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Supporting the Decision of the Order Processing Strategy by using Logistic Models: A Case Study

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Abstract.

The selection of a suitable order processing strategy from an economic and logistic point of view plays a fundamental role in the achievement of efficient and waste-free production processes. Many factors influence the order processing strategy and the choice of the order processing strategy affects many variables. The problem for companies that has not yet been solved is the holistic selection of the best possible order processing strategy for each product or product group and, if necessary, subordinate components.

The authors present an approach to analyze the effects of the choice of the order processing strategy on the economic and logistic objectives. The description and modeling of the interdependencies between the order processing strategies and the influenced objectives refer to existing logistic models. A case study to evaluate the impact of different order processing strategies on costs shows the practicality of the proposed approach. The exemplary application of the presented approach showed a potential of an average reduction of 30 percent of the variable costs resulting from the change of the order processing strategy. The savings varied between 1 percent and 62 percent depending on the order quantity and frequency for the individual products.

Keywords: Order Processing Strategy, Interdependencies, Logistic Models.

1 Introduction

The increasing amount of data resulting from digitalization and increasing networking offers both opportunities and challenges. Efficient use of data is discussed often in the context of improving production planning and control (PPC) or work operations. In the literature, numerous approaches related to the decision-making processes in the PPC exist. Scheduling [1], capacity planning [2] and lot sizing [3] are examples of widely discussed decision-making processes. In the last years, the use of methods such as data mining techniques increased in the PPC [4]. Especially for forecasting behavior [5] and planning of sales [6], such methods prove to be very suitable. The availability of data

also holds great potential in upstream decision-making processes. A decision prior to the above tasks is the selection of the order processing strategy. This decision interacts both with downstream PPC tasks and with upstream strategic aspects. Primary strategic decisions interacting with the order processing strategy can be found in areas such as product design and customer relationship management. Due to the high level of knowledge required and the lack of practice-oriented approaches, the systematic selection of the most suitable order processing strategy is a major challenge for companies.

This calls for a holistic decision support model to select a suitable order processing strategy from an economic and logistic point of view. Realizing this vision is a step-by-step process that requires continuous validation of the results through practical applications in industry. The approach presented in this paper is a first step in this direction and shows the practicability of the underlying idea. Section two describes the selection of the order processing strategy in the literature and in the industrial practice. The economic and logistic objectives are investigated with regard to the choice between make-to-order and make-to-stock in section three. Based on this, the general concept to determine the order processing strategy by using logistic models is presented. A case study in section four supports the practicality of the presented approach. Lastly, the conclusions of the paper are summarized and future research possibilities are outlined.

2 Decision-making in Theory and Industrial Practice

The literature usually distinguishes between the order processing strategies engineer-to-order production (ETO), make-to-order (MTO), assemble-to-order (ATO) and make-to-stock (MTS) [7]. In case of an engineer-to-order strategy, the product prescribes this strategy and does not offer any alternatives. This is different for the other strategies. Companies have the choice between MTO, ATO and MTS. The problem of selecting the order processing strategy and the associated positioning of the customer order decoupling point have been intensively studied for many years. The high amount of approaches dealing with the decision on the order processing strategy indicates the complexity of this problem. Considering the numerous interactions of the order processing strategy, a number of approaches focus on the optimization of a system for a given order processing strategy [8]. Other approaches deal with the decision between MTO and MTS [9]. According to a recent survey, MTO and MTS are currently the most commonly used order processing strategies [10]. To simplify matters, many authors severely restrict the decision criteria. In some cases, products are grouped together with the help of a few differentiating features. However, there are no rules in the literature for determining the criteria and their characteristics. The wide variety of characteristics leads to different results for the individual approaches. Furthermore, the results are only recommendations with regard to just a few or even only one objective, such as short delivery times. Approaches based on numerous criteria face the problem of not being able to make a uniform statement for the products. Simulation-based models can support the decision-making, but result in a high computational and modelling effort.

In practice, various combinations of MTO and MTS exist [11]. Besides ATO, there are other hybrid strategies such as configure-to-order. Due to variety of options and the

time pressure in industrial practice, companies often tend to simplify problems or rely on empirical values to make decisions. The selection of the order processing strategy usually relies 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 [12]. Lacking transparency about the reasons, it looks as if the decision highly depends on intuition or experience of the product management. Despite higher costs or a higher risk, there are strategic reasons for choosing a certain strategy. For example, the stock in a finished goods store provides an opportunity to differentiate from the competitors. Shorter delivery times and higher delivery capability enable companies to secure or expand market shares. Outsourcing is another important aspect in this context. The use of external capacities allows shorter delivery times. However, many companies prefer to build up stocks to protect in-house knowledge. In addition, regulatory constraints and dependence on suppliers can be key factors.

3 Make-to-stock versus Make-to-order

3.1 Economic and Logistic Objectives

Manufacturing companies aim to be economic, but they also have to satisfy their customers. To achieve this, companies must find the best possible position in the triangle of costs, time and quality [13]. Companies state that they could not compromise on the quality of their products and the choice of order processing strategy does not directly relate to the quality of products or processes. Therefore, the following analysis focuses only on costs and time. These two dimensions reflect themselves in the form of key figures in the economic and logistic objectives and in the organization of the production processes.

In the following, the focus lies on the two opposing strategies MTO and MTS. This helps to highlight the effects of different order processing strategies on the manufacturing and logistics costs as well as the logistics performance. From an economic and logistic point of view, both strategies have their individual advantages and disadvantages. For example, MTS has the benefit of producing a cost optimal lot size for the respective product. Production orders flow into a storage level, which makes them more flexible to control than MTO orders. This can indirectly have a positive impact on the utilization of production capacity. As the finished products are in stock, very short delivery times are possible. Operating a finished goods store generates costs and ties up capital for goods and infrastructure. Maintaining a high safety stock helps to ensure a high level of delivery reliability even during fluctuations in demand. This increases the risk costs for unsaleable products [14]. In MTO production, this risk does not exist, but therefore the delivery times increase. The quantities requested by the customer directly transform into production orders. Thus, the realization of economic production orders is not possible [15]. As shown in ETO industry, real-time capable production planning and control can decrease complexity [16]. This indicates new trends, like industry 4.0 and self-controlling processes can reduce the effort required in MTO production. A change in the cost-benefit ratio could make MTO production profitable for many companies.

The objectives are not only influenced by the chosen order processing strategy, they also influence the strategy itself. An example of this is the logistic objective delivery time. In MTS production, the delivery time equals the time in the dispatch process plus the transportation time. Whereas in the case of MTO production the throughput time is added on top of that. If the customer demands a very short delivery time and this is the primary purchasing criteria, the company will most likely choose MTS production. However, which order processing strategy is more beneficial always depends on the company's intentions and the particular product. Considering the numerous qualitative and strategic influences, it is necessary to decide on the order processing strategy individually for each product or product family.

3.2 Decision-making based on Logistic Models

Multiple authors used abstract, time-consuming mathematical models to tackle the problematic of the order processing strategy. For example, Hadj Youssef et al. [17] analyzed the effects of the priority allocation on the efficiency of the decision between MTO and MTS and the associated costs. Approaches like this and the observation in the context of previous research projects led to the basic idea of this project. Logistic models support the decision-making process by evaluating the effects of different order processing strategies on the economic and logistic objectives. As a first step, an analysis of the influencing factors related to the choice of the order processing strategy is required. The modelling builds on the assumption, that the costs per product are the determining criteria for companies. The influencing cost factors derive from literature search, interviews with companies from various industries and observations from previous research projects. The choice of the order processing strategy influences the cost per product resulting from the following aspects: storage costs in the produced goods store, purchasing costs, set up costs, storage costs in the finished goods store and costs for delays in delivery.

These influencing factors can be modelled using logistic models and simple calculations. The selected logistic models differ for the individual order processing strategies. For MTS production, on-time delivery is primarily a result of the service level in the finished goods store. In turn, the inventory in the finished goods warehouse has a considerable influence on the service level. The characteristic curve for stock-on-hand describes this interrelationship mathematically [18]. In the case of MTO production, on-time delivery results from the schedule reliability in the sales order-specific production area. The implementation of safety times can compensate for delays in production. However, this is at the expense of delivery time and the stock of completed orders. The underlying cause-effect relationships between the schedule compliance, the delivery time and the stock of finished orders can be modelled mathematically using the schedule compliance operating curves [19]. Lot-sizing models can be used to map the effects of the order processing strategy on set up costs, purchasing costs and storage costs in the produced goods store [20]. Figure 1 illustrates the general modeling approach by positioning existing logistic models. The exemplary operating points show the different cost distributions for of a similar amount of on-time deliveries in MTO and MTS production.

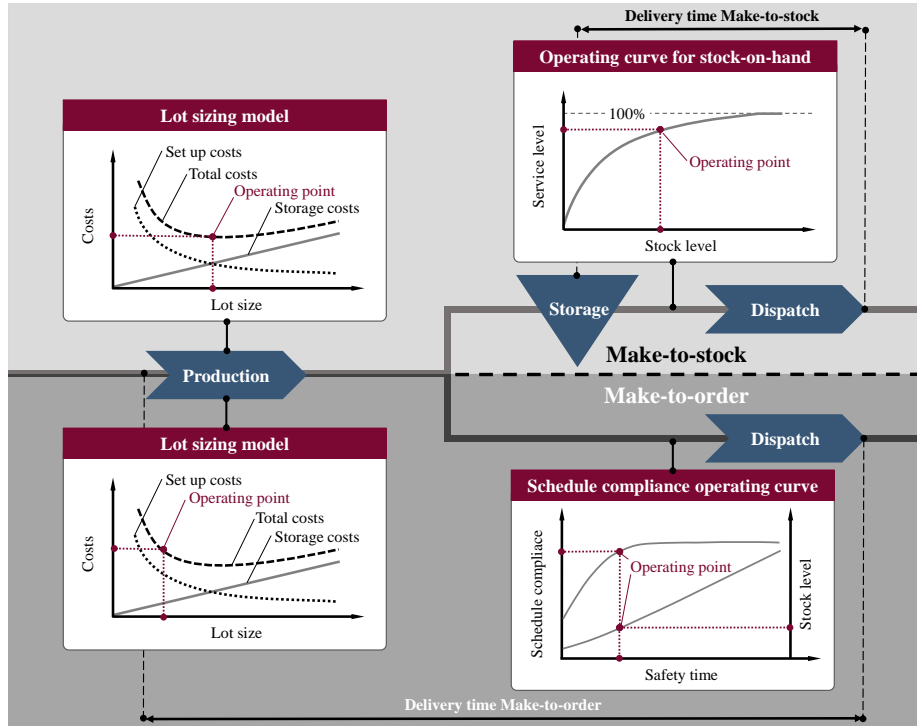


Fig. 1. Approach for the decision-making process by using existing logistic models

4 Case Study

4.1 Application of the Approach

At a manufacturer for construction industry components, the proposed approach helped to support the decision between MTO and MTS. The determining objectives in this single-stage production were delivery time, adherence to delivery dates and product costs. The analysis contained operating data as well as two years of historical data on production performance, schedule reliability and customer demand. The focus lay on quantitative values for the static evaluation of production performance and determination of the required stocks in the supply chain. The conversion of the influencing factors and interactions into accruing costs enabled an allocation according to the cause for the 63 individual products.

The developed tool determines the cost of an individual product in six steps. Figure 2 visualizes the working procedure of the developed tool. The user needs to enter operating data and if available data on the demand, the storage costs and the schedule adherence through the interface. The operating data contains data on the performance of suppliers, general company and manufacturing conditions (e.g. working days per year), cost rates, customer demand and desired values of the logistic objectives. As a

first step, the lot size is calculated. The storage model [21] provides the safety stocks and the minimum marginal stock level for the procured goods and the finished goods store. For MTS production, the service level in the finished goods store is modeled by the characteristic curve for stock-on-hand. The desired service level in the finished goods store results in the required stock level. For MTO production, the necessary safety time and thus the delivery time is derived from the schedule compliance operating curve. To compare MTO and MTS, the conversion of the results from the previous steps into costs is required. In practice, delays in delivery result in high fines, thus a low schedule compliance reflects in costs for delays in the tool. As a final step, the tool varies the demand by two defined percentages to evaluate the cost sensitivity. The dashboard provides data for MTO and MTS on delivery times, storage levels and costs (distribution and trends). Figure 2 visualizes the working procedure of the developed tool.

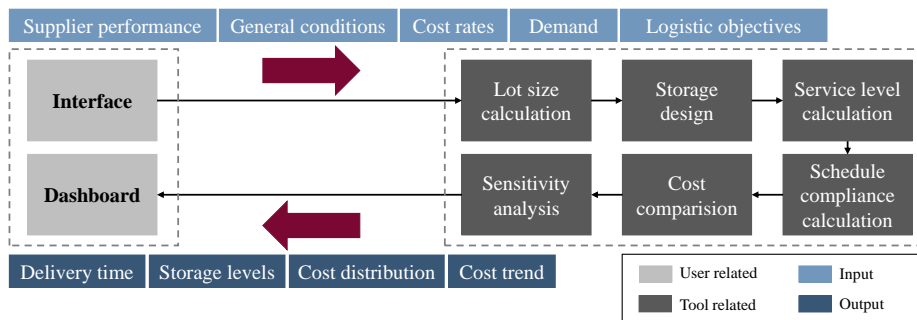


Fig. 2. Principle of the developed tool

4.2 Results

The comparison of a service level of 95 percent for MTS production and 95 percent adherence to delivery dates for MTO production, revealed on average a reduction of 30 percent of the variable costs resulting from the change of the order processing strategy. Depending on the order quantity and frequency, the savings varied between 1 percent and 62 percent for the individual products. The analysis of all 63 products showed a nearly equal distribution between MTS products (28) and MTO products (35). It is therefore necessary for companies to make the decision for each product individually. Due to the non-optimal lot sizes, MTO production generates higher set-up costs. The varying lot size causes difficulties in planning, thus purchasing costs are higher and more capital is tied up in the produced goods store. In addition, MTO results in higher costs for delays. These costs correspond to the costs of operating the finished goods store in MTS production. For higher quantities, the costs for MTO production increase considerably. Near the intersection point of the MTS and MTO cost curves, the detailed cost analysis highlights saving potentials. The delivery time acts as the elimination criteria for MTO production. The developed tool provides the base for an analysis of different scenarios by changing the desired values of delivery time and schedule compliance. In this way, the savings potential resulting from a change in the order processing strategy is comparable with the costs of implementing possible measures to increase

schedule compliance or shorten delivery times. As a result of the numerous company-specific qualitative and strategic aspects, the distribution proposed by the tool was not directly incorporated. Instead, the original workflow for determining the order processing strategy was modified by adding a new step. The developed tool is used to evaluate the cost of previously made decisions on the order processing strategy. In case the costs of the selected order processing strategy are too high, the decision is reviewed.

5 Conclusion and Future Research

The economic and logistic objectives influenced by the choice of order processing strategy are essential for the success of a company. Adherence to delivery dates and delivery times are directly decisive purchasing criteria for customers [22]. This paper presents an approach to support the decision of the order processing strategy by using logistic models. A case study to evaluate the impact of different order processing strategies on costs showed the general practicality of the approach.

The variety of qualitative and strategic influencing variables revealed some limitations of the presented approach. To achieve the vision of a holistic model, further development in an iterative process is required. As a next step, the validity of the identified correlations needs to be examined regarding hybrid order processing strategies. Therefore, the characteristic curves of logistic models have to be examined. Additionally, it is necessary to integrate more logistic models and, if necessary, modify the models. A simulation model can be used to validate the modelling work. A possible other extension of the developed tool could be the implementation of the utilization and management efforts, such as workload balancing, associated with the order processing strategy. Analyzing the interactions with additional downstream decisions such as the order generating process or order releasing process can provide some interesting insights.

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