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The effects of hybrid order processing strategies on economic and logistic objectives

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Abstract

In a dynamic environment, companies face the challenge of increasing customer requirements. Today's customers expect fast delivery of affordable and to their needs tailored products. As a result, companies need to act more flexible and thus move away from pure make-to-stock and make-to-order productions described in literature. Shifting the customer order decoupling point to in-between order processing strategies such as assemble-to-order can increase the probability of meeting the customised demand on time. In addition, companies in practice use a variety of different methods for processes like order generation, order release, sequencing and lot sizing to adjust their chosen order processing strategy to fit their individual needs. An example known from industry regarding such hybrid order processing strategy is a make-to-order production with fixed lot sizes. The share of a batch, which is not needed to satisfy the customer's order, is stored. These leftover products allow very short delivery times for small order quantities. In this paper, possibilities to generate such hybrid order processing strategies are identified and structured. Causal diagrams and logistic models are used to analyse the effects of hybrid order processing strategies on economic and logistic objectives.

Keywords: Hybrid Order Processing Strategies; Logistic Models; Flexible Production Systems

1. Introduction

Increasing customer requirements and shorter product life cycles challenge manufacturing companies. Such a dynamic environment calls not only for low product costs and high product quality but also for a high level of logistic performance. The order processing strategy has direct and indirect influence on various economic and logistic objectives and thus can help to improve the flexibility of manufacturing companies. Examples of the objectives influenced by the order processing strategy are [1, 2, 3]:

- due date compliance,
- delivery time,
- inventory costs in the finished goods store and
- manufacturing costs (production lot size, setup costs, etc.).

The literature mainly distinguishes between order processing strategies engineer-to-order (ETO), make-to-order (MTO), assemble-to-order (ATO) and make-to-stock (MTS) [4, 5]. A wide variety of approaches to determine the appropriate order processing strategy exists. However, these approaches rely heavily on a number of assumptions and require a high level of knowledge in the literature. In industrial practice, time pressure often forces companies to simplify problems or to rely on empirical values for their decisions. The selection of the order processing strategy usually depends on qualitative criteria or experience, either as a lump sum for certain articles and order types or on a case-by-case basis for individual orders [6]. Changing from one strategy to another requires a shift of the

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customer order decoupling point (CODP). Such a change usually requires a lot of effort and time considering the numerous factors influencing the order processing strategies. For this reason, companies rarely question a once made decision on the order processing strategy. Nevertheless, to be able to satisfy customer requirements, companies tend to move away from the pure order processing strategies described in the literature [7, 8].

As MacCarthy points out there is a need for flexibility in order fulfilment [9]. Besides the order processing strategy, flexible mass customization also benefits from the constant technological improvement and the continuing globalization. Flexibility generated in that way, enables the emergence of various hybrid order processing strategies. On the downside, the selection of the most suitable order processing strategy for each product and the production planning and control (PPC) of the overall system is getting very complex. This paper intends to support the decision on the choice of the order processing strategy investigating the effects of hybrid order processing strategies on economical and logistical objectives. The underlying research project aims for a holistic decision support model to select a suitable order processing strategy from an economic and logistic point of view (see Figure 1). Developing such a model is a step-by-step process where many different aspects have to be taken into account. The objectives and influencing factors for traditional ETO, MTS and MTO strategies have already been examined to a certain extent in the literature. ATO is in the majority cases the only strategy considered in relation to hybrid order processing strategies. Throughout the years, individual authors have addressed other hybrid order processing strategies. However, neither a common definition nor a uniform description of hybrid order processing strategies exists or a systematic analysis of the effects of these strategies and the associated control parameters.

The subsequent section deals with hybrid order processing strategies and locates them in a company's internal supply chain. Furthermore, the process of identifying hybrid order processing and the development of hybrid order processing strategies in the context of PPC are described. The effects of different order processing strategies on the economic and logistic objectives are explained in section three. Based on this, section four discusses the use of logistic models to predict these effects. Section five concludes the study and outlines future research possibilities.

2. Hybrid order processing strategies

In the past, companies usually used only one order processing strategy due to quite similar products. Nowadays many companies offer a wide range of products. Different customer requirements for the respective products call for an individual decision on the order processing strategy for each product or product family. Figure 1 presents the particular steps to realise the vision of a holistic decision support model on a single product base. The fundamental idea is based on the assumption that hybrid order processing strategies enable more flexibility in companies. Following the understanding of Abdollahpour and Rezaian, a hybrid order processing strategy should be suitable for any production environment, which aims to achieve a balance between conflicting objectives [10]. Consequently, strategies that are prescribed by the product are excluded. A recent survey indicates that MTS and MTO are currently the most frequently used order processing strategies in Germany [11]. Therefore, traditional MTS and MTO systems were taken as a starting point. Given that this survey only considers two hybrid strategies, it is necessary to evaluate the extent to which companies use other hybrid strategies.

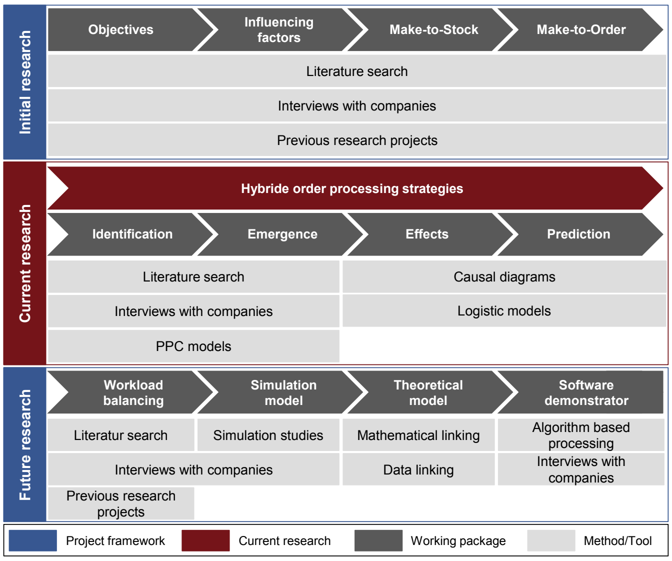

Figure 1: Position of the current research within the project scope

To identify hybrid order processing strategies a literature research and interviews with companies from various industries were conducted. The established scientific databases Scopus, Web of Science and Google Scholar were searched [12]. In so-called hybrids or combined MTS/MTO systems, a wide range of products forces most manufacturing companies to use several different order processing strategies simultaneously. From a production control point of view managing a production resource that is responsible MTS and MTO production at the same time is different from pure MTS or MTO systems. Peeters and van Ooijen refer to the control of such a system as a parallel hybrid MTS/MTO production control [13]. Therefore, such a system is not considered as hybrid order processing strategy. Sometimes the expression hybrid MTS/MTO system also refers to strategies with a CODP between MTS and MTO. However, to optimise a hybrid system, it is necessary to assign products to an order processing strategy first. A number of authors address this problem in hybrid MTS/MTO systems [14, 15, 16]. In practice, companies commonly implement even more order processing strategies than just MTS and MTO. Figure 2 shows the location of the identified hybrid order processing strategies in a company's internal supply chain. The decision among these order processing strategies depends primarily on economic and logistic influencing factors. The identified hybrid strategies are either part MTS and MTO or variations of a traditional MTS strategy. In the case of a high number of products and variants, the internal variance needs to be limited. Modularisation by subassemblies and a high degree of multi-use parts can contribute to this. Nevertheless, the economic advantages of modularisation are opposed to an increasing complexity in the PPC [17]. Therefore, other approaches attempt to shift the point of variant origin as far back as possible in a company's internal supply chain.

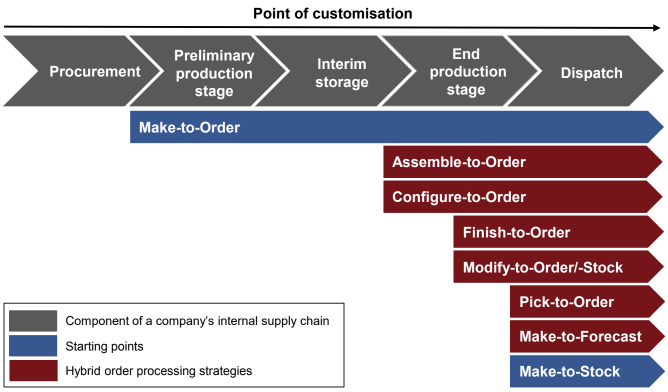

Figure 2: Order processing strategies in a company's internal supply chain sorted by the point of customisation [18]

ATO consists of a forecast-driven manufacturing and a customer order-driven assembly [19]. Hence, this strategy corresponds to a combination of MTS and MTO. Configure-to-Order (CTO) follows the same concept and therefore can be considered as a variant of ATO [20]. The main difference between ATO and CTO is the degree of individualisation [21]. The automotive industry is a common example for a CTO strategy. The customer can individually configure his car starting from the colour to the exterior mirror. In other industries, such as the pharmaceutical industry, the degree of customisation is lower because only a few individual parts are added to a standard product. However, in both cases CTO offers high flexibility regarding the product structure as well as low storage costs. Finish-to-Order (FTO) describes the post-processing of an almost finished product. FTO only changes the external appearance of a product and not functionalities or structure [22]. As such, FTO is both broader and more inclusive than ATO and CTO [23]. Modification processes result from two causes. Depending on the cause, either a Modify-to-Order or a Modify-to-Stock strategy is present [24]. Modify-to-Order refers specific to products, which include a modification process based on individual customer requirements. Modify-to-Stock on the other hand describes the placement of certain components for an in stock product. Either certain components are no longer available or improved components replace original ones. In practice, usually more than the two production stages shown in Figure 2 exist. Consequently, various versions of the order processing strategies located at the end of the production stage are possible.

In the case of the three strategies MTS, Make-to-Forecast (MTF) and Pick-to-Order (PTO), the allocation of customer orders takes place in the dispatch area. PTO allows the customer to choose from standard items [25]. The total selected parts equals a configured product. Nevertheless, the customer himself is responsible for making the product ready for use [26]. Applications for such a modular principle typically occur in the furniture industry or among electronics manufacturers. Improvements of forecasting methods and an increasing availability of data continue to make a MTF strategy more interesting for companies than a traditional MTS strategy. The main advantage of MTF is the ability to adapt stocks to the customer demand dynamically [27].

Besides shifting the CODP, hybrid order processing strategies also evolve from various methods of manufacturing control. Companies need to make numerous strategic decisions in the context of manufacturing control. Thereby, they constantly adapt their previously chosen order processing strategy to the company and product-specific requirements. The Hanoverian Supply Chain Model [28] and Lödding's Model of Manufacturing Control [29] were selected to support the search for further hybrid order processing strategies and modifications of already identified strategies. These PPC models shows the interactions between the PPC tasks and the logistic objectives in a company's internal supply chain. To track the emergence of hybrid order processing strategies, the PPC tasks listed in these models were examined in a stepwise manner. The evaluation revealed opportunities for the emergence of hybrid order processing strategies in various PPC tasks. PPC tasks located in manufacturing control can modify the order processing strategies shown in Figure 2. The essential tasks are the order generation, order release, sequencing and lot sizing. For example, specific machines may require a fixed production lot size. While in certain industries, companies can define a minimum order quantity for their customers, other companies simply charge higher prices for smaller purchases. As the Hanoverian Supply Chain Model can be considered an extension of Lödding's approach [28], additional important aspects for the selection of an order processing strategy can be derived. An example for such an aspect is the priority assigned to the various order processing strategies. For example, suppliers in the automotive prioritise MTS orders from original equipment manufacturers over MTO orders from the aftermarket [30]. In the case of major MTO customers, the opposite situation can occur. In this context, the potential of MTS and MTO for workload balancing should be further investigated.

In summary, hybrid strategies can be divided into the following three categories: combination of traditional MTS und MTO systems, variations of a traditional MTS and manufacturing control modifications.

3. Review of effects on economic and logistic objectives

Manufacturing companies must meet their customer requirements while producing as economically as possible. As the decision on the order processing strategy influences both economic and logistic objectives, many authors address the question of how products with different order processing strategies interact in a company. The focus lies mostly on a cost or performance optimisation of the PPC with multiple variables [31, 32] or on individual aspects such as scheduling [33, 34, 35] or inventory control [36, 37]. Hoekstra and Romme argued that the throughput times, linked costs and investments vary between the different order processing strategies [4]. However, the wide-ranging impact of the choice of order processing strategy shows in the different aspects focused on in existing approaches. For example, Rafiei et al. focused on the capacity coordination regarding the system performance of a hybrid

MTS/MTO system [38]. Whereas Beemsterboer et al. analyse the inventory level and backlog state without prioritising either MTS or MTO [39]. In the following, MTS and MTO are used as examples to explain the effects of the order processing strategy on the economic and logistic objectives.

MTS production orders can be controlled flexible, because customers are not directly linked to the production. Thus, influence the utilisation of the production capacity positively. Production orders do not derive from customer orders, allowing the use of a cost optimal lot size. In addition, short delivery times are possible. This requires the operation of a finished goods store, which is associated with costs and tied up capital for the infrastructure and goods. For a high level of delivery reliability, even in times of fluctuating demand, a high safety stock is necessary. As a result, the risk of unsaleable products increases [40]. In a MTO system, customer orders directly transform into production orders. This enables highly customised products as well as the possibility of including modification requests from customers after the start of production. As no finished goods store is required, the risk of unsaleable products does not exist. Consequently, the throughput times and thus the delivery times are clearly longer in comparison to MTS production. Furthermore, the realisation of economic production orders is not possible in a traditional MTO system [41].

Fawcett and Fawcett provide a good overview on the deliverables of an order fulfillment system and the associated costs of order fulfillment failures [42]. Companies use hybrid order processing strategies to decrease the risk of order fulfillment failures. By combining the specific advantages of MTS and MTO systems, they create a system that fits their particular needs. For example, a MTO strategy with fixed or minimum lot sizes is common in various industries. Each time a customer places an order and the company accepts it, the company initiates a request to its storage. The customer gets the order straight delivered if the stock of the product is high enough. Otherwise, the production planning and control system is searched for production orders of the ordered product. If no such job is in the system or the batch already is reserved for other orders, a new production job with the cost optimal lot size or a multiple of it is created. Not required finished products go straight into the storage. This strategy offers the advantage of short delivery times for small orders. Setup costs are reduced for a process related fixed or minimum lot size. If a cost optimal lot size is produced, this can be considered an MTS strategy without a safety stock.

The numerous possibilities for generating hybrid order processing strategies result in highly complex systems containing diverse interactions. The influencing factors and the effects of the different hybrid order processing strategies on the objectives were structured by using causal diagrams. Apart from obvious knock-out characteristics such as expiration dates of materials, especially the quantity and fluctuation of demand appears to be a key factor. Using a preorder strategy [43] and improved methods for sales planning [44] can help to compensate uncertainties in demand. Several authors investigated additional aspects such as the performance of suppliers for different order processing strategies [45] or the relation between the release of orders and delays [46]. Jia et al. developed a dynamic method for the determination of the CODP [47]. This shows that the choice of the order processing strategy needs to be made not only once but continuously. Determining the most suitable order processing strategy for each product requires a comparison of different strategies. As changing the order processing strategy is associated with considerable effort, a prediction of the effects on the economic and logistic objectives is necessary.

4. Prediction by logistic models

Logistic models proved to be practicable, efficient instruments for the universal quantification of various processes in a company's internal supply chain [48]. The various order processing strategies result in different operating points in the models. Combining several logistic models and additional analyses, such as an ABC analysis, helps to predict the effects on the economic and logistic objectives. Volland already studied the effects of lot sizes and sequencing rules on logistic characteristic curves [49]. The configuration of the production system and the implemented manufacturing control methods strongly influences the effects on the objectives. For the development of a universally valid model, the effects of the hybrid order processing strategies need to be taken into account. To achieve this, the possibilities for the emergence of hybrid strategies as well as logistic models must be mapped along a company's internal supply chain. The number and structure of production stages varies considerably within companies. Therefore, the models for each production stage needs to be assigned individually for each company. In this way, it is also possible to determine whether an unsatisfactory fulfilment of objectives is caused by the order processing strategy or by problems in individual processes. The time required for the order depends on the system performance. Improving the processes and thus reaching a better operating point may result in considering a previously rejected strategy after all.

A standard scenario serves to describe the changes in achieving the economic and logistic objectives caused by hybrid order processing strategies. Either a traditional MTS or MTO strategy is suitable as such a scenario. Depending on whether assuming an MTS or MTO strategy, slightly different objectives and models are relevant. In MTS production, service level and delivery capability are important, whereas in MTO production, schedule reliability and delivery time replace these. Individual objectives also require the use of different logistic models. The characteristic curve for stock-on-hand [50] and the storage model [51] describe the interrelationships in case of MTS. In a MTO environment the schedule compliance operating curve helps to model be relations between schedule compliance, delivery time and the stock of finished orders [52]. Other models, such as throughput diagrams [53] or lot sizing models [54], apply in both cases. For example, a change of the operating point in a lot sizing model results in different set up costs, purchasing costs and storage costs in the produced goods store. Table 1 shows possible effects of adding a fixed lot size to a traditional MTO strategy. Assuming a lot size, which is higher than the average lot size in the traditional MTO system, the costs in the produced goods store decrease. Improved planning due to the stable lot size can have a positive effect on manufacturing costs, utilisation and productivity. The throughput time increases due to the longer operation time of an order. Operating with a fixed lot size, but not using a predefined criteria for order generation, as in a traditional MTS system, can cause issues. A few orders of large quantities can easily cause the system to clog. This increases the pressure on already existing bottlenecks and thus leads to a lower due date compliance. With the remaining products flowing into the storage, it is possible to deliver small order quantities directly. The in general longer throughput times of production orders overlaid this effect. The remaining products of already started production orders enable a slightly higher schedule compliance. In case of partial deliveries, this effect is intensified.

Table 1. Example of effects of a MTO order processing strategy with fixed lot sizes compared to a traditional MTO production

Objective	Effect
Procured goods store	Slightly positive
Semi-finished goods store	No Effect
Finished goods store	Negative
Work-in-Process	Depends on other influencing variables
Manufacturing costs	Positive
Utilisation	Positive
Productivity	Positive
Throughput time	Negative
Due date compliance	Slightly negative
Schedule compliance	Slightly positive
Delivery time	Slightly positive

These exemplary effects can overlap with the effects of other possible ways of generating hybrid order processing strategies. In addition, other aspects, such as the availability of material, can strengthen or weaken the effects. Furthermore, the interactions with the other products manufactured on the same production line need to be taken into account. In the case of products competing for capacity, the priorities set for the different products are an important aspect. Medini showed in a case study, that simulation is a suitable method for evaluate order management process in the context of mass customisation [55]. Simulation models provide a useful opportunity to validate the effects of hybrid order processing strategies on the economic and logistic objectives. Thus, the amount of hybrid order processing strategies relevant for a particular product and the effort required to apply the logistic models can be reduced.

5. Conclusions and outlook

To meet the dynamically changing customer requirements and still produce economically, companies seek to achieve a flexible mass customisation. The order processing strategy affects the economic and logistic objectives of a company. Therefore, it should also be easily adjustable. Companies already recognise this and increasingly move away from traditional systems with only one order processing strategy. Operating a system with multiple order processing strategies and estimating the wide-ranging consequences of changing the order processing strategy of a product presents a major challenge for companies. Applying hybrid order processing strategies increases the probability of meeting the customised demand. Although many companies use hybrid strategies, classic models cannot adequately reflect them. A model is required, which supports hybrid order processing strategies, and not only the decision between MTS and MTO products or the general situation of the CODP. To enable an easy application of such a model for companies, the transfer of the results into a software demonstrator is required. This paper contributes to the achievement of this vision by systematically describing hybrid order processing strategies and exemplarily illustrating their effects on the economic and logistic objectives. The interactions between the products with different order processing strategies manufactured on the same production line need to be further studied. In this context, the aspect of workload balancing should be included and the results evaluated by a simulation model.

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References

[1] Olhager J. Strategic positioning of the order penetration point. International Journal of Production Economics 2003; 85: 319-329.

[2] Nywlt J. Logistikorientierte Positionierung des Kundenauftrags-entkopplungspunktes. Garbsen: TEWISS; 2015.

[3] Grigutsch M. Modellbasierte Bewertung der logistischen Leistungsfähigkeit in Abhängigkeit des Kundenauftragsentkopplungs-punktes. Garbsen: PZH; 2016.

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

[5] Wiendahl HP, Reichardt J, Nyhuis P. Handbuch Fabrikplanung. Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten. München: Carl Hanser; 2010.

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

[7] Williams TM. Special products and uncertainty in production/inventory systems. European Journal of Operations Research 1984; 15: 46-54.

[8] Adan IJBF, Van der Wal J. Combining make to order and make to stock. Operations-Research-Spektrum 1998; 20: 73-81.

[9] MacCarthy BL. An analysis of order fulfilment approaches for delivering variety and customisation. International Journal of Production Research 2013; 51: 7329-7344.

[10] Abdollahpour S, Rezaian J. Two new meta-heuristics for no-wait flexible flow shop scheduling problem with capacitated machines, mixed make-to-order and make-to-stock policy. Soft Computing 2017; 21: 3147-3165.

[11] Mundt C, Winter M, Heuer T, Hübner M, Seitz M, Schmidhuber M, Maibaum J, Bank L, Roth S, Scherwitz P, Theumer P. PPS-Report 2019. Garbsen: TEWISS; 2019.

[12] Martín-Martín A, Orduna-Malea E, Thelwall M, López-Cózar ED. Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. Journal of Informetrics 2018; 12: 1160–1177.

[13] Peeters K, van Ooijen H. Hybrid make-to-stock and make-to-order systems: a taxonomic review. International Journal of Production Research 2020: 1-30.
[14] Kaminsky P, Kaya O. Combined make-to-order/make-to-stock supply chains. IIE Transactions 2009; 41: 103-119.
[15] Rafiei H, Rabbani M. Order partitioning and order penetration point location in hybrid make-to-stock/make-to-order production contexts. Computers & Industrial Engineering 2011; 61: 550-560.
[16] Hadj Youssef K, Van Delft C, Dallery Y. Priority optimization and make-to-stock/make-to-order decision in multiproduct manufacturing systems. International Transactions in Operational Research 2018; 25: 1199-1219.
[17] Medini K. Modularity and variety spinoffs: a supply chain planning perspective. International Journal of Industrial Engineering: Theory, Applications and Practice 2015; 22: 753-768.
[18] Bogner E, Löwen U, Franke J. Systematic consideration of value chains with respect to the timing of individualization. Procedia CIRP 2017; 60: 368-373.
[19] Atan Z, Ahmadi T, Stegehuis C, de Kok T, Adan I. Assemble-to-order systems: A review. European Journal of Operational Research 2017; 261: 866-879.
[20] Song JS, Zipkin P. Supply chain operations: assemble-to-order systems. In: de Kok T, Graves S, editors. Supply Chain Management: Design, Coordination and Operations. Amsterdam: Elsevier; 2003. p. 561-596.
[21] Ivanov D, Tsipoulanidis A, Schönberger J. Global supply chain and operations management: A decision-oriented introduction to the creation of value. Berlin: Springer; 2017.
[22] Fernandes NO, Silva C, Carmo-Silva S. Order release in the hybrid MTO–FTO production. International Journal of Production Economics 2015; 170: 513–520.
[23] Wallace TF, Stahl RA. Building to customer demand. Cincinnati, Ohio: T.F. Wallace & Co; 2005.
[24] Bean WL, Schmitz PM, Engelbrecht GN. Adapting the SCOR Model to suit the military: A South African Example. In: Proceedings of the 14th Annual Logistics Research Network Conference: Volatile and Fragile Supply Chains. Cardiff: University of Cardiff; 2009.
[25] Aldanondo M, Veron M, Fargier H. Configuration in manufacturing industry requirements, problems and definitions. In: IEEE SMC'99 Conference Proceedings. 1999 IEEE International Conference on Systems, Man, and Cybernetics (Cat. No. 99CH37028) Vol. 6. 12-15 Oct. 1999. Tokyo, Japan: IEEE; 1999. p. 1009-1014.
[26] Ying-Lie O. Configuration for mass-customization and e-business. In: Proceedings of the Configuration Workshop at The 15th European Conference on Artificial Intelligence ECAI, Lyon, France. 2002. p. 11-16
[27] Meredith J, Akinc U. Characterizing and structuring a new make-to-forecast production strategy. Journal of Operations Management 2007; 25: 623-642.
[28] Schmidt M, Schäfers P. The Hanoverian Supply Chain Model: modelling the impact of production planning and control on a supply chain's logistic objectives. Production Engineering 2017; 11: 487-493.
[29] Lödding H. Handbook of manufacturing control: Fundamentals, description, configuration. Berlin, Heidelberg: Springer: 2012.
[30] Wang Z, Qi Y, Cui H, Zhang J. A hybrid algorithm for order acceptance and scheduling problem in make-to-stock/make-to-order industries. Computers & Industrial Engineering 2019; 127: 841-852.
[31] Iravani SM, Liu T, Simchi-Levi D. Optimal production and admission policies in make-to-stock/make-to-order manufacturing systems. Production and operations management 2012; 21: 224-235.
[32] Federgruen A, Katalan Z. The impact of adding a make-to-order item to a make-to-stock production system. Management Science 1999; 45: 980-994.
[33] Khakdaman M, Wong KY, Zohoori B, Tiwari MK, Merkert R. Tactical production planning in a hybrid Make-to-Stock–Make-to-Order environment under supply, process and demand uncertainties: a robust optimisation model. International Journal of Production Research 2015; 53: 1358-1386.
[34] Hadj Youssef K, Van Delft C, Dallery Y. Efficient scheduling rules in a combined make-to-stock and make-to-order manufacturing system. Annals of Operations Research 2004; 126: 103-134.
[35] Soman CA, Van Donk DP, Gaalman G. Comparison of dynamic scheduling policies for hybrid make-to-order and make-to-stock production systems with stochastic demand. International Journal of Production Economics 2006; 104: 441-453.
[36] Wu MC, Jiang JH, Chang WJ. Scheduling a hybrid MTO/MTS semiconductor fab with machine-dedication features. International Journal of Production Economics 2008; 112: 416-426.
[37] Rafiei H, Rabbani M, Vafa-Arani H, Bodaghi G. Production-inventory analysis of single-station parallel machine make-to-stock/make-to-order system with random demands and lead times. International Journal of Management Science and Engineering Management 2017; 12: 33-44.
[38] Rafiei H, Rabbani M, Hosseini SH. Capacity coordination under demand uncertainty in a hybrid make-to-stock/make-to-order environment: A system dynamics approach. Scientia Iranica. Transaction E, Industrial Engineering 2014; 21: 2315-2325.
[39] Beemsterboer B, Land M, Teunter R. Hybrid MTO-MTS production planning: An explorative study. European Journal of Operational Research 2016; 248: 453-461.
[40] Syska A. Produktionsmanagement. Das A - Z wichtiger Methoden und Konzepte für die Produktion von heute (engl. title: Production management: important methods and concepts for today's production). Wiesbaden: Gabler; 2006.
[41] Schmidt M, Münzberg B, Nyhuis P. Determining lot sizes in production areas – exact calculations versus research based estimation. Procedia CIRP 2015; 28: 143-148.
[42] Fawcett SE, Fawcett AM. The definitive guide to order fulfillment and customer service: principles and strategies for planning, organizing, and managing fulfillment and service operations. New Jersey: Pearson Education; 2013.
[43] Ahmadi T, Atan Z, de Kok T, Adan I. Optimal control policies for assemble-to-order systems with commitment lead time. IISE Transactions 2019; 51: 1365-1382.
[44] Syam N, Sharma A. Waiting for a sales renaissance in the fourth industrial revolution: Machine learning and artificial intelligence in sales research and practice. Industrial Marketing Management 2018; 69: 135-146.
[45] Ojha D, Shockley J, Rogers PP, Cooper D, Patel PC. Managing supplier flexibility performance as a relational exchange investment in make-to-stock versus make-to-order production environments. Journal of Business & Industrial Marketing 2019; ahead-of-print.
[46] Rocha F, Silva E, Lopes Â, Dias L, Pereira G, Fernandes NO, Carmo-Silva S. Materials Flow Control in Hybrid Make-to-Stock/Make-to-Order Manufacturing. In: International Conference on Computational Logistics. Cham: Springer; 2015. p. 559-568.
[47] Jia Y, Weng W, Fujimura S. A hybrid MTS-MTO production model with a dynamic decoupling point for flexible flow shops. In: 2017 IEEE/ACIS 16th International Conference on Computer and Information Science (ICIS). IEEE; 2017. p. 803-807.
[48] Nyhuis P, Busse T, Münzberg B. (2008). Logistische Beherrschung von Fertigungs- und Montageprozessen. ZWF - Zeitschrift für wirtschaftlichen Fabrikbetrieb 2008; 103: 400-403.
[49] Volland S. An approach for the determination of the impact of production lot size and sequence on logistic objectives in hybrid manufacturing systems. Journal of the Academy of Business Education 2013; 13: 107-120.
[50] Nyhuis P. Lagerkennlinien - ein Modellansatz zur Unterstützung des Beschaffungs- und Bestandscontrollings. In: Baumgarten H, Holzinger D, v Rühle H, Schäfer H, Stabenau H, Witten P, editors. RKW-Handbuch Logistik. Berlin: Erich Schmidt; 1996. p. 1-30.
[51] REFA-Verband für Arbeitsstudien und Betriebsorganisation. Methodenlehre der Planung und Steuerung. München: Carl Hanser; 1985.
[52] Schmidt M, Bertsch S, Nyhuis P. Schedule compliance operating curves and their application in designing the supply chain of a metal producer. Production Planning & Control: The Management of Operations 2014; 25: 123-133.
[53] Wiendahl HP. Fertigungsregelung. Logistische Beherrschung von Fertigungsabläufen auf Basis des Trichtermodells. München, Wien: Hanser; 1997.
[54] Münzberg B. Multikriterielle Losgrößenbildung (engl. title: Multicriterial lot sizing). Berichte aus dem IFA. Garbsen: PZH; 2013.
[55] Medini K. Customer order fulfilment in mass customisation context-an agent-based approach. International Journal of Simulation and Process Modelling 2015; 10: 334-349.