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Linked Accomplishment Of Order Management And Production Planning And Control. An Integrated Model-based Approach

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Abstract

Order management is a main PPC task in company internal supply chains. It provides the link between customers and the company's internal order processing processes. The boundary conditions defined hereby influence adjacent and subsequent main tasks in PPC. However, since usually conflicts between objectives, such as between utilisation of capacities and schedule reliability are caused in companies, the interaction between PPC tasks of order management and other main PPC tasks should be taken into account.

Existing approaches often examine the effect of PPC tasks and procedures in isolation for the respective main task. Especially in the task of order management, the focus of procedures and models lies more on economic and less on production logistics aspects. Nevertheless, these must be taken into account to assess the resulting effects on production (e.g. load and due-date situation) and thus on the logistics performance towards the customer.

To counteract this, the contribution presents a model-based approach, which considers the interactions between order management tasks and other PPC tasks. Furthermore, the determined interdependencies and links are used to derive the effects of order management on logistics objectives of production, and to identify how an integrated view can be used to raise production logistics potentials for improving a company’s logistics performance. For this purpose, proven models such as the Hanoverian Supply Chain Model and the extended Aachen PPC Model are used.

Keywords

Production Planning and Control; PPC; Order Management; Configuration; Model

1. Introduction

Companies face the challenge of positioning themselves in the trade-off between high logistics performance and low logistics costs in order to keep their competitiveness and ultimately their profitability high [1]. To achieve this, it is essential to configure the processes along the company's internal supply chain, and in particular production planning and control (PPC), as a key lever, with its tasks and procedures in a targeted and comprehensive manner [2,3]. Despite the high importance of PPC, which is also expressed in a large number of research publications, studies show that the understanding of processes in PPC, as well as the degree of utilisation of the available systems, is still needing improvement. For example, two studies in Germany conducted by research institutes, in which specialists and managers were surveyed, attest to the fact that only 20% of employees rate their understanding of the PPC system as high [4], and three-quarters of the respondents attest their employees no to moderate knowledge regarding the process effect in the context of production control [5]. Furthermore, only about 10% of the respondents state that the potential of

PPC systems is fully utilised in their company [6]. Considering these study results, it is not surprising that about two-thirds of the surveyed companies from the German mechanical and plant engineering sector are not satisfied with the organisation of their production planning and see high potential for improvement in the achievement of production logistics objectives, such as schedule reliability [7].

Based on the above-mentioned studies, it can be concluded that, on the one hand, there is still potential for improvement in PPC, but on the other hand, there is also a need to prepare tasks, processes and interactions in such a comprehensible way that employees are not only users but can also develop their own understanding of the processes taking place in the company. To address these aspects, model-based approaches have become established in science. This paper focuses on the model-based description and the interdependence between the PPC main tasks. The primary focus is on the PPC main task order management, which represents a cross-sectional task between individual PPC tasks, but also represents a continuous communication interface to the customer via order coordination tasks. In addition to these continuous functions in the order processing process, order management also has important tasks in the area of order clarification, feasibility checks and order acceptance, which are the focus of this article, especially for make-to-order (MTO) manufacturers (cf. [8]). The named tasks have an immense impact on the achievement of a company's objectives, as they control the load of the production.

In the literature, many approaches take a purely economic view (e.g. in the context of so-called revenue management [9]) and do not consider the complex interdependencies and dependencies with the other (main) tasks of PPC in sufficient detail. Therefore, this paper will also take a closer look at the strategic decisions that need to be made within order management and how these should be aligned with the information resulting from the other PPC tasks in order to optimally focus on the logistical objectives of companies. For this purpose, the essential basics of PPC and the main task of order management are first presented and then the interdependence between order management and other PPC tasks is discussed. A process view of the main task of order management derived from the Hanoverian Supply Chain Model (HaSupMo) is also presented, which addresses topics such as the strategic make-or-buy decision at the primary product level. The resulting conflicts of objectives in the context of order management are derived and presented transparently.

2. Fundamentals of PPC and order management

Taking a look at the tasks of PPC according to EVERSHEIM the planning and control of the manufacturing and assembly processes can be divided into schedule-related, capacity-related and volume-related tasks [10]. A central task, but one that is mostly underestimated, is order management. Because this is the interface to the customer, it is possible to influence the load on production directly but also indirectly. Thus, order management in the order processing process has the earliest and at the same time very strong possibility to control the load in production - e.g. through the strategic acceptance and rejection of customer orders - while at the same time also having a great influence on the profitability of the accepted orders.

Order management, therefore, has a significant influence on the achievement of the strategic corporate objectives of MTO manufacturers, which can be derived from the tactical and operational levels for the supply chain as an object of consideration. Looking at the main objectives of production logistics, high schedule reliability and short throughput times should be mentioned on the logistics performance side, but at the same time, the cost objectives of high capacity utilisation and low inventory levels should also be achieved [3,11,12].

A multitude of publications and frameworks can be found in literature (cf. [2]), dealing with the concept and the embedding of order management in corporate processes or PPC. The conceptual understanding of which tasks are to be located in order management strongly differs between the authors. Due to the large number of preliminary works, only the most important framework models and approaches for order management and

PPC will be mentioned here. For a more detailed overview and discussion of PPC frameworks respectively concepts such as Material Requirements Planning (MRP) and Manufacturing Planning and Control (MPC) as well as Hierarchical Production Planning (HPP) reference is made to MISSBAUER AND UZSOY [13].

2.1 Order management in existing PPC frameworks

A significant work in the field of order management is the one by WIENDAHL. Therefore, WIENDAHL defines the scope of application of order management following the Supply-chain operations reference (SCOR) model [14] as the procurement, production and delivery of goods, but differentiates order management from classic PPC systems. WIENDAHL criticises classic PPC systems, saying that there are deficits and too much complexity in the technology-oriented PPC systems (e.g. material requirements planning (MRP-) based) and develops a socio-technical, logistics-oriented approach to planning and controlling a supply chain that takes turbulence and disruptions into account. [15]

The extended Aachen PPC model is a comprehensive framework providing four perspectives on PPC. The described PPC tasks within the Aachen PPC model are differentiated into inter-company network tasks, internal core tasks and cross-sectional tasks. The main task of order management as a component of PPC is classified as a cross-sectional task and thus serves to integrate the network and core tasks and at the same time to optimise PPC. Order management further consists of the tasks of quotation processing, order processing and continuous integrated order coordination. [8]

The Hanoverian Supply Chain Model (HaSupMo) was first presented by SCHMIDT AND SCHÄFERS in 2017 [3]. The HaSupMo represents a synthesis of the considerations of the extended Aachen PPC model and the modelling approach of LÖDDING [16] and combines a PPC view, which differentiates main tasks and assignments, with a supply chain view, which structures the core processes along the company's internal supply chain with their specific logistical objectives. This enables a direct link between the PPC task and the logistical objective.

Within the model-based view of order management, an order passes through five tasks before real production orders are finalised and released (see Figure 1). After the task *clarify order* at the beginning, *roughly schedule production orders and plan safety time* as well as the customer order-related task *roughly plan resources* follow. Following these three tasks, the decisive check and subsequent decision are made as to whether this customer order can be realised.

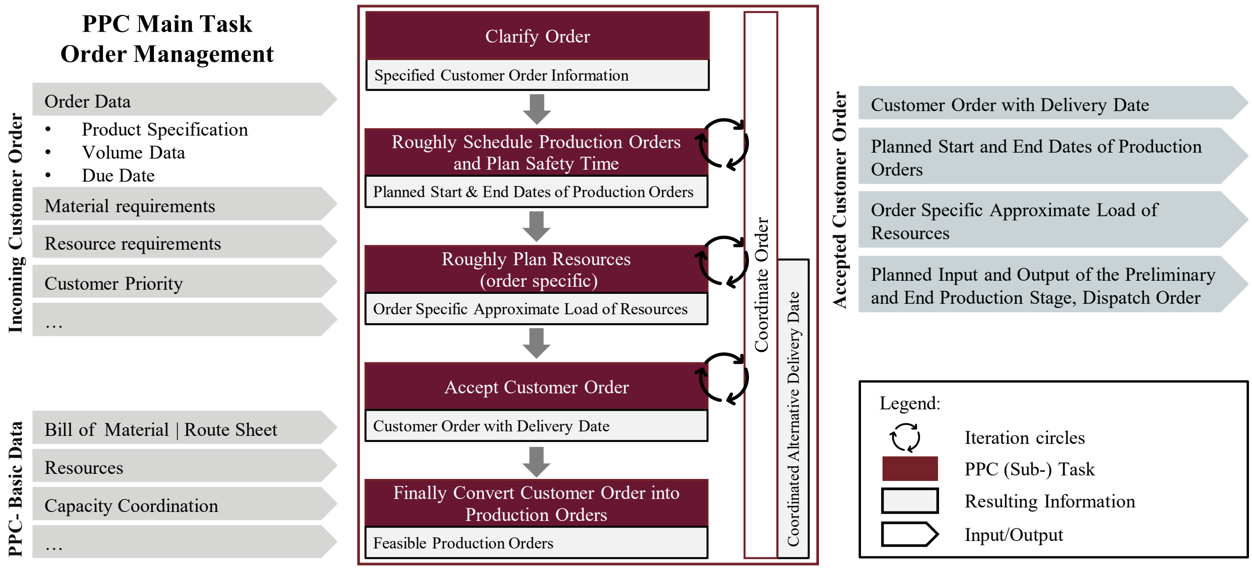

Figure 1: The PPC main task order management according to SCHMIDT [12]

If the check is positive, the order is accepted (*accept customer order*) and the subsequent task *finally convert customer order into production orders* takes place. Should the check be negative, however, the possible deviations of the delivery date are again coordinated with the customer (*coordinate order*). Only after renewed positive confirmation by the customer the two subsequent tasks of *accept customer order* and *finally convert customer order into production order*s take place [12,17]. In addition to the PPC tasks that run, Figure 1 also contains an overview of the possible incoming and outgoing information. For example, accepted sales orders contain information such as product specifications, quantity data and the customer's requested date, which is also referred to as the scheduled date. Basic data such as bills of materials (BOM), route sheets, resources or capacity coordination are already available in the PPC.

In a model-based view, accepted customer orders also generate a data output for PPC in form of the dispatch order and production program planning. Data such as contractually agreed delivery dates, planned start and end dates, planned resource allocation (planned capacity), but also planned inputs and outputs of the prepress and final stages of production and order dispatch are decisive objectives for further consideration in the HaSupMo.

2.2 Further research approaches in the field of order management

In addition to the two frameworks presented, there is a large number of works dealing with order management or with partial aspects or subtasks of order management.

For instance, approaches can often be found that deal with the topic of accept customer orders. The term revenue management [9,18], which has its origins in the airline and hotel business, is widespread and generally represents a variety of instruments for dealing with requests and limited production capacities. Other publications look at the question of how offers should be included in planning and how order acceptance and scheduling can be implemented, taking into account the acceptance rate [4,19]. Subjects such as combined production planning and contractors and demand uncertainty are also addressed [20]. KATE [21] describes two extreme examples in this context with regard to the design of order taking, which differ in terms of their degree of integration (cf. [22]), which describes the system characteristics between a completely hierarchical and a completely integrated planning procedure, of the Sales and Production areas.

Other approaches deal with decisions for or against the outsourcing of orders to suppliers or, in other words, the make-or-buy decision for primary requirements (finished goods) [23] or also the topic of the strategic inclusion of products from outside the portfolio to utilise production capacity [24]. There are also OR models for the integration of outsourcing decisions into PPC (cf. [25]). A good overview of approaches and decision determinants in this context was presented by SERRANO [26].

2.3 Interim conclusion

It is shown that an integrative view of order management with the other main PPC tasks enables possibilities for the comprehensive and target-oriented derivation of both order acceptance as well as outsourcing decisions. However, it was identified through a literature review that previous frameworks for PPC deal with the procedures and tasks of PPC in isolation and (deliberately) greatly simplify the complexity that would arise in particular with an integrative view across the boundaries of tasks.

This paper, therefore, builds on the existing frameworks and approaches and derives an extended representation of the task at hand and essential decision-making processes in order management, taking into account the interdependencies with other main PPC tasks and addressing conflict of objectives. The modelling is carried out in accordance with the previous descriptions in the HaSupMo - serving as a suitable modelling basis - and can thus be seen as an extended view, which transforms and supplements the existing knowledge of the HaSupMo from the previous task-related view into a more time sequence-oriented view. Building on the expanded view of order management created in this way, which also considers in particular the make-or-buy decisions and the question of order acceptance in companies, the resulting conflicts of objectives are discussed.

3. An integrated process model of order management

Between the individual tasks of PPC there is a multitude of interdependencies and dependencies, which have so far mostly only been investigated on a qualitative level with a very limited focus of observation (cf. [2]). In order to approach the question of the existing interdependencies between order management and the other main PPC tasks and the associated conflicts of objectives, an extended process-oriented view of the task of order management in the modelling logic of the HaSupMo was created in condensed form. Figure 2 shows the derived extended (process-oriented) view of the main PPC task of order management.

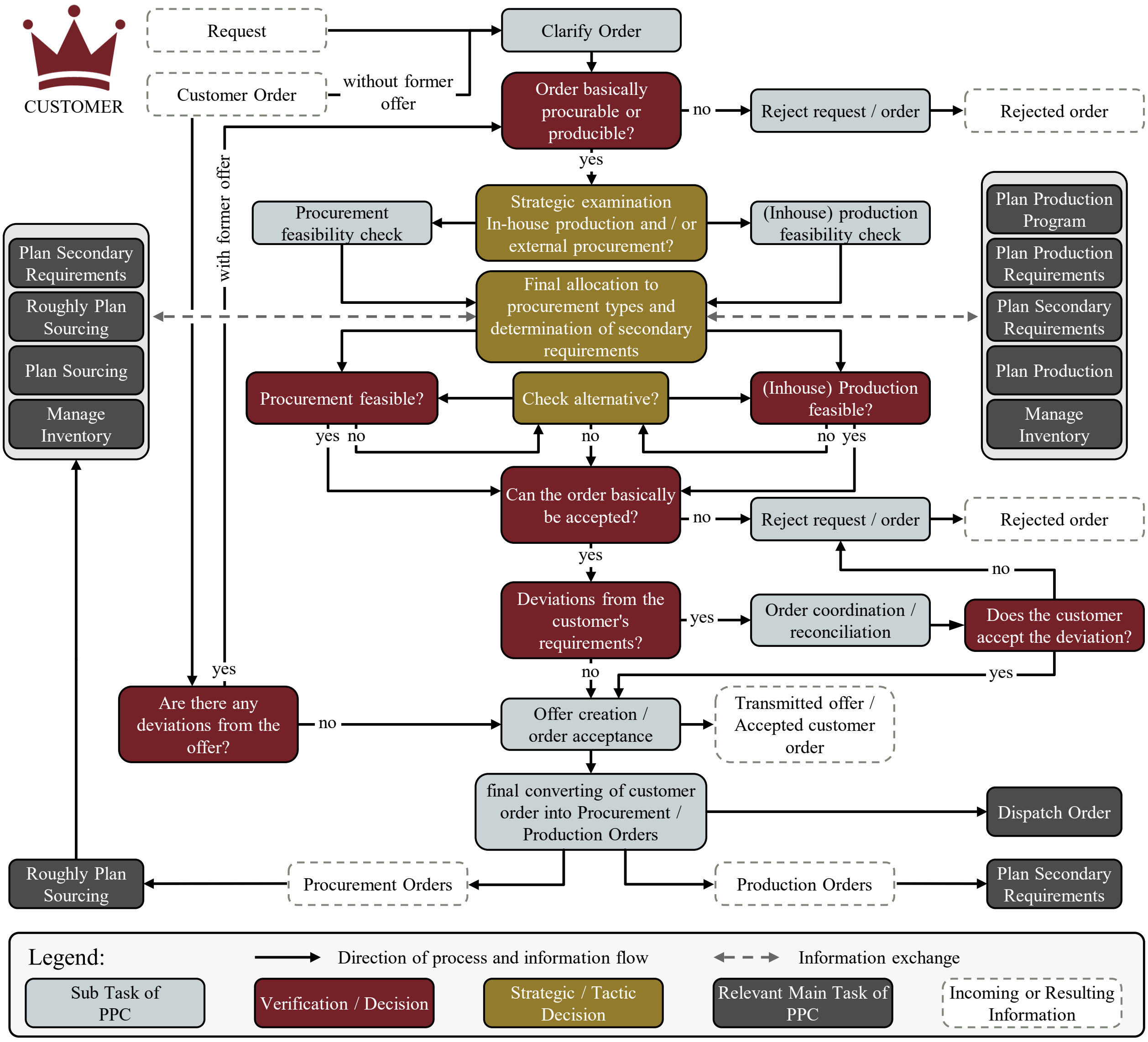

Figure 2: Extended process-oriented view of the task of order management in the modelling logic of the Hanoverian Supply Chain Model according to SCHMIDT AND SCHÄFERS [17] and SCHMIDT [12]

The main task order management is initiated by a customer request or an incoming customer order. If it is a request or a direct customer order for which there was no previous quotation, the first step is to *clarify the order*, which leads to a decision as to whether the customer's needs can in principle be met by the company. Within the framework of this inspection, organisational restrictions are not yet included, rather it is about the possibility of technical implementation, which is not given, for example, if the corresponding machines are not available and the order cannot be subcontracted to suppliers. If this first check is negative, the order or request must be rejected; if it is positive, a strategic decision must be made as to whether the request or order should be produced in-house or outsourced (*make-or-buy decision*). The strategic decision at this point focuses on the production of the primary requirement, e.g. the fully assembled article, and is usually made taking into account a large number of influencing variables and conflicting objectives. For example, the decision to outsource should not lead to the company's own production being drastically underutilised, which would also reduce its profitability.

In order to be able to derive a comprehensive decision, information is needed that is provided by other main PPC tasks. For example, the principle delivery capability of suppliers (resulting from the PPC main task *roughly plan sourcing*) must be checked as well as an overview of the utilisation of production that is as exact as possible, which, depending on the time horizon, includes the result of the PPC main tasks *plan production program*, *plan production requirements* or *plan production* in the considerations.

When the procurement and/or in-house production of the primary requirement has been evaluated, the procurement type must be finally determined and then the pourability or producibility of the dependent requirements (e.g. assemblies) must be checked. This requires the information from the task *plan secondary requirements*. Particularly at the level of secondary requirements, it may be possible that for some products both in-house production and external procurement are possible, which makes it possible, for example, to relieve the burden on in-house production through targeted external procurement. In order to carry out such a check, information is needed from the main PPC tasks of *external procurement* and *in-house production* as well as strategic decisions regarding questions such as know-how transfer to the supplier.

As soon as the procurement type for all secondary requirements has been carried out, the customer's request / order can be answered. Depending on the results of the previously performed checks, deviations from the customer's requirements, e.g. with regard to materials or the schedule, may result and need to be communicated. If the customer accepts the adjustments or if the request / order can be confirmed unanimously, the offer is sent to the customer or the acceptance of the order is confirmed. If the customer places an order on the basis of an existing quotation and no changes have been made to the quotation, the latter shall also take place.

As a final step, the customer order is converted into procurement and/or production orders and further processing is initiated in the other main PPC tasks.

4. Conflicting objectives and interdependence in order management

As already indicated in section 3, direct and indirect (reciprocal) interactions exist between the PPC main task order management and the other PPC main tasks. In the adjacent production program planning, the exchange of information with order management is important to integrate the accepted customer orders into the existing production program. At the same time, there is a close data exchange between order management and resource planning dependent on it. Secondary requirement planning, therefore, converts the information received from order management (mainly about the accepted production orders) and conducts a make-or-buy decision on the basis of this information. Depending on the type of procurement of primary and/or secondary requirements, there are various effects on the logistical objectives of a company. Decisions for or against outsourcing influence various control variables in production. These include the planned output and the planned input, whose difference determines the inventory level of production and thus has an impact on the objective work-in-process. This in turn significantly determines the realisable throughput times and thus also the extent to which the customers' target specifications can be met. If the inventory level becomes too high, for example because the input outweighs the output, it is necessary to initiate compensatory measures in order to be able to meet the specified delivery dates. Since order management has a striking influence on the initial load and thus the input of a production, it follows that reactions may become necessary within the framework of the PPC tasks plan production program and plan secondary requirements and that there is an immense influence on the achievement of logistical objectives.

If these interdependencies, which initially follow the order management in terms of time, are considered during the order management tasks, various conflicting objectives must already be taken into account. Here, economic or cost-oriented objectives (e.g. high capacity utilisation and high throughput) and logistics performance objectives (e.g. low throughput times, high schedule reliability) are opposed to each other.

Taking a look at the extended process-oriented view of order management (Figure 2), the consideration of the make-or-buy decision for primary and secondary requirements contained therein can have an immense influence on the conflicting objectives. Especially through the integrated view within order management, positive effects of the compensation measures on the achievement of objectives in production logistics can be expected, which can be exemplified in the following three cases.

Case 1 (Overload)

An MTO manufacturer whose production is already fully utilised in the current and future planning period receives an additional order from a strategic important customer at short-term notice. The new order is to be assigned to in-house production after inspection. According to the assessment of production utilisation, the additional order acceptance would lead to production overload. Usually, this results in an undesired order rejection or delivery date deviation. In contrast, if current independently produced primary or secondary requirements can also be assigned to external procurement, active control of the company's own production capacity utilisation is already possible at an early stage through order management. In this case, not only is it possible to accept orders in short term, but the decision to outsource also simultaneously creates the possibility of optimising company-internal economic and logistical objectives. Furthermore, accepting orders in short term results in higher turnover and at the same time avoids overloading production. Nevertheless, the objective of high schedule reliability remains and is not directly affected.

Case 2 (Underload)

In comparison to Case 1, the situation differs for companies that already procure a certain proportion of their primary and secondary requirements from external sources for reasons of capacity or economic efficiency. In case of an unforeseeable decrease in demand due to a (significant) reduction in customer requests, the consequence would be that the company's own production capacities for in-house production would only be used to a limited extent since a lower production volume would also be called up there. Using the early make-or-buy decision in order management, the products that are suitable for both in-house production and external procurement can now be produced in-house in short term by converting from buy to make. As a result, this compensatory measure can also maintain the company's internal target of production utilisation from in-house production at a similar initial level despite the declining turnover.

Case 3 (Order fluctuations and uncertainties)

If companies are generally exposed to many fluctuations or uncertainties regarding the order situation, the make-or-buy decision within the framework of order management enables them to cope with the constantly changing production load and thus with the utilisation. The order-related allocation of primary and secondary requirements to external procurement or in-house production enables access to capacities that can be used strategically. With the extended process-oriented view of the task of order management (Figure 2), both a short-term increase and a decrease in capacity are possible. A short-term capacity increase for the acceptance of additional customer orders for primary requirements is possible if the acceptance of additional customer orders allocates the new requirements to external procurement. At the same time, the economic objective of turnover is increased. Nevertheless, this approach is mostly associated with a higher risk and more extensive planning. The model can also be applied in reverse. This type of application should be chosen if a capacity reduction is necessary for economic reasons. In this case, the new requirements of the accepted customer orders must be allocated to in-house production at an early stage in order to keep production utilisation as constant as possible.

Resume

The presented form of order-related capacity flexibility brings significant advantages. Short-term fluctuations in demand can be absorbed while adhering to the company's internal targets. Active control thus enables the right steps to be taken at an early stage in order to survive on the market in the long term.

Even a strategic shift of orders or individual requirements to suppliers is a thinkable option in order to accept further, possibly even more lucrative orders. However, the economic efficiency and strategic importance of outsourcing should be examined in advance in all respects.

Apart from that, it is important to check which parts are suitable for both external procurement and in-house production. After this verification and selection of these parts, further important factors have to be taken into account for a target-oriented application of the described advantages. On the one hand, there are hard factors that define the framework of sourcing possibilities through legal and contractual requirements. These include, for example, the certification of suppliers, internal audits to ensure quality and working methods, political environmental targets or contractual requirements from customers. On the other hand, there are also soft factors that take into account the company's internal strategic actions. These include, for example, key performance indicators (KPI´s) and logistical objectives, knowledge transfer to other suppliers, the classification of suppliers from previous orders and supplier management to safeguard the company's own production.

5. Conclusion and Outlook

In this paper, it was shown that order management as a PPC main task with its input and output data has a significant influence on the logistical objectives of company-internal supply chains for MTO manufacturers. With the extended process-oriented view of the PPC main task order management, it was shown that the active control of primary or secondary requirements using a target-oriented make-or-buy decision can positively influence the production load and utilisation. This form of integrated capacity flexibility can thus be used for the targeted levelling of load fluctuations if products / parts can be assigned to both in-house production and external procurement. Building on this, economic and logistical trade-offs were identified from which strategic and economic decision-making options for MTO manufacturers to optimise their own production capacity utilisation can be derived.

Further research activities should focus on the interrelationships and effects of selected order management procedures on the logistical objectives. In particular, the minimisation of conflicts between logistical objectives through selected procedures should be considered. Furthermore, this more detailed investigation could lead to an optimisation approach of the strategic decision for internal supply chains of MTO manufacturers with regard to outsourcing in the short and medium-term. In addition, further consideration should be given to capacity expansion or minimization enabled by outsourcing opportunities to optimize internal company goals.

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Biography

Simon Hillnhagen (*1989) studied industrial engineering at the Leuphana University of Lüneburg and has been working as a research assistant at the Institute for Product and Process Innovation (PPI) since 2020 in the field of production management with a focus on production planning and control.

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