CONFERENCE ON PRODUCTION SYSTEMS AND LOGISTICS
CPSL 2022

3rd Conference on Production Systems and Logistics

Fulfillment of Heterogeneous Customer Delivery Times through Decoupling the Production and Accelerating Production Orders

Tammo Heuer[1], Janine Tatjana Maier[2], Matthias Schmidt[2], Peter Nyhuis[1]

[1]Institute of Production Systems and Logistics, Leibniz University Hannover, Garbsen, Germany
[2]Institute of Product and Process Innovation, Leuphana University of Lüneburg, Lüneburg, Germany

Abstract

Manufacturing companies are facing increasing customer requirements regarding delivery times and delivery reliability. In this context, customers have different desired delivery times. The fulfillment of heterogeneous customer delivery times represents a major challenge in the competition for customers. If companies succeed in reliably meeting their customers' desired delivery times, this results in an enormous competitive advantage. Instruments for achieving specific delivery times include especially the use of fast-track orders and shifting the customer order decoupling point. When these instruments are used, numerous interdependencies must be considered. Shifting the customer order decoupling point downstream toward a Make-to-Stock production results in higher stock levels. The use of fast-track orders induces longer throughput times for other orders and higher control effort. In this paper, taking these trade-offs into account, an approach is developed that allows delivery time requirements to be met through a systematic determination of the customer order decoupling point and a share of fast-track orders. For this purpose, interdependencies between both instruments and logistic objectives are identified and investigated using logistical models to meet the delivery time requirements at lower logistical costs.

Keywords

Delivery time requirements; Fast-track orders; Rush orders; Customer order decoupling point; Order processing strategy

1. Introduction

In the context of globalisation, companies are facing increasing competition. Products must be manufactured at low cost and high quality. The importance of delivery time and delivery reliability as decisive purchasing criteria continuously increased over time [1,2]. Nowadays, they are considered critical competitive factors [3]. Customers are willing to pay high price premiums to obtain delivery times below standard [4].

As customer requirements vary widely, companies must face heterogeneous desired delivery times. These can only be mapped entirely by a standard delivery time if the standard delivery time is less than or equal to the minimum requested delivery time. If delivery times below the standard delivery time are requested, these can only be realised by accelerating the orders in the order throughput [5]. Therefore, production planning and control must be designed to handle accelerated orders to avoid undesired effects such as an excessive extension of the throughput times of normal orders. Another central instrument to influence delivery times is positioning the customer order decoupling point (CODP) [4]. However, this can lead to high stocks of finished or semi-finished goods.

DOI: https://doi.org/10.15488/12188

Thus, a holistic view must be taken when designing the production system to map heterogeneous desired delivery times on the production side. As an initial step, section 2 identifies instruments for achieving specific delivery times and describes their suitability. Section 3 provides a literature review on approaches for positioning the CODP and the use of accelerated production orders. In section 4, these essential instruments are examined concerning their interdependencies with logistic objectives. For this purpose, the applicability of existing logistical models is described and possible modeling gaps are identified. Section 5 describes the interactions and trade-offs that need to be considered when using the instruments and setting their parameters. Section 6 summarizes the paper and outlines future research possibilities.

2. Instruments for achieving specific delivery times

There are many instruments to influence the delivery time. They differ in their effects on logistic objectives and their activation time. Mostly they have to be applied long before their effects can be recognized. With most instruments, a short-term reaction to a high number of orders with short delivery times entering the system is impossible. Others can still be used in the short term, although the interactions with the logistic objectives must also be considered. Figure 1 shows the main time components of the delivery time and, depending on the order processing strategy, which time components are effective on the delivery time to the customer.

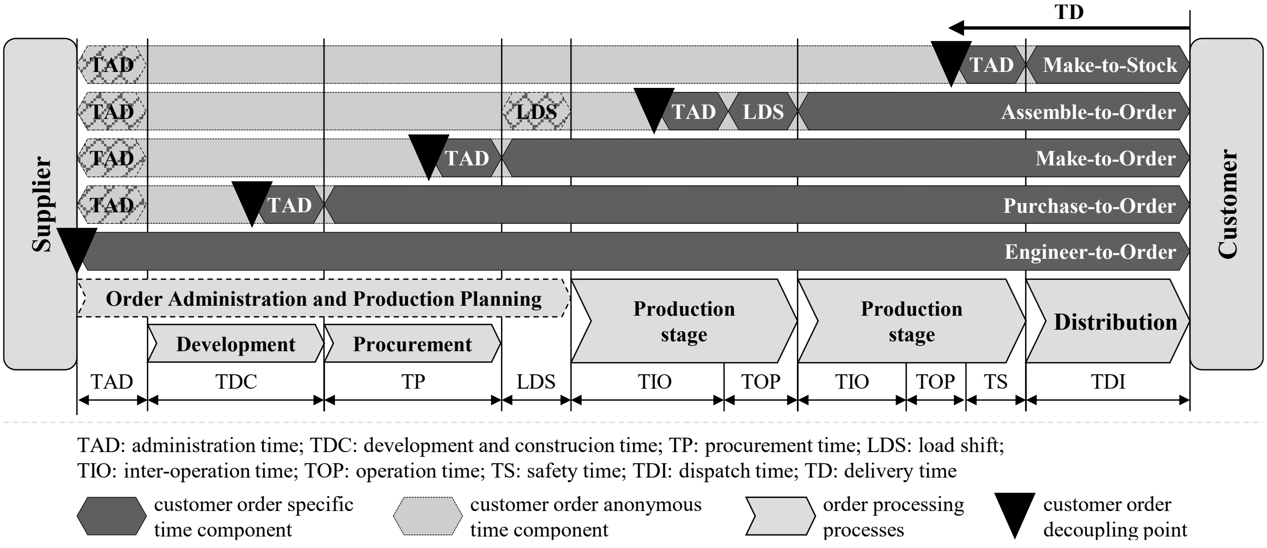


Figure 1: Time components of order processing processes (extension of [6])

According to the order processing strategy, the CODP is positioned differently and time components are either customer order-specific or customer order-anonymous. Thus, the position of the CODP can already be identified as the first elementary instrument on delivery time. There are many different strategies for order processing, but they can be summarised into five main strategies, which are explained below.

In Make-to-Stock (MTS), products are manufactured anonymously in stock, and customer orders are served from these stocks. Assemble-to-Order (ATO) is used when pre-fabricated components or assemblies are assembled to order. Make-to-Order (MTO) describes that production and assembly do not begin until the customer order is received. It is assumed that the raw materials are in stock in all these cases. [7] In Purchase-to-Order, raw materials are also procured on a customer order-specific basis [8]. Lastly, there is Engineer-to-Order, where development and design are customer order-specific [9].

The administration time is required primarily for creating orders [10] and is independent of the location of the CODP. It does not have a significant share in the order throughput but can be reduced, for example, through lean administration approaches [11]. For instance, by using concurrent engineering, development and construction time can be reduced [12]. Procurement time can be influenced through targeted supplier selection or long-term coordination with the supplier. For example, suppliers closer to the production site can be selected or framework contracts can be used to hold safety stocks at the supplier's premises for a short and reliable replenishment time. Additionally, the introduction of consignment stocks from suppliers close to production can reduce the procurement time. [10] In the short term, the procurement time can be shortened through express deliveries or different transport means like air freight [4].

The dispatch time can be influenced in both the short and long term. In the short term, dispatch time can be reduced analogous to the procurement time with express shipping through prioritised treatment in delivery or different transport means like air freight [4]. In the case of MTS production, the dispatch time can be reduced in the long term by setting up a distribution structure. For example, in addition to using the factory warehouse solely, stocks can also be stored close to the customer in central or regional warehouses to guarantee shorter delivery times [13]. However, this requires an accurate forecast of the customer demand.

Within the production stages, the load shift, the inter-operation time, the operating time and the safety time can be influenced. In all order processing strategies with an order-specific production run, an extension of the delivery time can be caused by a load shift. A load shift occurs when capacities are already utilised for a more extended period and new orders can only be scheduled later on when capacities are free [4]. Within this framework, the provision of capacity flexibility is a possibility to accept new orders and realise short delivery times by using additional capacity at short notice [14]. To this end, measures must be taken to create capacity flexibility. However, capacity flexibility is limited and cost-intensive [14]. Capacity can also be reserved within the framework of production planning to be able to schedule orders at short notice [15]. But if short-term orders fail to materialise, capacity utilization losses are a risk. To avoid this, the capacity reservation can be combined with a work-in-process (WIP) regulating order release so that orders are brought forward. [4] On the one hand, this leads to a negative schedule deviation and thus to finished goods stocks due to premature order completion. On the other hand, short-term orders can be realised without using capacity flexibility and without overloading the production system, which would result in a backlog.

The safety time can be scheduled as part of throughput scheduling to compensate for possible delays from production and still deliver on time. In this way, a safety time increases the delivery reliability, but simultaneously increases finished goods stock due to premature order completion. [16] To reduce the delivery time at short notice, less safety time or no safety time can be assigned during throughput scheduling. This might decrease the delivery reliability. The operation time can be reduced at short notice by splitting lots, assuming the availability of work systems that can be used in parallel. Work processes can also be carried out overlapping. [17] In the medium term, transport processes between work systems can be optimised. This aims at reducing the minimum transition time, which is the transport time as part of the inter-operation time [2]. A central possibility for shortening the inter-operation time is the use of accelerated orders [17]. Rush orders can be used to achieve maximum speed-up for time-urgent orders by prioritising these orders to the front of a queue [5]. Fast-track orders differ from rush orders as they are scheduled with individual inter-operation times just to meet the delivery date and are sequenced by the due date. Fast-track orders can thus also be accelerated as much as rush orders. However, this is only done when necessary. As a result, normal orders will probably not be delayed as much and higher shares of fast-track orders can be accepted than is the case with rush orders. [18]

It can be concluded that the positioning of the CODP and the use of accelerated orders are easy means to influence the delivery time in a targeted manner in comparison with the other means introduced before. Therefore, in section 3, existing approaches of achieving specific delivery times through fast-track orders and shifting the CODP are discussed to highlight the need for further research.

3. Literature review and need for research

TRZYNA modeled the throughput time of rush orders and, taking into account a rush order share, the throughput time of normal orders for single work systems [19]. This enables the calculation of the minimal achievable throughput times for given production systems. LÖDDING AND ENGEHAUSEN have developed an approach to maximise incoming orders in the context of heterogeneous desired delivery times using rush orders. This approach is based on pure MTO production. Therefore, only the rush order share is used as a control variable to realise different delivery times. In addition, simplifying a single-stage production is assumed. [20] Due to these assumptions, mainly the focus on MTO, the approach is limited for the application under consideration. Many other approaches focus on achieving different delivery times by using rush orders in an MTO production by providing production planning procedures. CHUNG ET AL. describe an order release that releases rush orders in a stock-controlled manner or at the same time interval so that the production system is not overloaded [21]. Some approaches focus on rescheduling when rush orders occur [22–24]. LIU AND LIU consider production and distribution together and minimise the delivery time using linear optimisation for scheduling, batching and delivering [25]. These works are essential for improving the usage of accelerated orders. However, they may not support the choice of whether to prefer accelerated orders or a shift of the CODP. Regarding this choice, the research done so far only provides for an upper limit of approx. 30% of the work content for rush orders. Otherwise, the rush orders would interfere with each other resulting in an increase in their mean throughput times and the throughput time variation [26,15].

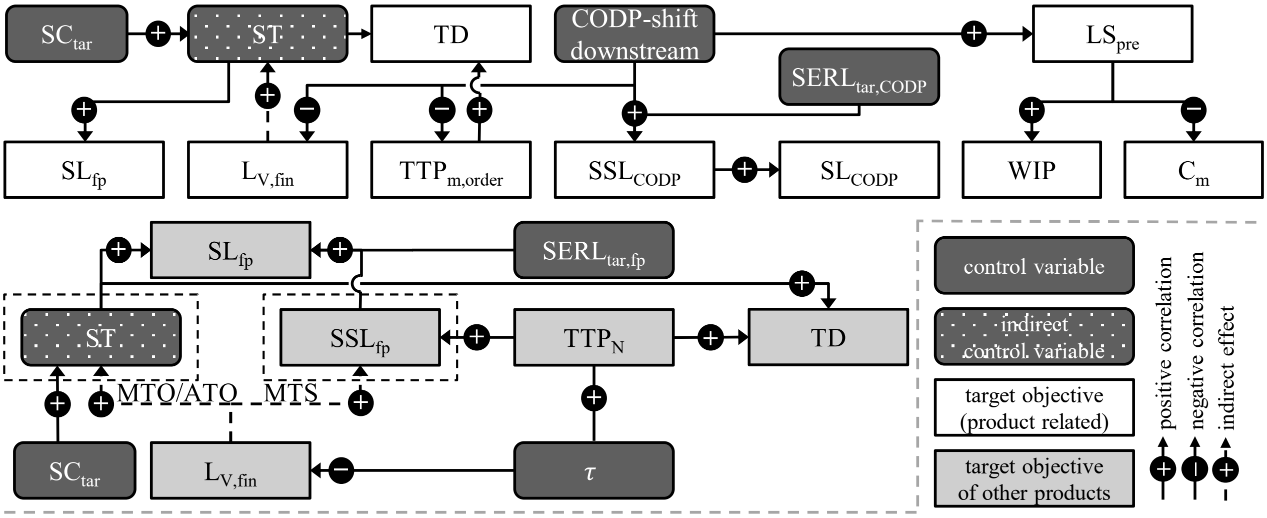
A systematic description of influencing the delivery time through shifting the CODP was performed by HOEKSTRA AND ROMME [8]. TEIMOURY ET AL. determine the appropriate position of the CODP using a linear optimisation model taking into account the product costs [27]. Most authors provide a procedure in which the CODP is positioned to achieve the lowest required delivery time. GRIGUTSCH developed a model-based positioning of the CODP. Contrary to other authors, this author clearly addresses delivery time and schedule compliance. [28] In the research project on which this paper is based, an approach was developed by MAIER ET AL. linking logistical models. This approach makes it possible to calculate which order processing strategy has the lowest logistical costs for each product, achieving a certain schedule compliance or a certain service level in the finished-goods store. In doing so, fixed delivery time requirements per product are assumed to narrow down the solution space. [29]

In summary, there is no approach yet that enables companies to design their production through the choice of order processing strategy and the use of fast-track orders so that heterogeneous desired delivery times can be served, but low logistical costs are achieved. Approaches to the use of fast-track orders are usually only geared to their processing within the framework of MTO production. Approaches to the choice of order processing strategy usually consider a fixed delivery time to be achieved and neglect the possibility of producing orders with a lower than the standard planned throughput time. For example, this can result in MTS being planned for a product to guarantee the fixed delivery time, resulting in high costs due to finished goods stock. However, the proportion of orders for this product that require a short throughput time could also be handled in the context of MTO production through fast-track orders. That would mean that no stocks of finished goods would have to be kept. However, interactions of the fast-track orders with other orders have to be taken into account.

Therefore, this paper aims to systematise these interdependencies to select the order processing strategy that would result in the lowest logistical costs under the assumption of the same logistical performance in service level (MTS) or schedule compliance (MTO, ATO) when using fast-track orders.

4. Effects of using fast-track orders and shifting the CODP on logistic objectives

Different order processing strategies with different needs for accelerating production orders are possible to serve heterogeneous desired delivery times. Therefore, this section describes the interdependencies that need to be considered when deciding between these options. The effects of shifting the CODP and using fast-track orders on logistic objectives and interactions were summarised in Figure 2 and are explained in the following.



C_m	manufacturing costs [€ / unit]	SL_{fp}	finished products stock level [units]
$L_{V,fin}$	variation of lateness in the final production stage [hrs.]	SSL_{fp}	finished products safety stock level [units]
LS_{pre}	lot sizes in pre-production stage [units]	ST	safety time [SCD]
SCD	shop calendar day	TD	delivery time [days]
SC_{tar}	target schedule compliance [%]	$TTP_{m,order}$	order specific mean throughput time [SCD]
$SERL_{tar,CODP}$	target service level in CODP [%]	TTP_N	throughput time of normal orders [SCD]
$SERL_{tar,fp}$	target service level of finished products [%]	WIP	work in process (WIP) [hrs.]
SL_{CODP}	CODP stock [units]	τ	share of fast-track orders on the work content [%]
SSL_{CODP}	CODP safety stock level [units]		

Figure 2: Effects of fast-track orders and position of the CODP on logistic objectives

A downstream shifted CODP (see the upper part of Figure 2) allows larger, more economical lot sizes LS_{pre} in the pre-production stage. Lot size calculation rules can be taken from [30]. Larger lot sizes reduce the manufacturing costs C_m due to lower set-up costs. However, larger lot sizes also affect a higher level of WIP in the pre-production stage. Furthermore, the shift affects a higher CODP stock of semi-finished products SL_{CODP}. [31] The calculation of the safety stock level SSL_{CODP} and the stock level SL_{CODP} depending on the target service level $SERL_{tar,CODP}$ can be taken from [32]. Since a smaller part of the order throughput is customer order-specific (see Figure 1), the throughput time $TTP_{m,order}$ for the product in question decreases. In addition, the variation of the lateness in the final stage $L_{V,fin}$ is reduced for this product as fewer work systems are passed through [28]. Thus, shorter safety times ST can be used to achieve the target schedule compliance SC_{tar}. As a result, the delivery time TD and the finished products stock level SL_{fp} due to orders completed too early are reduced [16].

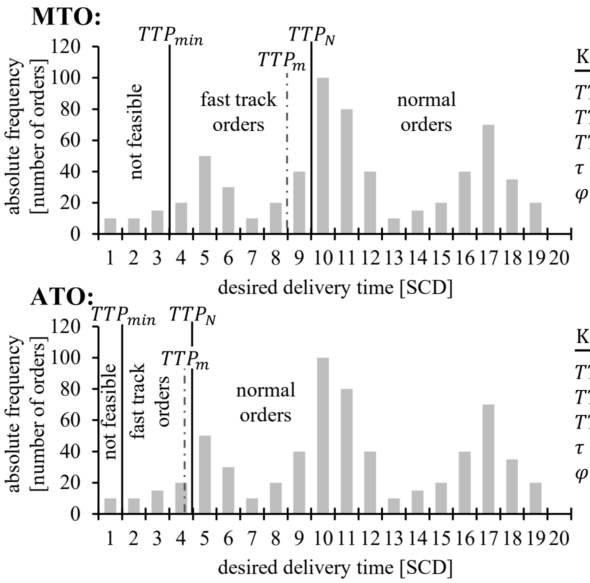
Shorter delivery times can also be realised by integrating fast-track orders into production [20]. However, the integration of a share of fast-track orders on the work content τ has the consequence that the throughput times of normal orders TTP_N are extended [18,19]. Similarly, the variation of the lateness of normal orders in the final production stage $L_{V,fin}$ may increase [18]. This interaction still has to be modeled to enable a holistic model-based evaluation of occurring logistical costs. Higher variation of lateness $L_{V,fin}$ and the longer throughput time of normal orders TTP_N result in higher safety stocks SSL_{fp} for MTS products. The calculation of SSL_{fp} and SL_{fp} in accordance with $SERL_{tar,fp}$ can also be taken from [32]. In case of MTO or ATO products, with a higher variation of lateness $L_{V,fin}$ higher safety times ST have to be allocated to reach the target schedule compliance SC_{tar}. How to dimension the safety time ST in accordance with the variation of the lateness $L_{V,fin}$ and the target schedule compliance SC_{tar} and which delivery time TD and which finished product stock level SL_{fp} result from this safety time, can be determined following [16].

5. Analysis of the delivery time related suitable order processing strategy

Based on the previously identified interdependencies between the positioning of the CODP and the use of fast-track orders with logistic objectives, this section examines interactions and trade-offs between the instruments and their parameterisation.

It is assumed that delivery times below the mean throughput time are served with fast-track orders if it is possible for the considered CODP position. Therefore, the position of the CODP determines how many orders can be served at all and how many fast-track orders must be used with which inter-operation time reduction. A product view and a resource view are described below for analysis purposes.

The product view is shown in Figure 3 with a fictional example for producing a single product. The diagrams show the absolute frequency of delivery times requested by customers in the number of orders in a reference period. The delivery times considered here have been adjusted for time components such as dispatch time so that it is essentially a maximum permissible throughput time. For simplicity, the term delivery time will continue to be used in the following. Three possible scenarios are MTS, ATO and MTO. Since there is no order-related production throughput time for MTS, the logistical costs for MTS with a specific target service level can be calculated following the interdependencies from section 4. Therefore, only MTO and ATO are considered concerning the fulfillment of the heterogeneous desired delivery times.



Key figures

TTP_{min} = 4 SCD
TTP_N = 10 SCD
TTP_m = 9 SCD
τ = 27 %
φ = 6 %

Caption

SCD	shop calendar day
TTP_{min}	minimal througput time [SCD]
TTP_N	throughput time of normal orders [SCD]
TTP_m	mean throughput time of all orders [SCD]
τ	share of fast track orders reg. this product (group) [%]
φ	share of rejected orders [%]

Key figures

TTP_{min} = 2,00 SCD
TTP_N = 5,00 SCD
TTP_m = 4,87 SCD
τ = 7 %
φ = 2 %

Figure 3: Fulfilling heterogenous desired delivery times with different order types

It is assumed that a rush order's progressing starts at each work system as soon as the last order in progress finishes (see [18]). All desired delivery times below this cannot be served by accelerated orders either, which leads to a rejection rate φ. In this example, the logistical positioning of planned WIP at MTO results in a mean throughput time TTP_m of 9 shop calendar days. Fast-track orders achieve delivery times shorter than the mean throughput time. The equilibrium condition, according to TRZYNA and HEUER ET AL., provides an approach to determine the planned throughput time for normal orders TTP_N as the boundary between normal and fast-track orders using the distribution of the desired delivery times, the minimum realisable throughput time TTP_{min} and the mean throughput time TTP_m (see Figure 4) [18,19]. All orders with a delivery time higher than the minimum delivery time and less than the planned throughput time for normal orders are therefore fast-track orders, which in their entirety give rise to a fast-track order share of τ in all orders.

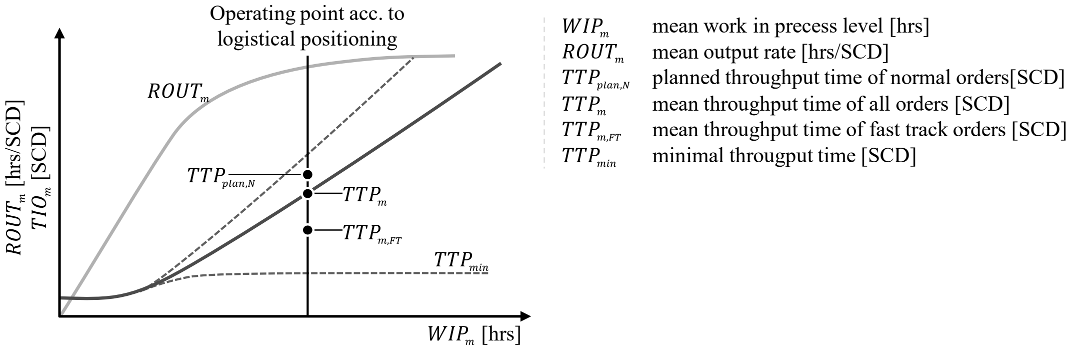


Figure 4: Output and Throughput Time Operating Curves with fast-track orders [18]

In the example for MTO, φ is 6%. These potentially lucrative orders cannot be accepted. With ATO, on the other hand, only 2% cannot be accepted. While for MTO both production stages are burdened with 170 fast-track orders, for ATO only the final production stage is burdened with 35 fast-track orders.

Due to the interactions with the logistic objectives of other products described in section 4, the product view described must be expanded to include a resource view to identify possible problems at the production stages under consideration and thus also other products (see Figure 5).

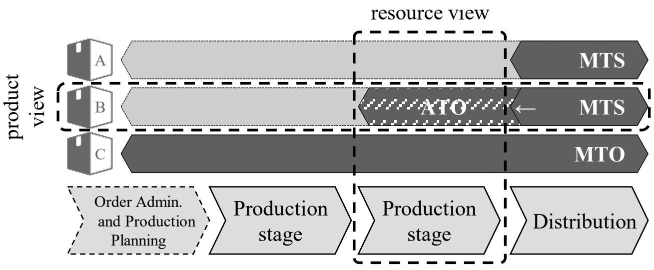


Figure 5: Product view and resource view

When deciding on a shift of the CODP or the use of fast-track orders, the same decision must always be made for other products. If the CODP for a product is set so that fast-track orders become necessary at a production stage, this must be taken into account in the resource view. The desired delivery times must be broken down to the maximum permissible throughput times in the order-specific production run on the individual production stages to be run through. Special effects such as a limitation of the inter-operation time reduction at work systems with set-up time-optimising sequencing may have to be considered. The resource view of a work system must be aggregated for all products whose maximum permissible throughput times are to be processed across all products. In this way, the resource view can derive planned throughput times for standard orders.

For example, a production with two MTS products (product A and B) and one MTO product (product C) is assumed. Product B is switched from MTS to ATO to save costs (see Figure 5). To achieve the desired delivery time of the customer without shifting the COPD downstream, orders of product B in the final production stage have to be partially scheduled as fast-track orders. To check the profitability of this change, the interdependencies shown in Figure 2 must be taken into account. By scheduling fast-track orders in the final production stage, the throughput times of all other orders in this production stage are extended. This means that the throughput time of products A and C are extended. Thus, with a higher replenishment time, the safety stock of product A in the finished goods stock must be increased to achieve the same service level for product A. While an increase in safety stock can compensate for longer replenishment times for product A, it must be checked for product C whether the desired delivery times can still be realised despite this throughput time extension. If this is critical at the final production stage, there is still the possibility of using acceleration potentials at the production pre-stage for product C. To assess the profitability of changing the order processing strategy of product B, the initial savings in the stock of product B must be weighed against the cost of the additional demand for safety stock for product A and secondary effects of product C.

6. Conclusions

Meeting customers' heterogeneous delivery time requirements holds great potential for companies to increase customer satisfaction and revenues. There are many instruments to realise shorter delivery times. Some of them should be chosen strategically and in the long term, others can be used in the short term. As two key instruments, the positioning of the CODP and the use of fast-track orders were investigated in this paper. While the positioning of the CODP, in particular, reduces the average throughput time, a specific range of different delivery times can be mapped through the systematic use of fast-track orders. So far, however, there is no approach that takes into account a coupled decision on the position of the CODP and the use of accelerated production orders, potentially resulting in higher logistical costs.

When positioning the CODP, numerous interactions with logistic objectives have to be considered. The positioning of the CODP per product cannot be done in isolation, assuming the use of fast-track orders. In addition, interactions with other products must be taken into account from a resource perspective. This paper describes the most important influences on logistic objectives and the interactions on the resource view. That makes the coupled positioning of the CODP using fast-track orders accessible to scientific research. Thus, a first approach for determining resource-based planned throughput times could already be developed to link the decision on product level and its influences on other products. That already allows a trade-off in the product-related decision to shift the CODP. The use of heterogeneous planned throughput times requires precise design but can meet heterogeneous delivery time requirements at the same target utilisation rates and lower stocks, thus being more competitive.

The approach proposed in this paper for the positioning of the CODP in the context of the use of fast-track orders must be concretised. Modeling gaps, like the interaction of the share of fast-track orders on the variation of lateness, have to be quantified. As a result, it will be possible to determine for the entire product portfolio which position of the CODP should be selected, considerung fast-track orders, in order to achieve minimum logistical costs in the context of heterogeneous delivery time requirements for a given target logistical performance.

Acknowledgements

The research project was carried out in the framework of the industrial collective research programme (IGF no. 20906 N). It was supported by the Federal Ministry for Economic Affairs and Climate Action (BMWK) through the AiF (German Federation of Industrial Research Associations eV) and the BVL (Bundesvereinigung Logistik eV) based on a decision taken by the German Bundestag.

References

[1] Handfield, R.B., Straube, F., Pfohl, H.-C., Wieland, A., 2013. Embracing global logistics complexity to drive market advantage. DVV Media Group, Hamburg.
[2] Wiendahl, H.-P., Reichardt, J., Nyhuis, P., 2015. Handbook factory planning and design. Springer, Berlin, Heidelberg, 501 pp.
[3] Gudehus, T., Kotzab, H., 2012. Comprehensive logistics, 2., rev. and enl. ed. Springer, Berlin, Heidelberg.
[4] Lödding, H., 2013. Handbook of Manufacturing Control: Fundamentals, description, configuration. Springer, Berlin, Heidelberg.

[5] Trzyna, D., Kuyumcu, A., Lödding, H., 2012. Throughput time characteristics of rush orders and their impact on standard orders. Procedia CIRP (3), 311–316.

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

[7] Wemmerlöv, U., 1984. Assemble-to-order manufacturing: Implications for materials management. Journal of Operations Management 4 (4), 347–368.

[8] Hoekstra, S., Romme, J., Argelo, S.M., 1992. Integral Logistic Structures: Developing Cus-tomer-Oriented Goods Flow. Industrial Press, New York.

[9] Wortmann, J.C., 1983. A Classification Scheme for Master Production Scheduling, in: Wilson, B., Berg, C.C., French, D. (Eds.), Efficiency of Manufacturing Systems. Springer US, Boston, MA, pp. 101–109.

[10] Schönsleben, P., 2012. Integral Logistics Management: Operations and Supply Chain Management Within and Across Companies, 5th ed. Chapman & Hall/CRC Press, Boca Raton.

[11] Chen, J., Cox, R., 2012. Value Stream Management for Lean Office—A Case Study. American Journal of Industrial and Business Management 2 (2), 17–29.

[12] Sohlenius, G., 1992. Concurrent Engineering. CIRP Annals 41 (2), 645–655.

[13] Chopra, S., 2003. Designing the distribution network in a supply chain. Transportation Research Part E: Logistics and Transportation Review 39 (2), 123–140.

[14] Kingsman, B.G., Tatsiopoulos, I.P., Hendry, L.C., 1989. A structural methodology for managing manufacturing lead times in make-to-order companies. European journal of operational research 40, 196–209.

[15] Thürer, M., Silva, C., Stevenson, M., 2010. Workload control release mechanisms: from practice back to theory building. International journal of production research 48 (12), 3593–3617.

[16] Schmidt, M., Bertsch, S., Nyhuis, P., 2014. Schedule compliance operating curves and their application in designing the supply chain of a metal producer. Production Planning & Control 25 (2), 123–133.

[17] Mertens, P., 2013. Integrierte Informationsverarbeitung 1: Operative Systeme in der Industrie, 18th ed. Springer Fachmedien Wiesbaden, Wiesbaden.

[18] Heuer, T., Maier, J.T., Schmidt, M., Nyhuis, P., 2021. Be in control of rush orders logistically. wt Werkstattstechnik online 111 (4), 185–189.

[19] Trzyna, D., Lödding, H., Nyhuis, P., 2015. Modellierung und Steuerung von Eilaufträgen in der Produktion. Zugl.: Diss. TUHH Institut für Produktionsmanagement und -technik, Hamburg.

[20] Lödding, H., Engehausen, F., 2019. Use Rush Orders Strategically: How Make-to-Order Companies Can Increase Their Order Intake. Zeitschrift für wirtschaftlichen Fabrikbetrieb 114 (7-8), 449–454.

[21] Chung, Y.H., Seo, J.C., Kim, C.M., Kim, B.H., Park, S.C., 2017. Reservation-based dispatching rule for make-to-order wafer FAB with high-priority lots. Concurrent Engineering 25 (1), 68–80.

[22] He, X., Dong, S., Zhao, N., 2020. Research on rush order insertion rescheduling problem under hybrid flow shop based on NSGA-III. International journal of production research 58 (4), 1161–1177.

[23] Psarommatis, F., Zheng, X., Kiritsis, D., 2021. A two-layer criteria evaluation approach for re-scheduling efficiently semi-automated assembly lines with high number of rush orders. Procedia CIRP 97, 172–177.

[24] Ren, X., Wang, X., Geng, N., Jiang, Z., 2021. The Just-In-Time Job-Shop Rescheduling with Rush Orders by Using a Meta-Heuristic Algorithm, in: 17th International Conference on Automation Science and Engineering (CASE), Lyon, France. IEEE, pp. 298–303.

[25] Liu, L., Liu, S., 2020. Integrated Production and Distribution Problem of Perishable Products with a Minimum Total Order Weighted Delivery Time. Mathematics 8 (2), 146.

[26] Jäger, Y., Roser, C., 2018. Effect of Prioritization on the Waiting Time, in: Moon I., Lee G., Park J., Kiritsis D., von Cieminski G. (Ed.), Advances in Production Management Systems. Production

Management for Data-Driven, Intelligent, Collaborative, and Sustainable Manufacturing, vol. 535. Springer, Cham, pp. 21–26.

[27] Teimoury, E., Modarres, M., Khondabi, I.G., Fathi, M., 2012. A queuing approach for making decisions about order penetration point in multiechelon supply chains. Int J Adv Manuf Technol 63 (1-4), 359–371.

[28] Grigutsch, M., 2016. Modellbasierte Bewertung der logistischen Leistungsfähigkeit in Abhängigkeit des Kundenauftragsentkopplungspunktes. Dissertation.

[29] Maier, J.T., Heuer, T., Stoffersen, H., Nyhuis, P., Schmidt, M., 2022. Data based analysis of order processing strategies to support the positioning between conflicting economic and logistic objectives. Procedia CIRP, (Full Paper accepted).

[30] Münzberg, B., 2013. Multikriterielle Losgrößenbildung. PZH-Verlag, Garbsen.

[31] Nywlt, J., 2016. Logistikorientierte Positionierung des Kundenauftragsentkoppelungspunktes. Dissertation.

[32] Nyhuis, P., 2009. Fundamentals of production logistics: Theory, tools and applications, Softcover reprint of the hardcover 1st edition 2009 ed. Springer, Berlin, Heidelberg.

Biography

Tammo Heuer (*1992) studied industrial engineering at the Leibniz University Hannover and has been working as a research associate at the Institute of Production Systems and Logistics (IFA) at the Leibniz University Hannover in the field of production management since 2018.

Janine Tatjana Maier (*1994) studied industrial engineering at the Leibniz University Hannover. Since 2018, she works as a research associate in the field of production management at the Institute of Product and Process Innovation (PPI) at the Leuphana University of Lüneburg.

Matthias Schmidt (*1978) studied industrial engineering at the Leibniz University Hannover and subsequently worked as a research associate at the Institute of Production Systems and Logistics (IFA). After completing his doctorate in engineering, he became head of Research and Industry of the IFA and received his habilitation. Since 2018, he holds the chair of production management at the Institute for Product and Process Innovation (PPI) at the Leuphana University of Lüneburg. In addition, he became the head of the PPI in 2019.

Peter Nyhuis (*1957) studied mechanical engineering at Leibniz University Hannover and subsequently worked as a research associate at the Institute of Production Systems and Logistics (IFA). After completing his doctorate in engineering, he received his habilitation before working as a manager in the field of supply chain management in the electronics and mechanical engineering industry. He is heading the IFA since 2003. In 2008 he became managing partner of the IPH - Institut für Integrierte Produktion Hannover gGmbH.