Why a systematic Investigation of Production Planning and Control Procedures is needed for the target-oriented Configuration of PPC

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Abstract - **The target-oriented configuration of production planning and control (PPC) confronts companies with major challenges. While there are already many publications dealing with the effect of specific procedures of PPC tasks on the logistic objectives, there is still a lack of a framework allowing a comprehensive and relatively simple examination of the target conformity of PPC configuration on the level of procedures. Furthermore, such a framework would thereby also enable companies to position their PPC among conflicting production and logistic objectives.**

This contribution presents the current state of knowledge on target-oriented and holistic PPC configuration and points out why a systematic investigation of the generally valid interdependencies of PPC procedures with each other as well as the impact on the most important objectives is necessary.

Further, it is outlined which future research activities are planned and with a demonstrative example illustrated how complex cause-effect relationships within PPC on the level of procedures arise.

Keywords - **Production Planning and Control, Framework, PPC Procedures, PPC Configuration, Logistic Objectives**

I. INTRODUCTION

Besides the product characteristics of price and quality, logistics performance has become a highly relevant customer requirement for manufacturing companies and a very important purchase criterion [1, 2]. However, companies are faced with the challenge to position themselves in the area of conflict between a high logistics performance and low logistics costs in order to achieve high profitability [3]. A target-oriented positioning is thus essential for companies to be successful in globalised markets with high competitive pressure and is significantly influenced by production planning and control (PPC).

With regard to production volumes and due-dates, the mission of PPC is to regularly plan the production and to realise this plan as economically as possible despite unavoidable disruptions such as shortage of staff or delays in supplies [4, 5]. In this context, the concrete PPC tasks are diverse and reach from long-term sales planning to lot sizing and sequencing at work systems in production. Various PPC models and frameworks provide an overview of these tasks and describe them in a generally applicable manner [5–8]. For fulfilling PPC tasks, there are numerous procedures to choose from. For example, the PPC task sequencing can be realised by the procedures "First-In-First-Out", "Earliest Operation Due-Date", "Setup Time Optimizing Sequencing" or "Shortest Operation Time" [8].

The selection of procedures to fulfil the PPC tasks and their subsequent parameterisation is referred to as PPC configuration. In practice, companies face extensive challenges to configure their PPC. The PPC tasks are, as already indicated, diverse. The interdependencies within PPC and, above all, the effect of PPC on the logistics objectives along the company's internal supply chain are complex. In addition, the solution space - i.e. the overall range of procedures available for fulfilling a task - is large and difficult to permeate. [9]

Currently, there is no consistent description and collection of the PPC procedures covering most of the PPC tasks. In addition, a consideration of the procedures and their interactions in the overall context the PPC is missing in present frameworks. As a result, there is often confusion about the practice- and target-oriented combination of PPC procedures. So overall, it is difficult for companies to select those procedures respectively combinations of procedures from the multitude of possibilities and to adjust their parameters in interaction in such a way that their logistic objectives are optimally supported. [9]

This is also indicated by a recent study in which only about a third of the companies surveyed stated that they select PPC procedures to influence logistic objectives in a focussed manner. Other reasons for the selection of procedures are the simple traceability of the procedures or a low effort in application [10]. For this reason, PPC configurations in companies have often been developed gradually as a reaction to problems and not systematically derived in accordance with superior objectives [11].

In the following, the state of the art is shown and it is derived why there is a need to be aware of the cause-and-effect relationships in PPC. To illustrate the complexity of the highly relevant practical problem of PPC configuration, an example is outlined focusing the main PPC task of production control.

II. STATE OF THE ART

A. PPC models and frameworks

A wide variety of models and frameworks describing and systematising PPC exist in literature. A very common framework is the advanced Aachen Production Planning

and Control Model, which is based on the work of HACKSTEIN and regards PPC from four so-called reference views [6, 12]. Another important PPC concept is the production control model of LÖDDING (Figure 1) [8].

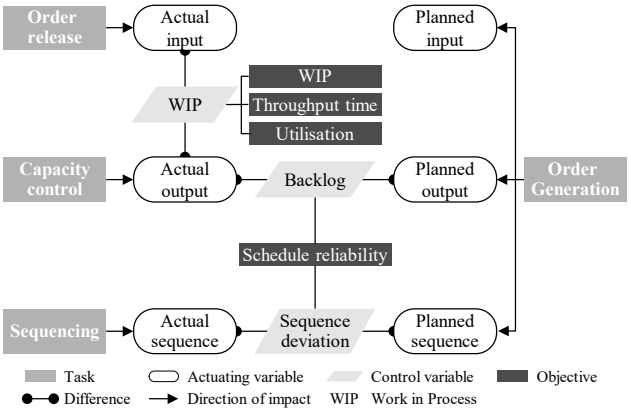

Fig. 1. Production Control Model by LÖDDING [7]

In his model, the four tasks of production control (order generation, order release, capacity control, and sequencing) are generally described and linked with logistic objectives. Thus, a qualitative description of the interrelationships between the tasks of production control and the four logistic objectives of a production is made.

Based on these two frameworks, the Hanoverian Supply Chain Model was developed by SCHMIDT AND SCHÄFERS [5]. It combines the modelling approach of LÖDDING and the comprehensive consideration of PPC within the advanced Aachen PPC model. The object of investigation is thus extended vertically from production control to the complete PPC and horizontally from production to a company's complete internal supply chain with the core processes procurement, preliminary production stage, interim storage, end production stage and dispatch [5, 9]. Figure 2 shows the considered logistic objectives along a company's internal supply chain. These are connected with the PPC tasks via the description of control and actuating variables. Figure 3 presents the considered main tasks of PPC, which can be further subdivided into different PPC tasks liked with the internal supply chain.

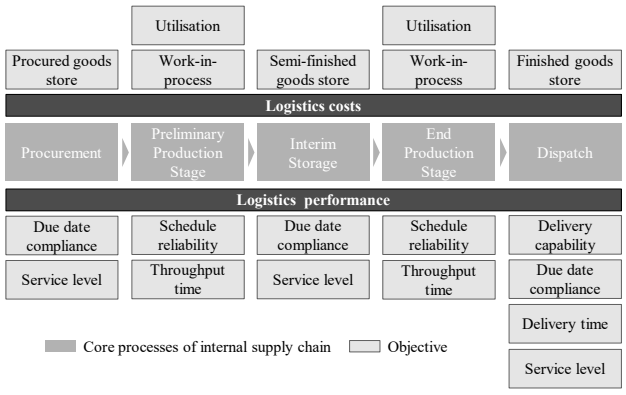

Fig. 2. Logistic Objectives in a company's internal supply chain [13]

For example the main task plan production consists of the tasks calculate lot size, schedule throughput (simply scheduling), plan resources in detail (short-term) and approve production plan [7].

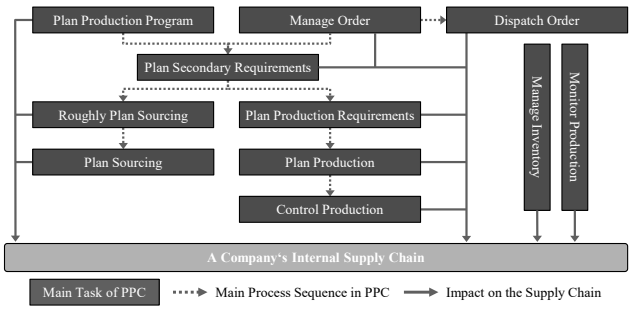

Fig. 3. Structure of the Hanoverian Supply Chain Model [5]

B. Procedures for fulfilling PPC tasks

For some PPC tasks, (for example calculate lot size) a large number of procedures exist to fulfil, while the fulfilment of other PPC tasks is hardly supported by specific procedures (for example safety time planning). Nevertheless, in existing frameworks, the PPC tasks are usually only described in general terms, and there is no presentation of the specific procedures for fulfilling the PPC tasks. This makes it difficult for the users to get a holistic overview of the wide variety of PPC procedures in the overall context of PPC. In addition, there is no theoretical basis helping to compare and evaluate the various PPC procedures. However, in order to achieve the logistic objectives set in a company, it is essential that the PPC procedures are consistent described and comparable, so that a target-oriented selection of procedures is made possible.

An exception are the remarks of LÖDDING in his work on his production control model. Here, several procedures are described for each of the four tasks of production control with regard to their mode of operation, their strengths and weaknesses and their application requirements. In addition, general indications of the effect of the described PPC procedures on logistic objectives are given at some points.

Furthermore, there are other works, which collect and compare procedures for a specific PPC task. An example is the work of GLOCK ET AL. [14]. Here, numerous procedures for fulfilling the PPC task calculate lot size are mentioned, partly described and structured according to different aspects. A consideration in the overall context of PPC and the effect on logistic objectives is unfortunate wise only marginally considered.

C. Existing approaches for PPC configuration

In practice, there is no universally predictable solution for the configuration of a company's PPC. Instead, the procedures for fulfilling PPC tasks always have to be selected based on the specific supply chain characteristics and business objectives of a company. Therefore, it is not only necessary to identify cause-effect relationships on the level of PPC tasks, but also to describe and evaluate them on the level of procedures. For this purpose, some approaches exist in literature.

A first systematic investigation of the suitability of PPC procedures in dependence of the industrial operating mode was carried out by SCHWARZMAIER. For this purpose, he categorized the industrial operating modes according to the organisational type of production (e.g. shop-floor production and flow production) and the recurring production type (e.g. one-time production and large-scale production). Subsequently, he conducts a comparison between the requirements of the different industrial operation types and the characteristics of PPC procedures. The result of this comparison is a suitability test of the considered PPC procedures for the respective industrial operating modes. [9, 15]

JODLBAUER has developed an iterative concept for production optimisation. According to this concept the PPC procedures and their configured parameters should be checked regularly. The selection of procedures is also discussed. However, only for some procedures of the category "mid-term consideration horizon" (e.g. MRP, Kanban, ConWIP) a concrete selection based on criteria is presented. For these procedures, the effect on logistic objectives is also addressed. [9, 16]

With a focus on production control LÖDDING presents criterions for the selection of procedures and offers solutions for some case studies [8]. Anyway, this is explicitly not a holistic approach for the selection of PPC procedures and is limited to the sub-area of the main PPC task of control production.

NYHUIS ET AL. present a three-step approach for selecting procedures for the tasks of production control in different manufacturing areas. After a process analysis and the identification of targets, the requirements and possibilities of specific production areas for production control are concretised. Finally, the procedures for each area and for each task can be selected. [17]

Certainly, it must be noted that the existing approaches primarily focus on isolated PPC tasks. In addition, not all available PPC procedures are recorded and consistently described. Thus, there exists no comprehensive framework providing a theoretical basis for a consistent configuration of PPC on the level of PPC procedures.

D. Mapping the effect of PPC procedures on logistic objectives

Again, with an isolated focus on single PPC tasks, studies can be found in literature, which analyse the effect of the various PPC procedures for fulfilling this task on objectives, partly qualitatively and often in the form of quantitative simulation studies. However, the impact of procedures and their parametrisation is often considered in isolation, which means that interactions between the single procedures of PPC tasks are purposefully put out of scope in order to investigate the "pure" effect of procedures of one PPC task.

One example of a first combined quantitative consideration of the interaction of procedures of two different PPC tasks is presented by RAGATZ and MABERT. They simulate the effect of five different order release procedures combined with four different sequencing rules under three operating conditions for a fixed test landscape. They conclude, among other things, that a meaningful order release rule can bring the effect of a simpler sequencing rule closer to that of a more complex one. In practice, this would be particularly advantageous, since, like mentioned before, in many cases simpler heuristics are chosen than complex procedures. [18]

E. Conclusion towards the State of Art

The more different PPC tasks and related procedures are considered, the more different possibilities exist for PPC configuration. Due to the large number of possibilities for combining the design of the company's internal supply chain, the selection of procedures for carrying out the PPC tasks and the parameterisation of the PPC procedures, the PPC and its configuration is highly company-specific.

Various high-quality PPC concepts already exist, which describe the PPC tasks and put them into a process-related context. However, these models and frameworks do not specify how the PPC tasks should be executed in concrete terms. For the precise execution of the PPC tasks, there are numerous procedures to choose from. These differ greatly in the required effort, in the result and in their effect on logistic and other objectives. Nevertheless, there is no continuous and consistent collection and description of these PPC procedures. In order to enable a comparability of the different procedures within a PPC task as well as the evaluation of different procedure combinations beyond the limits of looking only on single PPC tasks, such a collection and description is indispensable.

For the selection of procedures to fulfil the PPC tasks, various approaches can be found in literature. These use different criteria for the selection, are quite general and do not offer companies a comprehensive solution. Thus, the PPC configuration remains a great challenge for companies, especially because the effect of the individual PPC procedures and their combinations is not transparent

and general valid described respectively quantified. Only for individual tasks are there highly focused studies on the effect of PPC procedures on logistic objectives.

III. SYSTEMATIC INVESTIGATION OF PPC PROCEDURES

In the future research activities, the identified gap in current approaches has to be closed. The Hanoverian Supply Chain Model is therefore a suitable basis, as it already provides a comprehensive overview of the running PPC tasks and the linked logistic objectives (see Figure 2 & 3). Since the Hanoverian Supply Chain Model describes the interrelationships between the PPC tasks and the logistic objectives in general, it must be supplemented by the observation level of PPC procedures. For this, a general valid quantitative examination would be desirable, which, as an example will be done by means of networks that show the cause-effect relationships between the PPC procedures. It is important to note that the investigation will strongly focus the interaction of procedures of different tasks with each other and finally the impact on the logistic objectives.

For this reason, the procedures for fulfilling PPC tasks are to be collected, structured and described in a uniform form and language. Based on this, the direct as well as the indirect effects of the PPC procedures on the logistic objectives can be distinguished. The, if possible, quantitative description of the cause-and-effect relationships will be carried out by mathematically linking the elements of the company's internal supply chain and the objectives with e.g. the aid of existing logistic models.

The result of these investigations should be reliable and as far as possible generally valid statements about the cause-and-effect relationships, which are integrated in the Hanoverian Supply Chain Model as an overall PPC framework, guiding companies towards a target-oriented (re-) configuration of PPC.

IV. AN EXAMPLE: INTERDEPENDENCIES BETWEEN PPC TASKS AND PPC PROCEDURES

Sequencing at work systems is a central task of production control [8]. In a large number of research projects, the effect of different procedures of sequencing on the objectives of work system or a production area (see Figure 2) has been modelled, whereby especially the counteracting objectives schedule reliability and productivity (as a cost value) had been in the focus of investigations (exemplary [19, 20]). In a subsequent study, it was possible to link the partial models developed for some procedures of sequencing in such a way that a target-oriented deduction of a sequencing strategy for a production area in the conflict of objectives between productivity and schedule reliability could be achieved [21]. Thus, a target-compliant configuration of sequencing depending on the main influencing factors considered in the models and approaches (work in process (WIP), material flow structure and standard deviation of lateness in the production area's entrance) has been enabled.

Anyhow, these main influencing factors cannot be taken for granted in a superordinate and holistic view on PPC, but are influenced by procedures of other PPC tasks. For instance, the actual WIP depends on the one hand on the planned WIP, which is determined in scheduling, and on the other hand, is influenced by order release, for which a huge number of different procedures exist.

Thus, as an example, order release can give orders in production based on due-dates (Due-Date Based Order Release) or can have the target to regulate the work in process within production (WIP Regulating Order Release). Depending on the exact type of procedure, a WIP Regulating Order Release can support load balancing on individual work systems (e.g. Load Oriented Order Release) or not (e.g. Bottleneck Control). In addition, a classification can be done between decentralised and centralised approaches. [8].

According to the procedure selected, the actual WIP at the work systems can be kept more or less exactly constant in dependence on major parameters such as the advance release window (resulting, among other things, from scheduling and order management) but also product and material flow heterogeneity.

The actual WIP itself influences on the one hand the utilisation of the work systems and thus whether a work system achieves its planned output [22], on the other hand it also influences the effectiveness of sequencing procedures (e.g. productivity gain through setup optimised sequencing) [19–21]. Furthermore, in case of WIP Regulating procedures for order release, it can be assumed that the standard deviation of input lateness of a production area will increase, since, depending on the respective procedure, mix-ups occur in the release process compared to the planned sequence resulting from the production plan.

In contrast, Due-Date Based Release procedures have a decreasing effect on the standard deviation of input lateness, but they do not actively control the actual WIP in production or at work systems. The release to production is strictly done in accordance to the plan, so that the actual WIP is directly dependent on the planned WIP, the compliance of the production with the plan and, possibly, on the quality and feasibility of the production plan itself.

The theoretical considerations show that just by examining the tasks of sequencing, order release and scheduling, a complex system of cause-effect relationships is created which has a huge impact on the achievement of logistic objectives. Following on from this, it is foreseeable that depending on the main influencing factors that are to be identified (in this example likely the accuracy and quality of the production plan), some procedure combinations will be more suitable than others for a target-oriented overall configuration of PPC.

V. CONCLUSION

Within this contribution, it has been shown that up to now there is no consistent and systematic investigation of PPC procedures for the fulfilment of PPC tasks, although such an investigation is necessary to enable a target-oriented and holistic configuration of production planning and control. In addition, various PPC models were presented, of which the Hanoverian Supply Chain Model (www.hasupmo.education) was identified as a suitable basis due to its integrated consideration of PPC tasks and processes in a company's internal supply chain. It can be expected that due to the ongoing research efforts, companies and especially small and medium-sized enterprises, in which, as studies have shown, the concrete knowledge of interdependencies within the supply chain and the PPC is often missing, will have the opportunity to better and holistically align their PPC configuration to their logistic objectives.

With the proposed approach, an extended framework will be created, which thus enables the holistic view on PPC from different perspectives. By means of the deduced, uniformly and structurally described causal relationships at the level of procedures, the PPC can ideally be configured similar to a guidance, or the current configuration can be checked for its conformity with the objectives. Nevertheless, the configuration of PPC will remain a complex task, but with more knowledge about interactions of PPC tasks, procedures and logistic objectives, the chance of purposeful PPC configuration in companies will be profoundly increased.

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