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LOGISTICS MANAGEMENT OF LATE PRODUCT INDIVIDUALISATION. APPLICATION IN THE AUTOMOTIVE INDUSTRY

Lothar Schulze, Sebastian Mansky, Janusz Klimek

Leibniz Universität Hannover, Germany

ABSTRACT. Global markets and the increasing demand of customers for individual products lead to a steady rise of product-variants. Especially high quality goods on highly competitive markets like automobiles must meet customer's demands. The opportunity to configure a car according to one's preferences leads to an unmanageable number of variants. Manufacturers' strategies to handle this problem reduce the offered component-combinations but barely succeed in reducing the production-complexity. The approach of approach of the "Late Product Individualisation" faces this issue. The complexity of the production is reduced without limiting the customer's choice to a small number of variants. The production process is relieved from customisation activities while these operations are relocated to downstream processes of the supply chain. The approach of Late Product Individualisation is described and how it causes new challenges for the supply chain. Analytic instruments are presented which help to identify reasonable components of a product that should be individualised.

Key words: Late Product Individualisation, Logistics, Supply Chain, Efficiency Analysis, Analytic Hierarchy Process.

INTRODUCTION

The coalescence of markets to one single global market and the increasing requirements of customers lead to a steady rise of product variants. This applies in particular to high quality consumer goods such as automobiles. The Original Equipment Manufacturers (OEM) offer customers the opportunity to configure products out of a variety of combinations to satisfy their individual demands and wishes. The result of this development is the increasing complexity of the production processes and rising requirements of the entire supply chain. The manufacturers have to face it with appropriate strategies.

The established concepts of modularisation and postponement are proposed to control the product complexity. However, they disregard the necessity to reduce product variants during the production. The concept of the Late Product Individualisation (LPI) starts at this point. The individualisation of the product is taken out of the production process and relocated into the further processes in the supply chain. The resulting reduction of the complexity in the production enables the manufactures to achieve economies of scale due to a widely homogeneity of batches in the primary production and leads to a better controllable and manageable production process. Products manufactured according to Build-To-Stock (BTS) principle or Build-To-Order (BTO) principle are finally completed during the subsequent distribution process with components separated from the original production process.

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Therefore non-productive idle times during the distribution process can be used for value adding activities.

Logistics are confronted with completely new requirements when applying the LPI. Beyond existing services the logistics providers have to be able to assume the planning and controlling of the integrated supply chains. This can even imply typical OEM competencies such as selection, integration and coordination of suppliers. Besides the logistics providers have to offer installation services that fulfil the original manufacturer's quality requirements. A condition is to provide an adequate workshop infrastructure and qualified personnel. Distribution processes have to be designed and planned in such a way that these processes can be overlaid by value adding activities. A precondition is to realize an informational network between the original equipment manufacturer and the logistics service providers. This development exceeds the previous quality in data exchange. The logistics service providers become an integrated part of the value added chain.

To complete the concept of LPI, meaningful and practicable evaluation instruments are needed. Both the known Value Benefit Analysis and the Analytic Hierarchy Pro-cess are selected as approaches to identify the dedicated components for this concept. Thereby the Analytic Hierarchy Process is used in the descriptive decision theory to simplify and rationalize complex decisions. Also a model is defined, which facilitates an economical view of LPI in consideration of effects on costs and revenues. Using different methods results in a holistic approach, which enables integrating LPI into practice. First interest to the pilot project of this systematic realisation is given by the automotive industry.

INITIAL SITUATION AND THE IDEA OF LATE PRODUCT INDIVIDUALISATION

As already mentioned the production of automobiles is a prime example for a reasonable implementation of the LPI. Therefore the following remarks focus on an application in the automotive industry.

In the past 20 years the production situation of European car manufacturers drastically changed. The whole production was driven by the make-to-forecast principle, meaning that the output in terms of quantity and configuration of the vehicles was solely based on forecasts and not on specific orders of customers. A possible purchaser was only able to choose between already built cars in the retailer's showroom with a little number of variants of a car model he preferred. This way of manufacturing is also called BTS, because producing a car without an existing customer's order automatically leads to a build-up of stock. In this situation the manufacturers follow the so called push-strategy, meaning that the cars are pushed into the market to satisfy an assumed demand but the sale of the vehicles is uncertain [Bufka 2004].

Today the situation of European car producers is totally different. Due to high competition between manufacturers, saturation of the market and overcapacities, the output must be geared to consumers' preferences. Because of the high volatility of these preferences and the reduction of product lifecycles, a forecast-based production does no longer meet the demands of the market. As a second aspect BTS vehicles cause a high capital lockup until they are sold. Therefore the OEMs provide the opportunity for the customer to choose between various customisation possibilities for a car model. So production activities are now often initiated by already existing customer orders. The manufactures pursue a pull-strategy because in this case the cars are "pulled" into the market due to specific orders. Thus the sale of these BTO vehicles is certain and no unnecessary capital lockup occurs. Normally the OEMs implement a mixture of push- and pull-strategy: BTO processes are initiated by customer orders and BTS vehicles are additionally manufactured to operate at full capacity and to give the retailers an opportunity to immediately sell a showroom-car if the customer does want to wait [Bufka 2004, Wiendahl, Gerst and Keunecke 2004, Coronado et al. 2004, Miemczyk, Holweg 2004].

The implementation of a BTO production leads to an immense complexity of the manufacturing process. Because of the opportunity for the customer to add and combine numerous customisation components, billions of variants of a car model are possible and therefore nearly no vehicle is equal to another [Huang et al. 2007, Li 2007]. Thus many different components must be placed ready at different stations of the production line. Additionally the workers must be highly skilled to cope with the huge number of alternative components during the assembly process. As a consequence the production times are rising and the error quote is increasing. But on a highly competitive market customers do not accept delivery times above the average. There is a strong correlation between the delivery time and the customer's satisfaction, e.g. a six weeks delivery time of a BTO-car is unsatisfactory for more than one third of the customers [Hellingrath 2007, Grafen 2001, Fredriksson, and Gadde 2005].

Therefore manufactures are forced to implement strategies to handle the increasing complexity of the production process and shorten the delivery time. Modular product design is one of these strategies. The main idea is the partitioning of a product into independent modules to allow an assembly of product variants, e.g. different cockpit or front end modules. The use of modules allows a rapid assembly of different variants of a car. The larger the number of different modules and their combinations, the more complex the production process is [Fredriksson, Gadde 2005, Ernst, Kamrad 2000, van Hoek 2001, Simpson 2004]. Therefore often an additional strategy implemented is to limit the number of variants. While configuring the car during the ordering process, the purchaser is restricted to predefined combinations of components, e.g. a black car body limits the choice of alternative seat colours to black or grey. Another possibility is to permit the choice of a component only when an associated package of components is chosen, e.g. seat heating is only permitted if the whole winter-package is chosen, additionally consisting of heatable mirrors and heatable front window [Pil, Holweg 2004].

The above mentioned strategies limit the number of variants of a car but barely succeed in reducing the complexity of the production. The manufacturing process is not relieved from customisation operations that aim to individualize the car according to the purchaser's order. For this reason lot sizes with identical basic or additional operations at the different stations of the assembly line are very small. Therefore economies of scale are decreasing while production planning times and assembly times are increasing with the number of variants. The LPI approach does not intend to optimise the lot sizes under the restriction of diverse variants. It is a more practical than theoretical attempt that consists of three steps to relocate specific assembly activities to phases of the distribution where idle times occur.

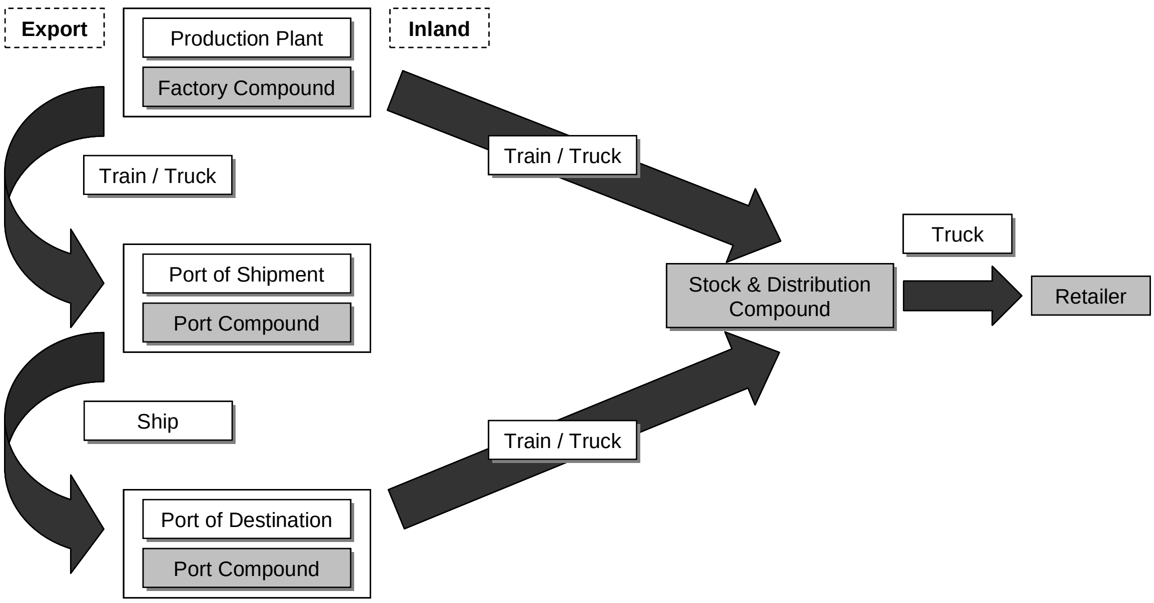

Fig. 1. Possible LPI stations of an exemplary distribution chain
Rys. 1. Możliwe punkty OIP przykładowego łańcucha dostaw

Idle times especially occur during the distribution process when vehicles are accumulated to generate big transportation badges or the follow-up transport does not start immediately, respectively. These situations arise e.g. at the factory compound, when cars for the same destination need to be gathered to fill a freight train. The same constellation but in larger dimensions appears at the port of shipment for overseas transport. Big car carriers have a capacity of up to 6,500 cars. At this station of a possible distribution chain the idle time often takes several days without any operations. At the port of destination a holding time of a few days arises when accumulation processes for the transportation to further destinations are necessary or retailers do not immediately recall the ordered cars. Additionally idle times occur when a BTS car has to wait at a distribution compound or at the retailer until a purchaser is found. Following figure shows an exemplary distribution chain for overseas or domestic transport; grey description fields mark possible stations for LPI.

The three preparative LPI steps as follows. The first step is to identify all components and associated activities that change a basic car model to a customised automobile. Complicating the assembly process or severely affecting the functional capability of the vehicle is the exclusion criterion in this selection phase. The second step is to identify stations of the distribution process where extensive idle times occur and if the build-up of an assembly workshop is reasonable at these stations. The last and most challenging step is to check if selected components could reasonably be relocated to specific stations of the distribution chain. By decoupling specific customisation operations from the assembly line, the production planning period can be reduced, the lead time is decreasing, complexity is reduced and economies of scale are increasing. The key difference to the well known approach of postponement is that a broader range of components is relocated and that phases of idle times are overlain with value adding operations.

The identification of customising components is very simple. Every part of the vehicle that allows the fitting of alternative modules as well as additional components that are not associated with the basic car model, are possible objects for LPI. Amongst others this could be wheels, seat covers, sun roof, navigation system, sound system, entertainment system, bumpers and side skirts.

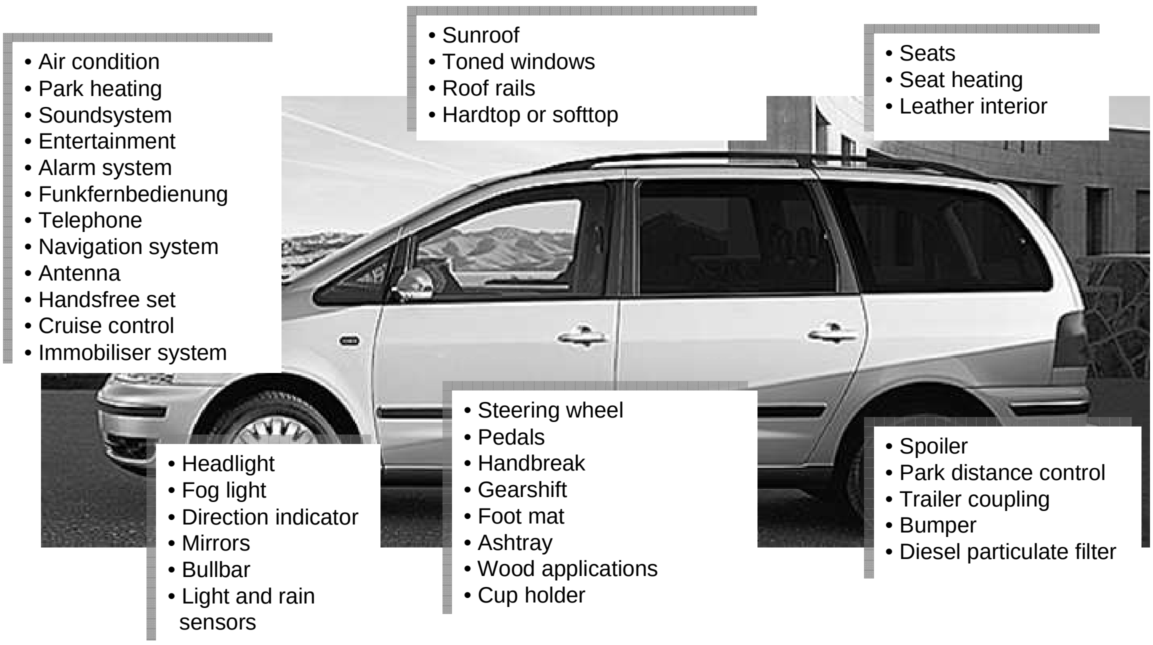

Fig. 2. Exemplary LPI components
Rys. 2. Przykładowe komponenty OIP

If the assembly of a component is skipped during the primary production for the reason of relocation, essential functions of the car must not be affected and the effort of a later fitting must not exceed predefined levels. In some cases the postponed fitting of certain parts or modules e.g. seats or wheels requires a temporary installation of so called dummy parts to assure basic functions of the vehicle until the skipped component is installed. Of course this additional operation must not exceed time and effort of the primary assembly process.

The designation of distribution stations where an implementation of workshops is reasonable, depends e.g. on the duration of idle times and the number of vehicles passing this station. The dimension of a workshop must be designed to manage a given volume of cars in a given amount of time. If there is only little volume of cars at a station or the idle time is too short, the implementation of a workshop is not suggestive. The identification and suitability of vehicle components as well as distribution stations can be evaluated by qualitative decision tools. The well known methods of Value Benefit Analysis and Analytic Hierarchy Process are suitable for this problem.

The final step of the LPI preparation implies an economical evaluation of the assembly of identified parts at designated distribution stations. The quantitative decision support results of a self-developed assessment model that opposes revenues and costs of LPI activities. Amongst others this model takes aspects of time, sales volume as well as prices into account and the resulting effects on revenues and costs. A profitability criterion is derived to check if the assembly of selected components at designated workshops of the distribution chain is reasonable.

A QUANTITATIVE DECISION MODEL FOR LPI

As already mentioned the qualitative methods of Value Benefit Analysis and Analytic Hierarchy Process are a suitable decision support to identify reasonable vehicle components and to designate distribution stations for workshops. Since the two methods are already widely discussed in the literature, here the description of the decision process is limited to the developed model.

The implementation of LPI causes effects on revenues and costs. These effects can be of a positive or negative nature, meaning that positive effects on costs lead to a reduction of costs while negative effects on revenue lead to a reduction of revenues. The model considers no dynamical effects, e.g. learning curves.

COSTS

The LPI will shorten the production planning period because of increasing lot homogeneity in the basic assembly process. The planning of LPI activities is more complex but it has no effect on the production planning time because it is independent of the production start at the manufacturer's plant. Therefore the total lead time is noteworthy decreasing but the planning costs P including LPI planning are increasing: $\Delta P > 0$. The reduction of the lead time can result in an increasing amount of BTO vehicle.

The reduction of variants during the primary production leads to faster assembly operations, thus the productivity is rising or the throughput is increasing, respectively. An increasing productivity leads to a reduction of production-costs per unit: $\Delta f_P < 0$. The overall productivity effect on costs when n cars are produced is $\Delta F_P = \Delta f_P \cdot n < 0$.

LPI activities lead to a change in material costs Δm_a of the individual components. The material costs of a component a consist of direct material costs MEK_a and costs of logistics handling l_a, e.g. transportation and packaging of the component. Therefore the primary material costs are $m_a = MEK_a + l_a$. Now LPI causes an increase of logistics costs. In Europe the key suppliers are usually sited near to the production plant. Now different workshops at distribution points i in different distribution chains j need to be supplied. Because of longer distances and smaller transportation badges depending on the location of station *i* in distribution chain *j*, the costs of logistics increase by factor α_{ij} . Additionally these costs increase if a dummy or serial part must be returned from point *i* to the production plant for the reason of reuse. These extra costs are considered by the percentage rate β_{ij} . The assumption is made that the factor α as well as factor β is an average percentage that is equal for all components at one station. Two binary variables $c_{a,ij}$ and b_a are introduced. The variable $c_{a,ij}$ is set to 1 if LPI component *a* can be assembled at station *i* of chain *j*. The variable b_a is set to 1 if a dummy or serial part that temporary replaced component *a* needs to be returned to the production plant. The change of material costs for the component *a* can be formulated as:

$$\Delta m_a = \sum_{i,j} c_{a,ij} \cdot l_a \cdot \alpha_{ij} + \sum_{i,j} b_a \cdot c_{a,ij} \cdot l_a \cdot \beta_{ij} \qquad (1)$$

To determine the overall change of material costs for all LPI components ΔM let x_a be the likelihood of a LPI component to be installed. The number of vehicles passing through all distribution chains is represented by *n*. Therefore the total change of material costs, considered to be $\Delta M > 0$ is:

$$\Delta M = \sum_a x_a \cdot n \cdot \Delta m_a \qquad (2)$$

At last a service charge for the assembly of LPI parts must be considered. The fitting operations at the workshops will not be executed by the OEM but by a logistics service provider who is in charge of the whole distribution process. The service charge per component is represented by d_a , thus the additional overall installation costs are:

$$F_{LPI} = \sum_a x_a \cdot n \cdot d_a \qquad (3)$$

Additional to the above mentioned effects the capital lockup and therefore the cost of capital is decreasing for LPI parts because the assembly process is delayed. At this point the effects on costs are adequately examined. Consequently the next step is to take a look at the effects on revenues.

REVENUES

Since the effects of LPI on costs have a negative impact, the success of LPI needs to be found in effects on revenues. The basic definition of revenue is $R = p \cdot n$ where *p* is the price of a car. Due to the fact that every car is different because of varying customisation settings for a car model, it is assumed that *p* represents the average price. According to the difference between BTS and BTO cars, the revenue has to be split. Usually the price realised for a BTS vehicle is below *p* because it is not 100 % compatible to the customer's preferences. Therefore retailers have to give a discount on the targeted price. Thus price and sales volume are split in BTS and BTO:

$$R = R_{BTO} + R_{BTS} = n_{BTO} \cdot p_{BTO} + n_{BTS} \cdot p_{BTS} \qquad (4)$$

Following p_{BTO} is set to $p_{BTO} := p$. In case of BTS vehicles the price is reduced by an average percentage for discount D . Therefore the BTS price is equal to $p_{BTS} = p \cdot (1 - D)$. The vision of European car manufacturers is to only produce BTO cars. The actual BTO quota of the total production is:

$$q_{BTO} := \frac{n_{BTO}}{n} = \frac{n - n_{BTS}}{n} \qquad (5)$$

With (5) the sales volume of BTS and BTO cars can be defined as $n_{BTO} = q_{BTO} \cdot n$ and $n_{BTS} = n \cdot (1 - q_{BTO})$. Considering the above mentioned definitions and assumptions, equation (4) can be reformulated as:

$$R = n \cdot p \cdot [1 + D \cdot (q_{BTO} - 1)] \tag{6}$$

One of the biggest potentials of LPI is the reduction of the *Order-To-Delivery* (OTD) time. Therefore the time of capital lockup for a car is reduced. A distinction between BTO and BTS vehicles is not needed because the OTD process is equal for all cars. The assumption is made that the time to realise a price p is shortened by t days. The realised price p can be reinvested with a daily yield percentage of y . The definition of revenue including the effect of time can be extended to:

$$R_{LPI,time} = n_{BTO} \cdot [p_{BTO} \cdot (1 + y \cdot t)] + n_{BTS} \cdot [p_{BTS} \cdot (1 + y \cdot t)] \tag{7}$$

$$R_{LPI,time} = R \cdot (1 + y \cdot t) \tag{8}$$

Comparing the primary equation for revenue (6) with the definition of revenue when LPI is introduced (8), the positive effect on revenue due to a shortened OTD time can be described as:

$$\Delta R_{time} = R_{LPI} - R = R \cdot y \cdot t > 0 \tag{9}$$

As already mentioned the delivery time has a massive impact on the customer's satisfaction. Some customers prioritise an immediate availability compared to total fulfilment of their customisation preferences. Therefore these customers prefer BTS over BTO vehicles. A decrease of the OTD time increases the attraction of BTO cars for impatient customers who would have preferred BTS cars because of the short-term availability. This attraction leads to a rise of the BTO quota by $0 < \Delta q_{BTO} < 1$. The effects of LPI on the sales volume of BTS and BTO vehicles as follows:

$$n_{LPI,BTO} = n \cdot (q_{BTO} + \Delta q_{BTO}) \tag{10}$$

$$n_{LPI,BTS} = n \cdot (1 - q_{BTO} - \Delta q_{BTO}) \tag{11}$$

Due to essential discount, the revenue of BTS cars is lower than the revenue of BTO vehicles. The effect of higher sales volume of BTO cars causes an increase of total revenue. This volume effect on revenue can be formulated as:

$$R_{LPI,volume} = (n_{LPI,BTO} \cdot p_{BTO} + n_{LPI,BTS} \cdot p_{BTS}) \tag{12}$$

$$R_{LPI,volume} = n \cdot p \cdot (1 - D + q_{BTO} \cdot D + \Delta q_{BTO} \cdot D) \tag{13}$$

$$\Delta R_{volume} = n \cdot p \cdot D \cdot \Delta q_{BTO} > 0 \tag{14}$$

So far revenue affecting effects of LPI on time and volume have been identified. But LPI has also effects on prices that lead to an increase of revenues. Positive effects occur in case of BTO as well as BTS vehicles. If the OEM allows a retailer not to immediately recall the BTS vehicles but to keep them located at an upstream distribution compound, a positive impact on p_{BTS} is possible. Assuming at the upstream distribution compound a LPI workshop is established, the retailer can adjust the configuration of a BTS car to the preferences of a purchaser. Therefore the customer's willingness to pay is higher and the retailer is able to enforce less discount. Additionally the OEM profits of this situation because the retailer can be charged for the costs of LPI operations and the realised price is higher. Let ΔD be the amount of reduction of the primary discount, then the new sales price for BTS automobiles is:

$$p_{LPI,BTS} = p \cdot [1-(D-\Delta D)] = p \cdot [1-D+\Delta D] \tag{15}$$

LPI activities can also have positive impact on BTO prices. A skipped assembly of LPI components to further stations of the distribution chain provides the opportunity for post-order marketing activities. LPI prolongs the possibility to change or to upgrade the ordered vehicle. Thus the marketing division of the OEM is able to contact the customer after the car is already ordered and offer upgrade-packages. Since the customers already accepted and maybe repressed the initial sales price, some will be willing to pay for upgrades or additional components, respectively. The percentile rise of the BTO sales price is represented by factor Π. The new price is set to:

$$p_{LPI,BTO} = p \cdot (1+\Pi) \tag{16}$$

Considering the equations (15) and (16), the effect on revenues due to changes in sales prices can be modelled as:

$$R_{LPI,price} = n \cdot p \cdot (2+\Pi-D+\Delta D) \tag{17}$$

$$\Delta R_{price} = n \cdot p \cdot (1+\Pi+\Delta D-D \cdot q_{BTO}) > 0 \tag{18}$$

PROFITABILITY CRITERION

After all major effects on revenues and costs have been identified a criterion needs to be derived to evaluate the profitability of LPI activities. Therefore the changes of costs and revenues must be summed up. The total effect on costs caused by LPI ΔK_{LPI} according to section 3.1 can be formulated as:

$$\Delta K_{LPI} = n \cdot \sum_a x_a(\Delta m_a + d_a) + \Delta F_P + \Delta P \tag{19}$$

Please consider the assumption that $\Delta m_a > 0$, $\Delta F_P < 0$ and $\Delta P > 0$.

The total change of revenue caused by LPI ΔR_{LPI} will be according to section 3.2:

$$\Delta R_{LPI} = n \cdot p \cdot [D \cdot [y \cdot t \cdot (q_{BTO}-1) + \Delta q_{BTO} - q_{BTO}] + y \cdot t + 1 + \Pi + \Delta D] \tag{20}$$

Assuming that R is the initial revenue and K are the initial costs then $G = R - K$ is the profit in a situation without LPI. An accumulation of costs over the total duration is assumed to be the capital employed. Therefore the *Return On Capital* (ROC) can be set to:

$$ROC = \frac{G}{K} \tag{21}$$

The profitability of LPI can be identified by a comparison of ROC in a situation with and without LPI. Thus the profitability criterion can be formulated as:

$$ROC_{LPI} > ROC \tag{22}$$

$$= \frac{R_{LPI} - K_{LPI}}{K_{LPI}} > \frac{R - K}{K} \tag{23}$$

$$= \frac{R + \Delta R_{LPI} - (K + \Delta K_{LPI})}{K + \Delta K_{LPI}} > \frac{R - K}{K} \tag{24}$$

$$= \frac{\Delta R_{LPI}}{R} > \frac{\Delta K_{LPI}}{K} \tag{25}$$

With equation (25) finally the condition for profitability of LPI is defined. R and K are considered as given based on data of the primary situation. ΔR_{LPI} and ΔK_{LPI} can be derived from equations (19) and (20), some of the variables need to be estimated or forecasted, respectively. Finally the change of profit due to LPI activities ΔG_{LPI} is described by $\Delta G_{LPI} = \Delta R_{LPI} - \Delta K_{LPI}$.

CONCLUSIONS

The introduced approach of LPI including the model represents a practical approach for manufacturers of high quality goods underlying a big amount of variants to evaluate possibilities to reduce complexity of the production process. Skipping specific assembly processes of variant-causing components and relocating them to stations of the distribution chain is the core of LPI activities. As a result the primary production process is relieved from customisation activities and therefore the complexity is reduced. This leads to bigger lot sizes and thus to increasing economies of scale. A stronger homogeneity of products causes lower costs per unit.

The reduction of complexity does not cause any disadvantages for the customers because a customisation according to preferences is still given. Only the point in time of assembly of individualising components changed. This delay of activities causes advantages for customers, manufacturers and retailers. LPI allows the customer to change or upgrade his ordered vehicle even when the production planning process at the manufacturer's plant is already finished. On the other hand this flexibility in LPI planning enables the OEM to run special and individual marketing actions for product upgrades, when a customer's car is ordered and the customer no longer worries about the initial sales price. If a LPI workshop is located at a distribution compound, retailers can have a major sales advantage for BTS vehicles. In a case where a retailer is allowed to station his BTS cars at this compound, there is the possibility to customise these cars to satisfy short term customers demand. Thus there is no need to give high discount because through LPI the BTS vehicle can be adjusted nearly completely to the customer's preferences.

The process of identifying LPI components and specifying the location of workshops is solved by qualitative methods like the Analytic Hierarchy Process and the Value Benefit Analysis. The quantitative analysis is done by a self developed model. As shown in section 3 LPI leads to an overall increase of costs. But effects on time, sales volume and price also cause an increase of revenues. The derived profitability criterion reveals if the implementation of LPI can be considered as economically reasonable. The model is limited to a static point of view but it is an efficient tool to support the decision process.

The main challenge is to implement LPI in the whole supply chain because suppliers as well as logistics providers are affected. Suppliers need to restructure their facilities and networks to satisfy the demand for components of the production plant as well as of the workshops. The task of logistics providers to manage transportation processes within distribution chains is enhanced by the coordination and execution of LPI activities at the workshops. Therefore a highly effective information infrastructure linking all parties with real time data exchange is essential.

The next step of research activities is to implement LPI and test the validity of the introduced model under real time conditions in collaboration with a major European car manufacturer. This will provide conclusions about further supply chain development and the expansion of LPI to other branches.

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LOGISTYKA OPÓŹNIONEJ INDYWIDUALIZACJI PRODUKTÓW W PRZEMYŚLE SAMOCHODOWYM

STRESZCZENIE. Konsekwencją istnienia globalnych rynków i rosnącego popytu na indywidualne produkty jest stały wzrost wariantów produktów. Produkty wysokiej klasy na konkurencyjnych rynkach, np. na rynku samochodów, muszą spełniać wymagania klientów. Możliwość "konfiguracji" samochodu przez klienta, zgodnie z jego preferencjami, prowadzi do nieograniczonej różnorodności wariantów. Dotychczasowe próby producentów w tym obszarze zmniejszają różnorodność wariantów, ale nie redukują złożoności procesu produkcji. Koncepcja "opóźnionej indywidualizacji produktu" rozwiązuje ten problem. Złożoność procesu produkcji ulega zmniejszeniu, bez ograniczania klienta w wyborze określonego wariantu. Z procesu produkcji jest wyodrębniana część operacji montażu, która jest ponownie włączana w kolejnych etapach łańcucha dostaw. W ten sposób można zastąpić bezproduktywne czasy przestoju działaniami dodającymi wartości. W artykule opisano wymagania dotyczące całego łańcucha dostaw oraz przedstawiono instrumenty analityczne pomocne w procesie wyboru montażu.

Słowa kluczowe: Opóźniona indywidualizacja produktów, logistyka, dodawanie wartości, analiza wartości, Analytic Hierarchy Process.

SPÄTE PRODUKTINDIVIDUALISIERUNG - UMSETZUNG IN DER AUTOMOBILINDUSTRIE

ZUSAMMENFASSUNG. Globale Märkte und die wachsende Nachfrage nach individuellen Produkten führen zu einer stetigen Zunahme von Produktvarianten. Insbesondere qualitativ hochwertige Produkte auf wettbewerbsintensiven Märkten, z. B. dem Automo-bilmarkt, müssen den Kundenanforderungen gerecht werden. Die Möglichkeit seitens des Kunden ein Auto seinen Präferenzen entsprechend zu konfigurieren, führt zu einer unbeherrschbar werdenden Variantenvielfalt. Die bisherigen Ansätze der Hersteller vermindern die Variantenvielfalt, reduzieren jedoch nicht die Produktionskomplexität. Der Ansatz der "Späten Produktindividualisierung" begegnet diesem Problem. Die Komplexität der Produktion wird verringert, ohne die Auswahlmöglichkeiten des Kunden noch stärker zu limitieren. Der Produktionsprozess wird von einem Teil der individualisierenden Montagevorgänge befreit, die in nachgelagerten Bereichen der Supply Chain wieder eingefügt werden. Dadurch können insbesondere in der Distribution unproduktive Wartezeiten mit wertschöpfenden Tätigkeiten überlagert werden. Die Anfor-derungen an die gesamte Wertschöpfungskette werden beschrieben und analy-tische Instrumente vorgestellt, die bei der Auswahl auszugliedernder Montageschritte helfen.

Codewörter: Späte Produktindividualisierung, Logistik, Wertschöpfung, Nutzwertanalyse, Analytic Hierarchy Process

Prof. Dr.-Ing. habil. Lothar Schulze
Dipl.-Oec. Sebastian Mansky
Dipl.-Oec. Janusz Klimek
Lager- und Transportsysteme (PSLT)
Leibniz Universität Hannover
Callinstraße 36
30167 Hannover, Deutschland
Tel: +49 511/762-4885
Fax: +49 511/762-3005
e-mail: mail@pslt.uni-hannover.de