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IFAC-PapersOnLine 49-2 (2016) 042–047

# Approach for the prediction of production segmentation potential

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**Abstract:** Effects of production planning and scheduling measures on the logistical capabilities of a company are limited by the production structure. The segmentation of production can help to improve logistical capabilities but is costly to implement. This paper researches opportunities to foresee the magnitude of possible improvements in logistical variables through segmentation by means of structural parameters as predictors. An approach is described to quantify segmentation potentials of numerous data sets and correlates those to potential predictors. Eight data sets are simulated concerning logistical capabilities in different structures to validate the approach.



*Keywords:* production planning and control, parameter identification, production systems, material flow, production logistics, simulation

## 1. INTRODUCTION

Today, manufacturing companies in high wage countries are faced with a dynamic environment and challenging market conditions. Short product life cycles, a proliferation of product variants and increasing customer orientation require flexible production systems (Brecher et al. 2011, Wiendahl 2014). Production planning and control has to contribute to sustain and strengthen the competitiveness of the manufacturing companies (Löffler et al. 2012, Wiendahl 1994).

The logistical performance of a production system is an important factor in the competitiveness of a manufacturing company. Low work in process (WIP) levels, high capacity utilisation, short throughput times and a high adherence to delivery dates are the factors contributing to a high logistical performance (Lödding 2008). There are two general possibilities in order to influence the performance in those factors: adjusting the production control configuration and applying changes to the production structure (Schuh et al. 2012). Adjustments made to the production control, for example changes in the priority rules, generally can help to improve logistical performance (Stevenson et al. 2005). However, the possibilities to improve on logistical performance are restricted by the production structure (Schuh et al. 2013, Schuh et al. 2014). Adjustments made to the production structure can further enhance the possible levels of achievement in the four logistical variables (Reuter et al. 2015). Figure 1 shows the performance of different control configurations in the logistical variables to be limited to vary within the light grey area. By employing a segmentation concept to the production system, the performance of the individual logistical variables can be extended to encompass the area shaded in dark grey as well.

Applying structural changes to production systems, e.g. implementing the concept of production segmentation, requires considerable expenditures in terms of time and money (Wildemann 2014). This holds especially true for the execution phase of such projects. Therefore a diligently performed planning phase generally includes reviewing assumptions via simulation.

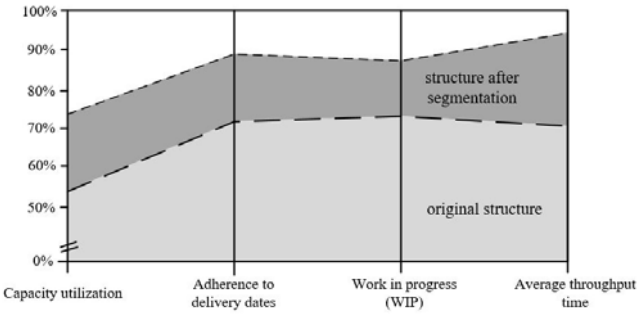


Fig. 1. Improved logistical capabilities by means of segmentation

In order to make use of simulation as a technique to keep overall expenditures low, it is necessary to prepare detailed concepts of promising production structures which properties can then be investigated in a simulation. However, at this point a considerable amount of effort has already been put into detailing possible production structures.

Therefore, this paper proposes a new method to identify structural parameters of production systems suited to assess the potential improvement in its logistical variables which is attainable via production segmentation. Values of characteristic structural parameters like degree of crosslinking or backflow ratio are hypothesized to have predictive capabilities towards segmentation potential. These parameter values should be to be easily available in order to be used for estimating the benefits of production segmentation before any detailed planning or detailing of potential production structures takes place. The paper is


10.1016/j.ifacol.2016.03.008

structured as follows: Chapter 2 discusses production segmentation and production system parameters as well as existing efforts to connect such parameters to logistical performances of different production structures. Chapter 3 subsequently presents the approach for identification of parameters with predictive power towards segmentation potential. The presented approach is then validated in a sample study of eight data sets in chapter 4. This paper concludes with a summary of its findings and an outlook upon further research in chapter 5.

## 2. STATE OF THE ART

This chapter describes the fundamentals of production segmentation and its effects on logistical capabilities of a production system. Material flows in production systems and their complexity are viewed in the context of systems and network theory, as well as complexity-related parameters introduced as a possibility to characterise production systems. Publications discussing the logistical performance of production structures in the context of such characteristics are reviewed and a research gap is identified.

### *2.1 Fundamentals of production segmentation*

The fundamental concept of production segmentation is to structure similar work contents and process chains in differentiated organisational units on the shop floor level. Core principle of production segments is the combination of flexibility advantages of a job shop fabrication and productivity advantages known from line production (Wildemann 1994).

Several design principles of production segmentation influence the material flows on the shop floor. The concentration of products with similar work contents and process chains in exclusive segments facilitates a pursued flow-orientation, as well as a potential one-piece-flow within the segments. Furthermore, the intended completion of all products within a single segment accomplishes a minimal number of material flows in between segments. Due to these positive impacts on material flows and a decrease in organisational complexity, segmentation approaches have proven to achieve improvements regarding the four logistical variables (Wildemann 2014, Wildemann 2007).

### *2.2 Characteristic complexity-related parameters of production systems*

As described in section 2.1, production segmentation affects the material flow connections in a production system. Those material flow connections in a production system can be described in terms of systems or network theory. In this context, the system elements represent resources while their relations depict potential or actual material flow connections. These concepts can be used to define characterising parameters for production systems. A production line for example, can be described by very few relations per number of resources. Furthermore, the number of elements and relations in a system also characterises its complexity (Windt et al. 2008, Espejo et al. 1996). Plurality and variety of elements and relations between those elements are considered important drivers for the complexity level of any system (Ullrich and Probst 1995).

Windt et al. (2008) have shown that the complexity-related parameters of a production system can be classified in the three dimensions temporal complexity, organisational complexity and systemic complexity. Each of those dimensions can in turn be divided into two categories. The organisational complexity comprises process-oriented and structural complexity. Time-related complexity incorporates static and dynamic complexity. Systemic complexity consists of internal and external complexity. The production structure, its influences on material flows and subsequently the logistical capabilities can be related to parameters of structural, internal and static complexity in this model. Examples for parameters of this kind are the number of relations divided by the total number of elements as well as the number of backflow-relations divided by the total number of material flow relations (Philipp et al. 2007).

### *2.3 Logistical performance of production structures in the context of their characteristic parameters*

For numerous real life projects, improvements in logistical performance achieved through the implementation of production segmentation are being discussed in context of structural complexity-related parameters in other publications (Wildemann 1994). However, no quantifiable analysis of a correlation between parameter values and performance of different structures is carried out in context of these project descriptions.

The correlation of structural, complexity-related parameters of production systems to their achievable logistical performance is being explored in simulation studies (Scholz-Reiter et al. 2006). In this case, object of investigation is the influence of production control on the logistical performance. The production control configuration is being varied systematically to differentiate between the benefits of centralised and decentralised production control depending on the complexity levels.

Finally, the relevance of structural parameters on the performance of several organisational structures is being investigated by means of simulation (Grobel 1993). In this publication, structural parameters, e.g. related to the structure of products and orders, are being varied systematically to obtain different data sets. These data sets are simulated in three types of organisational structure (product-oriented, functional, and homogeneous) each and analysed regarding their logistical performance. The types of organisational structure in this approach are broad, not limited to production but include indirect functions as well and do not focus on material flows.

These examples show that there is a gap in research regarding the correlation of characteristic structural parameters of production systems to their logistical performance in differently segmented production structures. We hypothesise the existence of correlations between complexity and material flow-related structural parameters of production systems and segmentation potential. This paper proposes an approach to