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A Meta-Model for Analyzing the Influence of Production-Related Business Processes

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Abstract

The improvement of business processes is viewed as a key to competitive success. Since the beginning of the 1990s, many companies could increase their efficiency through initiatives improving the production process. Despite the existence of numerous different scientific approaches to improve the supporting processes of indirect business areas, comparable successes could not be achieved. In the literature for business process management, the described guidelines and methods for process prioritization are often of very high level and hence not of much assistance when attempting to use them on production-related business processes. Further approaches focus the modelling and analyzing of single processes. These are often very detailed and do not taking into account the interrelations and influences that arise between the processes. An analysis and comparative evaluation of the production-related business processes of indirect areas does not exist. This paper presents an approach to analyze the influence of supporting business processes on the goals of their core process. Therefore, a meta-model is introduced to describe different types of interrelations between processes within in a process system by specific characteristics. The considered system includes the manufacturing process and its support processes as the interrelating elements. Based on the meta-model, influencing factors of the support processes on the characteristic values of the manufacturing process are determined. The paper contributes to theories on business process architecture and the modeling of process systems as well as the basics on system theory. In the literature review of this paper, different approaches for the selection of critical processes, the modelling of process systems and the interdependencies between processes are discussed.

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Keywords: business process prioritization; process systems modeling; process architecture; process interdependencies

1. Introduction

As part of the progressive digitalization holistic approaches for industrial processes, business models, services and labor organizations taking an increasingly important role [1]. The associated increase in complexity requires a paradigm shift. Operating point-optimized, corporate value chains have to be converted into flexible enterprise-wide value networks. Problem-specific IT solutions have to be replaced by an integrated production and supply chain management, and the focus of the function optimization has to be consummated towards more process orientation [2]. Particularly manufacturing companies face the challenges of dealing with extended and constantly changing value chains [3]. At least since the beginning of the internationalization of markets and the consequential cost pressure everything is given to optimize production processes and increase the added value in business processes [4]. During the last decades, the productivity of production processes could be increased significantly through continuous improvement by avoiding waste and consistent focus on the value added [5]. In indirect business areas (supporting departments, e.g. planning, development, administration, etc.) such increases in productivity could not be achieved [6]. A study of the Institute for Machine Tools and Industrial Management (*iwb*) of the Technical University of Munich, which focused the dissemination of lean principles

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and methods in indirect business areas, shows that these parts of the value chain, have major potentials for rationalization and improvement [7]. Over time, many approaches to improve business processes in indirect business areas have been developed. These focus mainly on extensive analysis to determine the performance of individual business processes and redesign them to achieve lower costs and improve quality [8]. Against the background of limited resources and a continued strong functional orientation in the indirect business areas it often comes to a local optimization of processes, which in many cases does not yield the desired success [9]. Few approaches grappled with identifying those processes that are truly important for value creation. As in manufacturing processes, companies are forced to analyze the business processes in the indirect areas in terms of added value [10]. This begs the question which processes are important for value creation and therefore which processes should be improved or supported [8; 11; 12] to secure a long-term corporate success. Because of the insufficient transparency in their process landscape, many companies struggle to make profound decisions about what processes make a contribution to value creation. This is mainly because the causal relationships between the supporting processes and the actual value creation process are not sufficiently known. Furthermore there are no benchmarks that would allow a comparative assessment of the different processes.

Starting from a brief literature review of process prioritization methods and the modeling of process systems, this paper presents an approach for analyzing the influence of supporting business processes on the goals of their core process. Therefore, a meta-model is introduced to describe different types of interrelations between processes within a process system by specific characteristics.

2. Literature review

2.1. Goals for improvement of business processes

In recent years, the improvement of business processes in indirect business areas was broadly investigated. Two different paths are followed substantially. The concept of Business Process Reengineering requires a radical redesign of business processes [13]. The focus is mainly on the identification and design of new and ideal processes, [14]. The other concepts pursue a continuous improvement approach. Here, existing processes will be further developed with regard to certain outcomes.

The literature about process improvement focus mostly on the increase of efficiency [15]. For this, single processes are analyzed and evaluated in terms of different performance parameters [14]. The different approaches in this field of research provide performance parameters like process quality or quality of results [16], process costs [17], but also the productivity [18], cycle time, delivery dates and waste or value of a processes [5; 7; 8].

The aim of most approaches is to identify the weaknesses that lead to a reduction of the performance parameters and take the adequate measures. However, the mentioned approaches only consider single main processes of a company. Supporting processes and their impact on the performance of the main process are not considered.

2.2. Prioritization of business processes

Due to limited resources, some of the existing approaches on process improvement state to make a selection of processes before starting the improvement initiatives [12; 19]. Therefore, we can find different selection criteria in literature. Besides the importance [20] of a process, Davenport names the urgency and conflict potential with the business vision as selection criteria [20]. Additionally to the importance of a process, Hammer & Champy suggest a focus on the most deficient processes on the one hand and the processes with the highest susceptibility to improvement measures on the other hand [13].

Recent approaches try to operationalize the evaluation of different criteria and integrate the findings into guidelines for practitioners. Ohlsson et al. e.g. describe a tool to analyse processes from different perspectives. Besides the alignment of the process with the business strategy, the process performance, the measurability, the formality and the availability of capabilities for process improvements also the degree to which a process interacts in a value network are regarded [9]. The interaction of processes arises among others in case of failure of a process that effects the organization or has an impact on organizational goals. Huxley presents these criteria in course of the development of a method for identifying critical business process [21], however, without specifying the dependencies.

The considered approaches show that there are different opportunities and criteria for selecting processes. However there is still no approach that takes into account the influences between processes within a focused process system.

2.3. Process system modelling

Similar to the company also the process landscape of a company can be considered as a system [22]. The interrelations and predominant causal chains within the system are manifold and difficult to comprehend [14].

To provide an overview of all the processes of an organization (core, support and management processes) and to visualize the relationships between them, so-called process maps are used [23]. Malinova & Mendling have shown that the correct design of process map can contribute to achieve the objectives of business process management, such as increasing the transparency as well as the efficiency of processes [24].

For optimizing business processes within a process system a high level view on their interdependencies is necessary [11]. Approaches within the field of Business Process Architecture are dealing with designing, structuring, managing and maintaining large process model collections [25 - 29].

Other approaches only focus on the formalizing of inter-process relationships in order to establish inter-process relationships in a process repository [30] or integrate existing information systems [31]. However, none of the approaches described is focusing on the specification of the relationships and interrelations between support processes and the associated main process.

Summarizing the state of the art, the influences of supporting processes on the manufacturing process are a highly relevant field of research for business process improvement. Despite the amount of knowledge created about improving single processes in indirect business areas, the modelling of process systems and the formalizing of interrelations between business processes, there is still a need for a model of the process system comprising the production process and its supporting processes that can be used to describe the influences within this system.

3. Influences within a process system

3.1. Defining the focused process system

Basis of the considerations is the understanding of a business process as a system. Figure 1 shows the meta-model of a process system, which should be examined as to the impact, the supporting processes can have on the objectives of the main process. It consists of several subsystems - the processes that are mutually in close operative relations and is delimited to the outside.

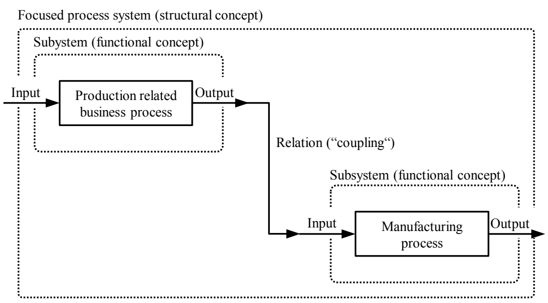

Fig. 1: Focused process system

The *manufacturing process* can be categorized as the primary and significantly value-adding core process (main process). A *production related business process* is a secondary, the main process supporting business process. It is defined as a collection of activities that create a direct output for the manufacturing process of one or more types of input [13]. As examples of production-related business processes maintenance processes, processes for delivery of materials and other resources but also for order processing and other information processes.

The definition is already an indication of the relation the subsystems have to each other. The occurring relation here can be described as a "coupling", in which the output of a subsystem is the input of another subsystem. Through this coupling relation, the production-related business process in any way affects the manufacturing process and can make an impact on its performance. The aim is to investigate which factors determine the degree of influence.

3.2. Dimensions of influencing factors

For the identification of the influencing factors it is necessary to look at the different elements of the considered process system. Table 1 shows the different dimensions of influencing factors and gives some examples.

Table 1. Dimensions of influencing factors

Attributes of production related business processes	Output	Relations	Influence factors of the manufacturing process
Repetition rate	Material	Trigger	Production type
Duration	Information	Enabler	Number of units
Volatility	Service		Batch
…			…

The first dimension is the *output* that is generated by the production-related business process and serves as *input* for the manufacturing process. In systems theory, the outputs are assigned to the categories of information, mass and energy. Also in the focused process system, the information is a potential output. One example is the order document, which provides information to accomplish a production task as a paper document or electronic format. A further output category is the material. Production-related business processes creating material as output are essentially logistic processes. These supply the production process with the necessary semi-finished products or raw materials. Also delivery processes for set-up tools or other needed materials can be allocated to this category. The last output category is service. Some production-related business processes support the manufacturing process by providing a service to it and thereby affecting its performance.

Other potential factors can be found in the *attributes of the production-related business processes*. As an example we can take a look at the attribute "frequency of repetition" of a process. Differ two loss-making processes only in the frequency of their repetition, it may be assumed that the process with the more occurrence takes a correspondingly higher impact on the production process. For the identification of potential influencing factors various approaches to attribute-based modeling of processes have been studied and compared. Here, more than a hundred attributes are identified. However, after an initial analysis, only a few can be used as factors within the meaning of this work. In addition to the above-mentioned frequency of repetition also the duration, reliability and the volatility of production-related business processes are factors influencing the performance of the manufacturing process.

In addition to the *output* and the *attributes of the production-related business process*, the present *relation* can influence the performance of the production process. Here it is to make the distinction between triggers and enablers. A trigger relation describes that the input of the production-related business process starts an action in the production process. In an Enabler relation a certain amount of time elapse until the use of accomplished inputs.

The extent of influences between production-related business processes and the production process depends not only on the factors already mentioned, but also and largely from the production process and its properties. For example there is different impact of a delay, caused by the production-related business process in a flow production than at a non flow-oriented production.

In this context, other influencing factors are existing which are not further discussed in this paper.

3.3. Specification of the impact

For further investigation, the impact that production-related business process have on the manufacturing process has to be specified. Therefore, the following aspects should be considered:

What types of effects should be assumed?

In this paper only the impact occurring on the outcomes of the production process should be considered. In addition, an ideal production process in which no structural changes have taken place is assumed. This means that no changes are made in the structural model of the subsystem "manufacturing process". Moreover, only to changes in the output of the production process are taken into account, resulting from a loss-making input. For example, the impact can be characterized by a reduction in productivity, decreased time delivery or an increased cycle time. Next to this impact types also a quantification of the effects in the form of rework costs is conceivable.

Which key figures of the production processes can be used to quantify the extent of impact?

Looking at the sub-system "Manufacturing process" and the input of the production-related business processes, it is evident that there is a “coupling” relation with the subsystems "Process steps" (Figure 2).

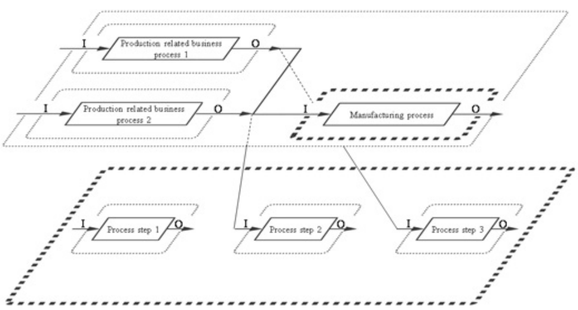

Figure 2: “Coupling” between production related business process and process steps of the manufacturing process

This also must be considered in the collection of effects. Therefore, the key figures of a “process step” have to be used for a quantification of an impact. Concerning this, the key figures of existing modeling rules, such as the value stream mapping according to Martin & Osterling can be used [32].

How can the comparability between the different processes will be made?

To ensure the comparability of the various processes the different types of impacts are used as a reference. Furthermore, for the collection of influences identical deficits are adopted for the production-related business processes. These are including delays or qualitative deficiencies (especially the material or information).

4. Results

First results will be shown on the basis of a fictitious and simplified example. The process system shown in Figure 3 comprises a simple manufacturing process and three

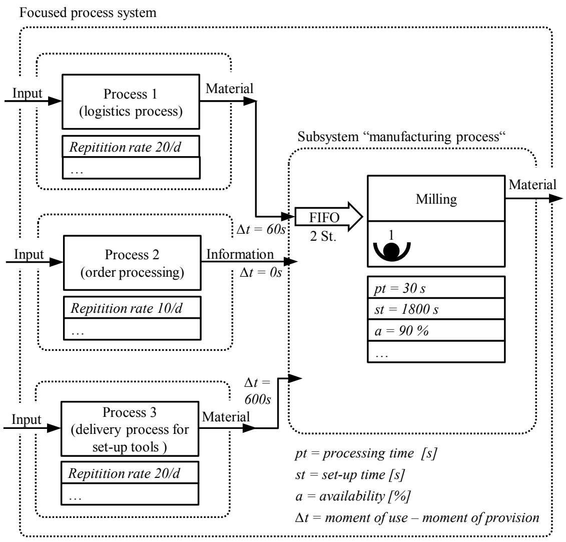

Figure 3: Simple process system for case-study

production-related business processes.

These all provide a direct input for the production process. However, there are different relations. While Process 1 and 3 can be understood as so-called “enabler”, the order processing is a “trigger” process. The difference is reflected in the index Δt, which represents the difference between the time of use and the time of deployment. As further influencing factors, different repetition rates for the production-related business processes are assumed.

To ensure comparability, we consider an identical delay for the respective outputs of t_v = 180 seconds. To determine the impact of each production related business process the following formula can be used.

$$impact\ i_{p_j} = (repitition\ rate * (180s - \Delta t))/pt \quad (1)$$

The result expresses how many components cannot be produced due to the delay. For each process arises therefore:

P1: 80 components
P2: 6 components
P3: 0 components

With the given boundary conditions and taking into account the few influencing factors, the logistic process has the greatest impact on the production process in the focused process system.

5. Discussion and future research

The findings from this paper have several implications for research. In this paper a meta-model of a process system is described which includes the production process and its supporting processes. With the selected system theory approach it is possible to limit the search for influencing factors according to the elements in the system. This paper sets a starting point for the investigation and quantification of influences between support processes and the main process. The approach can be used as a basis for the further identification of influencing factors. In terms of implications for future research, the analysis we present provides a basis for a methodology to determine influences of production related business processes in practice.

6. Conclusion

At the light of business process improvement, the relationships within existing process landscapes remain of interest for manufacturing companies. Up to date, research focused mainly on the improvement of single core processes. When it comes to prioritization of critical processes for improvement, the effect and the impact on organizational goals are provided as selection criteria but not really specified. Approaches dealing with process maps or business process architectures make a contribution to a better understanding and modeling of interdependencies. This enables an increased transparency of possible influences within process systems. This paper introduces a meta-model to describe different types of interrelations between processes within a process system. Results extend the understanding of influences production-related business processes have on the goals of the production process.

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