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Effects Of Different Order Processing Strategies On Operating Curves Of Logistic Models: A Comparison Of Make-to-Order And Make-to-Stock

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Abstract

Complexity in the decision-making process regarding the order processing strategy results from the interaction of various parameters. Exemplary influencing factors are the durability of products, the desired delivery times, and the required product variants. In practice, uncertainties of customer behavior and existing time pressure complicate decision-making processes even more. Given this scenario, continuously determining the most suitable order processing strategy for each product presents a great challenge for companies. Logistic models reflect logistic interdependencies and, therefore, can serve as a starting point for a holistic model assisting in selecting the order processing strategy.
However, logistic models are influenced by the order processing strategy. It affects the shape of operating curves as well as the position of operating points in logistic models. In this paper, the impact of the order processing strategies Make-to-Stock and Make-to-Order on the operating curves of logistic models is addressed. It includes a discussion of the effects of these strategies on the economic and logistic objectives as well as a description of the procedure used for analyzing the effects of the order processing strategy on the operating curves of different logistic models. The analysis focuses on individual products within a company's internal supply chain. An exemplary application on a data set from industry demonstrates the general practicability of the approach. The production operating curves and the storage operating curves are used as examples to show the effects of changing the order processing strategy as well as the effects of using both strategies at the same time.

Keywords

Order processing strategies; Logistic models; Operating curves; Make-to-Order; Make-to-Stock

1. Introduction

Customers expect individualized products and companies try to satisfy their customers by increasing their product portfolio diversity. Flexibility is essential for manufacturing companies in terms of the product range as well as in production planning and control (PPC). A key aspect to enable such flexibility is the order processing strategy. Literature generally distinguishes between the four different order processing strategies Make-to-Stock (MTS), Assemble-to-Order (ATO), Make-to-Order (MTO) and Engineer-to-Order (ETO) [1]. The classification is based on the position of the customer order decoupling point (CODP). The CODP, also known as order penetration point, represents the point in the material flow at which the production processes change from forecast-driven to customer order-driven [2]. Upstream of the CODP, cost-related objectives such as the utilization and the stock are prioritized. Whereas downstream of the CODP, time-related objectives such as the delivery time and delivery reliability are of particular importance (figure 1).

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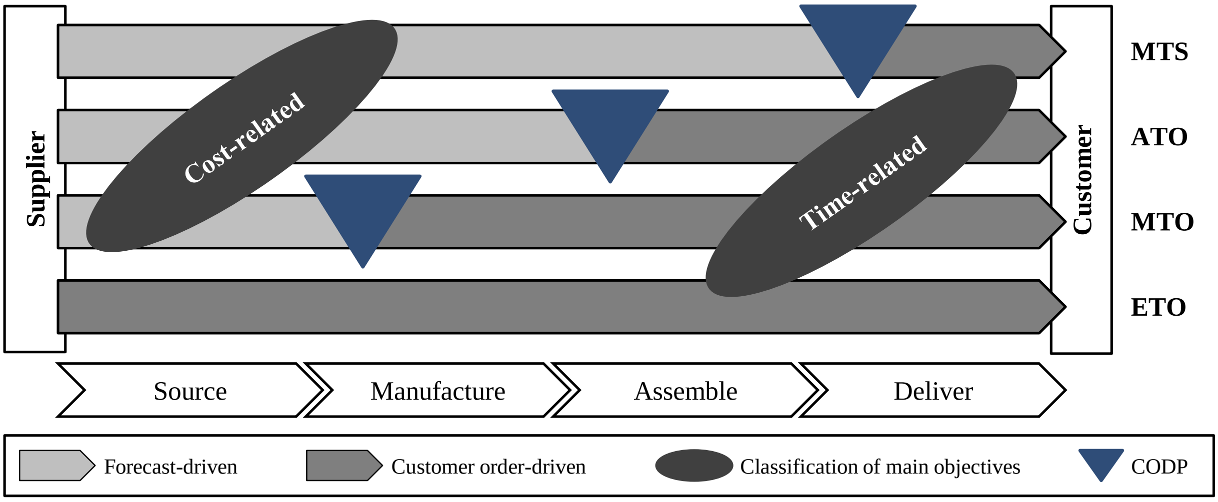

Figure 1: Main order processing strategies sorted by the position of the CODP, after [1, 2]

In MTS production, products are produced and stored in a finished goods store and from there are send to customers. This order processing strategy is used in the production of standard products [3], such as cell phones. ATO consists of a forecast-driven manufacturing and a customer order-specific assembly. This order processing strategy is typically used for products, which contain mostly standard components [4], such as notebooks. MTO production is characterized by the manufacture of customer order-specific products without an engineering component needing to be constructed. This order processing strategy is commonly used in mechanical and plant engineering industries [5]. In case of ETO production, parts of a product or whole products are designed, manufactured and assembled individually for each customer order [6]. As ETO is prescribed by the product, companies cannot change the order processing strategy while still meeting the customer requirements. Therefore, this strategy is not addressed further. In contrast, the decision between MTS, ATO and MTO is primarily determined by economic and logistic influencing factors. Thus, companies can choose between these strategies. The existing numerous qualitative and strategic influences (figure 2) make an individual decision and constant revision on the order processing strategy for each product or product family mandatory [7]. Upstream decisions can already have a strong influence. For example, the location of the production site might be overall beneficial for the company but the related import regulations, taxes, duties and administrative issues can already exclude an order processing strategy prior to the actual decision.

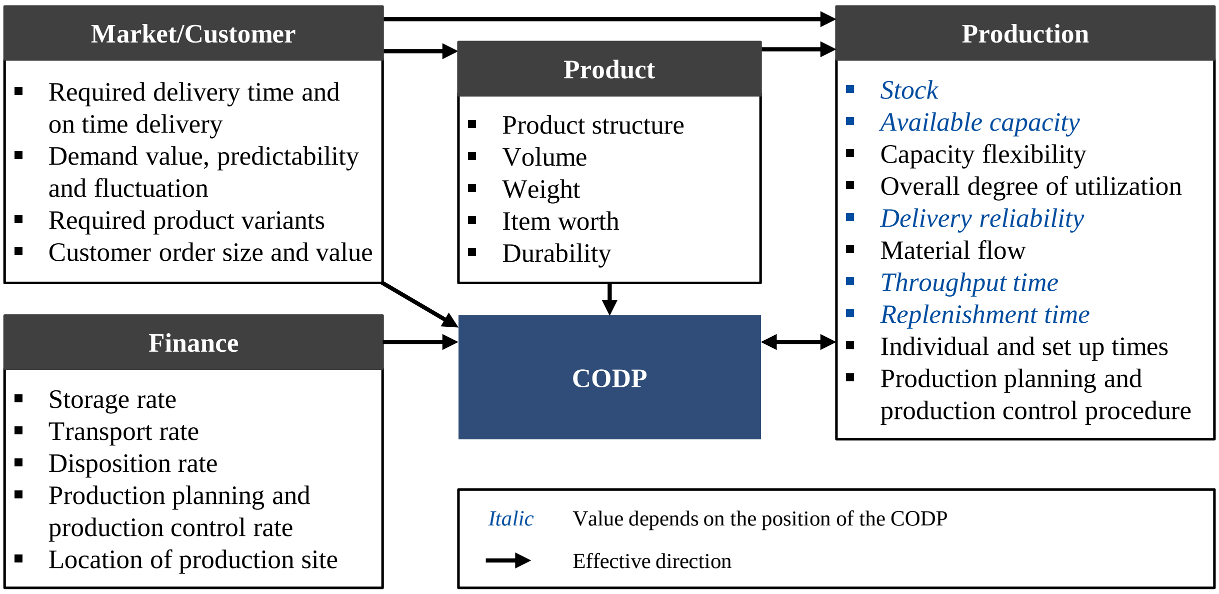

Figure 2: Influencing factors related to the position of the customer order decoupling point, after [8]

The subsequent section covers the selection of the order processing strategy in theory and industrial practice. Furthermore, the main effects of a MTS and a MTO production on the economic and logistic objectives are described. The focus on MTS and MTO production is based on the assumption that similar effects occur in an ATO production as it can be considered a mixture of a MTS and a MTO system. However, a merely qualitative analysis is not sufficient to decide on the order processing strategy. Companies have to position themselves facing the complex and, in some cases, contradictory paths of the economic and logistic objectives [9]. Changing the order processing strategy can lead to an overlap of effects on the objectives. This requires a detailed analysis of the effects of different order processing strategies on the individual economic and logistic objectives as well as the interactions between them. Besides a quantification of the effects, this calls for a standardized approach to compare different order processing strategies.

Logistic models highlight the essential interactions between the objectives and can be used to identify causes for insufficient values of the objectives, to estimate the effect of possible measures and to select suitable measures. In addition, they are easy to apply and allow the derivation of generally valid statements. Therefore, logistic models seem suitable to evaluate the effects of different order processing strategies on the economic and logistic objectives. After a description of selected logistic models for production and storage stages, the approach for analyzing the effects of changing the order processing strategy is explained in section three.

An example in section four helps to visualize the effects on the operating curves of logistic models. The effects on a production stage for a change of the order processing strategy as well as effects on a storage stage for using a MTS and MTO production at the same time are discussed. The approach can support the choice of an order processing strategy for new products as well as the continuous evaluation of the order processing strategy for existing products. In combination with an Enterprise Resource Planning (ERP) system, it provides the opportunity to estimate the effects of different order processing strategies and find a from an economic and logistic point of view suitable position between the partly conflicting objectives.

2. Selection of the order processing strategy

In industrial practice, the decision on the order processing strategy is made under time pressure. Therefore, companies use very limited and mostly qualitative decision criteria, group products together and rely heavily on the experiences of the employees [10]. Choosing an unsuitable order processing strategy can result in unsatisfied economic and logistic objectives. Companies are aware of this issue and increasingly move away from traditional systems with a single order processing strategy [11]. Managing a system with multiple different order processing strategies provides a great challenge for companies in terms of production control [8]. Nevertheless, controlling the inventory dynamically increases the flexibility of the workload control. Thus, uncertainties less affect the utilization and the work in process. The literature reflects this situation not entirely. The existing numerous approaches regarding the order processing strategy show the complexity of the topic. The majority of approaches focus either on the decision between MTO and MTS [12] or on the optimization of a system with a given order processing strategy [13]. However, the decision criteria vary widely and there are no rules for determining these criteria. In addition, the approaches often require a high level of knowledge, computational effort and are only valid for a specific case of application.

The first step to make a scientifically based decision on the order processing strategy is the analysis of the effects of different order processing strategies on the economic and logistic objectives. The aim is to enable a comparison between a change of the order processing strategy for individual products or product groups and implementing possible measures to improve the economic and logistic objectives. In the following, the effects on the economic and logistic objectives of moving the CODP from MTS towards MTO are described. The strength of the effects increases as the CODP is moved towards more customer order-driven process steps.

In MTS a constant lot size minimizing the sum of set-up and storage costs can be produced. Operating a finished goods store enables short delivery times and a high level of delivery reliability. Moreover, it helps to control productions more flexible and thus reach a high and continuous utilization of the production capacity. At the same time, stock and the associated infrastructure generate costs and tie up capital. In addition, there is a risk of unsaleable products. Switching to an ATO production the stock is shifted towards a semi-finished goods store. As a result, the capital tied up and the risk of unsaleable products decrease. It goes along with an extension of the delivery time and the possibility of a reduction of the delivery reliability. While the cost-optimal lot size can still be used during the forecast-driven process steps, the lot size during the customer order-driven process steps varies as it equals the quantities of the individual customer orders. In MTO production, the constant use of the cost-optimal lot size is not possible. The delivery time further increases as well as the probability of a reduction of the delivery reliability. As there is no other storage stage in MTO production apart from the produced goods store, there are no additional costs for the stock in this case. [14]

To compare the different order processing strategies, a company needs to position itself between the partly conflicting economic and logistic objectives and transfer the resulting values into costs. Logistic models display the cause-effect-relationships of the objectives and can be used to evaluate different scenarios. Depending on the type of the analyzed process step and associated objectives, different logistic models can be used (figure 3). Combining multiple logistic models can help to map the effects along a company's internal supply chain. The storage operating curves mathematically show the cause-effect-relationships between the stock level on the one hand and the delivery delay and the service level on the other hand [9]. In MTS production, delivery reliability is primarily a result of the service level in the finished goods store. Delays in transportation processes are not directly related to the order processing strategy and therefore are neglected. In turn, the service level is significantly influenced by the stock level in the finished goods store. As comparable effects occur in other storage stages, the storage operating curves can be applied to them as well.

The cause-effect-relationships within production stages are described quantitatively by the production operating curves [9]. Above a certain level of work in process, the output rate does not change significantly anymore. A reduced output rate or utilization due to material flow disruptions are not expected in this case. Whereas the inter-operation time, the throughput time and the range increase proportionally with the work in process in this area.

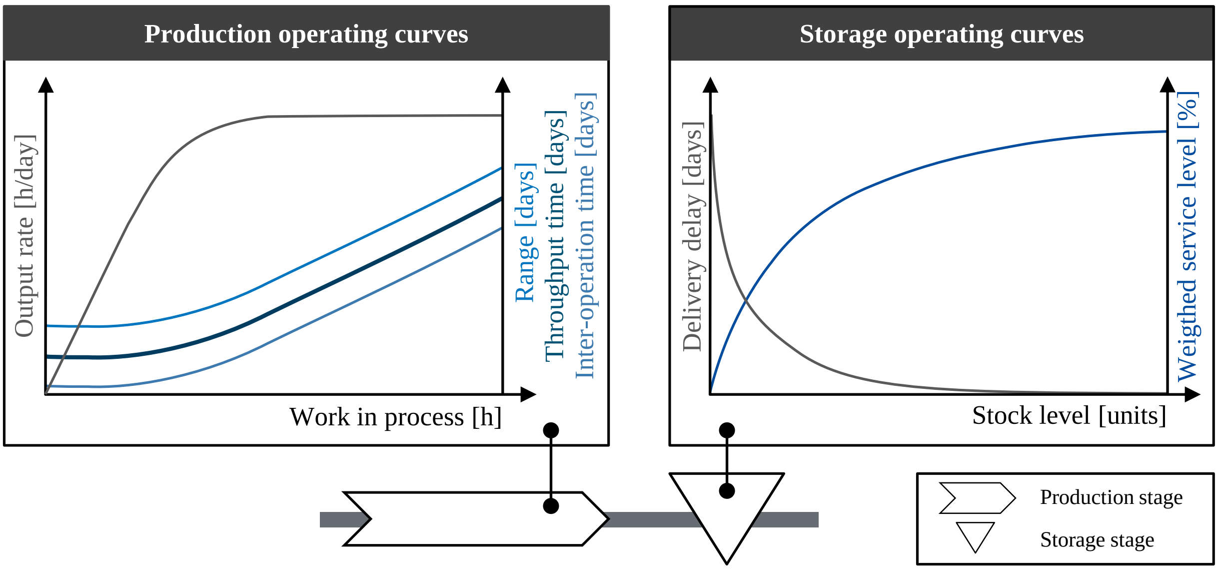

Figure 3: Operating curves for production and storage stages [9]

3. Procedure of the case study for the comparison of different order processing strategies

To expose the effect of different order processing strategies on operating curves of logistic models, an observation framework for a case study was required. It should be noted that the procedure is not intended for a continuous application in industrial practice due to the high number of process steps required. The overall objective was to take a holistic view. The focus of the study was limited to the internal supply chain to maintain a high availability of data and to prevent adding to the complexity of the system. The industrial relevance of the results was ensured through cooperation with companies from various industries. In an exemplary application it was possible to show potentials for improving the values of economic and logistic objectives as well as to clarify the reasons for an insufficient achievement of the objectives.

In the following, the procedure for the comparison of the effects on the logistic models of different order processing is described. The explanations refer to the exemplary application at a company which is discussed in section four but also include other examples not related to this company. To provide the application framework for the logistic models the selection of a suitable company's internal supply chain was necessary. The aim was to focus on effects caused by different order processing strategies while avoiding introducing effects originated from specific process scenario characteristics at the same time. A checklist procedure served as a first step to identify criteria for the selection of a company's internal supply chain. A checklist procedure aims to determine the suitability level of observed alternatives [15]. In this case, the observed elements were the company's internal supply chains. Developing evaluation criteria was necessary to rank a company's possible internal supply chains. These criteria included general conditions as well as company-specific aspects. General conditions were for example the existence of a data basis for a specified period. Moreover, the structure of the observed company's internal supply chain should provide similarity considering the composition of the process steps and their execution. Company-specific aspects refer to the particular product structure or product-related aspects in general, however, they strongly differ for each company. In addition, strategic company-specific aspects, such as already planned future changes in processes or even the relocation of individual parts of the company's internal supply chain, were considered. The evaluation of a certain share of considered general and company-specific criteria was conducted by referring to known facts.

In case a quantification of the aspects of the evaluation criteria was unfeasible or if it involved a disproportional amount of effort, a qualitative estimation was necessary. Therefore, interviews with employees were used as an adequate alternative. To receive reasonable estimations for the company-specific aspects of the evaluation criteria from these interviews, experts were selected with respect to their area of responsibility. Furthermore, they should have spent a considerable amount of time in their specific area and the investigated company to be considered reliable. In addition to criteria evaluation, company-specific elimination criteria existed. Fulfilling such a criterion equaled a disqualification of the particular company's internal supply chain. Along with the evaluation criteria, potential stumbling blocks of PPC were taken into account. Examples of stumbling blocks are missing responsibility for inventories or insufficient quality of feedback data [16]. After evaluating all required criteria (criteria for exclusion included) and stumbling blocks, one company's internal supply chain was selected.

The classification of the related product portfolio followed the determination of a company's internal supply chain. ABC- and XYZ-analysis helped to focus on the main elements during the analysis of effects of different order processing strategies on the operating curves of logistic models. The product value or the sales revenue is the main classification aspect for an ABC-analysis, whereas the XYZ-analysis sorts products according to the frequency of demand [17]. Referring to the same type of products ensured to assign the cause of the appearing effects to the order processing strategy as a variable parameter while keeping the remaining parameters fixed and standardized if possible. For example, screws are typical CX products, which are always in stock and do not need a detailed analysis. Other product classes, such as AX require further analysis due to the conflict between high product value and consistent product demand.

A high valued product advocates MTO production regarding upcoming storage costs whereas consistency in demand favors MTS production looking at the production systems workload. After estimating the potential of the product classes and selecting a production class, the examination of the individual products from the product class with the highest potential followed. Two products with different order processing strategies can only be compared in case the framework conditions such as the quantities are similar. Moreover, changing between order processing strategies should be feasible for the selected products. Critical aspects are the product itself, e.g. due to expiration dates, customer needs such as very short delivery times or complex customization requests [18]. These aspects cause the need to stick to a specific order processing strategy to fulfill fixed requirements. In case of very short delivery dates, only MTS production is possible. Whereas early expiration dates and complex customer requirements make the operation of a finished goods store from an economic point of view not acceptable. In this context, it is important to determine at which production stage the customer's request causes a change or in which storage stage short early expiration dates of products are an issue. Depending on the result of this analysis, one strategy is prescribed or the number of possible strategies is limited. For example, if the customer's request involves changes in the product construction, only ETO is feasible. Whereas in the case of a customer-specific coloring during the last process step, all strategies apart from MTS remain practicable.

Individual products with a fixed order processing strategy cannot be used to evaluate the change between order processing strategies. Furthermore, looking at the critical aspects the requirement’s source has to be analyzed. For instance, short delivery times can on the one hand be based on customer needs and on the other hand arise from decisions of the sales department or the upper management. In case the source is not directly linked to the customer need, aspects such as the market competition and the frequency of technological change have to be considered. Offering the customer a short delivery time can help to differentiate from the competition and increase market share. In this context, the willingness to wait for a product due to cultural aspects in the respective countries of sale needs to be taken into account. In case of strong discrepancies between countries, a country-specific selection of the order processing strategy for the respective product is required. A high frequency of technological change results in high costs for unsaleable products. The degree of multiple use of components, possibilities for the formation of subassemblies as well as the options for changing the sequence of production steps should be examined in this case.

Unless a specific order processing strategy was mandatory, it was important to consider all order processing strategies. With competitors offering a similar product and if the company has no advantage in terms of better quality, e.g. due to a unique production process or specific material properties, the only way to succeed against the competition is to offer the customer a lower product price or a higher logistic performance. The most suitable order processing strategy for a particular product depends heavily on a company's priorities regarding the economic and logistic objectives. Focusing on high utilization can lead to a competitive advantage if personnel costs are an extensive part of the total costs of a product. In case of high storage costs or tied up capital for goods and infrastructure, the reduction of the stock level tends to be the objective focused on. Time-related figures, such as delivery reliability, are the most important factors for companies if the logistic performance is the decisive criterion for the customer.

For this case study only already established products achieving sufficient values of the economic and logistic objectives were taken into account. This helped to avoid to introduce exceptional effects from company-specific processes, which could lead to misinterpretations of the results, to the analysis. Even in case of an insufficient achievement of the values of the economic and logistic objectives, an order processing strategy does not need to be discarded immediately. First, it is necessary to detect whether the cause is the order processing strategy or the company’s processes. The only direct exclusion criteria for an order processing strategy are the critical aspects mentioned during the selection of the product. Unless an elimination criterion is present, an analysis of the company's internal supply chain is required.

Starting from the dispatch area, the company's internal supply chain can be examined step-by-step until the critical process is identified. If the insufficient achievement of the values of the objectives results from the process instead of the choice of order processing strategy, additional actions are mandatory. For example, a data based root cause analysis by using cause-effect relation trees can help to improve the values of the objectives [19]. After identifying the root cause, it is possible to take counteractive measures. A typical example is the training of employees in case of wrong prioritization of orders.

After selecting a suitable company's internal supply chain, a product class and finally products, the different logistic models were linked to the respective process steps. In addition to the previously mentioned storage operating curves and the production operating curves, the schedule compliance operating curve, the allocation diagram and histograms were used.

4. Effects on the operating curves

An application on a data set from industry shows the effect of different order processing strategies on operating curves of logistic models. The data were directly extracted from the company's ERP system. After evaluating the data quantity and quality, interviews with employees from all areas of the company's internal supply chain were conducted to complete the data set. This was followed by data cleansing and the transfer of the data to suitable analysis tools. In the following, the analyzed production process is outlined and the general effects are described. The order processing strategies MTS and ATO as well as MTS and MTO were compared.

A semi-finished goods store serves as an example for the analysis of a storage stage. Two different finished products were examined. Both of them contain around 20 components and were produced over 10.000 times within half a year. As they require the same semi-finished goods, these products are suitable to analyze the effects of different order processing strategies. A MTS production is used for finished product 1, while ATO production is used for finished product 2. In the case of an ATO product, a customer order is directly connected to the production order. As the semi-finished goods store is the starting point of the analysis, it can be considered as a MTO process [20]. Therefore, only the term MTO production orders is used in the following. Figure 4 illustrates the general structure.

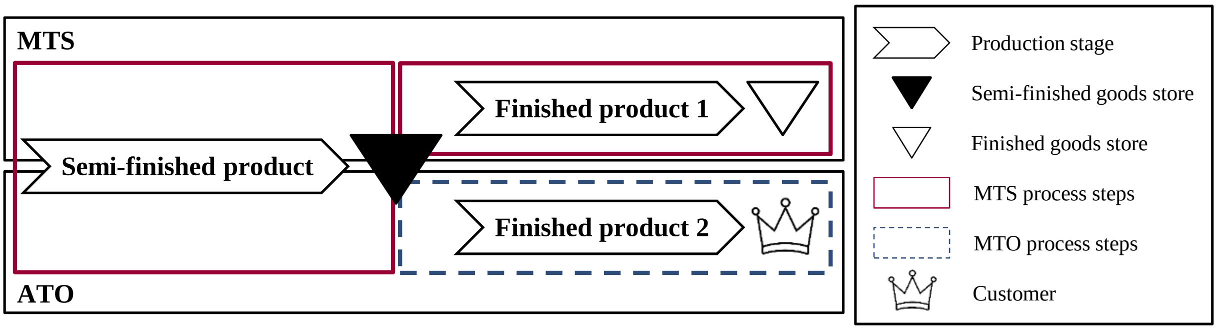

Figure 4: Exemplary scenario for the analysis of a storage stage

After the semi-finished goods store finished products 1 and 2 are produced on separate production lines. Consequently, they do not compete for production capabilities, but for the semi-finished products. The company assigns ATO and MTO production orders in general a higher priority than MTS production orders. This is based on the assumption that delayed ATO and MTO production orders have a direct negative impact on customer satisfaction. Whereas, for MTS production orders the safety stock in the finished goods store prevents negative consequences to a certain extent. The storage operating curves visualize the effects of this prioritization for the described scenario (figure 5).

As MTO and MTS production orders use the same semi-finished product, there is only one average service level operating curve and one average delivery delay operating curve for the specific semi-finished product. These average operating curves lie between the two extreme points of MTO and MTS production orders. The exact position depends on the respective proportion of MTO and MTS production orders. In comparison to MTS production orders, the prioritized MTO production orders achieve a higher value for the weighted service level at a fixed stock level. At the same time, the value for the delay in delivery is lower for MTO production orders. The usually smaller but varying lot size in MTO production intensifies these effects. MTO production directly transfers the customer order into a production order, whereas in MTS production the finished goods store can be seen as a customer, which demands a constant and more economical quantity. The variation of MTO production order sizes and the high lot size of each MTS production order complicate overcoming the negative impact on MTS production orders through measures such as workload balancing. It should be noted that in case MTS production orders are prioritized over MTO production orders the opposite effects can occur.

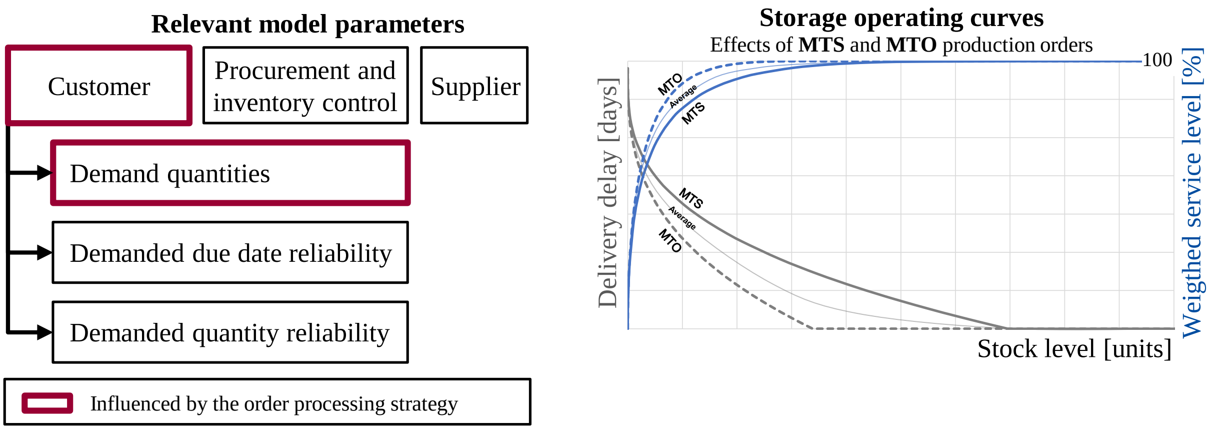

Figure 5: Storage operating curves of a semi-finished goods store showing the effects of MTS and MTO production orders requiring the same semi-finished product [9]

The preliminary production stage of a product containing similar components as the two products described before serves as an example for the analysis of a production stage. However, for this product the entire production process can be either MTS or MTO. For both order processing strategies a scenario was created and analyzed. Figure 6 shows the respective production operation curves.

The main difference between MTO and MTS production regarding the production operating curves is the lot size. Whereas in MTS production a constant lot size is generally applied, the lot size in MTO production varies. This results in a lower mean value, but a higher variation of the work content of the production orders. The production operating curves show that the maximum possible output rate of the production system is reachable at a lower work in process level in case of a MTO production. In contrast to MTS production, MTO processes commonly contain smaller lot sizes. This results in a higher quantity of lots to process the equal quantity. Set up times and transportation times appear to a higher extent. Available capacity is required for setting up or transportation. This leads to a smaller amount of available production capacity to fulfill the actual production process. In this case, the small lot size in MTO production resulted in a shorter inter-operation time. However, the increased set up time and transportation time nearly fully compensate for this effect. As a result, the operating curves of the throughput time and the range were very similar. It should be noted that in case the variation has a higher impact on the ideal minimum work in process than the mean value of the work content of a production order or the quantity of customer orders exceeds the cost-optimal lot size the effects will differ.

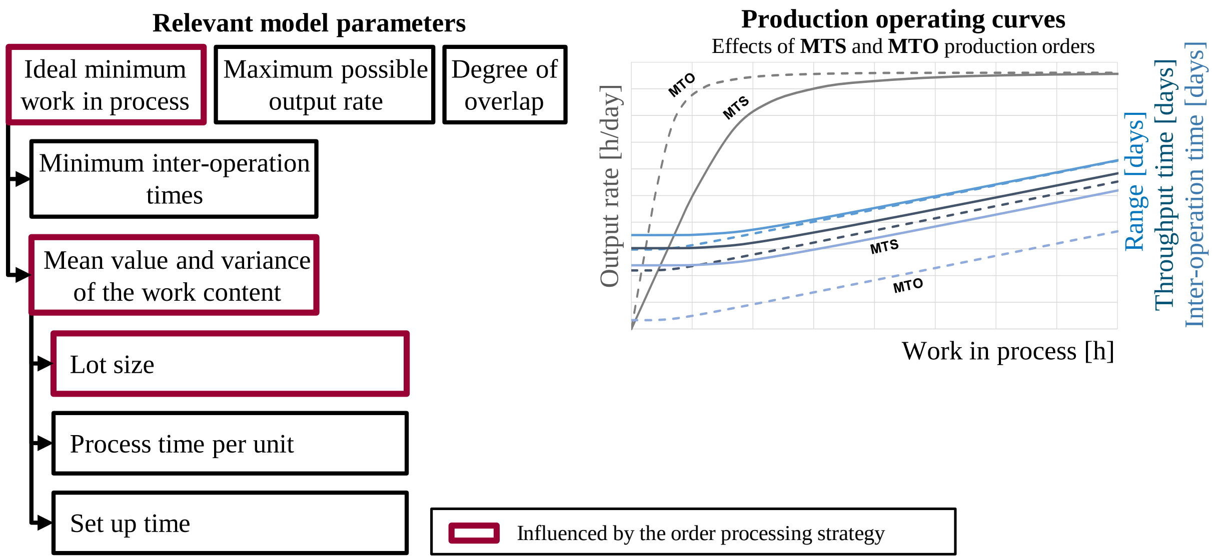

Figure 6: Production operating curves of a preliminary production stage showing the effects of MTS and MTO production orders for the same finished product [9]

In addition to the logistic models presented above, the schedule compliance operating curve and the allocation diagram are likewise effected by the order processing strategy. The observed effects mostly result from the selected company's internal supply chain and its individual processes. Being aware of scenario-dependent general conditions and mapping the effect to their root cause is important while analyzing the effects of different order processing strategies. For instance, framework conditions such as high process reliability, provision performance and supplier performance are required to realize a process under the approximation of ideal conditions.

5. Conclusions and outlook

The order processing strategy has a high impact on the economic and logistic objectives. The selection of a suitable order processing strategy on a single product base presents a major challenge for companies. The high frequency of technological change and the uncertainty of customer behavior add to the complexity and require a continuous evaluation of the chosen order processing strategies. The factors influencing the order processing strategy have already been discussed in detail in the literature. However, a lack of quantification of the effects regarding the choice of an order processing strategy on economic and logistic objectives is visible. Software systems, like ERP or Business Intelligence systems, can be used to examine the values of the economic and logistic objectives, but they require a high amount of data and cannot explain the reasons for an insufficient achievement of the values of the objectives. Logistic models can be used to explain the essential interactions between the objectives and to identify causes for insufficient values of the objectives. Therefore, using logistic models in combination with a software system provides the basis for the selection of a from an economic and logistic point of view suitable order processing strategy.

As a foundation for a holistic decision support model, this study presents a procedure to compare the effects of different order processing strategies. After selecting a company's internal supply chain, product class and products, logistic models are used to analyze the components of the company's internal supply chain. Starting from the dispatch area, the effects of different order processing strategies were compared. The present approach was exemplarily applied to a data set from industry. The effects of the order processing strategy on the storage operating curves and the production operating curves were described for the respective processes. The intensity of the effects highly depends on the demand patterns of the product and the prioritization of the order processing strategies in the company.

The comparison neglects any effects that may occur on other products flowing into the same storage and production stages. Negative effects on other products can be partially compensated for instance by workload balancing. The procedure provides the foundation for further research, but is not suitable for continuous industrial application due to the numerous process steps required. A potential additional aspect could be the interaction of different order processing strategies with downstream decisions such as the order generating process or the order releasing process. In addition, more data sets could be analyzed to create a detailed overview of the possible effects of different order processing strategies. Besides ATO, various other combinations of MTS and MTO exist in industrial practice [21]. To evaluate this amount of order processing strategies, simulation studies are essential. For a universally valid application in various companies, a quantification of the effects identified so far as well as the additional aspects mentioned is required.

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References

[1] Hoekstra, S., Romme, J., 1992. Integral Logistic Structures: Developing Customer-Oriented Goods Flow. Industrial Press, New York

[2] Sharman, G., 1984. The rediscovery of logistics. Harvard Business Review 62(5), 71-80.

[3] Ivanov, D., Tsipoulanidis, A., Schönberger, J., 2017. Global supply chain and operations management: A decision-oriented introduction to the creation of value, 2nd ed. Springer, Cham. https://doi.org/10.1007/978-3-319-94313-8

[4] Antan, Z., Ahmadi, T., Stegehuis, C., de Kok, T., Adan, I.H., 2017. Assemble-to-order systems: A review, European Journal of Operational 261(3), 866-879. https://doi.org/10.1016/j.ejor.2017.02.029

[5] Hendry, L.C., 1998. Applying world class manufacturing to make-to-order companies: problems and solutions. International Journal of Operations and Production Management 18(11), 1086-1100. https://doi.org/10.1108/01443579810231679

[6] Rauch, E., Dallasega, P., Matt, D.T., 2018. Complexity reduction in engineer-to-order industry through real-time capable production planning and control. Production Engineering Research and Development 12, 341–352. https://doi.org/10.1007/s11740-018-0809-0

[7] Soman, C.A., Van Donk, D.P., Gaalman, G., 2004. Combined make-to-order and make-to-stock in a food production system. International Journal of Production Economics 90(2), 223-235. https://doi.org/10.1016/S0925-5273(02)00376-6

[8] Olhager, J., 2003. Strategic positioning of the order penetration point. International Journal of Production Economics 85(3), 319-329. https://doi.org/10.1016/S0925-5273(03)00119-1

[9] Nyhuis, P., Wiendahl, H.-P., 2009. Fundamentals of Production Logistics: Theory, Tools and Applications. Springer, Berlin Heidelberg. https://doi.org/10.1007/978-3-540-34211-3

[10] Gudehus, T., Kotzab, H., 2012. Comprehensive Logistics, 2nd ed. Springer, Berlin, Heidelberg.

[11] Federgruen, A., Katalan, Z., 1999. The impact of adding a make-to-order item to a make-to-stock production system. Management Science 45(7), 980-994. https://doi.org/10.1287/mnsc.45.7.980

[12] Rajagopalan, S., 2002. Make to order or make to stock: model and application. Management Science 48(2), 241-256. https://doi.org/10.1287/mnsc.48.2.241.255

[13] Stevenson, M., Hendry, L.C., Kingsman, B.G., 2005. A review of production planning and control: the applicability of key concepts to the make-to-order industry. International Journal of Production Research 43(5), 869-898. https://doi.org/10.1080/0020754042000298520

[14] Grigutsch, M., 2016. Modellbasierte Bewertung der logistischen Leistungsfähigkeit in Abhängigkeit des Kundenauftragsentkopplungspunktes, PZH Verlag, Garbsen.

[15] Hales, B.M., Pronovost, P.J., 2006. The checklist - a tool for error management and performance improvement. Journal of Critical Care 21(3), 231-235. https://doi.org/10.1016/j.jcrc.2006.06.002

[16] Wiendahl, H.-H., v. Cieminski, G., Wiendahl, H.-P., 2005. Stumbling blocks of PPC: Towards the holistic configuration of PPC systems. Production Planning & Control: The Management of Operations 16(7), 634-651. http://dx.doi.org/10.1080/09537280500249280

[17] Aktunc, E.A., Basaran, M., Ari, G., Irican, M., Gungor, S., 2019. Inventory Control Through ABC/XYZ Analysis, in: Calisir, F., Cevikcan, E., Camgoz Akdag, H. (Eds.), Industrial Engineering in the Big Data Era. Lecture Notes in Management and Industrial Engineering. Springer, Cham, pp. 175-187. https://doi.org/10.1007/978-3-030-03317-0_15

[18] Hemmati, S., Rabbani, M., 2010. Make-to-order/make-to-stock partitioning decision using the analytic network process. The International Journal of Advanced Manufacturing Technology 48, 801-813. https://doi.org/10.1007/s00170-009-2312-4

[19] Stoffi, F.J.B., Gnecco, G., 2020. Causal tree with instrumental variable: an extension of the causal tree framework to irregular assignment mechanisms. International Journal of Data Science and Analytics 9(3), 315-337. https://doi.org/10.1007/s41060-019-00187-z

[20] Olhager, J., 2012. The Role of Decoupling Points in Value Chain Management, in: Jodlbauer, H., Olhager, J., Schonberger, R. (Eds.), Modelling Value. Selected Papers of the 1st International Conference on Value Chain Management, May 4th–5th, 2011, University of Applied Sciences in Upper Austria, School of Management, Steyr, Austria. Physica-Verlag HD, pp. 37-47. https://doi.org/10.1007/978-3-7908-2747-7_2

[21] Rafiei, H., Rabbani, M., 2011. Order partitioning and order penetration point location in hybrid make-to-stock/make-to-order production contexts. Computers & Industrial Engineering 61(3), 550-560. https://doi.org/10.1016/j.cie.2011.04.010

Biography

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