Productivity Strategies Using Digital Information Systems in Production Environments

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Abstract. High productivity is essential for companies in order to survive in international competition, especially for those located in high-wage countries. Recent developments of digitalization open up new opportunities to manage and increase productivity. The development of company-specific strategies for the management of productivity, which are increasingly embossed by digitalization, is therefore an elementary task. This paper presents a framework for systematic design of productivity strategies for industrial production and explains conceptual potentials for the design of strategies. A detailed description of terms provides the necessary understanding. The framework encompasses three axes, the goal of productivity, the application of digital information management in industrial production and the different direct production areas as well as indirect supporting areas. The application of this framework is described for different corporate levels considering task- and goal-setting for various time horizons as well as an integrative view on technological, organizational and personnel aspects.

Keywords: Productivity management · Industry 4.0 · Design framework · Digitalization · Strategic process development

1 Introduction

Successful companies guide their actions along a basic long-term guideline, the so-called vision. The approach for realizing this vision and thus the organization's orientation towards action in competition is known as a strategy (Neumann 2008).

In industrial manufacturing, processing is performed to transform input factors into output. These inputs contain raw materials and auxiliaries, intermediate products and other operating materials, which pass through value-adding production processes, resulting in finished products (Günther and Tempelmeier 2012). The relationship between output and the use of production factors is called productivity (Wöhe 2002).

The term Industry 4.0 describes the usage of information and communication technologies for industrial production processes to improve value creation (Roth 2016; ifaa 2016). Digitalized processes in the manufacturing industry open new possibilities for productivity improvement. At the same time, digitalization can be used to adjust a company's strategy as well as product and service offerings (Roth 2016).

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It is important for companies to have high productivity in order to survive in international competition. Productivity gains are essential to overcome higher costs compared to competitors. All processes in a company directly or indirectly influence its productivity. This applies to direct as well as to indirect areas.

For this reason, it is necessary to monitor productivity and influence it in an effective way. This should be done by planning and implementing a holistic strategic approach including strategic goals that can be measured by performance figures. They need to be continuously steered and controlled. These tasks are described by the term productivity management.

Productivity management is carried out for the continuous improvement of a company's activities with regard to increasing effectiveness and efficiency (Gackstatter 2011) and thus goes beyond the mere consideration of the ratio of output to input. The undertaken activities for influencing productivity should have at least a mid-term scope and therefore have to be linked to the company's strategic goals.

The term "productivity strategy" stands for the possibility to choose various options for influencing productivity within the boundaries of a previously defined organizational strategy with its business model and core activities (ifaa 2016). Within the context of strategic productivity management, a company's activities are geared towards long-term influencing and targeted use of productivity (enhancement) strategies. This includes the assurance of positive results by strategic productivity planning (e.g. defined values for selected productivity key performance indicators), the implementation of this planning, a continuous evaluation of the productivity development and its controlling (Dorner and Stowasser 2012; ifaa 2015).

Basically, productivity strategies can be classified by the aimed change of the ratio of output to input. Approaches to influence productivity focus – in general – either on the reduction of input (material, time etc.) or on the improvement of output (number of goods, customer satisfaction etc.) (Weber et al. 2017; Ruch 1982).

2 Use of Digitalization for Improving Productivity

A productivity strategy is determined by the production strategy chosen to implement the business strategy. The production strategy essentially describes the use of production concepts and technologies, including the production system and the process structure. To design a production system and its processes with an adequate flow of information, the design and implementation of state-of-the-art computer-assisted information systems is highly requested (Gackstatter 2011).

Improvements of productivity can be reached by using information and communication technologies if they are integrated in the design of industrial production and its processes. The recent developments of digitalization within this decade open up new opportunities for the management and improvement of production (e.g. human-robot-collaboration, data glasses, automated guided vehicles or exoskeletons, among others. See (ifaa 2016) for examples and their application). Mainly the adaptation of productivity strategies using computer-based information management in alignment with the specific surrounding conditions and requirements of the company in scope are

promising. The degree of utilization of IT-integration and digitalization already implemented in the company needs obviously to be considered. In order to be able to use additional digital tools and IT technologies, it may be necessary to adapt the IT infrastructure (Schlick et al. 2017).

Possible outcomes of implementing productivity strategies based on IT are – for example – improved resource allocation by optimizing production, preventive maintenance based on sensor-captured real-time machine data or the use of extensive simulations based on a continuous digital engineering using Augmented or Virtual Reality (Roth 2016).

However, the diversity of techniques, standards and their impact on all business processes makes it difficult to choose and implement them (Samulat 2017). It is therefore necessary to develop strategies for the management of productivity in IT-integrated and digitized work systems and to prepare them for practical application. All potentials of digitalization should be taken into account for the design of work places and processes. The technology can be used to support human performance, or to decrease the consumption of material or energy. There is also a great possibility for decreasing actual process times (Weber et al. 2017; Meiller and Niewiera 2016).

Since digitalization allows an improved information provision, it can be used to reduce the complexity of information handling (collection, transferring, processing, providing, usage), while at the same time improving productivity. For this purpose, the necessary steps from data collection to data usage must be coordinated, so that the data can be processed fully-digitized without media breaks and can be used in an integrative manner to influence productivity management strategically.

3 Framework for Clustering Productivity Strategies

Operational decisions to improve productivity focus on influencing input and/or output factors. One should have the best possible understanding of the interdependencies between those factors (ifaa 2016). Based on the information provided previously, the productivity goal – influencing input or output – and possible applications of digital information management in industrial production can be combined to a matrix. Additionally, a third axis can be added to assign approaches out of the matrix to the tasks performed in different direct production areas – including all material handling and intralogistic activities – as well as in the indirect areas supporting production, such as scheduling, controlling, management and leadership, training, legal advisory service etc. The resulting cube (compare Fig. 1) serves as a framework for the classification and further development of productivity strategies.

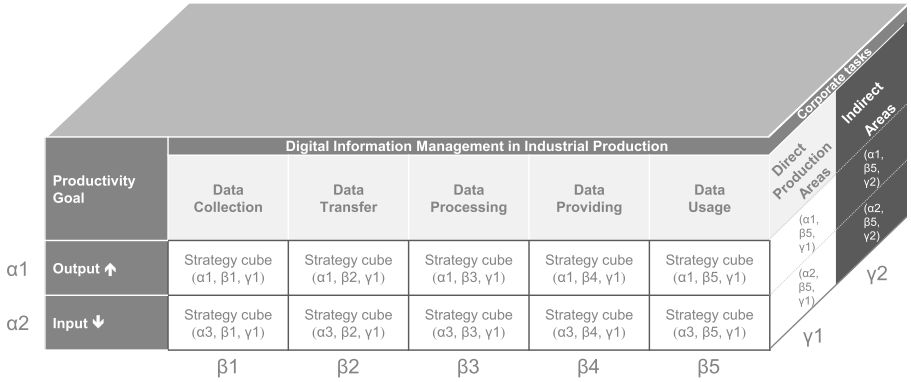

Fig. 1. Framework for systematic design of productivity strategies in digitized working environments.

For each of the twenty cubes of the so-called "organizational and design framework", different productivity strategies can be classified. These strategies can be independently of each other or have strong interactions with one another. Based on this framework, various productivity strategies for industrial production can be structured and evaluated, taking into account the impact of IT and digitalization. To do so, it is important to assess a productivity strategy for its contribution to each cube. Subsequently, fundamental potentials for the design and development of productivity strategies can be derived.

To identify a single cube, we use (α, β, γ) to describe them. α represents the main effect influencing productivity, β stands for the application of digital information management and γ for the corporate application area. α1 and α2 assign the productivity goals of output enhancement and input diminishment. Digital information management is described by using β1 to β5, referring to data collection, data transfer, data processing, data providing and data usage. Finally, γ1 is used for all direct production areas and γ2 for the supporting indirect areas.

For example, (α2, β4, γ1) describes the cube for productivity strategies aiming at a decrease of input (α2) using digitalization for data providing (β4) within the production (γ1). A practical application could be the usage of handheld tablets to support the worker in manufacturing operations – e.g. by showing each single assembling step – which will lead to a decrease in time input necessary for performing the task. Other examples are given in (Weber et al. 2017).

4 Application of the Framework

The framework serves as a basis to sort and categorize productivity strategies into so-called strategy cubes. On this basis, a systematic design of strategies is supported. According to the cubic structure, this includes first an integrated analysis of the application of digitalization (from data collection to data usage), second the distinction between direct and indirect production tasks and finally a view on different aims to be reached by the strategies (enlargement of output or decrease in input).

4.1 How to Classify Productivity Strategies

The following three-step procedure is generally recommended (other approaches are possible as well) for the classification of existing productivity strategies into the framework:

- Step 1: Identification of columns most suitable categorizing the technical solution based on information and communication technology (determining β).
- Step 2: Determination of the area where the technology is applied (determining γ).
- Step 3: Examination of the impacts that can be achieved or that are expected from using the technology (determining α).

Especially in step 1, the distinction has to be made between the aspects offered by the strategy itself, and the components needed for a successful implementation of the strategy that are provided by supporting use of other technologies (e.g. before using a tablet for data providing as a possible main scope of a productivity strategy, these data obviously have to be processed before).

4.2 How to Search for Productivity Strategies

Searching a strategy within the framework can be done vice versa using the above mentioned proceeding. For example one can first focus on the application area (γ) in which productivity should be improved. In the second step, it can be regarded what can be done to decrease input, e.g. reducing the need for raw materials (α). Finally an application area for digitalization can be chosen to do so (β).

Other search strategies are possible as well, depending on the scope of search. In general, the company's specific needs should trigger the search for a suitable strategy within the framework. For example, the starting point could be a specific technology already in use (e.g. data glasses) and the searcher may look for increased effectivity to influence productivity. In this case β would be the starting point for this search within the framework.

4.3 Combining Productivity Strategies

The applicability of the framework and thus the possibilities for the implementation of selected productivity strategies adapted to specific corporate needs are versatile. This includes the selection of adequate productivity strategies, i.e. a selection of several strategies for a targeted influence on productivity, taking into account the opportunities of digitalization. For example, usage of sensor applications and individualized information provision by means of tablets can be used in parallel and ideally complement each other. The parallel use of several strategies is called strategy mix. A mix will probably be necessary in most cases to cover all needs of the organization to successfully influence productivity on the one hand and to take into account all data-related aspects needed for the implementation of IT-based strategies on the other hand.

The long-term goal of influencing and developing productivity requires a dynamic adaptation of the strategy mix. This will enable the organization to have always those

productivity strategies on hand that are currently required. The current status of usage of digitalization does not need to be the optimal one in another point in time.

Determining the right strategy mix is quite challenging. The non-linear and reciprocal relationships between input and output factors are often difficult to determine. In addition, the company should focus on those factors which it can directly affect (ifaa 2016; Wenger et al. 2011). Designing individualized productivity strategies and adapting them over time – within the constraints given or hardly to be changed – is an elementary task.

5 Incorporation of Productivity Goals and Data Management

Strategic approaches to achieve (long-term) productivity goals need to be successively broken down and concretized – e.g. in line with the St. Gallen management model (Rüegg-Stürm 2003) – in order to influence the daily work processes in a targeted manner. There are three major fields that need to be taken into regard (Fig. 2):

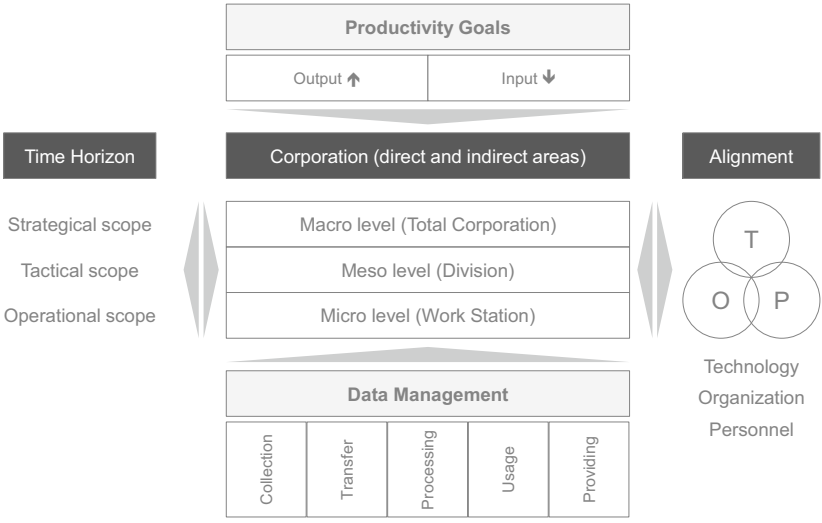

Fig. 2. Integrated view on productivity strategy implementation.

These three major fields to be considered while implementing productivity strategies can be specified as follows:

- Corporation: Productivity strategies using information and communication technologies – regardless of whether direct or indirect areas apply them – need first to be specified for different corporate levels. This means that the corporation as a whole (the macro level) needs to determine actions – as well as interdependencies among them, and these actions must be broken down for each single division (meso level) and further down to each single work stations (micro level).

- Time Horizon: For each application level of a productivity strategy, actions and goals – including key performance figures with their respective target values – must be set for several time horizons, namely for the long-term strategic scope, the mid-term tactical scope and the short-term operational scope. Therefore, every application level from macro to micro should have specific tasks and goals to be reached within different time horizons.
- Alignment: Finally, every usage of information and communication technology for long-term influencing of productivity must be successfully implemented. This requires that the three aspects technology (in a sense of selection, implementation etc.), organization (in a sense of process design and process interactions) and personnel (in a sense of ergonomics and human-oriented work design) need to be considered in an integrative manner.

For every productivity strategy categorized into the framework, all these aspects need to be considered to ensure a successful implementation.

6 Conclusion

Important terms like productivity management and strategies as well as an understanding of digitalization are explained in this article with regard to their integration into the strategic, long-term development of business models and processes. Fundamental opportunities of digitalization – also referred to as Industry 4.0, Smart Factory or Advanced Manufacturing among others – are presented. Based on this, a framework for systematic structuring and designing of productivity strategies is developed, in which various productivity strategies can be classified taking into account the use of information and communication technologies. This framework is based on three axes: the first axis addresses the desired outcome like improving output or decreasing input. The second axis describes the scope of the information and communication technique used. The third axis distinguishes direct or indirect areas for application.

Aspects for successful strategy implementation are mentioned, mainly that productivity strategies must be in-line with the actions performed by the whole company as well as by single work stations, that goals and tasks need to be specified for the long-run as well as for the short-run and that technological, organizational and personnel aspects need to be considered for designing work.

Researchers can classify IT-related strategies for productivity improvement by using the framework and taking into regard the above mentioned details while designing productivity strategies. Practitioners can first get ideas how to structure their existing approaches and how to search new ones systematically. In the long run, the framework will serve as a basis to list a multitude of productivity improvement strategies and identify good-practice examples. Therefore, the presented cube for structuring approaches of digitally supported productivity management and its integration into the strategic context of an organization needs to be further examined with regard to its operational applicability and practicability. The authors currently carry out several surveys to do so.

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