The Application of the Maturity Model SIMMI 4.0 in Selected Enterprises

Full Paper

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Abstract

The increasing digitalization of business and society leads to drastic changes within enterprises. Therefore, they are confronted with enormous challenges when dealing with digitalization topics. One of these challenges represents the complex field of Industry 4.0/the Industrial Internet (as part of the digitalization), especially the realistic classification of the company's own IT infrastructure in terms of Industry 4.0 requirements. Addressing these issues with the maturity model SIMMI 4.0 (System Integration Maturity Model Industry 4.0), we provide a toolset for enterprises to assess their current IT system landscape. In this paper, we present the next step of the iterative development of our model—the application of SIMMI 4.0 in selected enterprises as proof of concept. Therefore, we used a questionnaire-based approach to apply our model. We present the results and conclusions from this application as well as several further steps in our long-term research project to improve and refine SIMMI 4.0.

Keywords

Maturity model, Industry 4.0, Digital transformation, Digitization, Digitalization, SIMMI 4.0

Introduction

A major challenge companies are currently confronted with and "forced" to cope with is the digitalization/digital transformation of an entire business often associated with the buzzwords *Industry 4.0/the Industrial Internet*. Fichman et al. (2014) have formulated this issue in a striking way: "It is not too much of a stretch to think we have entered a golden age of digital innovation. Owing to the 50-year march of Moore's Law, we have witnessed the creation of a relatively cheap and increasingly easy-to-use world-wide digital infrastructure of computers, mobile devices, broadband network connections, and advanced application platforms." These advanced technological opportunities, especially the merging of the physical with the digital world, result in new fundamental paradigm shifts affecting all industry sectors. Companies must handle global digital networks, improve automation of individual or even of all business processes, and reengineer existing business models to gain momentum in digital innovation. The prevailing and steady high dynamics in everyday business show that constant changes and adjustments (to which also digitalization belongs) will be no exception, but rather the rule in the future economy. Many companies must already deal with and handle new information and communication technologies in order to successfully improve and manage core business processes and remain competitive. However, the complexity of the field of digital transformation/Industry 4.0 comprises manifold organizational as well as crucial technological implications. It has never been more important for enterprises to understand and be able to rely on the capabilities IT can provide to them. Companies need a deep understanding of information technology in general and of Industry 4.0/digital transformation in particular as stated by many researchers (e.g., Bley et al. 2016; Mathrani et al. 2013; Pagani 2013; Sambamurthy et al. 2003).

However, missing at this point are the companies' levels of knowledge concerning their own digitization. Several authors have already addressed this topic by applying different studies with various interrogation techniques (e.g., Berghaus et al. 2016; Bley et al. 2016; Consoli 2012; Fitzgerald et al. 2013; Kane et al. 2015; Ollo-López and Aramendía 2012; Schäffer and Beckmann 2014; Westerman et al. 2011; Youngjin Yoo et al. 2010). In these studies, the authors show which information and enterprise systems are used in enterprises (especially in small and medium-sized enterprises [SMEs]) and in what condition the IT-infrastructure of the companies appear. The studies can be summarized as follows:

- A basic understanding of the importance of digital development or digital transformation exists, but there is still a need to clarify the respective challenges and effects.
- The opportunities arising from digitization are somehow acknowledged, but the implementation in the companies is not gaining momentum. Especially SMEs still underestimate the possibilities and opportunities of digitization.
- SMEs have failed to demonstrate the courage to implement far-reaching changes in their value chains or in business models, even though they have greater flexibility than large companies.
- Enterprises and here also SMEs are aware that an appropriate ICT infrastructure is essential for successful digitization.
- SMEs often overestimate themselves in terms of ICT use and their level of digitization, and they are not ready to deal with the challenges of digitization.

However, there is still the unanswered question of how an IT landscape must be designed so that a company can "move forward" in the field of Industry 4.0. Recognizing and evaluating what systems are needed, and in which way and for what purpose, still embody a challenge for enterprises. Many companies—not only, but especially SMEs and young (often fast-growing) companies—still have difficulty recognizing and evaluating what ICT is needed, how processes should be optimized, in which way and for what purpose business model changes will become necessary, and other relevant questions. Therefore, we developed a tool (a maturity model) that enables companies to classify their own IT system landscape in terms of the needs of an Industry 4.0 IT system landscape. This results in the main research question for our research project: **What should a maturity model look like to assess a company's IT system landscape in the context of Industry 4.0?**

With the maturity model SIMMI 4.0 (System Integration Maturity Model Industry 4.0), we provide a toolset for enterprises to verify and assess their current IT system landscape. As part of the development of SIMMI 4.0, the paper at hand records (as part of our long-term research) the first application of our model. After its initial design and implementation, we developed a questionnaire to enable companies using SIMMI 4.0. Therefore, the research question for this paper is: *Are companies capable of independently analyzing the state of their digitization level / IT system landscape regarding Industry 4.0 requirements by applying SIMMI 4.0?*

In order to answer this question, the paper is composed of five sections: Following this introduction, the second section provides a conceptual background, whereas the third section summarizes the development and the components of SIMMI 4.0. The fourth section deals with the composition of the associated questionnaire for applying SIMMI 4.0 in enterprises and the results of the application of our model in selected enterprises. The paper concludes with a short discussion and summary, as well as an outlook for future research in our project.

Conceptual Background

Industry 4.0

During the last years, the topic of *Industry 4.0* or the *Industrial Internet* has gained increasing importance in enterprises. It is characterized as the fourth stage of the industrial revolution and consists of an increasing digitization of products and systems associated with their interconnectedness. Focusing on the enhancement of the automation, flexibility, and individualization of products, production, and the connected business processes (Kagermann et al. 2013; Lemke and Brenner 2014), the Industrial Internet aims at connecting the physical and virtual worlds. Embedded systems, cloud computing, as well as big data and business analytics represent the main systems and functions of Industry 4.0 when it comes to

the construction and use of autonomous, cyber-physical systems (CPS) in production and logistics (Reinheimer 2015). From a production perspective, Industry 4.0 is understood as the movement of intelligent workpieces that independently coordinate their paths through the factory. Machines are able to "realize" these tracks and communicate in real time with the corresponding warehouse. If necessary, orders are automatically triggered. By means of targeted calculations, errors can be computed at an early stage of production, and the right interpretation enables a machine to change its production order. Information is primarily used to assess and control current processes (Kaufmann 2015). Thus, an essential feature of Industry 4.0 can be seen in information aggregation in engineering and operations across different projects, plants, and plant operators (Bauernhansl et al. 2014).

However, a universal definition for the term "Industry 4.0" does not exist. Despite this, from the aforementioned descriptions and further characteristics of Industry 4.0, we deduced a working definition to serve as the foundation for our research: *Industry 4.0 describes the transition from centralized production towards one that is very flexible and self-controlled. Within this production, the products and all affected systems, as well as all process steps of the engineering, are digitized and interconnected to share and pass information and to distribute this along the vertical and horizontal value chains and beyond in extensive value networks.*

Maturity Model

Maturity models are reference models that deal with the current state and the evolution of maturity in organizations and their applied technologies with the aid of development or maturation paths (Pöppelbuß and Röglinger 2011). Development stages are synonymous with maturity levels. The degree of maturity defines a particular state of development within a scale range, determined by an initial point (lowest development degree) and an end point (highest development degree). A change to a higher degree is equivalent to an improvement. A specific level of maturity includes the respective characteristics of previously defined objects and their required characteristics (Becker et al. 2009).

A maturity model can be regarded as an artifact and is thus subject to the principles of design science research (Becker et al. 2009; Mettler and Rohner 2009). Therefore, Becker et al. (2009) followed Hevner et al.'s (2004) design science research guidelines and developed a "manual for the theoretically founded development and evaluation of maturity models" (Becker et al. 2009). Based on eight design requirements, Becker et al. (2009) presented an approach for the development of a maturity model considering the following eight phases: (1) problem definition; (2) comparison of existing maturity models; (3) determination of development strategy; (4) iterative maturity model development; (5) conception of transfer and evaluation; (6) implementation of transfer media; (7) evaluation; and (8) rejection of the maturity model. This approach was also applied for the development of SIMMI 4.0.

The Maturity Model SIMMI 4.0 (System Integration Maturity Model Industry 4.0)

Following the above mentioned procedure model (Becker et al. 2009), SIMMI 4.0 is currently in its third iteration of phase 4 (iterative model development) in combination with phase 7 (model evaluation). We identified an existing problem faced by enterprises within the field of Industry 4.0 (phase 1), and we compared existing maturity models (phase 2) by conducting a systematic literature review (see Leyh et al. 2016). With our development strategy (phase 3) of first focusing on Industry 4.0 requirements derived from the literature and then applying the thus developed model to selected enterprises for phase 4 (the model development), findings from the analysis of the literature about the general structure of maturity models were combined with the requirements for an IT system landscape of a company that wants to operate entirely in the context of Industry 4.0. Our model consists of five maturity stages. Each stage describes a corresponding level of Industry 4.0-maturity within an enterprise. Additionally, each maturity stage is divided into four dimensions that represent different enterprise focus levels:

- *Vertical Dimension*—This dimension focuses on the components of the lowest level of an enterprise, where different physical things ([semi-] products, machines, etc.) need to exchange information throughout the level itself and with the levels above it.
- *Horizontal Dimension*—Industry 4.0 requires horizontal integration across the different value

networks. Accordingly, an essential criterion has emerged from the requirements above. An automated and integrated information flow is necessary along the horizontal enterprise level as well as beyond the enterprise borders. Without this information flow, a business-wide value network is not realizable, meaning that the various enterprise systems of the different partners in the supply chain and in the value networks require interoperability at the data level.

- *Digital Product Development Dimension*—For the engineering's digital continuity, it is especially important that each process step is represented digitally. For this purpose, at least one enterprise system should be integrated into each respective process step. In addition, the resulting data and information of each step must be forwarded to the next and previous step/enterprise system.
- *Cross-sectional Technology Criteria Dimension*—This dimension focuses on assessing the extent to which technologies are used across all different fields of Industry 4.0. Based on the requirements, the respective fields are: Service-oriented architecture, cloud computing, big data, and IT security.

Every stage consists of all four dimensions, but is characterized by different occurrences in the particular dimension. Table 1 gives a brief overview of SIMMI 4.0. Detailed information about the choice for our procedure model and about the development process itself can be found in (Leyh et al. 2016) as well in (Leyh et al. 2017), where a detailed description of SIMMI's components is also given.

Dimension Vertical Integration	**Dimension Horizontal Integration**	**Dimension Digital Product Development**	**Dimension Cross-sectional technology criteria**
Stage 5–Optimized full digitization: The company is a showcase for Industry 4.0 activities. It collaborates strongly with its business partners and therefore optimizes its value networks.			
Continuous cross-corporate integration that is constantly optimized.	Continuous cross-corporate integration and collaboration in value networks.	Product development is processed digitally inside and outside the company (digitized end-to-end solution).	Simulation and optimization of value and information flow in real-time within the value network. IT security adjusts promptly to new risks. Occurring security problems are immediately solved. Encryption is optimized along the value networks.
Stage 4–Full digitization: The company is completely digitized even beyond corporate borders and integrated into value networks. Industry 4.0 approaches are actively followed and anchored within the corporate strategy.			
Description → see (Leyh et al. 2017)			
Stage 3–Horizontal and vertical digitization: The company is horizontally and vertically digitized. Requirements of Industry 4.0 have been implemented within the company, and information flows have been automated.			
Description → see (Leyh et al. 2017)			
Stage 2–Cross-departmental digitization: The company is actively engaged with Industry 4.0 topics. Digitization is implemented across departments; first Industry 4.0 requirements are implemented in the company.			
Description → see (Leyh et al. 2017)			
Stage 1–Basic digitization level: The company has not addressed Industry 4.0. Requirements are not or only partially met.			
Integration of enterprise systems only department-specific. The enterprise systems along the enterprise's value chain only support their respective fields of activity.	Integration of enterprise systems only department-specific. The enterprise systems along the enterprise's value chain only support their respective fields of activity.	Product development is not digitally supported.	No service-oriented or cloud-based approaches. Data and information flows are not used for product improvement/optimization. Confidentiality, availability, and integrity of the data are not guaranteed.

Table 1. Overview of SIMMI 4.0

Results of the Application of SIMMI 4.0

Questionnaire-based Approach

Since our long-term research project was designed to provide insight into and an understanding of the companies' ability to assess their level of Industry 4.0-maturity, we need an understanding regarding to

what extent this aim can be fulfilled via our model SIMMI 4.0 in its current stage of development. Therefore, as part of our research project, this paper is the first application of SIMMI 4.0 in a real enterprise setting following the literature based model development. As a test/proof of concept of our model, this step should help to improve the existing configuration of SIMMI 4.0 and develop a user oriented and practical approach to provide a tool for enterprises to self-assess their Industry 4.0 IT system landscape.

Therefore, we designed a short questionnaire that addresses all components of SIMMI 4.0. This questionnaire is not overly complex and is thus applicable to various enterprises. It consists of 15 questions divided into five sections. In the first part, we collect general information about the enterprises for classification purposes. This section does not need to be included in the final questionnaire tool. However, it is included in this step because it is important for us to understand the companies' backgrounds for further model improvement. The second part of the questionnaire refers to the vertical dimension and therefore to organizational and strategical aspects. The third part focusses on the horizontal dimension and the integration of cross-company processes. The fourth part concentrates on the digital product development dimension. In this part of the survey, the companies are asked about their digital support in production processes using enterprise systems along the entire value chain. The last part is the cross-sectional technology criteria dimension. This section seeks to uncover knowledge about the implementation of a service-oriented architecture and the use of cloud computing, information aggregation, and information processing as well as appropriate IT security. Table 2 provides an overview of the different questions. The detailed answer options are not reported in this paper but can be obtained from the first author upon request.

Question Number	Question
Section 1–Company information	
1.1	How many employees work at your company?
1.2	What is the annual turnover at your company?
1.3	To which industry does your company belong?
Section 2–Organizational/strategical aspects *(Dimension: Vertical Integration)*	
2.1	How is your company organized?
2.2	What is the planning period for your business?
2.3	How is strategic planning carried out in your company?
2.4	How do you assess the support of business planning through enterprise systems? Which of the following enterprise systems do you use to support business planning?
Section 3–Enterprise systems *(Dimension: Horizontal Integration)*	
3.1	Which business areas/departments of your company are supported by enterprise systems?
3.2	How do you assess the integration of your IT department?
Section 4–Digital production *(Dimension: Digital Product Development)*	
4.1	How do you assess the digital production support in your company?
4.2	Do you collect data about the way customers use your products?
4.3	If so, how is the data used to improve the products?
Section 5–Cross-sectional technology *(Dimension: Cross-sectional technology criteria)*	
5.1	Is your company using service-oriented cloud applications?
5.2	Is your company using big data applications?
5.3	How do you assess your company's privacy and data security?

Table 2. Overview of the Questionnaire to Apply SIMMI 4.0

In addition to the questions considering the different dimensions and the general information, we asked the companies two more questions; i.e., these questions were intended letting assess the companies themselves in total in terms of their Industry 4.0 maturity. One question ("How do you assess the

Industry 4.0 level of your company?") used specifically provided answer options, and the other question presented an overview of SIMMI 4.0 (similar to Table 1) to the enterprises and let them choose their maturity level. With this, we were able to compare the self-given maturity level with the calculated level after completion of sections 2-5 (see Table 2). By doing so, we were able to draw conclusions about the companies' ability to self-assess as well as the applicability and suitability of our model.

Maturity Level Calculation

Level Score–Dimension Vertical Integration (VI): The level score of the vertical dimension (VI) is determined by questions 2.1-2.4. By question 2.1, the organization of the enterprise is determined, and by question 2.2 its planning period. These aspects do not occur directly in SIMMI 4.0, but they are an important prerequisite for implementing Industry 4.0. For this reason, the answers to these questions are only one-fifth of the calculation of the level score of this dimension. The remaining four-fifths are derived from questions 2.3 and 2.4. In question 2.3, five possible answers are available. The points for this question (between one and five points) go directly into the calculation of the level score. The last question that is needed to calculate the level score of the vertical dimension is question 2.4, which provides data on the use of different enterprise systems to support planning processes in the company. A matrix is provided for this purpose. A point is assigned for each enterprise system used in the company. When a company uses an enterprise system that has direct interfaces with other enterprise systems, two points are awarded. In the case that an enterprise system is not relevant for a company, it is excluded from the overall evaluation. Within the matrix, a company can reach a maximum of 16 points. These are then normalized so that they can be used for determining the level of maturity.

Level Score–Dimension Horizontal Integration (HI): The level score of the horizontal dimension (HI) is determined by questions 3.1 and 3.2. Question 3.1 is weighted by two thirds and question 3.2 by one third into the score of this dimension. Question 3.2 determines the integration of the IT department within the company, which is not directly part of the maturity model SIMMI 4.0, but it is also of great relevance within the framework of the implementation of Industry 4.0. Question 3.1 determines the degree the enterprise systems support the company departments. The question is structured in a matrix form. Depending on the type of support, one to five points can be obtained.

Level Score–Dimension Digital Product Development (DPD): Digital product development is identified by questions 4.1, 4.2, and 4.3. Question 4.1 has seven possible answers. The second to fourth answers represent the second level of maturity and thus yield two points. In this question, a maximum value of five points can be achieved. Questions 4.2 and 4.3 focus on data collection and the way data is used by the company to improve its production. Question 4.2 covers maturity levels 1 to 3 and merges into the results with a maximum of three points. Question 4.3 is based on question 4.2. This is used to determine whether a company has a maturity level of 4 or 5. The score of this dimension is calculated as the average of question 4.1 and the combination of questions 4.2 and 4.3.

Level Score–Dimension Cross-sectional technology criteria (CTC): The fourth dimension of SIMMI 4.0 is determined by questions 5.1, 5.2, and 5.3. Question 5.1 determines whether the company uses cloud applications. Question 5.2 identifies the use of big data solutions. Question 5.3 determines the implementation of data security and data protection within the company. For this purpose, a response matrix is provided. If one of the given privacy and data security aspects is not relevant for the company, this aspect is not included in the calculation of the score. One point is assigned for solutions that are in the implementation phase, and solutions that have already been successfully implemented score two points. Projects that are still in a planning phase receive zero points.

Calculation Example

For all dimensions and for the overall maturity level, Table 3 shows the formulas and an example calculation based on the answers given by company C1 (see Table 4). All mentioned calculation aspects per dimension are integrated into the formulas. However, within this paper, we cannot provide all sub-formulas resulting in the scores/question results (QR) for the matrix questions. Since we have not listed all answer options for the questions of Table 2, it would be misleading to provide these sub-formulas here. Those additional formulas as well as the different answer options can be obtained from the first author as supplementary material upon request.

Dimension	Formulas	Question Results (QR)	Level Score
Vertical Integration (VI)	$VI = \left(\frac{QR2.1 + QR2.2}{2}\right) \times \frac{1}{5} + \left(\frac{QR2.3 + QR2.4}{2}\right) \times \frac{4}{5}$	QR2.1 = 0 QR2.2= 1 QR2.3= 3 QR2.4= 3.93	**VI = 2,87**
Horizontal Integration (HI)	$HI = \frac{(2 \times QR3.1) + QR3.2}{3}$	QR3.1 = 3.63 QR3.2= 5	**HI = 4,09**
Digital Product Development (DPD)	$DPD = \frac{QR4.1 + (Combined\ QR4.2\&4.3)}{2}$	QR4.1 = 5 QR4.2&4.3 = 4	**DPD = 4,5**
Cross-sectional Technology Criteria (CTC)	$CTC = \frac{QR5.1 + QR5.2 + (3 \times QR5.3)}{5}$	QR5.1 = 4 QR5.2 = 4 QR5.3 = 4,64	**CTC = 4,38**
Overall Maturity Level	$\boldsymbol{SIMMI\ Level = \frac{VI + HI + DPD + CTC}{4}}$	**Overall Maturity Level = 3,96 ≈ 4**	

Table 3. Maturity Level Calculation Based on the Answers of Company C1

Model Application

After conducting several pre-tests with various researchers from the responsible institutions and multiple adjustments of the questionnaire, we chose several companies to participate in the initial model test. Those companies were chosen from the German internet platform 'Industrie 4.0' (www.plattform-i40.de), which lists about 189 companies that have successfully implemented Industry 4.0 projects. We only chose companies that stated to have at least two positive effects resulting from their projects. Out of these companies, six enterprises agreed to participate. The companies come from the manufacturing, service, and commerce sectors (see Table 4). Within the field of manufacturing, an electrical engineering company and an automation technology company took part. From the service sector, a company that is engaged in consulting and system engineering and a tax consulting company participated. One of the two companies from the commerce sector specializes in the distribution of innovative filter technology.

Company	Industry Sector	Number of Employees	Annual Revenue (million euros)
C1	Manufacturing	50-99	10-50
C2	System engineering/consulting	>499	100-250
C3	Manufacturing	>499	>500
C4	Service provider/tax consultant	1-19	<1
C5	Commerce	20-49	1-10
C6	Commerce	1-19	1-10

Table 4. Overview of Selected Companies

As shown in Table 4, two of the companies employ between 1 and 19 employees, and another two companies employ more than 499 employees; the remaining two companies employ 20 to 49 and 50 to 99 employees each. The companies stated that they generate annual revenue of between less than 1 million

euros per year up to a total of more than 500 million euros per year. With those companies, we were able to acquire a suitable representation of different sectors and enterprise sizes.

Of the selected companies, four companies indicated that according to their own assessment, Industry 4.0 is part of the company's strategy and the company's business model is designed for Industry 4.0. This corresponds to maturity level 4 in SIMMI 4.0. One company indicated that the company is part of a value-creation network and develops new strategies and business models in the area of Industry 4.0 (maturity level 5). Another company from the commerce sector stated that the challenges of Industry 4.0 are known, but they had no implementation strategy yet. This was assessed with the one of the two additional questions ("How do you assess the Industry 4.0 level of your company?"). The second additional question through which the companies assessed their maturity level directly in SIMMI 4.0 was answered by five companies. Two of them perceived themselves at maturity level 4, while the remaining three companies indicated that they were at level 3 and level 2, respectively.

Once we were able to show that the companies are capable of applying the maturity model, we investigated whether companies are also able to understand SIMMI 4.0 to assess themselves in a better way. For this purpose, as shown in Figure 1, the additional question for the self-assessment of the companies (blue bar in Figure 1) is compared with the self-assessment using SIMMI 4.0 (red bar in Figure 1) and the calculated level of maturity (green bar in Figure 1) from the questionnaire sections 2 to 5 (see Table 2). Figure 1 shows that four of the six companies perceived maturity levels based on the additional question was at a higher stage than the calculated stage (C2, C3, C5, C6). Only one of the six companies chose a higher stage of maturity in SIMMI 4.0 than the calculated stage (C2), and two chose the identical level in the SIMMI 4.0 assessment as the calculated stage (C1, C3). However, two companies chose a lower maturity level using SIMMI 4.0 than the calculated level (C4, C5) C6 did not answer this part of the questionnaire.

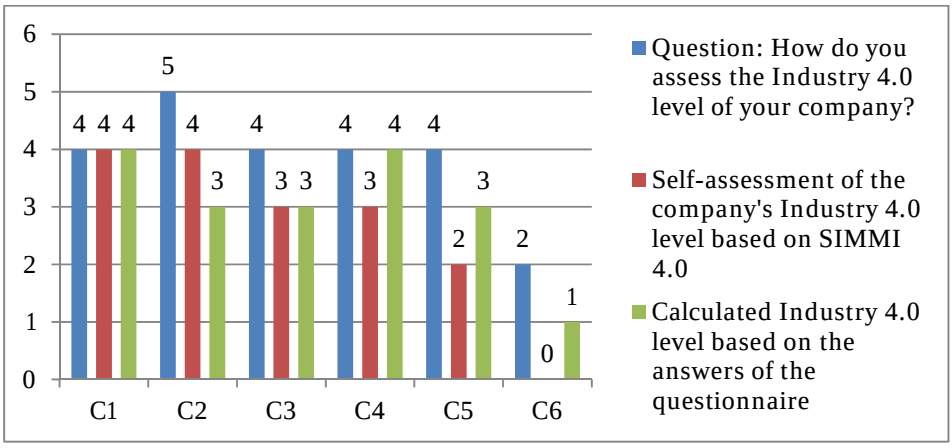

Figure 1. Comparison of Industry 4.0 Levels – Self-Assessment vs. Calculated Level

With the application of SIMMI 4.0 by these six companies we are able to answer our research question: Companies are capable of independently analyzing the state of their IT system landscape regarding Industry 4.0 requirements by applying SIMMI 4.0. With the help of the questionnaire, the enterprises were able to easily assess their maturity levels in the four dimensions and their overall Industry 4.0 maturity level. In addition to the model application, we conducted an expert interview with the participant of company C1 to get a deeper understanding where problems regarding the application of SIMMI 4.0 might have occurred. When asked whether the company was able to cope with the model, the interviewee stated that they had managed well with both, the maturity model and the respective questionnaire. The company had no difficulty in answering the questions of sections 2-5. Furthermore, the company was able to understand all specific terms used in the questionnaire. Summing up the feedback from participating companies and the detailed feedback from the interviewee, we are able to show that our model is an appropriate and suitable tool to support companies in assessing their IT system landscape regarding the requirements of Industry 4.0.

However, some further aspects arose during the model application. As shown in Figure 1, only one company (C1) assessed its Industry 4.0 maturity at being at the same level regardless of how this assessment was conducted. As we know from a prior study (see Bley et al. 2016) that many enterprises often wrongly self-assess their IT system landscape compared to its actual state we can conclude that SIMMI 4.0 provides the right maturity level or at least one that better matches their real situation. However, we cannot take this as given. A broader study is necessary to clarify the correctness of our model. Since the Industry 4.0 requirements are deduced from literature an evaluation step with a larger number of companies is necessary, especially with companies who have not yet successfully implemented Industry 4.0 projects and are thus less experienced. This step is already planned as part of our development procedure. In addition, we have to clarify the enterprises' perception of the validity of our model. This means whether companies–whose results of the calculated scores differ from their self-assessed maturity level–"accept" the SIMMI-score and thus, will act/react according to their calculated maturity level in future or if they still stick to their self-perception. Therefore, the usefulness of SIMMI 4.0 in terms of this aspect has to be addressed in detailed interviews. This will improve our understanding of how our model can help to correct a wrong self-perception.

Conclusion and Future Aspects

The aim of our long-term research is to provide support for enterprises in terms of a toolset to classify and assess their IT system landscape in the context of the Industry 4.0 requirements. Through a systematic literature review (see Leyh et al. 2016; Leyh et al. 2017) we demonstrated that the literature contains no maturity model that meets the needs of Industry 4.0 in terms of a company-wide and even a cross-corporate IT system landscape. However, due to the drastic changes resulting from the digitalization of businesses and society itself, enterprises must realistically assess their IT system landscape. Therefore, an easy-to-handle tool could provide adequate support for assessment. With this in mind, we designed a new maturity model (System Integration Maturity Model Industry 4.0 – SIMMI 4.0) to assess the readiness of a company's IT system landscape in terms of Industry 4.0. Within this paper, we followed our procedure model (as we described as future aspects in Leyh et al. 2017) and we presented a first successful application as proof of concept of SIMMI 4.0. Therefore, our model has the potential to support enterprises in an appropriate way, especially addressing or closing the gap with the wrong self-assessment of their digitization level.

Since this is just a first application and evaluation of SIMMI 4.0, as mentioned above, further steps must follow. For example, the surveyed companies were only companies that have already implemented and conducted Industry 4.0 projects in a certain way. Therefore, as shown, their maturity levels are quite high in most cases. As a next step, we will evaluate our model with selected companies that are not that active in the field of Industry 4.0. After this step, a wider evaluation of the maturity model will follow with a large number of companies applying our model based on the questionnaire approach. Those future steps as well as the resulting design/adjustment decisions based on them, more detailed evaluation steps, and the model's scientific as well as practical contributions will be addressed in subsequent papers.

In addition to the development of SIMMI 4.0, we identified additional links and needs for further research. For example, some maturity models already exist for the field of Industry 4.0 that deal with the organizational aspects or system-specific aspects in detail. A mapping of these maturity models would be necessary to combine their different points of view. Different maturity level assignments and dimensions between these models should be developed to enable companies to fully classify themselves in terms of Industry 4.0 requirements at all levels of their enterprise. With this work, companies would be able to determine their overall maturity in the field of Industry 4.0.

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