Restructuring of Production vs. Continuous Improvement Processes - How to Increase Production Performance

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Abstract
The approach presented in this paper helps companies to systematically evaluate whether a restructuring of a production is desirable or the optimization of the production processes in the current structure should be preferred. Based on the results the companies' decision for or against restructuring the production will be facilitated.

Keywords: production planning and control, restructuring of production

Introduction
More than ever manufacturing companies are challenged by the global competition to develop continually. One reason for increasing competitive pressures can be found in the challenge to offer products matching individual customer demands at competitive prices. A consequence of the increasing individualization of products is the decrease of production volume of single variants and a growing number of variants (Wiendahl 2006), which leads to an increasing complexity in production planning and control. At the same time, logistic performance has become more and more a decision criterion for customers. Markets require short delivery times with high adherence to delivery dates. (Schuh et al. 2011, Schuh and Stich 2011, Zäh 2011) Therefore, to improve or ensure their competitive position companies constantly have to optimize their production.

Motivation and Case Study
To improve production performance processes in direct and administrative areas can be improved. In consideration of process improvements on the shop floor level continuous improvement processes (CIP) are the first option to optimize production performance. In this context a new configuration of the production planning and control (PPC) is often used as an adjusting lever. However, the following case from an industrial partner in the IT-sector shows, that a new configuration of the PPC leads not automatically to any increase of the production performance.

Case study
The clients question in this project was, if it is possible to optimize the sequence in which

the orders get released to increase the production performance. Every day the companies PPC created a production schedule that comprised a certain amount of orders which were needed to be released on this same day. The evaluation parameters were output, adherence to delivery dates and work-in-process.
In the first step of the project a simulation model of the production was built up. Based on this model and an exemplary production program various collations of the order release sequence were investigated. The reference scenario were simulated with the original order release sequence, additionally other collations were developed on the basis of various criteria that were defined by the project team.
The results showed a low variance of the performance indices. A validation of the quality of the model was aspired with an analysis of the stability of sequence – both in the real feedback data and in the data from the simulation. Two results could be found: On the one hand the number of permutations in reality and in the model was very similar, which confirmed the high quality of the model. On the other hand the analysis showed that the absolute number of permutations was surprisingly high. The reason for the low stability of sequence could be referred to the structure of the system. Redundant work stations where orders are able to pass each other because of different lead times cause this effect.
In summary, it can therefore be noted that the adjusting lever "optimization of the PPC" did not have the desired effect on the production performance. The influence of the structure of the logistic and production was seriously underestimated.

Similar situations can be observed in other projects, but it is very hard to evaluate a priori the potential of an optimization of the PPC. Questions that cannot be answered at the moment and are often not even asked are the following:

- Which maximum performance can be achieved with a new configuration of the PPC?
- How is the current performance assessed?

It should be noted that with an increasing degree of maturity of the actual system the effort to improve the production performance even slightly rises disproportionately. Therefore, sometimes companies choose another approach to increase production performance by restructuring their system. There are different definitions for the structure of a production. In this paper the following definition is used: The structure of a production compromises all elements for the operational implementation of production specific activities (e.g. products, production factors, production processes and relations between structure elements).
For a reasoned decision of remaining in the existing structure or changing the current structure basically, the questions from above have to be added by the following ones:

- How high is the performance after the change in production structure?
- What are the ratios of performance enhancement in the new structure? When will the efforts and dissipation have been amortized?

The relation between these two "poles" is illustrated in Figure 1.

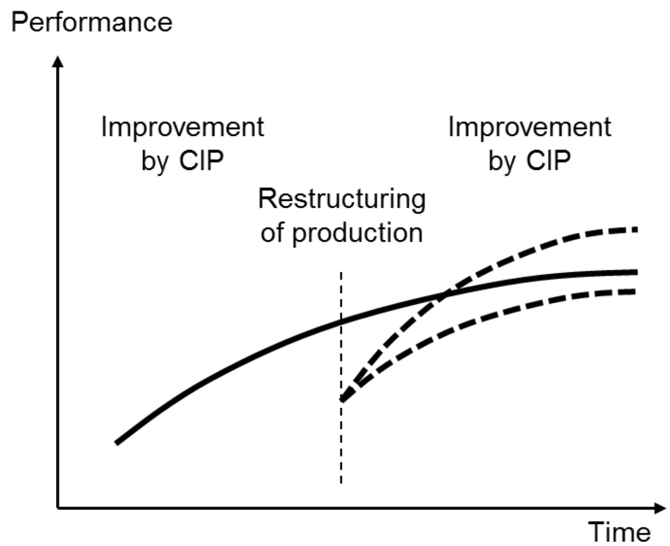

Figure 1 – Restructuring of Production vs. Continuous Improvemtent Processes (CIP)

State oft the art

In order to evaluate the potential performance of a certain production structure that can be achieved by the reconfiguration of the PPC, knowledge about the capabilities of the various control procedures is required. Especially it must be known how the procedures work in combination with each other and which dependence on structural parameters is given.

The analysis of performance of control procedures via simulation is a well-known issue in science. In the following the results of a literature research about simulation studies on different control procedures are presented. As a framework for the description of PPC the model of PPC by Lödding should be used (Lödding 2005). It is assumed that this model fully describes all tasks of PPC by differing (1) order creation, (2) order release, (3) sequencing and (4) capacity management and that it is accurate. No reference was found which generally calls the model into question.

To conduct a performance evaluation of the control procedures appropriate evaluation parameters are needed. For this purpose those logistic key figures are chosen, which are mainly influenced by the respective control procedure.

The research is limited to selected control procedures. A variety of other methods was not considered. The selection is based on the following criteria under which mutual interactions are not excluded:

- International recognition
- Meaning for the praxis
- Consideration in studies

Job creation

There is no separation of job creation methods and job release methods in the examined studies. Rather both methods are considered together. No studies, which deal exclusive with job creation, could be found through the extensive research. It remains unclear whether such studies exist.

Job release

In the research 23 studies from the years 1990 to 2009 were examined. Table 1 shows the studies and examined job release methods.

Table 1 - viewed studies of job release

job release	author and year
MRP	Chan 2001, Gilland 2002, Huang 1998, Jodlbauer 2008, Roderick 1992, Roderick 1994
Basestock	Bonvik 1997, Duri 2000, Geraghty 2005, Karaesmen 2000, Paternina- Arboleda 2001, Veach 1994
Reorder point (ROP)	Yang 1998
KANBAN	Bonvik 1997, Duri 2000, Gaury 2000, Geraghty 2005, Gstettner 1996, Huang 1998, Jodlbauer 2008, Karaesmen 2000, Kleijnen 2003, Lambrecht 1990, Muckstadt 1995, Paternina- Arboleda 2001, Pettersen 2009, Spearman 1992, Takahashi 2002, Takahashi 2007, Veach 1994, Yang 1998
CONWIP	Bonvik 1997, Chan 2001, Gaury 2000, Geraghty 2005, Gilland 2002, Gstettner 1996, Huang 1998, Jodlbauer 2008, Kleijnen 2003, Koh 2004, Lambrecht 1990, Muckstadt 1995, Paternina- Arboleda 2001, Pettersen 2009, Roderick 1992, Roderick 1994, Spearman 1992, Takahashi 2002
Hybrid KANBAN-CONWIP	Bonvik 1997, Gaury 2000, Geraghty 2005, Kleijnen 2003, Paternina- Arboleda 2001
Bottleneck	Chan 2001, Gilland 2002, Jodlbauer 2008, Koh 2004, Roderick 1992, Takahashi 2007

The following conclusions can be deduced from an analysis of the studies of job release:

1) There is no consistent approach to evaluate the examined methods. Different evaluations and measurements are realized.
2) The results of the studies are in many cases completely contradictory - especially, when the statements regarding the comparison of two methods are considered.
3) The models of production used in the studies differ greatly, so that results cannot be compared overall studies.
4) Often no information is given about key structure parameters such as the number of different products, number of machines, etc.. Thus it is clear that in these cases the production structure is not recognized as a determining factor for the performance of the system.

Sequencing

Many studies on sequencing, which compare different sequencing rules respective their performance via simulation, can be found in the literature since the 1960s until today. Widely cited overview articles are Day (Day 1970), Panwalkar (Panwalkar 1977), Blackstone (Blackstone 1982), Haupt (Haupt 1989) and Ramaseh (Ramaseh 1990).

In many studies newly developed sequencing rules are compared with the common sequencing rules. In this research 23 studies, which compare a part of the considered priority rules, were analysed. Table 3 shows an overview of the studies.

Table 3 - viewed studies of sequencing

sequencing	author and year
FIFO (First in-First out)	Bahaji 2008, Barman 1997, Brah 1996, Fischer 2007, Framinam 2000, Holthaus 1997, Huang 1984, Moodie 1968, Rochette 1976, Russell 1987, Vepsalainen 1987, Waikar 1995
SPT (Shortest Process time)	Anderson 1990, Baker 1983, Barman 1997, Chen 1999, Chiang 2007, Fischer 2007, Framinam 2000, Holthaus 1997, Huang 1984, Jayamohan 2000, Kanet 1982, Kim 1990, Moodie 1968, Pierreval 1997, Raghu 1993, Rajendran 1999, Rochette 1976, Russell 1987, Sculli 1990, Waikar 1995
LPT (Longest Process time)	Fischer 2007
EDD (Earliest Due Date)	Bahaji 2008, Barman 1997, Brah 1996, Chen 1999, Chiang 2007, Huang 1984, Jayamohan 2000, Kanet 1982, Moodie 1968, Raghu 1993, Rajendran 1999, Rochette 1976, Russell 1987, Sculli 1990, Vepsalainen 1987, Waikar 1995
Slack	Brah 1996, Chiang 2007, Fischer 2007, Kanet 1982, Kim 1990, Moodie 1968, Rochette 1976, Russell 1987, Sculli 1990, Waikar 1995
COVERT	Anderson 1990, Baker 1983, Brah 1996, Chen 1999, Chiang 2007, Holthaus 1997, Kim 1990, Pierreval 1997, Rajendran 1999, Russell 1987, Vepsalainen 1987
Critical ratio	Bahaji 2008, Baker 1983, Barman 1997, Chiang 2007, Kanet 1982
WINQ	Bahaji 2008, Holthaus 1997
RANDOM	Huang 1984, Waikar 1995

The following conclusions can be deduced from an analysis of the studies of sequencing:

1) The number of working systems used in the models of production has a very wide range of 1 up to 85. Therefore the size of the production is very different.
2) There are not so massive differences of the used model of production in the studies on sequencing as in the studies on job release. Usually the general assumptions of the job-shop-scheduling are made, like they are mentioned from Raghu (Raghu 1993) and Chiang (Chiang 2007).
3) Essential information on structure parameters are not given, so that here also may be assumed that in many cases the structure of a production system is not considered to be essential for the performance of a system.

Operational capacity management

Only one study, in which methods of capacity management are compared, could be found in the searched literature. Begemann (Begemann 2005) compares the performance of the time considering capacity management (TKS), which he had developed, with the backlog rule of Lödding (Lödding 2008). The lack of further comparative studies emphasizes that the systematic design of a capacity management is a relatively new subject of research with so far only a few articles issued.

Conclusion

The results obtained in the studies are not sufficient to estimate a priori the performance of a production when reconfiguring the PPC of a production. It is also not possible to deduce the maximum performance of the system. Therefore the remaining potential of the system cannot be evaluated.

Approach

In the following the concept of a methodology is introduced, that provides the required information to support the decision-making whether a change in production structure is useful or not. The research question, the central solution components, the solution hypothesis and the possible target image to present the result should be discussed first. These elements form the basis of the methodology.

Research question

To take a systematic decision the following research questions, which can be derived from the explanations in chapter 2, have to be answered:

- Which maximum performance can be achieved with a new configuration of the production planning?
- How is the current performance assessed?
- How high is the performance after the change in production structure?
- How high is the performance after the change in production structure?
- What are the ratios of performance enhancement in the new structure? When will the efforts and dissipation have been amortized?

Summarizing these questions the superior research question results:

- How can the potential performance of a production structure determined?

Solution elements

There are two solution components that allow the later described methodology. The first solution component is a simulation platform. The platform offers a method library for the configuration of the PPC. The library is based on the model of PPC by Lödding and therefore the methods are divided into four areas: job creation, job release, sequencing and operational capacity control. Furthermore it allows an automated modelling of a certain production based on simple feedback data. With this platform it is also possible to execute and evaluate experimental designs automatically. Due to these conditions the realization of many simulation runs with different configurations of the PPC can be done in short time. Typical logistic key figures like lead time, WIP, workload, adherence to delivery dates and throughput are recorded for analysis.

The second solution component is a experimental design, which considering the principals of the DoE (Design of experiments)-approach systematically examines the influence of the PPC on the logistic key figures. At the same time it focuses on a minimum amount of simulation runs. Combining the different methods may otherwise generate a great number of simulation runs, which leads to long computing times and as a consequence the approach would not be practicable.

Solution hypothesis

To answer the question posed above three assumptions are postulated:

1) The performance of a production is determined to a significant proportion by its structure! It is a trivial correlation, but as a first step in the causal chain it is essential for further considerations. Due to the given job program with products

that have a certain number of process steps and a certain processing time, which are typical structure determining sizes, a certain limit is given that cannot be exceeded with a reconfiguration of the PPC.

2) The influence of the production structure can be determined by the variance of the performance of the production control! The more sensitive a performance indicator changes - influenced by the production planning and control - the lower is the ratio to the performance, which is due to the structure fix. The same applies the other way, see case study in Chapter 2.

3) The sensitivity of the performance indicator concerning the production control allows conclusions about the CIP potential! The idea of the thesis is that the system performance consists of a fixed part, which is determined by the structure, and a flexible part that can be influenced by organizational measures. If the structural part of the performance is low, the performance indicator is relatively sensitive for organizational measures.

Possible target image

A possible target image for presentation and interpretation of variety of runs is given in Figure 2. The presentation of results in a parallel coordinate system is suitable in a special way, because the sensitivity of all considered targets is obvious. The different indicators are applied to the parallel vertical axes, whereas the value of the indicator in the different simulation runs are represented by the horizontal lines.

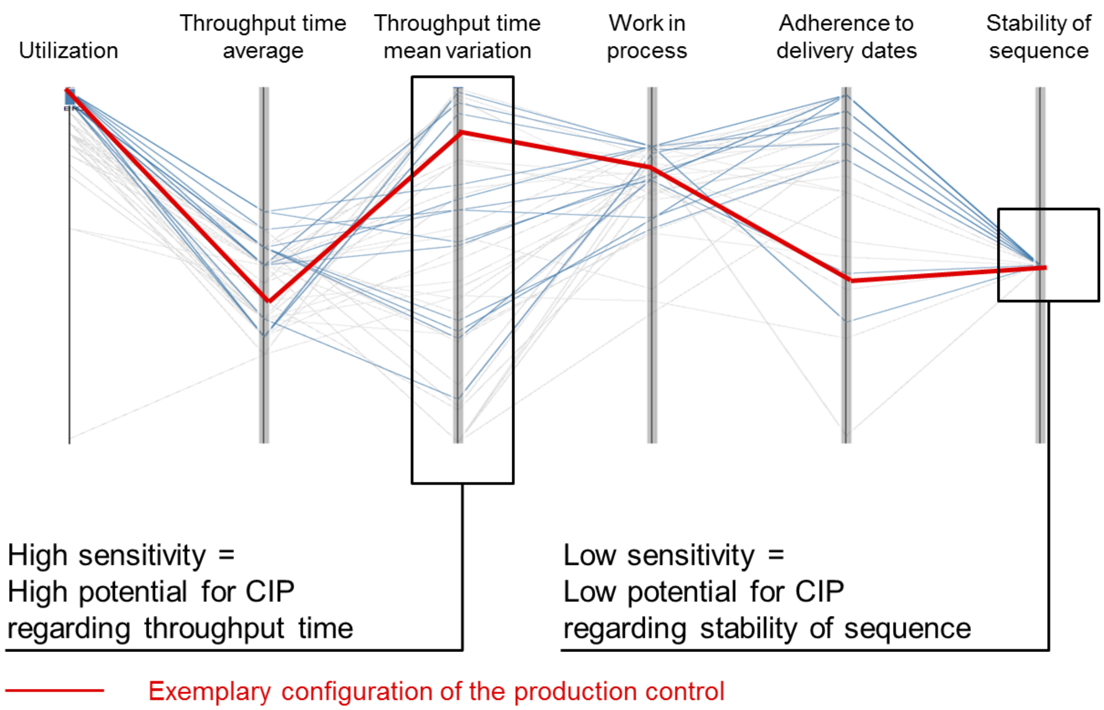

Figure 2 – Visualization concept with parallel coordinates (CIP = Continuous improvement Processes)

Methodology

Hereinafter a systematic approach to decide whether a change in production structure is useful is presented.

The procedure includes the following steps:

1) Data acquisition and processing, creation of the simulation model: The main characteristics of a production are considered as input data to set up the specific simulation model. A pragmatic approach is the use of production data which is typically recorded for most of the production sites. Thus the production program, all machinery, the process chains as well as processing- and machine set-up time are considered. Furthermore data for the availability of machines should be used. This indicator cannot be taken from production data and has to be recorded additionally.
2) Automated simulation of the experimental design (different configurations of the PPC) and evaluating of the current configuration: The platform is able to execute automatically all runs defined in an experimental design.
3) Introducing structural changes: After creating the initial scenario and the evaluation of the potential performance of the original system in the following step desired structural changes are made within the data set. This could include for example an adjustment of the product portfolio or rewriting of work plans. Afterwards the experimental design is again applied on the changed data set.
4) Summary and interpretation of results: Finally, the scenarios are compared with each other and a strategic decision has to be taken. The following information is available to the decision makers after the execution of step 1) to 3): From step 2 one can estimate the potential of the original structure by comparing the maximum values of the target indicators of different simulations and the results of the original scenario with actual configuration. The same information is delivered in 3 for a modified system.

The aforementioned method has to be supplemented by an economy analysis, in which the investment requirements for eventual restructuring are estimated.

Conclusion

This paper introduces an approach that helps to decide whether a production should be improved by a change in production structure or by process improvements in the given structure. As a contradiction continuous improvement processes and the restructuring of a production were compared. Via a comprehensive literature research it was shown that an evaluation of the potential performance of a production system by the results of simulation studies is not reasonable. Based on the shown practical problem and the theory shortfall the concept of a method was introduced whereby a systematic decision making should be made possible.

Acknowledgments

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