Segmentation and Evaluation of the Order-to-Delivery Process of Agricultural Machinery

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Abstract
In the current business environment quite different supply chains may function alongside, each requiring appropriate operating structure. This paper develops an approach for segmenting the supply chain in different Order-to-Delivery (OtD) processes. In order to provide a multiple product delivery strategy for different market requirements, the supply chain will be allocated to three categories. The approach is based on empirical investigation, on a customer survey (n=426) about the satisfaction of the OtD process and on-site visits at a global manufacturer of agricultural machinery with volatile and seasonal demand. Finally, specific production strategies will be dedicated to an OtD segment.

Keywords: Order-to-Delivery Process, Supply Chain Segmentation, Industrial Case Study

Introduction
In the evolution of production systems, mass customization has been playing a major role. In the last decades, the markets have changed from supplier to buyer markets. Supply chains have to deal with a wide range of products and markets. This diversity has long been recognised, and the concept that *one size does not fit all.* Even when products are identical, customers may have different needs. Each customer group has a different degree of requirements. Thus, it makes sense for the supply chain to devise entirely different setups for each product family (A.T. Kearney, 2004). In the current business environment quite different supply chains may function alongside, each requiring an appropriate operating structure. At one extreme, a unique supply chain would be provided for each product in each market. This would be extremely expensive, unmanageable, and inefficient. At the other extreme, all products to all markets would be forced down the same or similar supply chains. The optimal solution lies somewhere in-between.

However, manufacturers suffer from increased vulnerability of variations on the demand-side (e.g. demand and seasonal fluctuations) and disturbances on the supply-side (e.g. material supply issues), which lead to unpredictable knock-on effects and at the end to unreliable deliveries, longer OtD times and higher operation costs to make up of lost capacity and time. Hence, these effects impair the balance of Make-to-Order (MtO) supply chains. Accordingly, the success of a MtO strategy does not entirely reach expectations. Especially, the market performance measures e.g. high on-time delivery and short lead times of products become more and more to a unique selling proposition, giving a company a competitive advantage (Wiendahl, 2010). However, MtS with a short OtD time is appealing, due to its desirable performance properties: high capacity utilization, high availability and short lead times. Thereby, a MtS strategy has the advantage to level the production capacities and increase the utilisation of available resources (Olhager, 2003). At the end, hybrid production strategies are elaborated to serve the different requirements (Köber, 2012b). Particularly, in the automotive sector high-volume standardized products are assumed to utilize a level planning approach, i.e. MtS, whereas low-volume and customized products are expected to choose a chase planning strategy, i.e. MtO. Furthermore, beside the two segments, customized (MtO) and standardized products (MtS), large orders (e.g. sales campaigns, fleet orders) erode supply chain behaviour significantly. To win these large orders (LO) are strategically important for a company and will be further elaborated in this paper.

The topic of defining and designing the downstream (agile approaches) and upstream (lean approaches) processes of the order penetration point is intensely discussed in the literature. Methods, i.e. postponement, modularization, flexibility or responsiveness have received high attention in the academic literature.

However, in these discussions a segmentation and evaluation of the OtD process in the field of manufacturing supply chains of agricultural machinery with seasonal and volatile demand has still not been sufficiently covered. In this contribution, the authors have segmented the OtD process of agricultural machinery into three categories. The approach is based on an industrial case of a global manufacturer of agricultural machinery with volatile and seasonal demand. The case research considers a customer survey and on-site visits of customers, sales dealers, production facilities and suppliers. The market requirements with focus on the OtD process were ascertained through a customer survey of over 420 customers on a reference market. A segmentation of the OtD process is based on the main criteria like variation coefficient of demand, order size and the ratio between production lead time and desired delivery time. In addition, the structure of a manufacturing supply chain was transformed into a generic simulation model. With the help of system dynamics, the cause-effect structure and the impact of different OtD policies on the market and operational performance can be evaluated.

Related Literature

The paper reviews existing contributions and synthesises these into a conceptual approach to segment the OtD process in categories and align different supply chain policies. First, the topic supply chain segmentation is reviewed to demonstrate the advantage of multiple supply chain that fit to diverse market requirements. Second, since the focus lies on the demand-side of a supply chain, the OtD processes and different strategies will be explained. Third, the overall targets performance is a central concern of a production or supply chain. The key performance indicators are important to measure the success of supply chain segmentation. The authors have developed a system dynamics model to evaluate the effect. The cause-effect relationship and structure of system dynamics simulation model is explained in detail in Köber and Heinecke (2012a). Based on the related literature an approach is developed to segment the demand-side of supply chains in three categories.

Supply Chain Segmentation

Supply chain segmentation is defined as an adequate alignment of logistics and supply chain structure to different requirements by specific customers or product segments (Prockl, 2007). One supply chain structure will not meet all requirements. The topic has recently been developed by Fisher (1997) to identify two main categories of products: functional or innovative. These two types of product should be treated differently in segmented supply chains. However, the same product can have different requirement e.g. delivery time by different customer groups. Lovell (2005) states that supply chains must be carefully matched to market requirements. It is equally clear in the current business environment that quite different supply chains need different operating structures. At one extreme, there would be a unique supply chain for each product in each market. At the other extreme all products for all markets would be forced down the same or similar supply chains. Hence, the number of different supply chain strategies can differ between one-fits-all to market-of-one (Lovell, 2005). The optimal solution lies somewhere in-between. The ratio between the individualisation and the complexity of the solution, which can also be quantified in costs, influences the right number of supply chain strategies. In Lovell et al. (2005) different factors e.g. product, market, source, geographic and commercial environment factors and methods (e.g. product value density) are presented to segment the supply chain. The focus of this contribution lies particularly in supply chain segmentation due to different customer needs in customization of products, OtD time and size of orders.

Order-to-Delivery process

From a supply chain perspective, the OtD process is one of the most important processes to manage (Forslund, 2009). It can be considered as a cross-company business process from the customer over the OEM back to the customer. An OtD process starts with the recognition of a need to order and ends with the product delivery In general, the major sub-processes involved are (Forslund, 2009):

i) The ordering sub-process at the customer starts with the recognition of a need at a certain time and ends when a customer order reaches the supplier (manufacturer);
ii) The production sub-process at the supplier starts with the receipt of the order and ends when the goods are available for shipment;
iii) The deliver sub-process starts when the ordered goods are available to be picked up and ends when the goods have been unloaded at the customer;
iv) The goods receipt sub-process starts when the ordered goods have been received and ends when they are available for use.

The performance of an OtD process traditionally concerns lead time and on-time delivery. Lead time is typically defined “as the time between recognition of the need to order and the receipt of goods” (Forslund, 2009). On-time delivery is the extent to which the lead time and the delivered quantity corresponds to what has been confirmed. However, lead time length is normally not considered to be the most important OtD process performance dimension. Other dimensions such as on-time (reliable) delivery, capacity utilization or low inventory levels are often ranked as being more important.

Order-to-Delivery Strategy

The decision of the right supply strategy for a specific market defines in detail the position of the order penetration point in a supply chain. Hence, it defines also the production strategy e.g. MtO or MtS. Due to the competitive landscape, manufacturing companies have developed particularly the strategy of MtO supply chains to be more flexible and responsive to the volatility of demand and to allow higher product variability (Gunasekaran, 2005). MtO refers to a demand-driven production approach, where a product is scheduled and built in response to a confirmed order received from a final customer (Holweg, 2004). The increasing interest in product customization is explained by the fact that customers are demanding highly customized products (Piller, 2006). Furthermore, customization has been marketing driven and provided by manufacturing firms with an approach that is claimed to improve the competitive position of the company (Holweg, 2004).
The order penetration point (OPP) defines the stage in the manufacturing value chain, where a particular product is linked to a specific customer order (Sharmann, 1984). Sharman defines the OPP as the point where product specification typically get frozen, and as the last point at which inventory is held. As a rule, the OPP coincides with an important stock point from which the customer has to be supplied (Kuhn, 2010).

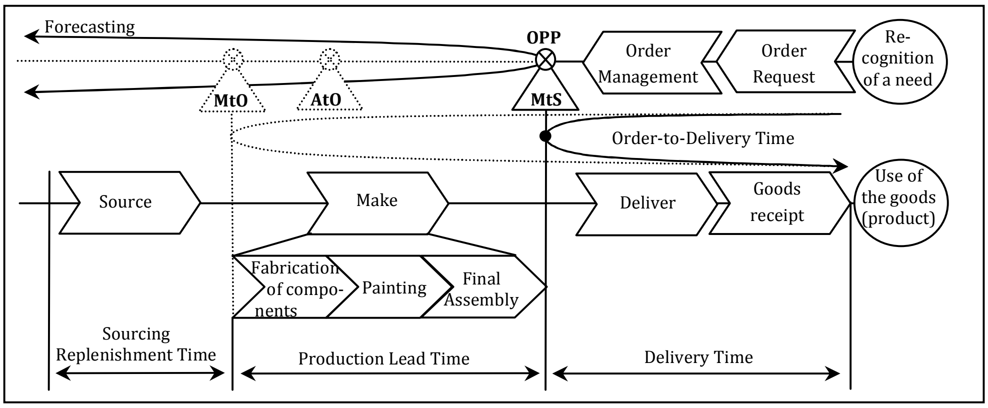

Figure 1 – OTD process and possible positions of the OPP

Figure 1 shows a generic supply chain, sub-process of OtD and demonstrates the principle of different OPPs. On the downstream side of the OPP the finished goods are pulled by customer orders. On the upstream side, the production is driven by forecasts.
On the one side, an MtS production is characterized by forecast-based source and make processes. Only the delivery process is triggered by customer orders. Hence, the OtD time of a MtS strategy relatively short in comparison to a MtO strategy. Furthermore, all downstream processes, which are based on forecasts, are optimized in regard to capacity utilization and inventory level. On the other side, in a MtO strategy also the make and deliver processes are based on customer orders. Hence, the OtD time is longer as in a MtS production strategy. Only the source process of materials is based on forecasts. The

main advantage of MtO is the make processes are driven by customer orders, which enables a production of customized products and low inventory levels. Especially, in supply chains with a high product variety is it difficult to predict the right product specification. In the literature and practice the terms BtO/AtO and MtO are used inconsistently. In MtO, components and parts are made and then assembled driven by customer orders while in BtO/AtO all main fabricated components are pushed on stock and the final assembly is triggered by customer orders. Many manufactures follow the vision to come to an OPP, which allows a MtO production. However, they have to consider that the OtD time is shorter than the customer desired OtD time. Also, practice shows that the volatility and seasonality of demand, unpredictable supply chain disturbances and increase of complexity of value chain leads to a new era of supply chain management (Christopher, 2011). As a result, a segmentation of the supply can be a viable strategy to serve the increase diversity of product and market requirements in future.

Key Performance Indicators

Key performance indicators (KPIs) of a production system according to Wiendahl are (2010): (i) delivery time, (ii) on-time delivery, (iii) capacity utilization and (iv) inventory level. From the market perspective a very short delivery time and adherence to delivery dates, which lead to a high on-time delivery, are crucial. From the perspective of the operational level, it is essential to have a high and stable utilization of capacity and low inventory levels of raw material, work in process and final products. Additionally, the price realisation (v) is an important KPI of the efficiency of the supply chain. It illustrates which customer price has been achieved compared to the list price. In general, the price realisation for MtS is lower than with MtO products because the product configuration, which is available on stock, often does not match customer requirements (Holweg, 2004). Hence, products are sold with price discounts or over specification to win the customer order. The five performance measures, which influence customer satisfaction and profitability of the enterprise, are shown in (Köber, 2012a). However, they create an internal conflict between having high on-time delivery and short delivery times on the one hand and low inventory levels, high capacity utilization and high price realisation on the other hand. Regarding the case study, where the manufacturer operates in a saturated buyer market, the market targets are arguably more important than the operational targets. In a customer survey about the satisfaction of the OtD process of agricultural machinery, which will be explained in the following section, has shown that customers do not want to wait longer than 12.6 week for their customized agricultural equipment. An OtD time over 12 weeks leads directly to dissatisfaction by customers. Nevertheless, since operational targets affect enterprise profitability, all five KPIs have been embedded in a generic simulation model to defining the right supply chain segmentation (Köber, 2012b).

Contribution

In the following subsection the focus lies especially on the demand-side of a supply chain. The supply-side of the supply chain also significantly influences the performance and structure of the supply chain. The authors have demonstrated the impact of supply chain disturbances on the supply-side on the performance measure in (Köber, 2012a), which based on the same case study. Two significant falls in production volume in November

2010 and February 2011, however, are due to two major disruptions on supply-side. Both had a delayed effect on the service rate, which is defined as the percentage of punctually fulfilled orders compared to the total amount of orders during a certain time span. Disturbance on the supply side influence can also influence the operational and market performance. In further subsection the focus lies particularly on the demand-side.

Supply Chain Segmentation of the OtD Process of Agricultural Machinery

The right OtD or supply chain strategy depends on a lot of different criteria; see e.g. Sharman (1984), Olhager (2003), Pagh (1998), Lovell (2005), Kuhn (2010) and Köber (2012a). Particularly, the classification of Olhager indicates two main criterion, the coefficient of variation (CV) and ratio of production lead time (P) and desired delivery lead time (D) (Olhager, 2003). CV is an indicator for the predictability of the demand. A low CV leads more to a forecast-driven (MtS) strategy and, vice versa, a high CV leads to an order-driven (MtO) strategy. Further, the ratio of P/D indicates that a product could be produced in less time than the customer desired delivery time. If the ratio is less than one, then a MtO strategy can be implemented. Otherwise, the production lead time will be greater than desired delivery time and lead to unsatisfied customers because of a too long OtD time. Hence, a late OPP in general and a MtS strategy in specific have to be chosen. Figure 2a shows the effect of seasonal demand. In general, the desired delivery time change over a fiscal year. The demand in front of a seasonal peak is significantly shorter than behind it. Furthermore, the production utilization is at the seasonal time period mostly near the maximum and low at unseasonal time period. The desired OtD time is correlating to the seasonal demand behaviour. The customers want the ordered products available at seasonal time period and not before. In the unseasonal period the desired OtD is long and decrease step by step to the seasonal peak (Figure 2a). As a result, the ratio P/D is not a static parameter rather a variable. On the one hand, P is determined by the demand volume per time unit, capacity utilization and flexibility. On the other hand, D is depending on the customer requirement. This effect has to be consider when segmenting the supply chain and choosing the right production strategy. Figure 2b and 2c show the segmentation of the OtD process and supply strategy based on criteria CV, P/D and order size. If the CV and/or order size is high then a MtO is preferred. Otherwise, if the P/D is above 1 then a MtS is advisable.

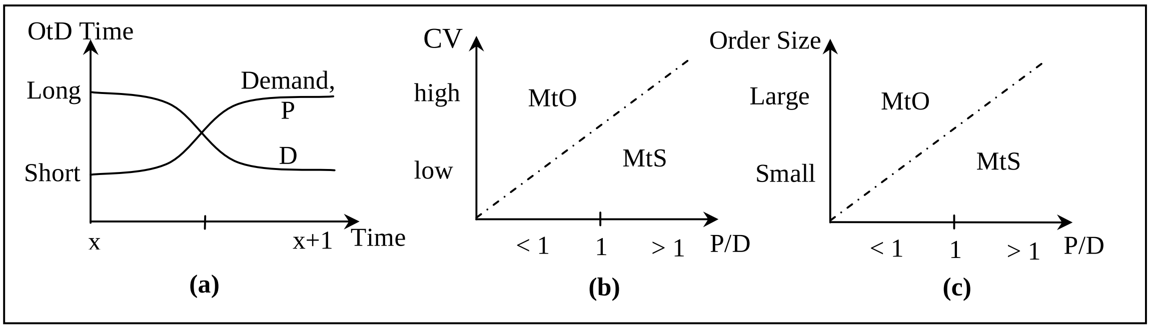

Figure 2 – Criteria to segment the OtD process by seasonal demand.

Industrial Case Study

The present industrial case study is based on data from the supply chain of a medium-sized manufacturer of agricultural machinery that produces combine harvesters, forage

harvesters, balers, forage harvesting machinery and tractors. These markets are characterized by low volumes, seasonal demand, series production, increasing product variety and globalization of operations. A customer survey and on-site visits of customers, sales dealers, production facilities and suppliers have lead to the following characterization of the market and OtD processes. The market is a highly-competitive industry characterized by large competitors, relatively mature products, and slowing growth (Salvador, 2007). The products differ from high-technology products to low cost products for development countries. Furthermore, the equipment sales in this market is structurally and inherently affected by seasonality (Figure 3), where consumers typically buy equipment for the harvesting season or postpone purchases another year.
The seasonality challenge has historically translated into finding ways to increase capacity without incurring fixed costs. Alongside natural seasonal peaks exists artificial seasonal peaks e.g. vehicle licening or accounting influences. Besides the seasonality challenge, agricultural machinery faces additional uncertainty and complexity in serving the market requirements, some of which stems from the heterogeneity of customer needs. The spread of the global market span form high technology machines to best-cost domestic versions, which leads to new products and product variants. The customers' needs, retailers' requirement and competitors' actions deserve attention. (Salvador, 2007) For each product family a set of product models can be selected by the customer.

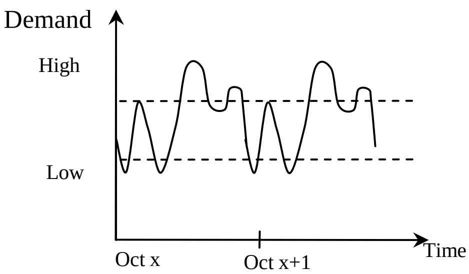

Figure 3 – Seasonal demand of agricultural machinery

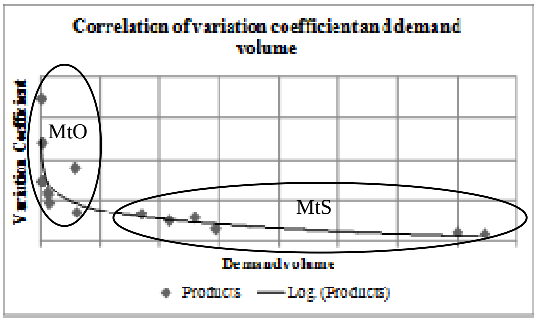

Figure 4 – Correlation of variation coefficient and demand volume

Typically, product variants would differ across a product family in terms of engine power and brand, size, cabin options, integrated guidance system and tyre size and other accessories, etc. Figure 6 shows that only few products with high demand exists. A lot of different exotic products are developed to serve the customer needs. However, a low demand volume correlates with a high CV and makes it difficult to produce these products on stock. Finally, once a customer has chosen a product model within a certain product family, the customer can customize the product with appropriate attachments, based on the specific work that the product is expected to perform. Since, the market has changed from supplier to buyer and is extremely price sensitive, the competition of serving customized products in a short OtD time comes to a unique selling proposition. An empirical analysis of the industrial case shows a price realisation advantage of circa three percent, when all products could be produced according to customer requirement and in the right time. Actually sales dealers have to give monetary discounts for produced products on stock to sell them. Furthermore, by a MtO strategy the final inventory will be reduced and lead to a significantly costs decrease of working capital. As a result, a MtO strategy should be the default strategy of a manufacturer of agricultural machinery. However, the volatile and seasonal demand and the limited capacity and responsiveness of manufacturing process lead to an underachievement of the default strategy MtO.

Customer Survey

In 2011, a customer survey of the satisfaction of the OtD process of agricultural machineries in reference market was carried out. Figure 5 shows the preference of the customer and comparison between the real, accepted and ideal OtD time.

On the one hand, a group of customers (74%) want their own *customized products*. The survey has shown that this group wants their agricultural equipment ideal in 12.6 weeks. In comparison with the actual situation, the MtO rate is under 50% and the OtD is 17% longer as accepted. Furthermore, these customers are not willing to accept a stock machine with different specification or only with a high discount to compensate the mismatch between the required and available products. On the other hand, another group of customers (23%) want the product as soon as possible available for use (*express delivery*). In general, the availability of the product is for this customer group more important than the customization of the product. In practice, this group of customers intends to replace old equipment quickly.

(a) Preference of the customer

(b) Comparison between the real, accepted and ideal OtD Time

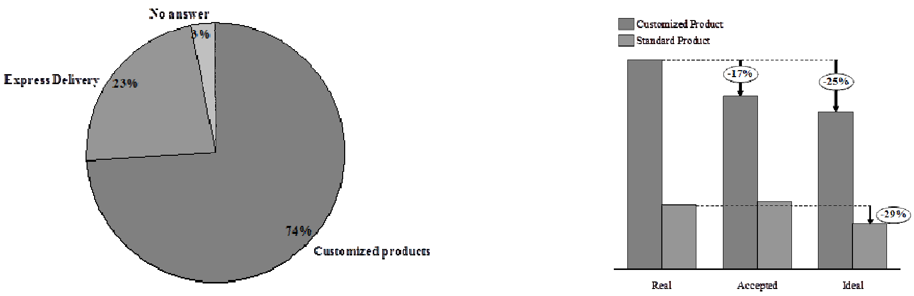

Figure 5 – (a) Preference of the customer and (b) Comparison between the real, accepted and ideal OtD Time

They would accept products from stock with a similar configuration to their requirement. Additionally, they would also pay the full price of a product, which is available on stock. However, this machine has to be available within about 3.6 weeks. Furthermore, customers e.g. enterprises they working as a subcontractor to do custom harvesting, nationalized enterprises or governments require a high amount of equipment and place mostly LO. LO are characterized by a relative high order volume, high uncertainty of occurrence and at the end a late order request. Hence, these orders have a short OtD time, need a high responsiveness of resources and they are unpredictable in case of volume per product type and time.

The rating scale of the customer satisfaction starts with 1 (highly dissatisfied or unimportant) and ends with the highest scale of 5 (highly satisfied or important). The survey has shown for the industrial use case that the KPI on-time delivery on an average base was by the MtS strategy 4.24 and by the MtO strategy 2.91. Normally, MtO would be the default strategy for agricultural machineries. However, the empirical investigation at industrial use case and customer survey in the reference market has shown that the key performance is behind the expectations. Furthermore, the market requirement in case of customization of products, OtD time and size of orders are significantly different. Additionally, the demand of agricultural machineries is volatile and seasonal, which lead to the challenge for production to utilize the capacities. In a nutshell, one supply strategy (MtO) does not fit to all.

Framework

The Figure 6 shows three supply chain segments and their OPP in a supply chain. The three segments are covering the different market requirements in field of agricultural machineries. First, the demand of customized products, which are characterized with high CV and low demand volume, dedicated to a MtO strategy. Hence, interlocked MtO processes needs a high amount of flexibility to absorb volatility and seasonality of the demand. The OtD time is relative long compared to a MtS strategy. However, a customer who wants a customized product is willing to wait for his own made product. A standardization or modularization helps to postpone the OPP downstream in the supply chain, which leads to a shorter P. Otherwise, sales incentives for an early ordering are supporting to increase D and, hence, to reduce the ratio of P/D. Second, the customer requirement of express product delivery can be achieved by producing on stock (MtS).
This strategy required a high degree of forecast quality to produce the right equipment on stock. A standardized or modular product structure supports to match the customer requirement with the available stock-keeping units. Thirdly, the supply chain segment LO is in-between of MtS and MtO. Especially, a very high degree of supply chain flexibility is required to win and realize LO. Additionally production and logistic capacity have to adapt because a postponing of existing orders lead to longer OtD Time. Particularly by seasonal demand, it is difficult to postpone received orders might be behind a seasonal peak. As a result, a well-thought-out sales incentive system has to carry out to win LO at unseasonal period. In a nutshell, a segmentation of the OtD processes in a supply can be a viable strategy to serve the increase diversity of product and market requirements in future.

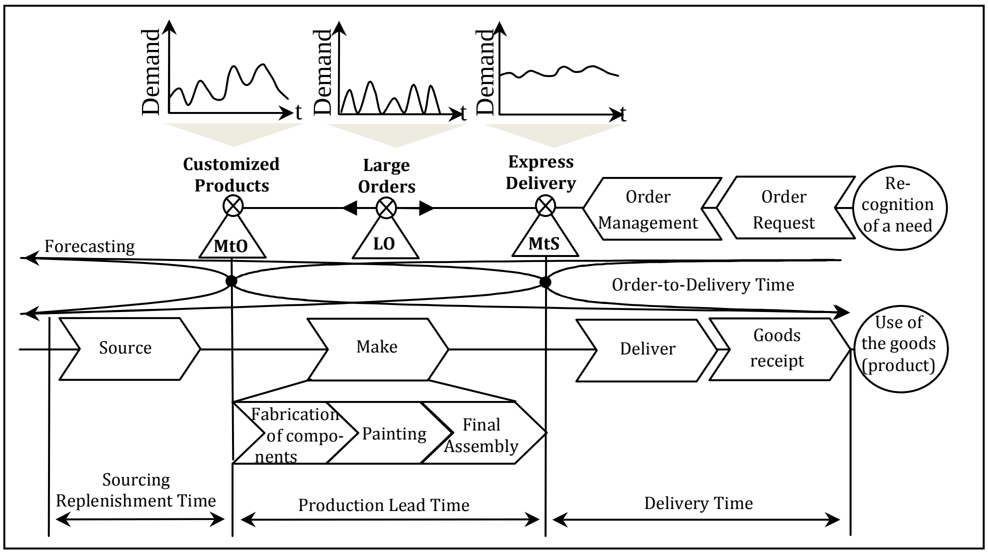

Figure 6 – OTD process and possible positions of the OPP

Conclusion and Outlook

In the field of seasonal and volatile manufacturing supply chains are exists a potential by a segmentation of the OtD process. The authors have been focused on an efficient answer to actual customer demand through a segmentation and evaluation of the OtD process. It provides an applied-orientated framework for management on how to balance responsiveness to market requirements and operational efficiency. Three key findings could be established: First, the concept of segmentation the OtD process has a simple logic that aligns itself to a wide range of supply chain strategies. It was found that previous contributions mainly have only addressed a subset of the order-to-delivery process. Second, the OtD process of agricultural machinery can be grouped into three segments – customized products (MtO), express delivery (MtS) and LO – to provide a holistic understanding of the market requirement. Third, there cannot be one single policy of how an economical balance of operational and market performance can be achieved. The evaluation has to accomplish with the help of a simulation model in future research.

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