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PRODUCTION CONTROLLING IN THE DIGITAL AGE

Publisher

University of Rijeka, Faculty of Economics and Business

For the Publisher

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Print

Ispis, Zagreb

Edition

300 copies

Published

February 2019

ISBN 978-953-7813-44-4

The CIP record is available in the Catalogue of the Rijeka University Library under the number 140606011.

Under the Decision of the Publishing Committee of the University of Rijeka CLASS: 602-09/19-01/05, FILE NO.: 2170-57-03-19-2, this work has been published as a publication of the University of Rijeka.

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EFRI

Rijeka, 2019

Faculty of Economics
and Business

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PREFACE

The aim of this book is to present one of the most important parts of controlling – production – in its current 21st-century form – digitalization. Production is critical for the development of all societies and this is why measuring effects and overall company performance is of utmost importance. Digitalization is the current and future perspective embedded in almost every job and all segments of life. Controlling supports the management in the decision making process and is therefore not excluded from the impact of digitalized business processes.

This textbook is written for academic courses and practicing professionals. For the purpose of academic courses, the book is written as a core text for graduate and postgraduate students who want to acquire in-depth knowledge of the production controlling concept. For specialists like controllers, analysts, accountants, auditors, and other similar professions, the book provides an opportunity to apply their knowledge of the methodology that is to be used in strategic and operational process controlling. The five chapters of the textbook describe the essential approach to production controlling adapted to the needs of both students and professionals. Chapter 1 introduces the technological basis – Big Data. Cyber-physical systems are introduced for the purposes of business model creation and controlling. The introduction covers the impact of digitalization, and Chapter 2 describes the concrete concept of smart production, new forms and benefits of industrialization, business model in relation to smart production and economic dimension of Big Data, and the role of controllers. Chapter 3 discusses key performance indicators and a ratio system that can be used for controlling purposes. Chapter 4 deals with production process controlling starting with their components and determinants as success factors. Strategic and operational process controlling is described in detail by the methods and key performance indicators of value stream controlling. Production business model controlling is covered in the fifth chapter in which methodology is presented as a combination of process-oriented production controlling, supply chain controlling, and corporate controlling. Business model controlling methodology is based on innovation in production engineering and computer science, which calls for powerful IT business applications.

The beginning of this century was very dynamic. Rapid technological inventions, especially in IT, have been growing tremendously. What are the challenges of production controlling and what does it take to make it successful? The answers can be found in this textbook!

Acknowledgments

The authors would like to thank the reviewers, Professor Tina Vuko and Professor Tihomir Luković for their support and encouragement, Denisse Mandekić for diligent proofreading, and special thanks go to Antonija Petrlić for technical support during the review process. The authors thank the editor, University of Rijeka, all members of the Publishing Committee of the Rijeka Faculty of Economics and Business as well as the members of the Publishing Committee of the University of Rijeka who have supported and approved the publishing of this textbook.

Authors

September 2018

1. The Impact of Digitalization

Technological innovations bring possibilities and create a digital world. The impact of digitalization on the organizations' performance and business model creation is evident. "Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business."[1]

The fourth industrial revolution will lead to modular networking of processes in industrial companies or factories. An intelligent factory consists of Internet-based production in which manufacturing facilities, products, materials, and tools communicate. Make to order (MTO) means production based on customer requirements. This generates costs for configuration of a wide range of product variants. On the other hand, globalization leads to high competition and pressure caused by rising costs which can only be solved by using high end technology. The vision of individualized products and services with manufacturing costs from batch production has become reality by pioneering development in manufacturing and information technology.

The search for and analysis of avoidable costs has lately focused on both technological competence and process competence. Process competence defines the ability to perceive complexity and guarantees that the process will result in suitable solutions and value added for the customer.

Digitalization is an ongoing process that will continue in the 21st century. However, it is also a tool for obtaining and handling information within the organization and its environment. The effects of digitalization are continuous and entail both opportunities and challenges for the controlling profession.

Controlling is a function that helps companies perform more efficiently and effectively in order to achieve the set goals and objectives. By using different analytical tools, controllers analyze various aspects of performance, coordinate plans between departments and make integrative conclusions suitable for decision making.

The role of controlling in the digital enviroment has been facing a challenge. Self-service business intelligence (SSBI) enables the employees in various departments to select data themselves. The controller's role of a gatekeeper in the controlling enviroment has become obsolete in the digital age, because in the past controlling was predominantly focused on data collection and processing, while nowadays employees can do it themselves. However, if anyone could select the data by self-service, every employee would select the data supporting their own argumentation. Data selection is in that case not objective, but subjective, and controllers' meetings will be postponed to set enterprise-related global data models and governance for data harmonization.

1 Gartner IT Glossary, http://www-it-glossary/Digitalization

The analysis of digitalization controlling has an additional role – to harmonize data in coordination with the IT department. Generally, data are signs adhering to a specific syntax. Data become information if they have a meaning for the recipient. Models make sections of reality less complex in order to make understanding of the context easier for model users. The data model definition is used to find out which data are needed and how they relate to each other. The data model must be specified by controlling in coordination with the IT department. Only strict governance can ensure harmonized data and enable the management to access decision-relevant data.

The future role of controlling is to derive meaningful conclusions from the selected data, which are now Big Data. Quantitative methods, i.e. mathematical-statistical methods, can be used to measure the correlation of the factors influencing the behavior of customers, to understand the development of market data and to predict the development of customer behavior and market data, provided that test results are successful.

The central task of data scientists is application of statistical methods using information technology. On the other hand, business interpretation and development of concepts in response to forecasting is a task of controlling.

Classic instruments of product cost controlling are based on classic costing and the focus is on production time cost as a part of the entire production process. Using sensors, data are made available every second through running production processes. Monitoring of the production processes takes place in real time. Thus, production controlling is always informed about the current state of production processes and can make timely decisions accordingly. Besides, the search for alternatives can be automated by self-learning systems when there is a problem in production. Therefore, the established production controlling needs to respond to this progress with new approaches.

1.1. The Technological Basis of Semi-Autonomous Organizational Units

Building a modular, flexible production structure is inconceivable without developments in the field of the information and communication technology, such as:

- Real-time data collection
- Short-term response to events
- Calculation and visualization of production process indicators
- Support of continuous improvement
- Steering, control and monitoring of the production in real time.

The following three chapters, chapter 1.1.1 to 1.1.3, provide an introduction to the main characteristics of the technology which is the basis for networked production units.

1.1.1. Internet, the Driver of Change in Communication and Cooperation

Technological progress has enabled a quick response of the organization regarding business combinations and collaborations.

Nowadays, the Internet enables the customer to find several potential vendors and distributors for the requested products in a short time. Small and medium-sized enterprises cannot rely on their product quality alone. The availability of defect-free products brings up the same question in each company: why should the customer buy only their products? The results of technological progress are increased expectations of the buyer's market in terms of product variety and manufacturers' flexibility.

Through the IOT (Internet of Things), the digital world is now additionally connected to the physical world. Techniques such as sensor technology and radio frequency identification enable the transformation of analog data into digital data and the resulting common electronic processing of the data, regardless of their origin. Therefore, the connection of business models to "Business Services" enables "Connected Business Models". This is the communication basis, not only among people, but also in human-machine communication. Development of the so-called "framework" enables communication of different technical systems at unimaginable speeds. The results of the study clearly show that the importance of transparency of global SCM[2] processes increases as well as the significance of operative production controlling.

1.1.2. The Revolutionary Approach of Cyber-Physical Systems

The enormous progress in sensor technology as well as information and communication technology enables the vision of a production environment in which production and logistics systems are organized by themselves, without human intervention.

The central elements are cyber-physical systems representing technological basis. These systems are distributed networked production units – intelligent objects that are linked in a web of data and services and controlled autonomously.[3]

2 SCM – Supply Chain Management

3 Fecht, N.: Industrie 4.0: die schöne neue Produktionswelt? Interview mit Prof. Dr. Thomas, Bauernhansel. 04/2013, availiable at www.openautomation.de/uploads/pics/o30421zsh_emo_industrie_4.pdf, 2013, p. 3.

This involves the virtual image of the real world of production supplemented by information. This virtual image can be found in the IT application system, revealing all possibilities of the participants in manufacturing – humans and machines.

Based on process information in a real and a virtual process, each participant and location (machine, transportation, storage...) can make decisions in the production process and communicate them to other participants. For example, if a tool recognizes its wear or loss, it orders its replacement via another tool supplier. The task of the sensors is to control the condition of the location. Actuating means handling systems such as tool-changing systems. Embedded systems are decentralized intelligence and make decisions based on process information.

The cyber-physical system (CPS) has impacts on the industrial production in technical, organizational, and business matters:

- Automation is possible for smaller series that enable consideration of a wide range of product variants.
- Flexibility continues to be the key factor of production work in the future.
- Each CPS has information on the entire production process and can therefore configure itself. Thus, the cost-intensive set-up time can be considerably shortened.
- Based on the embedded intelligence, the CPS can optimize itself. For example, the CPS is searching for the next optimal location based on the actual information on the production process.
- Interruptions in the production process could be cleared by searching for alternative strategies and their actualization in production orders.
- The production controlling has been transforming into a decentralized instrument for planning and controlling the production processes.
- The function-oriented production organization, historically defined by Taylor[4], is replaced by process organization, which strives for continuous improvement.

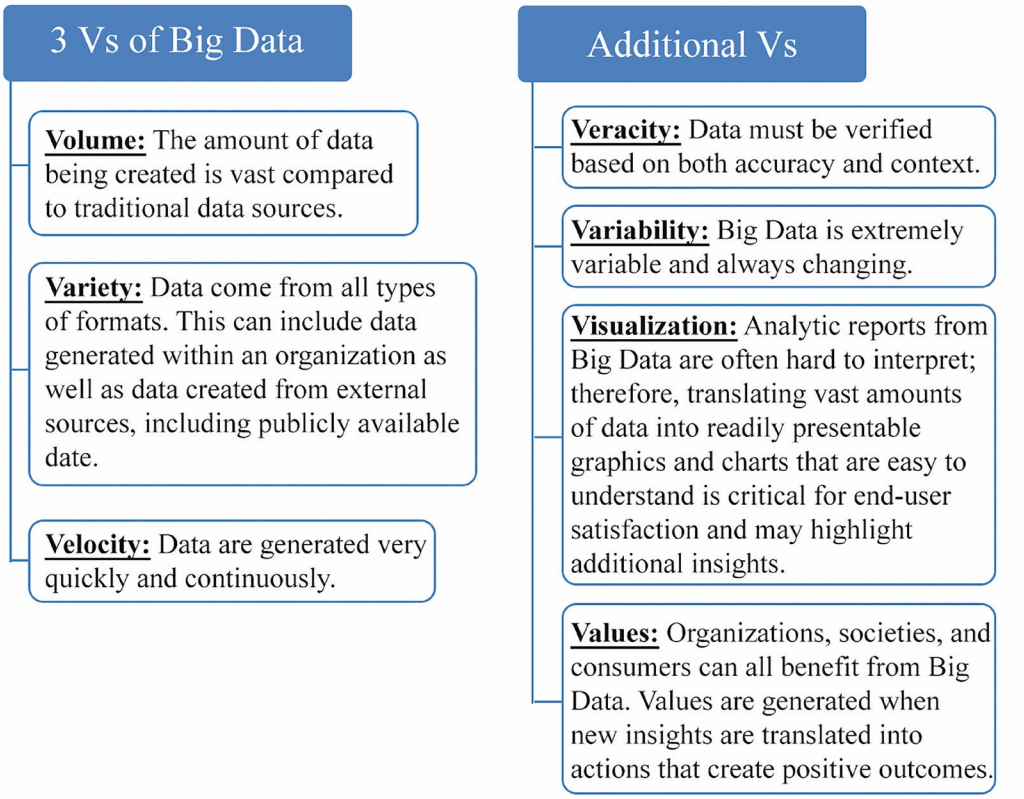
The road to autonomous, decentralized production structures has been outlined by the progress of production technologies, particularly for sensors and actuators. Ten Hompel and Henke detect: The extent of decentralization and self-organization of production processes increases with the complexity of logistic processes.

4 Frederick Winslow Taylor (1856-1915) laid down the fundamental principles of large-scale manufacturing through assembly-line factories in his book 'Principles of Scientific Management' from 1911. He emphasized gaining maximum efficiency from both machines and workers, and maximization of profit for the benefit of both workers and management.
http://www.businessdictionary.com/definition/Taylorism.html

1.1.3. Big Data as Controllers Potential

Big Data is a term used for the collection of large and complex data sets that are almost impossible to process due to multiplicity, heterogeneity, and autonomy of the sources. Big Data includes information generated from social media, data from Internet-enabled devices (smartphones and tablets), machine data, videos, voice recordings, etc. Big Data are usually characterized by three Vs - *volume, variety, and velocity,* but there are four additional Vs that explain accuracy and reliability, variability, visualization and value, or cost-benefit of data collection:

Figure 1: The Vs of Big Data



Source: GTAG Understanding and Auditing Big Data, p. 9

In relation to the scope of Big Data for analytical purposes, it could be characterized as follows:[5]

- High volume of data that needs to be analyzed in detail.
- Data diversity where diversity is both a challenge and opportunity. Data could be structured in databases, semi-structured in log-files, and unstructured like text.
- Processing power and rapid availability due to temporarily validity, especially of process data.
- Quantitative methods for analysis and evaluation of data, calculating alternative scenarios and processing simulations.

Regarding the volume which can be used in a Big Data system, it is possible to use a line item instead of just aggregated data. Specialized Big Data systems are used for updating and processing the Big Data volume. It is clear that detailed data provide a much higher analytical potential than aggregated data to make actual data-based decisions.[6]

The question arises whether Big Data are more within the scope of tasks of the information technology department, whose aim is to provide data in a short time and accurately. In this regard, the predominant opinion is that the information technology assumes the role of enabler who provides the data using practical capacity of computer equipment and powerful organization of the IT department.

Due to great possibilities of Big Data, the analytics methods are changing from descriptive to prescriptive:

5 McKinsey: Chief Marketing and Sales Officer Forum – Big Data, analytics and the future of marketing and sales, 2013, p. 16.
6 Bakhshaliyeva, N., *et al.*: SAP Predictive Analytics, Bonn, 2017.