JCC
Journal of
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GRADUATE BUSINESS SCHOOL

Short Communication

Model-based Reorganization of Factory Structures

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Abstract

Producing companies are facing a turbulent environment and, therefore, the reorganization of a factory becomes a continuous task. In this paper, the first part of a model-based support for the planning of a factory's organizational structure is shown. A description model consistent of different structure elements will be presented. This paper shows the first part of a description model for the reorganization of a factory.

Keywords: Reorganization planning, factory structure, description model

JEL Classification codes: D20, M11, L23

http://dx.doi.org/10.7835/jcc-berj-2015-0107

Factory planning became a continuous task for producing companies. Due to the transformation from a suppliers' market to a buyers' market, and the connected rising desire of the customers for individualization, an increased diversity of variants arose, that producing companies need to deal with. The greater segmentation and the resulting quicker saturation of market segments led to a shortening in product life cycles in the last decades. Thus, companies have to deal with the challenge to develop and introduce new products and therefore realize the production within their factories. This not only results in a higher frequency in planning factories, but also in different requirements for factory planning: the planners need to realize shorter planning times within the review of the existing factory concepts, although there is to some extent only a vague database (Figure 1).

In particular, the reorganization, i.e., the modification of factories, can be identified as the planning case that is the most common one. For the evaluation of a production's competitiveness, it is necessary to review the underlying connections and dependencies between single elements of a factory because these elements and their connections are determining the production and, therefore, the performance of the factory (Schulze, 2013). The elements of a factory and their connections among each other are also referred as factory structure (Harms, 2004). However, there is no comprehensive description model in the literature that is able to point out the need for changes. Therefore, the Institute for Production Systems and Logistics of Leibniz University of Hannover developed a description model for the reorganization of factories. The objective of this research project is to develop a model-based analysis of impacts of external and internal changes, so-called change drivers, on an existing factory structure. The idea is to determine the influenced elements with this analysis and to display the elements to the planner that are affected the most by the change.

The second part of this paper presents the fundamentals for the further explanations. This includes, among others, the definition of terms and the change drivers for reorganizations in factories. The third part starts with the definition of the considered system, its boundaries and possible interactions with the company's surroundings. Subsequently, the relevant elements of a factory structure will be introduced. Then, a short overview on the intended description model will be given. Finally, the paper concludes with a summary and an outlook on the further research activities.

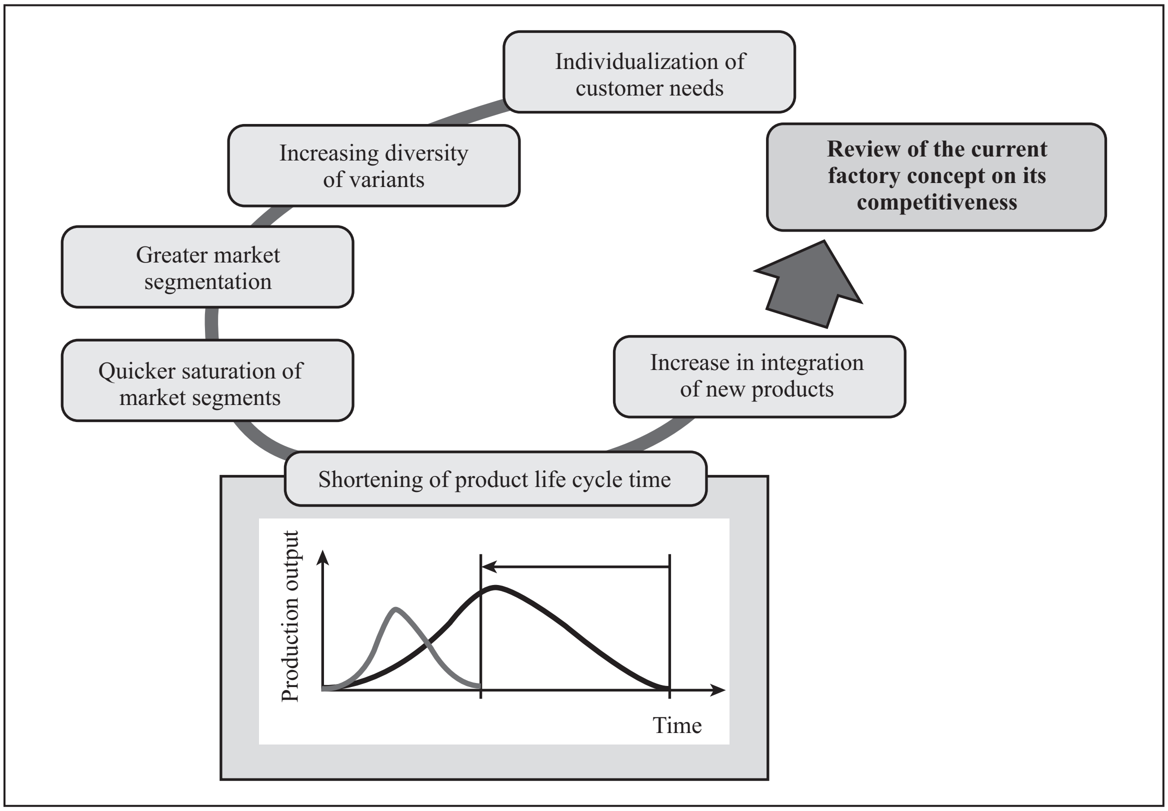


Figure 1. Increasing importance of factory planning (Nyhuis, 2014).

Fundamentals

Factory, Factory Structure, and Structure Elements

The term factory has been defined by the Association of German Engineers (VDI), by the conclusion of different understandings in literature, as a "place where value is created by the manufacture of industrial goods based on division of labour while utilizing production factors" (VDI, 2011).

The structure of a factory has also been defined in the VDI guideline 5200 as functional and organizational units and their connections among each other (VDI, 2011). For the development, as well as for the reorganization of a structure, the partition into factory levels is quite helpful. These have also been defined by the VDI into: workstation, section, factory, site, and production network (VDI, 2011). The level production network is not subject of factory planning (Schulze, 2013) and for this reason it will be excluded of the further considerations. During the structure planning, these levels can be considered and detailed out separately and be brought together in a later planning step. Different segmentation options, as explained by Wiendahl, Nyhuis, and Reichardt (2014), can be used.

The elements of a factory structure can be considered as the smallest relevant units of the considered system, although they can be understood as systems for themselves as well. For example, in the system factory, the means of production are considered as elements although the machine tool can also be understood as a system (Wiendahl, Nyhuis, & Reichardt, 2014).

Factory Planning Process

The VDI established a planning process in the VDI guideline 5200, which has been applied successfully several times and therefore it can be considered as reliable. The planning process is subdivided into seven phases which are processed sequentially or iteratively when needed: setting of objectives, establishment of the project basis, concept planning, detailed planning, preparation for realization, monitoring of realization, and ramp-up support. The planning process has to be supported by a professional project manager (VDI, 2011) to ensure the achievement of the defined goals regarding time and costs.

Structure planning and dimensioning are part of the phase concept planning, therefore it represents the first part of the development of the factory concept. For the reorganization of a factory, the existing processes and planning restrictions need to be understood and evaluated in the phase of the establishment of the project basis. Necessary changes then need to be identified and expanded to include the aspect of the feasibility of planning results within the current factory operation (Schulze, 2013). Due to the fact that the result of the structure planning is the basis for decision along the further factory planning process, the selection of the most suitable structure variant is of particular importance (Pawellek, 2008).

Reasons for Reorganizations

The reorganization, also considered as replanning, is along with the development planning and the expansion planning, one of the basic types of planning (Wiendahl et al., 2014). Furthermore, it is the most common basic type of planning. (Dombrowski, Hennersdorf, & Palluck, 2007). Enabler for changes can result out of the surrounding of a factory as well as the company itself and are characterized in the following as external and internal change drivers, according to Klemke (2014).

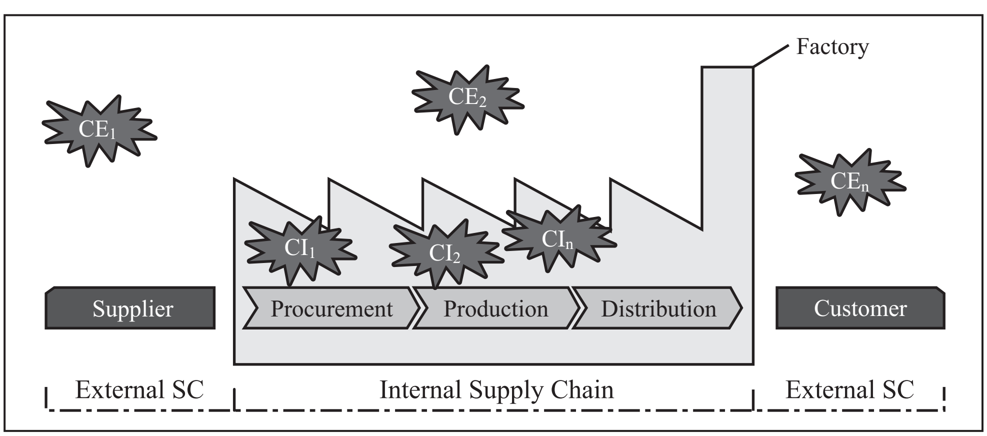
The generally admitted selection criteria have been developed as the general basis for the description model and the influences, which could have an impact on the factory structure through internal or external change drivers. Applying these, the change drivers with a direct impact on elements of the factory have been identified (Richter, Lübkemann, & Nyhuis, 2014). This catalog of change drivers represents the first part of the description model.

Structural Elements of a Factory

Description of the Considered System

It is necessary to define the system and the system boundaries of the subject that needs to be modeled, in order to develop a description model. The considered system of the presented research project is the factory, which is a socio-technical system (Heinen, 2011; Kuhn, 1998).

In modeling the system we focus on the internal supply chain that is from procurement through production to distribution (Injazz & Paulraj, 2004). When we consider the structure, the main links to the surrounding of the factory are usually the incoming and outgoing goods departments. In particular, the processes and concepts for procurement and distribution play an important and influencing role of the system, because they determine the procedures within these departments. However, the production is mainly influenced and determined by the manufacturing processes. The boundaries of the system are characterized by the interaction with suppliers and customers to ensure the consideration of the direct and indirect value adding processes with a significant impact on the factory structure. As shown in Figure 2, the system is influenced by a high number of different change drivers, which do have an either external or internal character. In some cases, there are even combinations of change drivers that increase the pressure for change.



Note. CE = External Change Driver; Cl = Internal Change Driver; SC = Supply Chain.

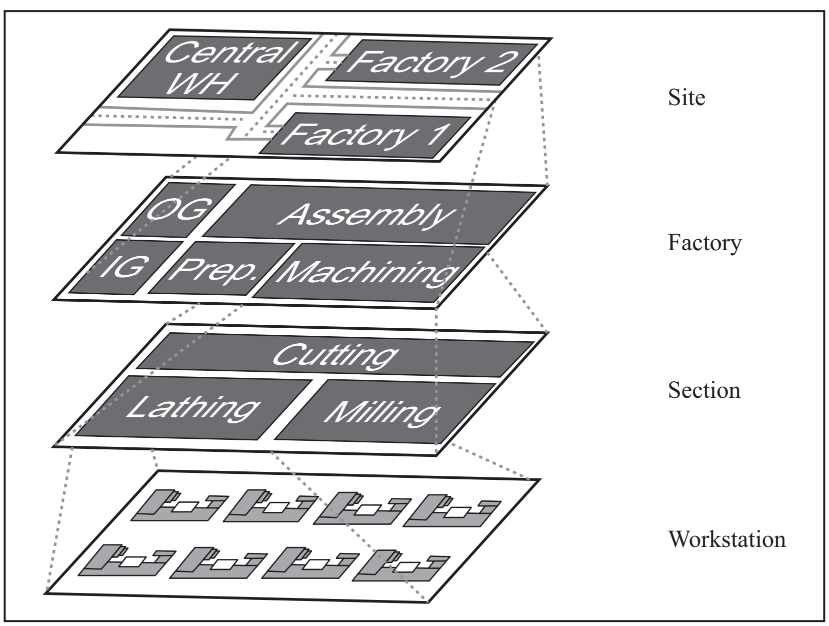
Figure 2. Considered system.

Structure Elements

For the identification and description of the elements that need to be taken into account, the considered system is subdivided by the application of the factory level approach (see also Figure 3). Each of the levels can be described individually and can be combined with the other levels later on. If the factory is well known, a top-down approach can be recommended to describe the present situation, for example, for the identification of defined sections by the consideration of the organigram and the plant layouts. The great advantage of the level approach is the fact that each level is an aggregation of the lower level information. If this information is now aggregated into subsections for the modeling of the next higher level and combined with other information, it results into a description of an area, as well as the relationships between the subsections.

An example for this relationship is illustrated in Figure 3. The site in this example consists of two factories and a central warehouse. On the factory level, the structure of factory 2 is illustrated. It has a separate section for incoming goods as well as for outgoing goods, one section for the material preparation, for the machining and also for the assembly. The machining section is further broken down into the subsections cutting, lathing and milling. On the workstation level, several manufacturing facilities (in this case lathing machines) that are assigned to the subsection lathing are illustrated. It is now possible to describe the different processes (e.g., logistics, material supply) to get a more detailed view.

According to Wiendahl, the manufacturing facilities can be characterized as manufacturing, assembly and logistics means (Wiendahl et al., 2014). Besides the information of the assignment of individual production equipment to different (sub)sections of the factory, it is now possible to describe the processes and connections between individual facilities from a more detailed perspective by adding information of different concepts that were taken into account. Among many other concepts, there are the manufacturing principle and the inventory concept, as well as the order penetration point, which can be identified for each product family. It is now possible to visualize the material as well as the information flow inside the factory. It is also possible to derive further information, such as material supply or the transport routes concept between individual areas. However, it is obvious that the same elements are used only in an aggregated form in the structure.



Note. WH = Warehouse; OG = Outgoing Goods; IG = Incoming Goods; Prep. = Material Preparation.

Figure 3. Factory levels and elements.

Hence, it can be summarized that the structure of the factory can be modeled from a manageable number of physical elements: production facilities divided into manufacturing, assembly, and logistic means. These are complemented by a wealth of information on a conceptual level, which will be referred to in the context of modeling as conceptual elements. These include, as already mentioned, some concepts such as material supply and distribution, the segmentation options applicable to the formation of areas, as well as the fire-prevention concept (Wiendahl, 2005).

Description Model

The description model for the reorganization of factory structures consists of three parts. The first part is the catalog of change drivers with a direct influence on the structural elements of a factory, whose development is described in Richter, Lübkemann, and Nyhuis (2014). The second part is the catalog of factory structural elements, which can be used to model the factory‘s structure and which were described in the third section of this paper. In the third part of the description model, different concepts of factory planning and factory operations are described.

For merging the different parts of the model, a qualitative impact analysis has been carried out to describe the impacts between the different contents of the three blocks. Here, the connections were described initially within each of the three parts and further on across the parts of the model.

The merged and described interrelationships represent the model to describe the reorganization of factories. In order to make it applicable in practice of factory planning, an approach has to be developed to visualize the initial situation of the factory planning project. By querying data that has been received within the basic evaluation, the model is supplied with information that allows an evaluation of impacts caused by change drivers, using the described interrelationships. The collected information includes the production processes and currently available areas of the factory and their description.

The aim is to operationalize the model in a way that a list of relevant structural elements is presented to the user, as far as possible ranked by the degree of influence, so that the experienced factory planner is able to put a special emphasis on the further planning of the factory structure. The interpretation and checking whether and to what extent the various structural elements have to be adjusted is the concern of the factory planner.

Conclusion

The factory planning has become a continuous task in producing companies. The planners of factories are faced with the challenge of being able to react quickly to changes and to give an estimation of their impact on the factory. At the Institute for Production Systems and Logistics at the Leibniz University Hannover, a description model is developed within the framework of a research project, which is aimed at estimating changes to the structure of an existing factory. The paper describes how the considered system is defined, which sections of a factory need to be evaluated, and what the essential elements of a plant structure are. The fourth part of the paper gives an idea on the further research activities that need to be taken into account.

The described model needs to be operationalized in the further course of the research project. For this purpose, the elements listed in this paper, in particular the illustrated structural elements as well as the different concepts, are comprehensively examined and detailed by using attributes or qualitative statements. Then, the calculated effective relationships between all elements and drivers for change are brought together to form a complete model, which opens to the possibility in a user-friendly tool as described in the description model section. This helps the factory planners to examine new possible forms of the structural element in a short time. The procedure for application of the tool is also described in detail and subsequently validated. In the future, the model will help to reduce planning times and support the planner in the process to achieve a higher planning quality.

The big advantage of the final tool is the fast and easy analysis of the current situation and the consequences that result for the factory. The planner will not only be able to collect the necessary information, but also receives a quick analysis, in which structural elements are affected by the present change driver. This allows the planner to consider the most relevant changes. He loses little time in contrast to today’s conventional manual evaluation of information and can focus on adapting the factory structure. In general, the described approach helps to considerably reduce the planning time for reorganization.

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This research was made possible through the generous funding by the German Research Foundation (DFG) in the context of the project "Model-based Redesign of Factories (ReFa)", which is funded under the sign NY 4/56-1.