful transformation of concepts and innovations between industries. The results contain an evaluation of different supply chain structures and processes, an analysis of cross-industry results and an analysis of late stage customization solutions.

## 2 METHODOLOGY

The research strategy applies descriptive case studies in form of interviews as the main method for data collections (Yin 2009); the chosen method are semi-structured interviews. The research methodology of this paper can be described in several steps. First, a comprehensive literature review is conducted to reveal the state of the art of in supply chain management and expose important indicators to analyze supply chains in different industry sectors. Based on this literature overview and the identified key parameters for evaluating supply chains, an interview guideline is designed. Second, eleven high-ranked decision makers from three different industry sectors are surveyed regarding their supply chains using the interview guideline. These companies were chosen regarding their size and industry impact to show valid trends despite the limited sample size. Third, the results are evaluated in order to make the supply chains comparable using a strength and weakness analysis for each individual sector. At last, the results are summarized and presented. The described procedure is shown in the following figure.

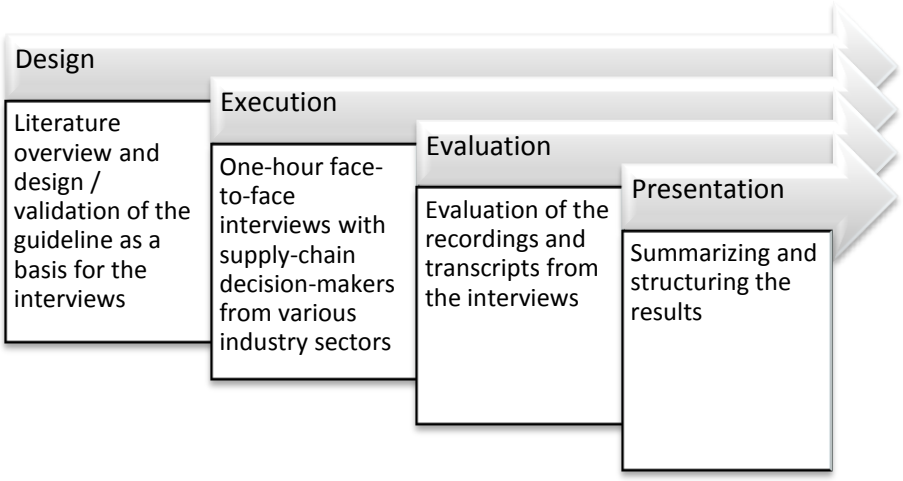


**Figure 1: Methodology**

In the next chapter, a short summary of the results from the literature overview is given.

## 3 CHALLENGES IN SUPPLY CHAIN MANAGEMENT

Today, it is widely recognized that supply chain management has a great impact on the overall business functions (Li et al. 2006). Successful management of the supply chain has become essential

for the long-term success of an organization. Suppliers, manufacturers, and customers, must be effectively integrated in order to achieve financial and growth objectives (Tan et al. 1999). Many efforts are undertaken to optimize SCM activities. But when conducting a supply chain optimization project one has to face several challenges. An important key parameter for successful projects is collaboration between (external and internal) partners. Managers need to align goals and benefits with their partners for creating collaborative advantages such as reducing excess inventory, avoiding costly bullwhip effects, enhancing business synergy and quality, providing flexibility, and increasing joint innovation (Cao and Zhang 2011). However, often misaligned incentives, power-based negotiations, and the tendency to act opportunistically hamper the advantages (Fawcett et al. 2011).

The aim of this paper is to analyze supply chains from different industries as a whole by interviewing supply chain experts. Furthermore it exposes the main advantages of enabling other industries to learn from them. This provides a manager with working concepts from other industries and gives new implications. In contrast to a common approach, this paper does not seek for or fix specific weaknesses in an isolated part of a supply chain by considering all impacts on other. The abstraction level is mostly the strategic and tactical level (Schmidt and Wilhelm 2000).

Two different groups of key parameters were identified: Those used to present the structure of the supply chain and those used to expose the strengths and weaknesses of the supply chains. Key parameters regarding the structure are the number of different stages, the geographical responsibilities of these stages as well as whether the operations are performed in-house or externally. To expose the strengths and weaknesses it has to be evaluated how the supply chain handles diversity of variants, what the main objectives are and how the supply chain performs on specific other objectives (e.g. inventory optimization, obtaining high service levels, capacity utilization etc.). Finally the usage of late stage customization resp. postponement strategies is evaluated.

The interviews were conducted in the second half of 2011 by using the above described guideline and lasted about one hour each. The results of the evaluation for each industry are presented in the next chapter.

## 4 RESULTS FOR EACH INDUSTRY

In this chapter, the evaluated results are presented separately for each industry to provide a structured overview of the different supply chains. The analysis and comparison of the results will be done in chapter 5 then.

The expert interviews were conducted within the automotive, food and pharmaceutical industry. For each industry sector the structure represented by the various value adding stages is shown on the horizontal axis in Figure 2. The vertical axis differentiates between global, regional and local supplying locations describing the geographical responsibility. The operations describe a main differentiation of the logistic concepts used for the specific industries and are explained in the corresponding subchapters.

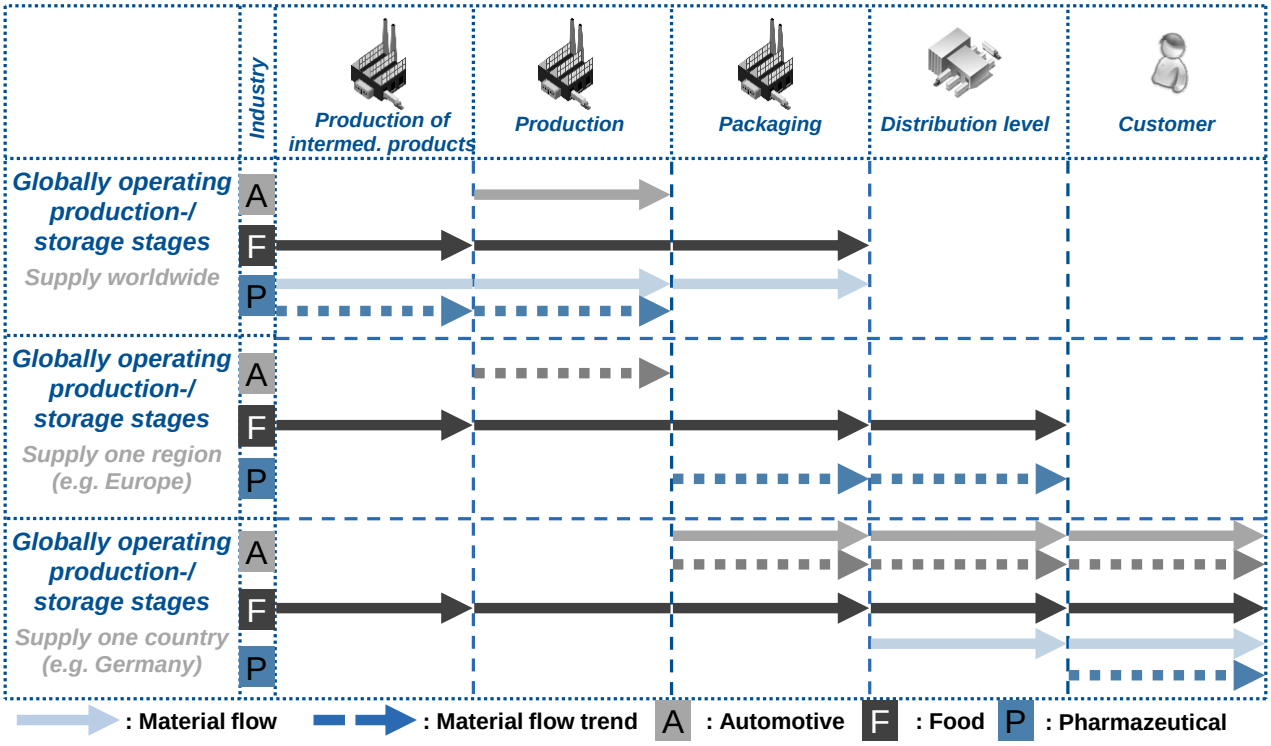


**Figure 2: Structure of the various industries**

Figure 2 shows the current supply chain structure for each industry sector and illustrates how it will evolve in future according to the surveyed companies. The industries are specified in the second column (using the colors grey, black and blue). The first supply chain stage in the figure (production of intermediate products) must not be the first stage in the whole supply chain. It is rather the upstream stage for the surveyed companies.

In the next three chapters, the identified results are explained separately for each industry sector.

### 4.1 Automotive industry

From the manufacturers' point of view the automotive supply chain starts with the production of components by external suppliers (e.g. interior modules, transmission, cable harness, etc.). The following value adding processes are then performed by the car manufacturer himself. The production is mainly the assembly of the car containing vehicle body, paint shop and final assembly. This is often followed by the 'packaging' of the vehicles which is a generic description for the preparation of the cars after transportation in consolidation centers. The last distribution level contains the selling of the vehicle. This is done by an independent dealer who is in most cases strongly related to the car manufacturer. All supply chain stages from production down to the distribution level can therefore be considered as in-house operations or at least strongly dependent on the Original Equipment Manufacturer (OEM).

As shown in Figure 2, the different stages are mostly separated geographically. The production of intermediate and the final product is generally done globally (per production series) which means that these sites supply customers worldwide. Because of tax restrictions the finished vehicles get completely knocked down again after assembly for some markets before they are transported (Plehn et al. 2011). The consolidation centers and end customers are mostly situated locally. A trend within the automotive industry is to regionally produce for the markets because of tax and customs systems that are difficult to manage.

Between the supply chain stages individual parts, modules and finished products have to be transported. The preferred modes of transport between all stages are train and truck. For the distribution of finished cars over long distances also vessels are a preferred mode of transport.

Figure 3 shows the material and information flows within the automotive industry. It can be noted that the operations in the automotive industry are mainly distinguished between make-to-stock and make-to-order.

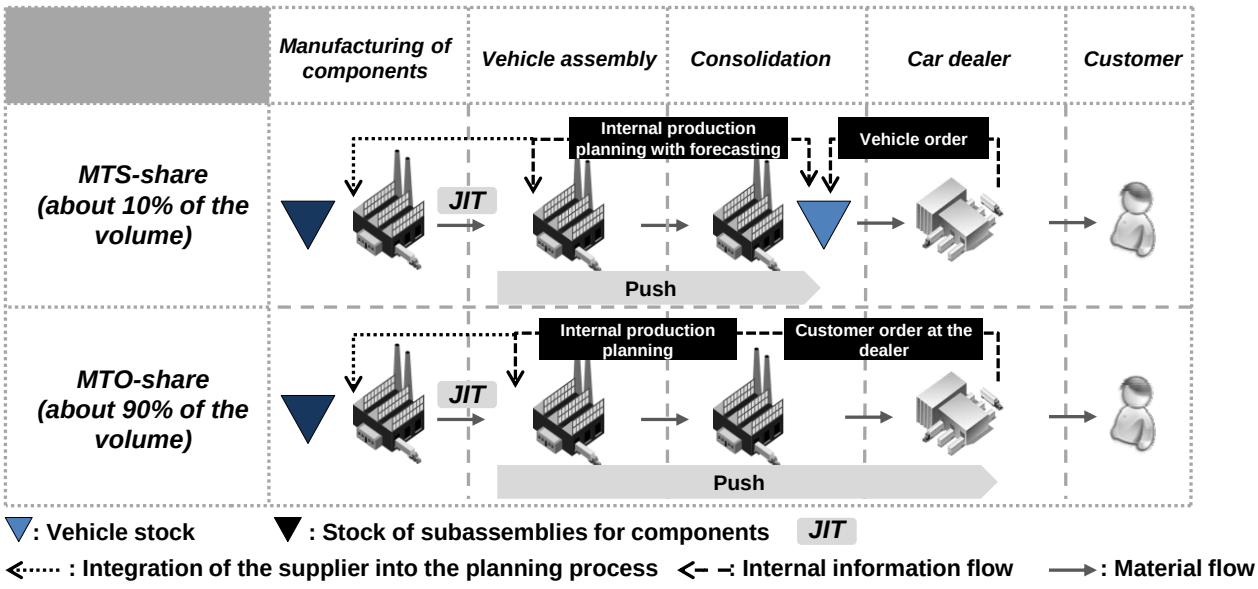


**Figure 3: Supply Chain Operations – Automotive industry**

Both processes start with the just-in-time (JIT) delivery from the first tier suppliers. JIT describes a concept to synchronize successive production- and transport-processes in a way that the processes provide the material not until it is needed by the corresponding subsequent processes (Arnold et al. 2008). Primary elements of JIT are to only have the required inventory needed, to improve quality to zero defects, to reduce lead times by reducing setup times, queue lengths, and lot sizes, to incrementally revise the operations themselves, and to accomplish these activities at minimum cost (APICS 2010). Just-in-sequence (JIS) is an advanced concept common in the automotive industry where parts are delivered in the order needed for the vehicles at the production line (Arnold et al. 2008).

For the make-to-stock share vehicles are produced based on forecasts and without customer order. The dealer has access to information regarding inventories stored in the consolidation centers. The share of make-to-stock orders is about 10% of the total production. From assembly to the consolidation centers the process follows a push production. A push system means pushing the order based on a given schedule planned in advance in the direction of the added value, without need of customer influence or a definite customer order (Schönsleben 2011). At the consolidation center the cars are stored until pulled by or demanded from the dealer resp. the customer.

For the make-to-order share the customer starts the production resp. the assembly by the order of his desired vehicle configuration. Even though the lead time generally encompasses a couple of months, the benefit of getting the vehicle in the desired configuration makes this the preferred concept for most customers. The share of make-to-order is about 90% of the total production.

Generally, the supply chain in the automotive industry is very efficient regarding its inventories. The finished vehicles are stored only when produced make-to-stock. Otherwise the process is make-to-order with the according lead times for the customer.

All in all, the transparency within the automotive supply chain is very high. By close collaboration between the supply chain partners low inventories can especially be achieved for 1$^{st}$ Tier suppliers (the suppliers that supply the car manufacturer directly).

### 4.2 Food industry

The food industry supply chain consists of the stages shown in Figure 2. First, the intermediate products (which are the raw products in this case) are produced resp. harvested. In a next step, the final product is manufactured. This can for example mean to cut, mix, shape, cook or bake the raw products. Next the product is packaged for the customer (e.g. retailers). In many cases there is a specific packaging for each customer. At the end, the product is either stocked or delivered directly to the customer. This differentiation is explained later (see Figure 4). In general, a stocking level for finished goods isn’t that common within the food industry compared to other industries. The

products are rather delivered to the customer as fast as possible after production because of the limited shelf life. The value adding stages performed in-house by the interviewed companies are the food (end product) production, the packaging and the storing of the products if necessary. Driven by supply risks the companies tend to more and more control the raw material production.

Whether the stage is supplying worldwide, regional or local strongly depends on the shelf life resp. the possibility of storing the products. Because of that no clear supply chain structure was identified. Generally there is a conflict between the companies aspiring to have a more global structure (benefit from economies of scale) and the shelf life of the products demanding for a denser structure.

Between the different stages the products are mostly transported by truck and train. Exceptions are the raw materials which are often transported by vessels.

As already mentioned, the operations within the food industry highly depend on the product to be produced. One differentiation is between seasonal (products that must be processed within one season mostly) and non-seasonal (products that can be processed during the whole year) goods. Figure 4 shows the corresponding material and information flows.

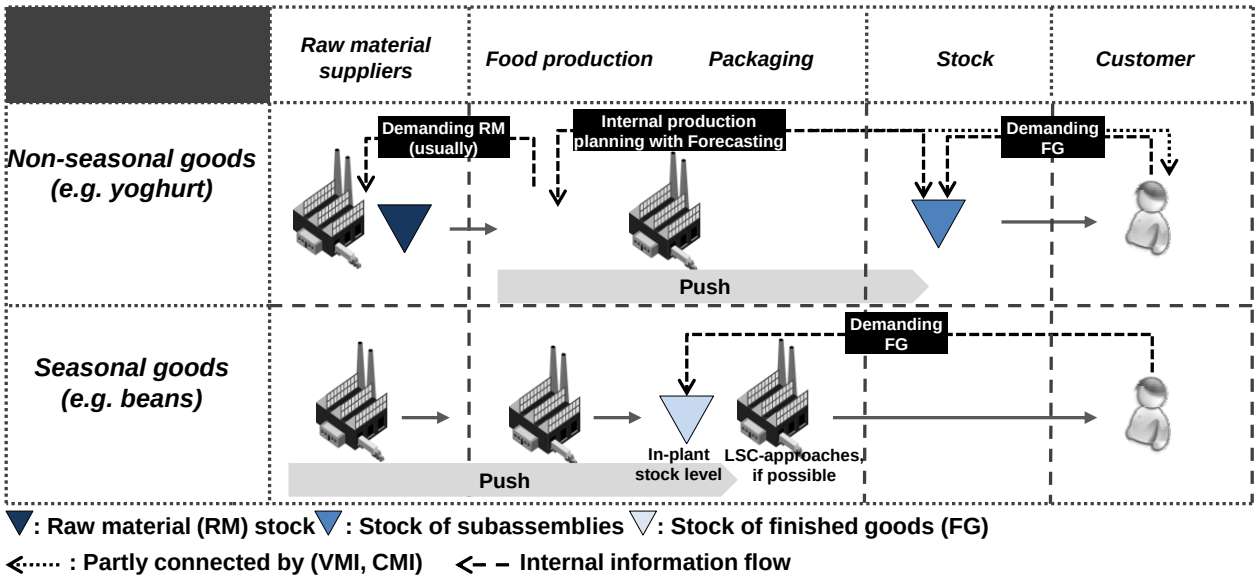


**Figure 4: Supply Chain Operations – Food industry**

Non-seasonal products are produced based on forecasting and in close coordination with the customer. Because of continuous availability of the raw materials the products are pushed to the finished goods stock after demanded from the raw material stock by the production plant. Non-seasonal and perishable goods have to be processed right after harvest. That means, they are pushed by the suppliers whenever available and are immediately processed. If possible, the producers try to interim store and assign the non-seasonal goods as late as possible to the customer by individual secondary packages. Customer-specific recipes and specific primary packages impede this. Therefore late stage customization (see chapter 5 for explanation) is an important concept for seasonal products. This is also the case for non-seasonal food. But for non-seasonal goods the food industry mainly convinces by the close linkage of production and packaging processes. By taking advantage of appropriate technology the production in the food industry is fast and flexible.

Altogether, the food industry is mostly driven by customer-specific desires and the limited shelf life of the products.

### 4.3 Pharmaceutical industry

For the pharmaceutical supply chain the production of intermediate products (see Figure 2) means the production of the active ingredient (e.g. acetylsalicylic acid). After that the product is further processed by formulating the active ingredient to guarantee the desired bioavailability (e.g. to aspirin pills). In a next step the product is packaged (primary and secondary packaging). At the distribution level the products are stocked. The customer is e.g. a wholesaler, hospital or pharmacy. All described stages are generally performed in-house by the producer.

Economies of scale are especially taken advantage from in the first two value adding stages - production of the active ingredient and formulation. This is done at one location that supports globally and will remain at a global level in future because of the expensive equipment. Today, the packaging is also done at the plant but there is a trend to package regionally. This increases the

flexibility and speed to market. The stocking of the finished goods is often done at a local level today. To make use of the economies of scale, the trend favors regional distribution centers.

Between the different geographically separated supply chain stages train, truck and plane are used to transport the goods (except for the transport to the customer (last mile) where the plane is generally not used). An indication for the plane is the relatively small size and the high value of the products (Schönsleben 2011).

As seen for the automotive industry (Figure 3) the differentiation between make-to-order and make-to-stock products also is a useful concept for the pharmaceutical industry.

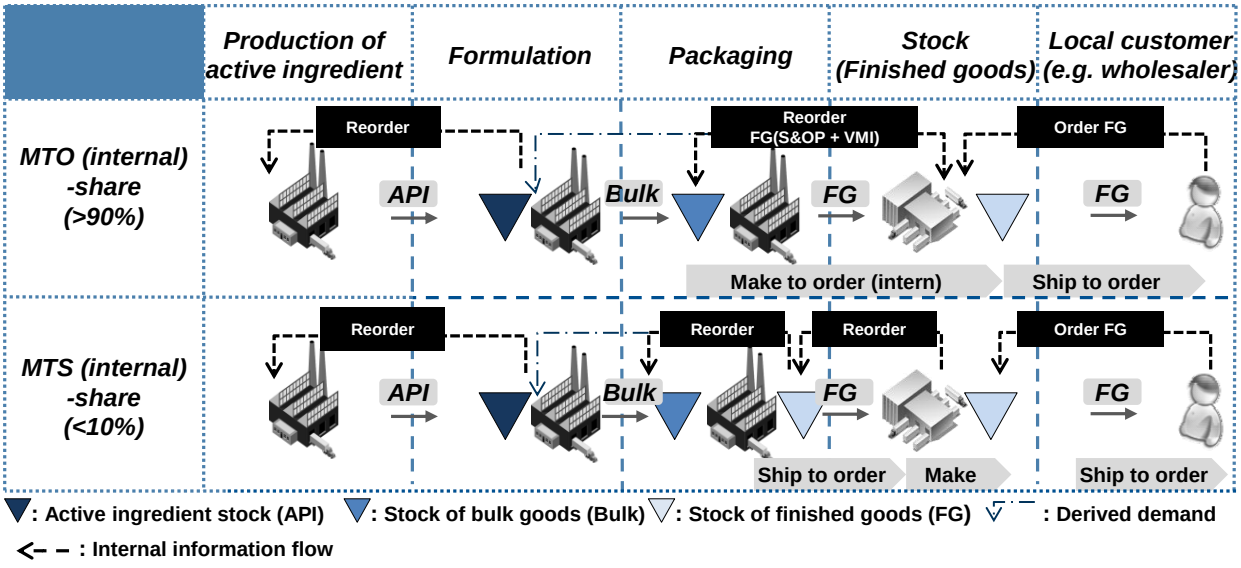


**Figure 5: Supply Chain Operations – Pharmaceutical industry**

In contrast to the automotive industry, both approaches refer to the internal information flow between packaging and stocking. For the make-to-order processes the stored products are not packaged until they are reordered by subsidiaries. The make-to-order process is e.g. triggered by a subsidiary responsible for a specific regional market. To coordinate the information flows, the pharmaceutical industry uses internal vendor-managed inventory (VMI) concepts. VMI means that the supplier has access to the customer's inventory data and is responsible for maintaining the inventory level required by the customer (APICS 2010). For make-to-stock processes the finished goods are stocked. The same packages are used for several countries. Reorders can therefore be

fulfilled directly from the stock. Compared to the MTO share, the MTS share is relatively small encompassing less than 10 % of the total share (see Figure 5).

By an integrated ERP-solution between the production and distribution level a good visibility within the supply chain is achieved. The visibility also enables Vendor-Managed-Inventory (VMI) - concepts for various stages. All in all, the cycle times are very long in the pharmaceutical industry compared to other industries. The advantages of this industry lie in the highly sophisticated processes for quality control.

After the results of the different industries were presented separately in this chapter they will now be jointly analyzed and compared in the next chapter.

## 5 ANALYSIS OF THE RESULTS

After presenting the results for each industry sector, it is now evaluated what the main strengths and weaknesses of each supply chain structure are. In other words, it is analyzed where one supply chain manager can learn from his colleagues.

As seen in the previous chapter, there are remarkable differences for the supply chain structures and operations among industries. This has its reasons mainly in the different requirements and characteristics that often vary substantially between the different industries. The evaluated requirements (blue) and characteristics (grey) are presented in Figure 6.

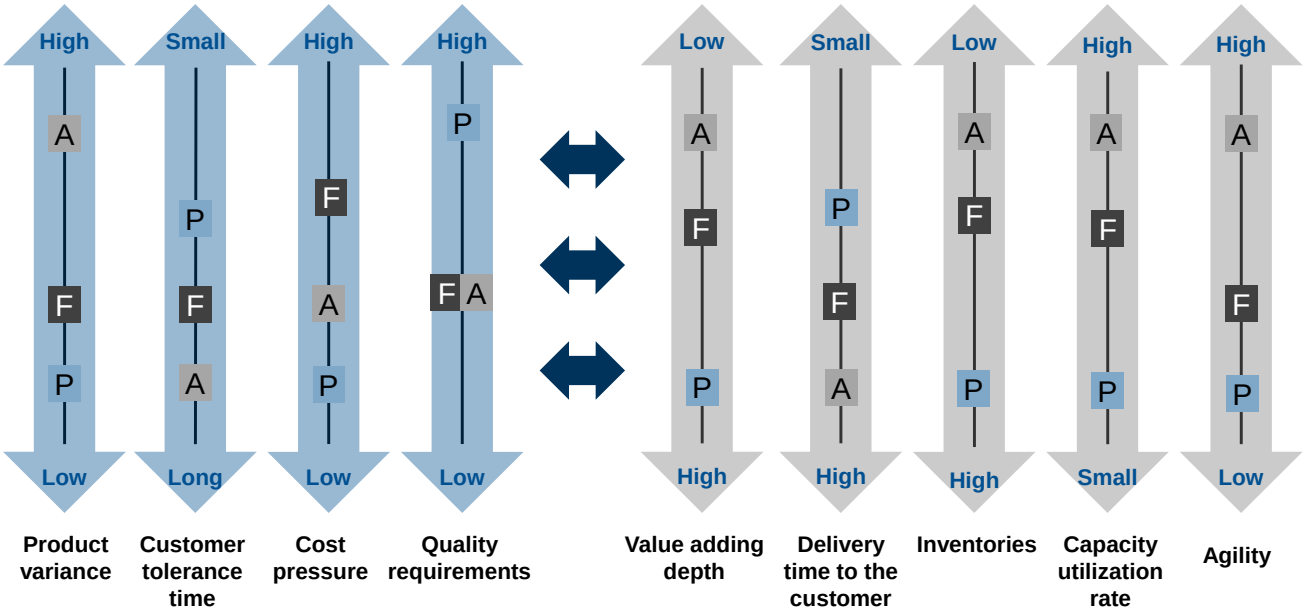


**Figure 6: Supply chain requirements (blue) and characteristics (grey) (average assessment of the interviewees)**

The figure shows that e.g. the requirements in the automotive industry regarding product variance are high whereas they are more likely to be low in the food industry and low in the pharmaceutical industry. This can be explained by the high status that cars have on most markets nowadays meaning that the customer desires the exact configuration of the car he wants. The customer delivery time is more likely to be small in the pharmaceutical industry because of several distribution stages and high in the automotive industry where the customers have to wait up to several months until they get the ordered car. This directly corresponds to the customer tolerance time the industries have to face. For the food industry the tolerance time highly depends on the product. Another interesting finding is the result on the product quality. In the automotive and food industry the quality control already is an important instrument. But because of very strict regulations and the possible health risks, the pharmaceutical industry has the highest quality standards. The consequences of a failure like resulting image damage and claims for compensation can have fatal impacts on the affected company.

Altogether, it can be noted that every supply chain has its own advantages and qualities. In the automotive industry there are very low inventories irrespective of the high product variance. This can be achieved by making consequent use of agile make-to-order processes (that are difficult to

implement for other industries) and by close collaboration with suppliers. The food industry is subject to high cost pressures whereas very short cycle times are needed. This problem is solved by fast and flexible production and packaging processes using inline technology and a close coupling of the processes. The customers in the pharmaceutical industry have a very small tolerance time whereas there are extensive quality requirements at the same time. This challenge is faced by a fast distribution with stocking levels located close to the customer as well as quality and validation processes for ensuring the quality of the product.

Looking at possible solutions to the conflict of having individual, high quality products at a low price late customization seems to be a promising concept. Late customization means that product modules are characterized by commonality up to high level of product structure such that many variants can be produced within the customer tolerance time (Schönsleben 2011). Since several years late stage customization (LSC) resp. postponement approaches are successfully implemented in industries like the electronic or textile industry (Lee et al. 1993, Dapiran 1992, Brown et al. 2000). By LSC significant economies of scale along the supply chain can be realized. A late customization of the product or the package also enables the producer to better react on fluctuations in demand. Using this concept, inventories can be reduced and potential depreciations are avoided.

This study shows that LSC approaches vary between the different industries due to characteristics of products and packaging. The automotive industry uses them extensively whereas there is still potential for LSC in the food and the pharmaceutical industry even though the implementation seems difficult due to the requirements and characteristics. Generally, there are two important parameters that determine the preferred type of LSC to be implemented (Cooper 1993). First the question of whether the product is the same for all markets resp. all customers and second whether the packaging is the same. That results in four groups. For the pharmaceutical industry the product for the different markets is always the same but the packaging is different. An approach for LSC should therefore be to have the customer-specific labeling as late as possible (preferably at the distribution center). For

the automotive and food industry this assignment is more difficult since it can vary from product to product. The customization should preferably be late in the production or assembly.

Generally, some remarks about the current status and the trends regarding LSC in the different industries can be noted. In the automotive industry LSC approaches are widely implemented by the standardization of parts and subassemblies. In future the number of same components in the production must be increased to have a later customization of the vehicles. In the food industry no general conclusion about the current status is possible since it is very specific. Because of the high cost pressure, this industry will be forced to find ways implementing LSC in future. In the pharmaceutical industry the products are mostly assigned to the customer at the packaging level today and not at the bulk level anymore. Future efforts should focus on the implementation of LSC within the packaging level.

## 6 CONCLUSION AND OUTLOOK

This paper names important differences between the supply chains of various industry sectors. It was shown that the automotive industry has an excellent integration of its suppliers, the food industry is characterized by fast production processes, whereas high product quality standards are ensured within the pharmaceutical industry by well-planned processes. It was also shown that late stage customization (LSC) as a potential concept for lowering the costs while at the same time ensuring flexibility and product variety for the customer is a promising concept that is not exploited by the surveyed companies yet. Every industry has its advantages and disadvantages and all supply chains are well performing corresponding to the different requirements they have to fulfill. As a logical consequence, no industry can simply copy the exact structure of a different sector which never was the goal of this study. The aim was to learn which industries have which requirements and where to search for solutions when facing similar problems (e.g. when trying to lower the inventories, the pharmaceutical industry should critically look at the lean concepts in the automotive industry and check if they can at least be implemented partly). Showing the structure, operations, characteristics,

requirements, advantages and disadvantages of the analyzed industries, this study provides a good basis to look at for this goal.

The interviews in this study were conducted with representative companies from different industry sectors to have a valid representation of the current state and the future trends. The results allow a good overview of the current situation. Nevertheless, it has to be noted that exceptions not considered in this study exist.

Future research can go into several directions. One possibility is to have further studies with much more participants throughout more diverse industries. This could provide a more holistic way of characterizing supply chains providing more implications for cross-industry learnings. Another way is to analyze specific problems that were revealed in this study in greater detail (e.g. the comparably high number of distribution stages within the pharmaceutical industry) and search for appropriate solutions in other industries resp. for ways on how to change the requirements in order to make other solutions applicable for a specific problems. Both ways seem very promising.

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