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Impacts on Supply Chain Management through Component Commonality and Postponement: A Case Study

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***Abstract*—Component commonality and postponement have been the focus of research for the last twenty years. Since then numerous models and theories have been developed, but industrial evidence is still rare. This work will make a contribution and show the positive benefits of postponement and component commonality in the automotive industry. The insights from literature and a case study are combined to evaluated the impacts on the supply chain variables coordination, collaboration and configuration. The notion of this work is to convince companies in making combined component commonality and postponement decision rather than separate ones.**

***Index Terms*—component commonality, postponement, supply chain management, case study research**

I. Introduction

In the last few years companies have increased their product variety in order to develop new markets and niches. This led to a disproportionate increase in components and suppliers, which resulted in a high level of complexity in the manufacturing process. Different methods and tools have been introduced to reduce complexity, while retaining product variety. Yet, these methods are mainly dealing with distinct design principals.

In this work, the impacts on supply chain management through component commonality and postponement are evaluated. In this analysis component commonality is highly linked to inbound logistics and manufacturing, whereas postponement corresponds with outbound logistics and the customer specific demand. The two concepts are closely related and by correct implementation, companies can achieve competitive advantages along the entire supply chain. Even though both design principals have been discussed in the literature before, the combination is rare and especially industrial evidence is limited. The case study presented will show the positive effects of combining component commonality and postponement on reducing the supply chain coordination effort.

The remainder of this work is organized as follows. The next section will cover the basics on supply chain management, component commonality and postponement. In section 3 the methodology used is described and section 4 will present a case study and the evaluation of the impacts on supply chain management. Finally, the last section concludes and presents directions for future research.

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II. Literature Review

A. Supply Chain Management

The approach of supply chain management is to design, organize and execute all activities that occur within a value chain from supplier to the final customer [1]. First theoretical research and working definitions of supply chains and supply chain management can be found at the end of the 1980's and since then supply chain management subsequently gained tremendous attention [2]. The reasons for the popularity of supply chain management are manifold and can be related to specific drivers such as global sourcing and emphasis in time and quality-based competition [3]. Further facts for the development of supply chains and supply chain management can be found in specialization and search for suppliers who can provide low cost quality materials [4].

Various definitions of supply chain and supply chain management have been offered in the past several years as the concept has gained popularity. A detailed overview of the numerous definitions can be found in [4] and [5]. In this work a supply chain shall be defined as: a network of nodes through which material and/or information flows through upstream and downstream linkages, whereas a node represents a organization or resource, which can provide a specific service. In this context the definition of supply chain management will be adopted from [6]; therefore supply chain management is a philosophy to manage the total flow of a distribution channel from supplier to customer.

Due to the origin of supply chain management in the field of logistic management, first approaches see supply chain management as an enhancement of logistics [7]–[9]. Further to this focal, supply chain management has been seen as a cooperation along the whole value chain [10], [11]. Due to increasing customer requirements of flexibility and logistics, the creation of value and with that the satisfaction of customer requirements, have to be realized along the whole way of net value added [12]. In order to satisfy competitive requirements and to ensure proper operation along the creation of value, a continuous improvement of the material and information flow is necessary. From this point of view enterprises have to be seen, due to specialization and taylorism, as part of a value chain with the need of cooperation along the value chain [13].

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As a result of this, trust and collaboration along the supply chain partners is critical and can be seen as one of the success factor [14]. The goal of collaboration is to create transparent, visible demand pattern that paces the entire supply chain [15]. According to [16] three types of collaboration have been identified: collaborative product development, collaborative logistics planning and collaborative demand planning, which resulted to concepts such as vendor managed inventory, collaborative forecasting planning and replenishment and continuous replenishment [15].

B. Component Commonality

The overall goal of component commonality is the reduction of variety within the value chain [17], [18] and is based the fact, that products in product families are composed of similar components [19]. By extension component commonality can be seen as an operations strategy to offer a high customer product variety with a low production variety [20]. More specifically, component commonality refers to "the replacement of several different components by one component" [21, p. 76]. Component commonality is not limited to a specific product and by that [22] measures the degree of variety of a product family that can be produced with the same components.

Different authors use the term standardization as synonym for component commonality, but under circumstances this term might be misleading [23]. According to [24] the goal of standardization is to develop, produce and sell exactly one product. Furthermore standardization can be seen as the goal to achieve standards in companies, areas of business or industries [22].

Component commonality affects different corporate divisions. From the product development point of view component commonality leads to a reduction of development time, cost and risk due to the re- and subsequent use of existing parts [25], [26]. From the production point of view, it eases the production planning and control process, the use of economies of scale and a reduction of complexity in procurement and production [22], [27]. Even in after-sales there is evidence for positive effects [28]. Risk pooling can be achieved through component commonality, which leads to more accurate forecasts [18]. A mathematical proof of the risk pooling benefit can be found in [29], who showed a reduction in inventories based on component commonality.

Still, while implementing component commonality, a company should also consider its negative effects [30]. It can lead to higher volatility in production, even though the average work in progress is lower [31].

C. Postponement

Postponement is an organizational concept by which activities are postponed until customer orders are received [32]. Originally the concept has been introduced by [33] to minimize risk and uncertainty in marketing and has been refined by [34] to shift risks in a supply chain. Within the last years the concept gained attraction and has been refined to the primarily use in supply chain management [35], [36].

Postponement can be differentiated in form, time and place postponement [34], [37]. Furthermore time postponement can be sub-classified according to the value chain activities in production-, assembly-, packaging- and labeling postponement [38]. While form postponement aims at the highest possible standardization of a component before the differentiation point [35], [39], time postponement aims at the possible latest differentiation and by that shifting the differentiation point to the customer [35]. Place postponement means the transfer of goods after the receival of customer orders to a downstream node in the supply chain [37].

Within a supply chain numerous differentiation points can occur. A model with two differentiation points is developed by [40]. Within this model the first differentiation point separates the product families while the second parts the products. In this special case the latter differentiation point is also the customer decoupling point, which defines the position in the supply chain, when orders are associated with a specific customer [41]. The position of the differentiation point is depending on the postponement strategy [42] and we refer the reader for an overview of different strategies to the work of [43], [44] and [45]. Further on, the position of the differentiation point divides the supply chain in two regions. Prior to the position of the differentiation point a push strategy is used, while a pull strategy is applied after.

Postponement offers a wide variety of benefits: a reduction in the obsolescence of stock [46], a reduction of work in progress [35], [47], shortening the lead- and delivery time [48], while increasing customer satisfaction at the same time [45], [49]. Furthermore postponement allows reacting to short-term changes in customer specific demand [48]. Form the procurement point of view postponement enables economies of scale [47]. Yet, one has to consider that this is highly dependent on the product architecture. A general improvement can only be achieved, if the development cost and the over engineering of functional requirements are less than the cost reduction due to economies of scale [47].

The product architecture is of prime importance for a successful integration of postponement. In many cases this means, that existing products have to be redesigned [48]. At this component commonality and product modularization are the right choice of design principals [47], [50]. According to [35] and [47] part commonality and standardization are requirements for implementing postponement and are effective when the investment cost and incremental processing cost required are low.

III. Methodology

According to [51] case study research can be used to analyze "how" questions and it is especially useful in where it is impossible to separate the phenomenon from its context [52].The objective of this paper is to evaluate the impacts on supply chain management through component commonality and postponement by using a case study. The evaluation is based on in-depth interviews and on-site observations. Since a re-engineering of the existing product was necessary to implement postponement and component commonality, we had been following this project for two years.

A study protocol to conduct the research has been defined. The interview guideline consists of questions capturing the characteristics of component commonality and postponement in terms of supply chain coordination effort. Other questions in the interview guideline are formulated to explore the manufacturing improvements due to the product design

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strategies implemented. The interviews have been carried out with industrial and design engineers, supply chain managers, logistics and purchasing directors. Interviews with more than one actor of a special field were used to triangulate the data. Triangulation is adequate for verifying statements [53].

IV. Case Study and Discussion

A. Case Study

The company under analysis is a automotive supplier, which is a worldwide leader in automotive safety. With approximately 40.000 employees (approx. 10 % in Research and Development) and a revenue of 5.120 Mio. $ the company offers a wide variety in seatbelts, air bags and night visions. The company develops, produces and sells its products in over 30 countries and creates 70% of its revenue in Europe and North America.

Subject of analysis are car sensitivity sensors (CSS), which are part of the passenger safety seatbelt retractor system. The CSS's purpose is to initiate the retracting and looking of the passenger seatbelt by using accelerating forces to displace a multi-directional pendulum device from its rest position. When a large deceleration is detected, the CSS triggers the lock of the seatbelt retractor to lock the spool and thereby secures the safety belt in place during the crash. Figure 1 schematically depicts a CSS. The rest position is depending on the installation position inside the automotive and is defined by the geometrical shape of the lower part and the lever of the CSS. The rest position is of great importance for the functionality of the CSS and therefore other components were designed in interaction with it. This resulted in a highly integrative product architecture and a specific assembly unit is needed for each installation position in the automotive.

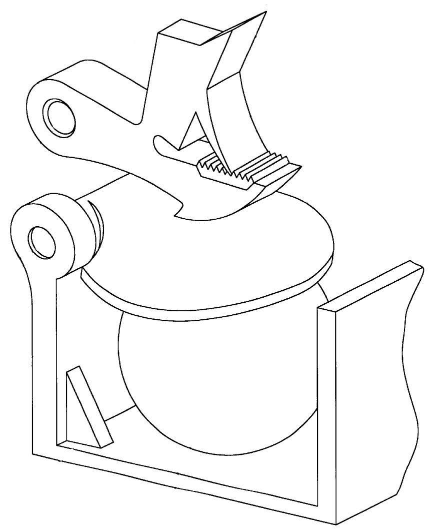

Fig. 1. Schematically representation of a car sensitivity sensor

In order to cover the different installation positions required by its customers, the company produces around 100 variants. A CSS consists mainly of five components from which three of the five are assembly unit specific. Due to the high number of product variants and distinctive components as well as the safety issue, the assembly process is carried out manually. In the case of lot changes, transport-containers at the assembly line are needed to be changed too. Furthermore the customers of the company request a just-in-time delivery, which leads to retooling of the assembly line around 10-20 times per day. Retooling and re-equipping the assembly line increases the risk of using mismatched components and therefore additional measure are required to safely avoid mismatching, e.g. using colored components. Moreover, different CSS's variants are composed of different injection molding components and materials, which are purchased from 7 different suppliers. For the production of the injection molding components necessary tools have to be financed by the company. The accretion of the different materials and suppliers evolved over a period of 10 years due to the constant expansion of the array of products.

Within the scope of renewing the array of products and the exigency of lower cost per item from its customers, the company has chosen to rework and redesign the CSS. The goals of this uprising project were to reduce of component variety, to build an automatic assembly line, the customer and installation position specific customizing at the assembly line as well as the verification of the customizing process by video systems. The project used simultaneous engineering to integrate all relevant corporate divisions and shorten the development time. Part commonality and standardization of the components are requirements for integrating postponement in manufacturing [35] and therefor the company has chosen to focus on these product design principles, since they already increased their productivity and effectiveness applying these product design principles by other products.

The result of the project is a new version of the CSS composing of six components, which can be customized in the assembly line. The customization of the CSS and by that defining the customer differentiation point, is realized by modifying one component of the CSS changing the shape via a mechanically bending process and hereby enabled automatic assembly. In order to verify the bending process and its outcome by video system, the shape of one component needed to be leveled at one side and defined edges needed to be added. Through automation of the assembly process, the production time and by that the overall lead time have also been shortened. Figure 2 shows the new car sensor.

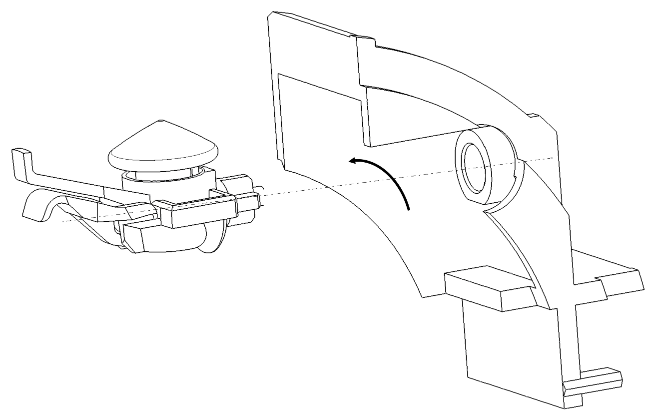

Fig. 2. Schematically representation of the new car sensitivity sensor

In relation to the different injection mold materials of the old CSS, the company choose to use a uniform injection mold material. Five of the six components are based on this uniform material and the sixth components is composed of Zamac. By reducing the number of distinct materials,

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TABLE I
COMPARISON OF OLD AND NEW CAR SENSITIVITY SENSOR

Variable	**old**	**new**
Number of components	6	4
Number of distinct variant specific components	3	1
Number of distinct components in inbound	approx. 180	4
Number of distinct materials	12	2
Number of suppliers	approx. 9	2
Assembly related coordination and operation effort	high	low
Afford to enable automatic assembly	high	low
Position of decoupling point	Inbound logistics	Assembly line
Inventory	1 week demand per variant	max. 1 day

the company already reduced the number of suppliers and in addition to that the company choose a single-sourcing strategy to reduce the number of provided injection mold tools.

Even thought the company claims to follow a make-to-order strategy, a stock of an average one week demand for each variant of the old CSS was kept at the companies distribution center, due to the high number of different CSS's. Within the scope of redesigning the CSS the company successfully implemented the concept of postponement in their organization and customer orders are now assembled after their receival. This resulted in a minimization of the inventory, since in general no inventory is held by the company for the new CSS version. Table I compares the old and new CSS.

B. Discussion

Generally supply chains are analyzed by means of supply chain design and supply chain planning and management [52]. Supply chain design is closely related to supply chain configuration and collaboration, whereas supply chain planning and management refers to supply chain coordination. In order to evaluate the impact of component commonality and postponement on supply chain management, we part the supply chain in two areas: (1) supplier network and (2) manufacturing and distribution to the customer.

From the configuration and collaboration point of view of the supplier network combining component commonality leads to a reduction of suppliers, which allows for in-depth development of the remaining suppliers. In the case of the case study presented, component commonality reduced the number of suppliers from 9 to 2. By that the coordination effort in the supplier network is also reduced and also the demand is leveled by postponement. This positive effects has also been verified by [54], who evaluated supply chain structures through modularization and postponement. In their study, modularization led to a higher level of component commonality and the reduced the coordination effort with the suppliers. But, yet the reduction of suppliers or the adjustment to single sourcing can lead to a higher risk in supply outages. One of the senior managers of the case study company spoke of the peculiar sound of silence in one of its assembly buildings after the single sourcing supplier failed to deliver due to machine breakdown. The followed ramp-up management and partly customer delivery by helicopters resulted in unexpected challenges and a very high financial effort for the company.

From the manufacturing and distribution point of view the combination of component commonality and postponement is leading to numerous benefits. Due to the reduced number of distinct components, the reduced risk of mismatched components and by that a reduction in complexity the assembly process and the inbound logistics are slenderized. In the case presented it was also possible to automate the assembly process. Through the integration of postponement, changes in customer specific demand can be satisfied without retooling or re-equipping. This resulted in a reduction of setup times and by that increased the supply chain performance. Yet, this performance improvement is mostly obtained in manufacturing, as seen in [55]. The assembly related coordination and operation effort has been reduced, which offers the company the capability to invest the gain from the reduced effort in the process of ongoing improvement. Furthermore the production and deliver time is reduced, which leads to an overall reduction in lead time and by that reducing inventory cost and capital tie-up.

V. CONCLUSION AND FUTURE WORK

Competition in business has forced companies to view the supply chain in an integrative manner and by that it is not adequate to optimize manufacturing and assembly without considering the effects on the supply chain. This case study research shows, that the benefits from combining component commonality and postponement are not only limited to the manufacturing company. Furthermore, this work showed especially the positive aspects of redesigning products. In spite of the fact that component commonality should be forced also in new product development, redesigning products offers ability to reflect on the necessity of all current implemented product features. It offers a high potential for reducing design and manufacturing complexity by eliminating expendable functions.

In context on the impacts on supply chain management, the combination of both design principals resulted in an overall reduction of coordination effort. Yet, one has to admit, that this reduction in effort is most bold in the supplier network and the manufacturing company. Furthermore the reduction of the distinct number of components lead to a lower number of suppliers needed, which increased the possible time spend on developing this certain supplier. The supplier is now regularly audited to maintain the current status quo. From the customer point of view, delivery lead times have been shortened and the manufacturing firm is capable of reacting

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to changes in demand. Similar result can be found in [47], who also consider the redesign cost.

This case study research has been based on one supplier in the automotive industry. Its applicability to other sectors or industries thus needs to be validated. Further research is required to identify the common competencies that are required to combine component commonality and postponement. Furthermore this case study research primary investigated the impacts in the supplier network and on the manufacturing company. Therefore research is also required in extending the evaluation of the impacts in distribution centers.

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