

# A Maturity Model for Business Model Management in Industry 4.0

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**Abstract.** In a continuously changing business environment and the era of digitalization, business models need to adapt constantly to allow organizations to differentiate themselves from their competitors and to secure their economic survival. However, organizations are neither able to review their business model management nor systemize it productively. Hence, the combination of Industry 4.0, business model and business model management aspects emphasizes an organization's potential and results in an increased competitive and operational success. To guide an organization's advancement, a maturity model for business model management is developed, which delivers assistance suitable to an organization's requirements and strategic orientation. It assesses the organization's current maturity level and proposes sequential steps to advance towards a refined business model and process mastery by indicating improvement potentials. Thus, the maturity model links an organization's existing organizational and operational knowledge to new concepts and makes it accessible through a modified business model for Industry 4.0.

**Keywords:** maturity model, process mastery, business development, digitalization, business model innovation

## 1 Introduction

### 1.1 Motivation

Today, companies striving to survive in an increasingly ambitious environment need to undergo substantial transformations. To achieve durable success in the market business models can be utilized as a navigation instrument. Therefore, business model management needs to be equipped to react, enable and control those newly emerging business models. Thus, organizations discovered the potential of Industry 4.0 as an opportunity to thrive, boost their revenue and improve customer satisfaction. [1-3] To measure the degree of progress and advancement, maturity models were developed. Usually applied to new technologies, their goal is to provide insight into continuous

process improvement and status quo analysis [3]. As a whole, the maturity model describes an anticipated, desired or typical development trajectory [4]. It therefore serves as a scale to evaluate the management of the considered objects of a selected domain [5]. Maturity models also represent theories about organizations' capabilities to evolve in a stage-by-stage manner along an anticipated, desired, or logical path [6], which proves them to be a versatile tool in achieving process mastery.

By combining the three competences of Industry 4.0, business models and maturity models, a framework for optimization can be constructed. The adaption of business models through management while including aspects of Industry 4.0 can be measured with the help of a maturity model by classifying management processes and ranking them towards process mastery. This helps companies to renew business models to drive innovation. Hence, a maturity model can guarantee confirmation of business model management's performance and to measure its capability and success.

## **1.2 Problem Statement**

To internalize newly generated knowledge, implicitly available knowledge has to be collected, documented and transferred to explicit knowledge [7]. Ideally, organizations should recognize problems or not yet optimized factors and advance. Hence, a maturity model for business model management in Industry 4.0 will enable companies to strive towards an optimized business model in order to benefit according to their strategic goals, responsibility and spirit.

However, a structured business model management rarely exists and companies could struggle to associate obstacles in one sector of their company to solutions or obstacles in another sector. This is especially the case in the era of Industry 4.0 where changes occur frequently and require organizations to keep up. Flawed operational decisions can lead to a downward spiral if not interrupted by alert systems such as a decrease in profit [8]. A maturity model, in which a company's status quo can be categorized, provides a proposition of steps to be taken in order to prevent this downward spiral and loss of control [1]. It poses a clear structure of steps, which can be applied to a company depending on its strategic orientation.

## **1.3 Objective**

This paper's aim is to detect how modified business models can be managed to generate assistance, guidance and, hence, profit for a company by developing a maturity model for business model management in Industry 4.0. The development will follow a procedure model and the intermediate results of adopting or altering business model management have to be visible in the maturity model. Therefore, multiple stages representing process advancement must be defined to create an evolution of steps with the goal of process mastery of each respective element.

The model's purpose is to identify improvement potentials. Hence, a business model needs to be matched to the maturity model's stages by analyzing its own processes. It also needs to give information about further approaches, show already adopted measures and indicate the significance and effectiveness of business model

management. The model's evaluation can be outlined but will not be conducted. The maturity model's levels provide indications about required alterations to the business model orientation and enables business model management. In the end, the maturity model reveals a business model management, which manages the company's ideal business model and adds value to a company.

#### **1.4 Methodology**

The maturity model is based on the design theory in information systems and the design science approach [4,5,10]. The procedure model for maturity model construction [9] led through the development process providing an outline of the order in which the maturity model components were derived. It depicted the elements relevant to the maturity model.

For this paper, research concerning existing maturity models and maturity models in Industry 4.0 were reviewed. The maturity model's development in section 3 focuses on the procedure model and the derivation of the underlying business model in Industry 4.0. Requirements for a successful maturity model construction were identified and defined through a literature analysis. Following the model's construction and item selection, the evaluation approach is discussed in section 4. The conclusion in section 5 presents future implementation and improvement potentials.

Preliminary to the maturity model construction, the business model for Industry 4.0 was developed [11]. The included elements originated from a literature analysis. A requirement analysis for maturity models and process based quality models was conducted to determine factors for the maturity model's continuous operation. Additionally, the business model's items were derived from the resulting business model. They were subdivided into an advancing sequence towards process mastery. The relevant literature is extracted from the databases Springer, IEEE Xplore, Google Scholar and Citeseer. They were searched for the terms: "maturity model", "business model management", "Industry 4.0", "business model", "business model innovation", "Industry 4.0 challenges" and "business model maturity model" among others. Qualifying articles and papers were taken into account, regardless of their publication date. When multiple articles and journals described the same facts, the newest article was considered. Furthermore, the weighting factors quantity, information content and amount of citations of those papers were examined and then considered if they added value to the maturity model and covered this paper's topic.

## **2 Related Work**

### **2.1 Existing Maturity Models**

From developments in the software industry, various models derived some years later. Three of these models are still applied in the software industry: CMMI [12], SPICE [13] and BOOTSTRAP [11, 12]. The most prominent maturity model is the Capability Maturity Model Integration (CMMI). Its aim is to continuously improve processes in software development by applying them to five maturity levels, which all

have their individual generic goal with characteristics and requirements. To fulfill the criteria for the next level, all requirements of the next level have to be met as well as all previous requirements. Due to the maturity levels' structure, it displays the recommendation for action making it more practicable. This generates a foundation for assessing process maturity and indicates strategies to optimize processes [12]. Based on the assumption of predictable patterns of organizational evolution and change, maturity models represent theories about how organizations' capabilities evolve in a stage-by-stage manner along an anticipated, desired, or logical path [6].

Different models display the functionality and structure and are, therefore, representable for all models—specially, since they are still general enough to be used for the Business Intelligence domain with slight modifications [16]. By regarding different maturity models, it can be decided which approach to choose to develop a model applicable for business models in Industry 4.0. In this case, the most promising characteristics of each model can be derived to form a new, goal-oriented model.

## **2.2 Maturity Models in Industry 4.0**

A common procedure to methodically support the implementation of Industry 4.0 has not yet been established throughout the industry and, hence, maturity models are not notably common as well. Moreover, procedure models are generally applied [17], which mostly lack a specific assessment or measurement [18].

Industry 4.0 enables the management and optimization of entire value networks through the development of intelligent monitoring systems and autonomous decision processes. This vertical integration of entire organizations with embedded systems can lead to new business models and optimization in logistics and production. It can, therefore, be utilized to facilitate operational process optimization [19] and form dynamic networks, which require innovative tools to plan, regulate and control new concepts deriving from Industry 4.0. As a consequence, interrelations and interdependencies emerge from the integration of various components [20].

The acatech Industry 4.0 Maturity Index focuses on processes in manufacturing companies applying Industry 4.0 technologies. By colliding an organizations current situation, capabilities can be determined which need to be adopted in order to enable Industry 4.0 from a strategic point of view. The six-stages index assesses the organization according to structural and functional areas [21].

One CMMI inspired maturity model found discusses Industry 4.0 and is constructed with five steps. It considers descriptive characteristics of Industry 4.0 and takes the number of those applied into account. Hence, technologies are the foundations of this model and their impact on the maturity depends on the phase it is assigned to. If a technology is applied and appears in the model, it is considered a match. All matches are added up and count towards the maturity level. The result is a trend in the organization's handling with Industry 4.0 [22]. The higher the maturity level, the lower the risks when establishing and introducing a new technology [23].

### 3 Maturity Model Development

#### 3.1 Procedure Model

To support the maturity model’s development, design a model range and enable the evaluation of results, a guideline needs to be established. Therefore, a procedure model was chosen, which distinguishes between six different phases [9].

For a holistically applicable model, all criteria affecting the maturity stages and functionality can be determined with the chosen procedure model. Hence, by identifying all influence factors, information about the practitioner’s process mastery can be optimized. This procedure model delivers a development process specifically for maturity models in the context of performance management with which a maturity model can also be assessed at the same time [9]. Its underlying requirements are based on design science to guarantee a steadily increasing solution quality [10].

Key Partners	Key Activities	Value Proposition	Customer Relationship	Customer Segment
<ul style="list-style-type: none"> <li>Added Value Partners</li> <li>Value Proposition Cooperation</li> <li>Partner</li> </ul>	<ul style="list-style-type: none"> <li>Automated Optimization</li> </ul>	<ul style="list-style-type: none"> <li>USP</li> <li>Object</li> </ul>	<ul style="list-style-type: none"> <li>Extent</li> <li>Customer Relationship Management</li> </ul>	<ul style="list-style-type: none"> <li>Market</li> <li>Customer Area</li> <li>Customer Region</li> </ul>
	<b>Key Resources</b> <ul style="list-style-type: none"> <li>Means of Production</li> <li>Knowledge/ Know-How</li> <li>Employees</li> <li>Finances</li> <li>Data</li> <li>Technology</li> <li>Partner Network</li> </ul>			
<b>Cost Structure</b>		<b>Source of Income</b>		
<ul style="list-style-type: none"> <li>Cost Orientation</li> <li>Use Orientation</li> </ul>		<ul style="list-style-type: none"> <li>Types</li> <li>Pricing</li> <li>Method of Payment</li> </ul>		

Figure 1. Business Model in Industry 4.0 based on Business Model Canvas

#### 3.2 Business Model Management in Industry 4.0

Business models in Industry 4.0 differ from common models regarding their performance in partners, added values, resources and activities. This is mostly because the recent era of digitalization left a gap in the world of digital business, which needs to be filled [24]. Furthermore, Industry 4.0 enables values based on individualization, interaction and hybridity and allows access to Big Data through professional approaches and tools to accomplish business model development [25].

Industry 4.0 triggers a proactive behavior in organizations and their business model and enables opportunities to differ from their former core business. This can be regarded as ambivalent technology innovation and ambivalent business models [26].

However, no business model was found which describes an Industry 4.0 business model needed to base the maturity model on. The structure of the underlying Industry 4.0 business model depicted in *figure 1* therefore provides the first stage of content for the maturity model. Hence, the business model canvas' nine building blocks and their respective elements pose the business model's outline. It was created by merging information about the business model canvas, Industry 4.0 and data derived from the Bitkom handbook [27]. The elements describe the structure of any organization completely and to their entirety. However, selected elements are not disjoint. Hence, multiple elements can be chosen in order to describe an organization's business model. The entrepreneurial mode of business model management aims for risk affinity and change promotion, whereas the adaptive mode pursues consensus regarding reactivity and gradual adjustments. The planning mode prefers analytical procedures to reach target values and establish complex strategies [28]. The management aspect of business models derives from the strategic adaption of business models through the maturity model.

### 3.3 Requirements for Process-Based Quality Models

Besides content-related specifications, requirements for process-based quality models need to be established and elucidated. Essential specifications for the operationalization of quality are completeness, adaptability, comprehensiveness and sustainability, which were derived from literature involving general requirements for quality models [29].

**Completeness.** All relevant quality characteristics have to be taken into account when constructing a maturity model [29]. Multiple elements of one cluster can be chosen simultaneously in order to improve business model management and move to the following maturity stage. The maturity model itself must be complete as well – in the sense of it complying with certain requirements facing completeness in the long run – those necessities being the potential of improvement, multidimensionality, focus, functionality, reliability, usability and efficiency. If mentioned specifications are all met, then the condition of completeness is sufficiently accomplished [30].

**Adaptability.** Business models are exposed to constant change. Thus, so are the technologies, processes, methods, techniques change entails and so is their management. The matching requirements, individual elements or process steps can therefore be exchanged at any time. Hence, the adaptability of the maturity model is given [31]. Furthermore, the practitioner has to possess methodical knowledge and expertise in the field of business models, their management, Industry 4.0 and emerging technologies to ensure an optimal adaptability of the maturity model [15].

**Comprehensiveness.** In order for a quality model to be comprehensive, it needs to be unambiguous, consistent and have the lowest complexity possible [31].

**Sustainability.** Sustainability explains how much the model succeeded over time and to what extent the model is expected in order to prove it practically relevant. One important factor towards sustainability is an empirical foundation, where an extensive literature analysis occurs and experts are questioned. This increases the chances of the model being accepted throughout the industry and being applied universally [15].

### 3.4 Maturity Model Construction

The model's construction depends on the definition of aspects regarding the model's requirements to enable the assessment of its validity later on. Thus, four distinct requirements were identified and will be explained and defined in the following.

**Purpose.** The maturity model is expected to continuously improve processes by mastering processes of business model management in organizations where Industry 4.0 components can be implemented. Hence, the scope of application can be described as general opposed to domain-specific. This first version of the maturity model is intended for an internal audience due to confidentiality obligations. Organizations need to have an established drive for implementing Industry 4.0. This is necessary, because the maturity model is developed to enable assessments of business model management in Industry 4.0. Otherwise, many elements of the model cannot be matched to the actual business model and therefore distort achieved results.

**Generic Objective.** The maturity model poses a guideline for the development or alteration of a successful Industry 4.0 capable business model management. Additionally, management can discern where progress did not advance as anticipated. It is crucial that the model's goal is not solely the assessment of maturity but also focuses on the factors that influence further evolution and change – specially, when considering that Industry 4.0 can never be an “end state”.

**Structure.** The maturity model's structure follows the business model's design. Hence, the business model's nine building blocks separate into independent elements, reflecting a fundamental and distinct characteristic of the business model. Besides the five final, steadily advancing maturity levels, several other criteria need to be displayed. The process steps are arranged in sequential order along one axis whereas the business model elements' order can be displayed at random or to the preference of the practitioner along the other axis. Since business models can be subdivided into fragments, it can be determined beforehand what criteria underlie the individual elements. Business model elements become indicators for each maturity stage. These elements qualify for the ranking system applied in maturity models and are chosen to represent the maturity levels. Their attributes and requirements, however, illustrate with which characteristics and specifications these elements may be improved. Requirements, are specifications of actions, standards, methods or technologies necessary for the successful implementation of an Industry 4.0 business model. Attributes are characteristics, consequences or impacts unique to Industry 4.0 business models and, hence, their management.

**Stages.** There are five possible maturity levels to be reached, the higher the level, the more mature the business model. By dividing the model into different performance levels and criteria, an objective basis for a target-oriented evaluation is created [3].

Hence, the staged function is chosen opposed to the continuous function, since it adapts best to the conditions given and provides a clear path for further improvement. The individual stages' characteristics and descriptions are determined according to the chosen items' process mastery and can be defined generically for the entire maturity model. Respective items can be found in *table 1*. The degree of achievement of each business model element, however, is customized for each respective element.

**Table 1.** Business Model Management Items for Maturity Model

<b>Building Blocks</b>	<b>Business Model Elements</b>	<b>Items</b>
Customer Segment	Market	Market Selection
	Customer Area	Customer Area Selection
	Customer Region	Expansion of Customer Region
Value Proposition	Object	Product and Service Adaption
	USP	Automated USP Evaluation
Channels	Sales Channel	Sales Channel Adaption
	Extent	Selection of Channel Extent
	Scope	Acquisition of New Channels
	Orientation	Selection of Orientation
Customer Relationship	Extent	Implementation of one Direction
	Management	Customer Integration
	Types	Automated Type Evaluation
Source of Income	Types	Automated Adaption
	Pricing	Optimization through System Solutions
	Method of Payment	Customer Individualized
Key Resources	Means of Production	Data Integrated Optimization
	Knowledge/ Know-How	Conquering New Training Areas
	Employees	Optimization of Employee Motivation
	Finances	Automated Financial Source Selection
	Data	Business Model Enhancement
	Technology	Development as Provider and Operator
	Partner Network	Extension of Partner Network
Key Activities	Automated Optimization	
Key Partners	Added Value Partners	Competitive Success Through Systems
	Value Proposition Cooperation	Joint Elaboration of Business Models
	Partner	Standardization and Transparency
Cost Structure	Cost Orientation	Cost Structure Optimization
	Use Orientation	Selection/ Optimization of Orientation

*Implicit.* This stage identifies the business model elements by describing the stage of process progress. This step is based on experience and generated without norms.

*Defined.* Based on the level of process mastery from the previous maturity stage, this stage includes the theoretical background and information about goals and the scope



of possibilities. Screening potential features and designating factors generate a more exclusive knowledge about the advancement of process mastery. This can ultimately lead to a better understanding of business process management.

*Validated/ Standardized.* The third stage provides confirmation about the selected features' performances by applying methods, techniques and technologies in order to assess collected data to increase overall efficiency. This way, standardization can be achieved and Industry 4.0 technologies can be implemented to detect further improvement potentials as well as establishing computer-aided approaches to generate harmonization and compatibility of different selected features.

*Analyzed.* During this stage, the selected features' opportunities are analyzed and adapted according to the analysis results and validity of the preceding maturity level. For this purpose, required technologies may be implemented to advance the maturity level towards process mastery and optimized management while also applying benchmarking, factor and data analyses, customer surveys and conducting research.

*Optimized.* The final stage consists of the definite selection of features, which achieve the optimal results concerning the organizational operation. This includes the implementation of further methods, techniques and technologies and a continuous expansion of the selected features. An automated analysis controls and monitors the adaption or exchange of features in case of occurring obstacles.

Building Blocks	Business Model Elements	Implicit	Defined	Validated/ Standardized	Analyzed	Optimized
Value Proposition	USP	no deliberate emphasis of USPs	explicit designation of USPs	validation of designation through market research	analysis of selected USPs through factor analysis within market research	automated USP analysis through software sensors such as customer sentiment analysis
	Object	...				
Channels	...					
...						

**Figure 2.** Extract of the Maturity Model for Business Model Management in Industry 4.0

## 4 Evaluation

Evaluations of the maturity model and its underlying theoretical foundation have not yet been conducted. However, as part of the procedure model, evaluation possibilities were preselected. A complete model is not automatically a finalized model. Thus, it needs to be evaluated regarding validity of construction. This will ensure the model's functionality and viability and guarantees an unobstructed and frictionless application. One possible method is the Delphi method. It identifies trends, future events and technological developments. A case study can assess the maturity model in its future environment. Both aim at improvements by analyzing the practical application with a questionnaire. Evaluation also has to occur concerning the model's theoretical

foundation. Thus, it is required to conduct empirical studies to back the underlying theory and ensure validity. Stylized facts will be used additionally to determine or confirm the selected maturity stages of each business model management element. Also, a cross validation of the scale can be conducted to develop valid norms for the scale. The result evaluation and, hence, the review whether the resulting maturity level is valid can be part of the model's application process. This is part of future research and was currently not subject of the model's development.

## **5 Conclusion**

By combining the three areas Industry 4.0, business models and maturity models, a framework for optimization was constructed. It classifies management processes and ranks them towards process mastery. It is based on a set of criteria and the relationship between them [5]. Thus, the maturity model links existing organizational and operational knowledge about to new concepts and makes it accessible through a modified business model for Industry 4.0 and the created sequence of process steps. The conducted literature analysis ensures the accuracy of the derived models.

An organization can be matched to one of the maturity stages depending on the chosen method of process analysis and evaluation. The sequence of maturity stages provides recommendations for the future through the implementation of Industry 4.0 related technologies, techniques and methods. Hence, the organization's determined maturity level can indicate improvement potentials. Recommendations are not mandatory, but leave room for options depending on an organization's strategic drive. Nonetheless, further development levels need to be reached to achieve sufficient results. As a result, the maturity model enables the optimization of business models and operational decision-making through process mastery and a holistic view over the entirety of an organization.

## **6 Outlook**

Business model management could be continuously optimized by other factors than process mastery. Technologies, which have proven to advance the maturity of specific business model elements, could be identified and integrated directly into the maturity model. Furthermore, the level of Industry 4.0 technology use could indicate maturity, as could the degree of innovativeness.

A prospective operating principle can be specified as followed: by individually deciding for each element whether and how much it applies to the organization's current condition, it is measured how advanced a business model is and which countermeasures to take. Depending on the quantity and quality of requirements and attributes met, the level of maturity can then be determined. Operators can compare the successfully implemented elements to elements required for each maturity stage. The stage with most accordance is then determined to be current maturity level. The organization can implement technologies to advance to a superior level and remains in one stage as long as a certain percentage of conformance is reached or all

requirements are fulfilled [12]. The model's operating principal guarantees one valid result and its application occurs by assessment methods such as a questionnaire [9]. By matching the model's process states to the organization's ones, and applying of predetermined thresholds for each stage to the result, the outcome will be unambiguous and consistent. By combining environment and knowledge base throughout multiple iteration steps, the model will be sophisticated enough to withstand field-testing [10]. Furthermore, it could be assessed, how the application of a maturity model influences organizations and their business model management. Since a standard covering this specific topic is not yet in use, conclusions about purpose and intention could be analyzed.

However, solutions regarding possibly occurring problems concerning the application in different industry sectors need to be identified to guarantee the model's success in future. This may lead to the decision to apply the maturity model in specific industry sectors and location bound at first.

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## References

1. Schlick, J., Stephan, P., Loskyll, M., Lappe, D.: Industrie 4.0 in der praktischen Anwendung. *J. Chem. Inf. Model.* 53, 650 (2014).
2. Scheer, A.W.: *Industrie 4.0: Von der Vision zur Implementierung.* , Saarbrücken (2016).
3. Puchan, J., Seif, H., Mayer, D.: Bestimmung des Stands deutscher produzierender Unternehmen auf dem Weg zu Industrie 4.0 und Verwendung der Ergebnisse für ein Industrie-4.0-Reifegradmodell Jörg. *Angew. Forsch. der Wirtschaftsinformatik Prozesse, Technol. Anwendungen, Syst. und Manag.* 1, 58–68 (2015).
4. Becker, J., Knackstedt, R., Pöppelbuß, J.: Developing Maturity Models for IT Management. *Bus. Inf. Syst. Eng.* 1, 213–222 (2009).
5. Kuznets, S.S.: *Economic Growth and Structure: Selected Essays*, (1965).
6. Gottschalk, P.: Maturity levels for interoperability in digital government. *Gov. Inf. Q.* 26, 75–81 (2009).
7. Nonaka, I., Takeuchi, H.: *The Knowledge-Creating: How Japanese companies create the dynamics of innovation.* Oxford Univ. Press. 3, 25–27 (1995).
8. Zott, C., Amit, R.: Value Creation in e-Business. *Strateg. Manag. J.* 22, 493–520 (2001).
9. Knackstedt, R., Pöppelbuß, J., Becker, J.: Vorgehensmodell zur Entwicklung von Reifegradmodellen. In: *Business Services: Konzepte, Technologien, Anwendungen.* pp. 535–544. Österreichische Computer Gesellschaft, Wien (2009).
10. Hevner, A.R., March, S.T., Park, J., Ram, S.: *Design Science in Information Systems Research.* 28, 75–105 (2004).
11. Osterwalder, A., Pigneur, Y.: *Business Model Generation.* John Wiley & Sons, New York

- (2010).
12. CMMI Product Team: Capability Maturity Model ® Integration ( CMMI SM ), Version 1.1. 1–645 (2002).
  13. Hindel, B., Hörmann, K., Müller, M., Schmied, J.: Basiswissen Software - Projektmanagement. (2013).
  14. Stienen, H., Engelmann, F.: Die BOOTSTRAP–Methode zur Bewertung und Verbesserung der Software–Entwicklung. *Wirtschaftsinformatik*. 38, 609–616 (1996).
  15. Ahlemann, F., Schroeder, C., Teuteberg, F.: Kompetenz- und Reifegradmodelle für das Projektmanagement: Grundlagen, Vergleich und Einsatz. (2005).
  16. Rajterič, I.H.: Overview of business intelligence maturity models. *Manag. J. Contemp. Manag.* 15, 47–67 (2010).
  17. Felser, W.: Ein Rahmenwerk, um Industrie 4.0 jetzt auch für den Mittelstand greifbarer zu machen! 2013, 48–55 (2015).
  18. Erol, S., Schumacher, A., Sihn, W.: Auf dem Weg zur Industrie 4.0 – ein dreistufiges Vorgehensmodell. In: *Industrial Engineering and Management*. pp. 247–266. Springer Fachmedien Wiesbaden, Wiesbaden (2016).
  19. Kagermann, H., Lukas, W.-D., Wahlster, W.: Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution. *VDI Nachrichten*. 3–4 (2011).
  20. Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., Hoffmann, M.: *Industry 4.0*. *Bus. Inf. Syst. Eng.* 6, 239–242 (2014).
  21. Schuh, G., Anderl, R., Gausemeier J., ten Hompel, M., Wahlster, W.: *Industry 4.0 Maturity Index. Managing the Digital Transformation of Companies (acatech STUDY)*. Herbert Utz Verlag, Munich (2017).
  22. Huber, W.: *Industrie 4.0 in der Automobilproduktion*. (2016).
  23. Feld, T., Hoffmann, M., Schmidt, R.: *Industrie 4.0 - Vom intelligenten Produkt zur intelligenten Produktion*. *Inf. Manag. und Consult.* 38–42 (2012).
  24. Al-Debei, M.M., El-Haddadeh, R., Avison, D.: *Defining the Business Model in the New World of Digital Business*. *Proc AMICS 2008*. 1–11 (2008).
  25. Gebauer, H., Fleisch, E., Friedli, T.: *Overcoming the service paradox in manufacturing companies*. *Eur. Manag. J.* 23, 14–26 (2005).
  26. Burmeister, C., Luettgens, D., Piller, F.T.: *Business Model Innovation for Industrie 4.0: Why the “Industrial Internet” Mandates a New Perspective*. *SSRN Electron. J.* 0, 1–31 (2015).
  27. Bitkom: *Big Data und GeschäftsmodellInnovationen in der Praxis: 40+ Beispiele*. (2015).
  28. Wirtz, B.W.: *Business Model Management. Design–Instrumente– Erfolgsfaktoren von Geschäftsmodellen*. Gabler Verlag, Rostock (2010).
  29. Büker, B.: *Qualitätsbeurteilung investiver Dienstleistungen: Operationalisierungsansätze an einem empirischen Beispiel zentraler EDV-Dienste*. Lang (1991).
  30. Malik, F.: *Management-Systeme, in der Reihe» Die Orientierung «*. Hrsg. Schweiz. Volksbank Bern (1981).
  31. Reißling, R.: *Bewertung der Qualität objektorientierter*, [http://www.worte-projekt.de/reissing/Dissertation\\_Reissing.pdf](http://www.worte-projekt.de/reissing/Dissertation_Reissing.pdf), (2002).