Developing a Maturity Model for Digital Servitization in Manufacturing Firms

Theoni Paschou[1]([✉]), Mario Rapaccini[2], Christoph Peters[3], Federico Adrodegari[1], and Nicola Saccani[1]

[1] Department of Mechanical and Industrial Engineering, University of Brescia, Via Branze 38, 25123 Brescia, Italy
t.paschou@unibs.it
[2] Department of Industrial Engineering, University of Florence, V.le Morgagni 40, 50131 Florence, Italy
[3] Institute for Information Management, University of St. Gallen, 9000 St. Gallen, Switzerland

Abstract. In today's rapidly changing markets, manufacturing firms are increasingly challenged by the convergence of digital technologies and servitization, which is defined as Digital Servitization. Enterprises struggle to grasp this phenomenon's vision, constantly facing pressures to obtain and retain competitive advantage, inventing and reinventing new products and services, reducing costs and time to market, and enhancing quality at the same time. They need to define improvement actions to be taken to navigate through the transformation process and prioritize between different activities. Prior research has highlighted the importance of how to proceed into this transformation, however less emphasis has been put on suggesting suitable activities that fit the organization's current status and future goals. To overcome this challenge, we propose a maturity model for digital servitization that serves as an assessment tool. Based on a literature review and qualitative expert interviews, this study proposes a maturity model that allows a holistic view on the areas affected by digital servitization. The model consists of four dimensions, strategy, business processes, customer experience, organization and culture that consist of a requirements list with 13 indicators. The contribution of this study enables practitioners to diagnose and assess their activities with the digital servitization transformation.

Keywords: Digital servitization · Maturity model · Digital transformation

1 Introduction

The growing digital disruption across industries is blurring boundaries and forcing industrial enterprises to improve their agility and responsiveness to gain ability to manage the whole value-chain. Recent research suggests that the application of digital technologies (DTs) can further advance servitization by enabling sophisticated and novel service offerings [1, 2]. In fact, the adoption of digital technologies such as the Internet of Things (IoT), Data and Analytics, Artificial Intelligence can alter the features of the delivered services significantly [3–5] and enable novel business models [6],

thus, reshaping industry competition [7]. Indeed, DTs shape servitization strategies, structures and activities aiming at increasing the service delivery efficiency and value of service offerings [1]. For instance, KONE, one of the largest global elevator companies, developed, sophisticated condition monitoring and predictive maintenance services together with IBM. Both these services are based on IoT technology and have resulted in lower downtime and speed up equipment restoration [5].

The convergence of DTs and servitization is called digital servitization and refers to the development of new services and/or the improvement of existing ones through the use of DTs by enabling new digital business models, finding ways of co-creating value, generating knowledge from data, improving a firm's operational performance and gaining competitive advantage over rivals [8, 9] and received lots of attention over the last years from the research community and practitioners. Despite the phenomenon's growing relevance, the issue of defining how digital servitization changes a company's strategy, processes, and culture remains unexplored [10].

Evidence shows that organizations often struggle with understanding the impact of digital servitization on their business and industry [9]. One key barrier is their inability to decide where to begin their own transformation process. To date, to the best of our knowledge, the existing research has not provided tools, such as maturity models for practitioners to master this transformation. Specifically, more attention has to be focused on helping organizations to decide when and why they need to take an action to progress and teaching them which actions should be considered. The introduction of such maturity model in the digital servitization, could therefore allow managers to position and compare their current state to the best-practices in related business fields and map their new strategy accordingly, which will increase the firm's overall performance.

Hence, the aim of our research project is to develop a maturity model (MM) that can ease the decision making, and assess the digital servitization maturity in manufacturing companies based on highly relevant requirements. To achieve our goal, we follow the maturity development process of [11] and aim to answer the following two research questions:

– RQ1: What are the key requirements for digital servitization in manufacturing?
– RQ2: What stages can be observed in the process of digital servitization?

In pursuit of answering the two research questions, our paper is structured as follows. Section 2 sets the theoretical background. Section 3 describes the research method, and Sect. 4 presents the maturity model for digital servitization. Section 5 discusses the findings and suggests avenues for further research.

2   Theoretical Background

Technologies and software have been inherently involved in servitization since its infancy [12], shaping servitization strategies and structures. For example, Rolls-Royce has used a variety of sensor-based technologies to facilitate smart solutions [2, 4]. However, the role of technology was neglected in the early servitization literature, and for a long time these issues were investigated separately either focused on the customer

value or manufacturing process value [13]. The increasing interest, both from practitioners and scholars, on the convergence of digital transformation and servitization has set the path for a new phenomenon, named digital servitization, to flourish.

Digital servitization refers to the development of new services and/or the improvement of existing ones through the use of digital technologies, by enabling new digital business models, findings ways of co-creating value, generating knowledge from data, improving a firm's operational performance and gaining competitive advantage over rivals [1, 8, 9, 14, 15]. It is seen as profound and fundamental change that affects multiple business units within the organization, e.g. strategy, processes, organization and culture, etc.

Although, the phenomenon of digital servitization has been of a great interest for researchers of various disciplines the last years [16], its transition and implementation seems far from easy, creating numerous challenges. Since this transformation is not a linear process, there are different courses of actions. Evidence shows that enterprises often struggle to decide where to begin their own digital servitization journey and no tools are provided, such as maturity models, for practitioners to master this change. It would be beneficial for managers to know about these difficulties, in order to make an informed decision about prioritizing between different steps and to lay the foundation for successful change.

Descriptive models (maturity models) for practitioners need to be developed to support companies towards their digital servitization journey by defining how the adoption of digital technologies changes the whole organization in practice [10, 17]. Therefore, we need to know more about how companies actually face such a transformation, what makes them successful, and how organizations approach their transformation. A maturity model provides some guidance in this respect, since it gives an overview of the different areas and maps out typical paths of how organizations go about their digital servitization.

According to [11], maturity models consist of a sequence of maturity levels for a class of objects and represent an anticipated, desired, or typical evolution path of these objects shaped as discrete stages. Their application enables firms to achieve competitive advantages [18], by generating awareness of the analyzed aspects (their state, importance, potentials, requirements, complexity), and by serving as reference frame to implement a systematic and well-directed approach for improvement, ensuring a certain quality, avoiding errors, and assessing one's own capabilities on a comparable basis. There are several MMs but in this study, we use the Capability Maturity Model, which defines a set of process areas that reflect organizational capabilities which have to be developed to achieve the maturity goal of the service development process. [19], as the main reference due to its wide acceptance in industry.

The development of a MM entails critical requirements that occur throughout the digital servitization process and should be rooted in both scientific grounding and practical relevance. In the case of digital servitization, these critical requirements also impact the manner that a company relates to the other chain elements such as customers, partners, competitors [20] and internal relationship changes. Hence, this study has identified four main dimensions (strategy, customer experience, business processes, organization and culture) to analyze how they should be considered during the digital servitization process of manufacturers. The four dimensions were defined by using the

St.Gallen Business Engineering Map as a guide to group the critical requirements within the same type of relationship. The critical requirements for all the dimensions are obtained from the literature and are used to create an initial concept of the maturity model.

3   Research Methodology

Our research aims at developing a MM for digital servitization in manufacturing. The development of MMs is established [21], and numerous models for a variety of purposes have been developed [11, 22]. In contrast to the large number of MMs, the research on how to develop these models is rather sparse [11]. We identified the two popular development processes [11, 21], as it is indicated by literature, on how to conduct MM design. We decided to apply [11] to develop our MM since they follow a Design Science Research (DSR) development process according to DSR guidelines [23]. Despite [11] propose a seven-step development process, we decided to reduce the complexity of the model by merging three process steps (the conception of transfer and evaluation, the implementation of transfer media and the evaluation) into one, the evaluation step. In addition, we incorporated the "determination of a development strategy" in the second step, the comparison process, because it is based on its results. The procedure applied in our research consists of four steps, and we describe each of them in Table 1 according to the tasks performed and the techniques used.

Table 1. Procedure model.

	Problem identification	Comparison of existing MMs	Model development	Model evaluation
Performed activities	Problem identification and motivation	1. Deduction of maturity model requirements 2. Identification and evaluation of existing maturity models	Conceptualization of maturity levels	Evaluation
Use techniques	1. Initial literature review 2. Exploratory expert interviews	In-depth literature review	Model development & expert interviews	Expert interviews

In the first step (*Problem identification*), we specified the research problem and focus of the MM, provided its practical relevance and justified the value based on an initial literature review and exploratory interviews with experts to get better insights.

Based on the problem identification, in the second step (*Comparison of existing MMs*), we gather requirements by conducting a systematic literature search using the

Scopus database, which is widely acknowledged as a world leading source and provides the best coverage in this research field. We applied the search combination of servitization ("servitization", "product (-) service system* (PSS/IPSS)", "integrated solution*", "service transformation", service infusion") and different terms for digital transformation and technologies ("digital technology/ies", "digitization", "Artificial Intelligence", "Big Data", "Cloud", "Digital Technologies", "digitalization", "Industry 4.0," Internet of Things", etc.). The search, between 2000 and 2019, yielded 86 usable articles. These articles were used to derive an initial list of requirements, which was structured according to the four MM dimensions derived in the theoretical background section. For the coding process the software Atlas.ti was used. Moreover, we operated a second literature review (using keywords such as "digital servitization", "servitization", "business/enterprise/organizational transformation", "digital transformation", "assessment model", "maturity model") to identify any shortcomings or lack of transferability of existing MMs, which are devoted to same or similar domains. In particular, 16 studies emerge from the field of servitization, [22, 24] and 11 from digital transformation. Subsequently, we analyzed the MMs according to their domains and functionalities as well as their capability to address the defined research problems.

In the third step (*Model development*), we used model adoption mechanisms [25] in the rigorous creation of a MM (structure and content). After formulating the model, the study sought expert opinions to confirm support for the model. Emails with a questionnaire to guide open conversations were sent to ten individuals, academics and practitioners involved with digital servitization for over a decade. There were six respondents who provided in-depth feedback through interviews regarding the model, which had a duration of 60-120 min each one. The majority of the responses acknowledged the importance of evaluating manufacturers' use of digital servitization and supported the overall structure of the model. Comments included suggestions for definition of stages, notes about wording, suggesting the possibility of needing less stages, need for clarifying requirement description, questions about how the model will be measured and by whom, and proposing extra dimensions/requirements. These opinions were taken into consideration and the model was revised accordingly in order to be more precise and complete.

During the last step (*Model evaluation*), we evaluated the comprehensiveness of the model, validity in self-assessment and the capability of supporting the future development of a roadmap with the same experts, discussing the final version of the MM. Table 1 describes the steps according to the tasks performed and the techniques used achieved in complementing our research.

4   Proposed Digital Servitization Maturity Model

4.1   Dimensions and Requirements of Maturity Model

The identified requirements both from literature and expert interviews were summarized in four dimensions. For each dimension, the corresponding maturity criteria were defined, which describe the fields of action. Activities in these fields show the penetration of digital servitization maturity. Hence, we employed "Strategy", "Customer

Experience", "Business Processes" and "Organization and Culture" as dimensions that serve not only as a conceptual basis but for collecting the exploratory identified requirements but also as a theoretical lens for the MM (see Table 2).

Table 2. Identified dimensions and maturity criteria in the individual steps of the study.

Dimensions	Requirements	Literature	Expert interviews
Strategy	Strategic orientation	✓	✓
	Business model	✓	(✓)
	Digital service offering	✓	(✓)
	Digital service ecosystem	(✓)	✓
Customer Experience	Customer centricity	✓	✓
	Customer trust	(✓)	✓
Business Processes	Production	✓	✓
	Marketing	(✓)	(✓)
	Human resources	(✓)	✓
Organization and Culture	Digital service business mindset and culture	(✓)	✓
	Governance and leadership	(✓)	✓
	Organization design and talent management	✓	(✓)
	Competences	✓	✓

✓ = frequent mention (✓) = occasional mention

The **Strategy** of digital servitization is embedded within the overall business strategy and focuses on how the business transforms or operates to increase its competitive advantage through digital initiatives in service. "Strategic Orientation" was identified as an important prerequisite for digital servitization and it refers to the exploitation of the overall growth strategy aiming at developing digital service offerings and innovating the company's portfolio by keeping its heritage [26, 27]. "Business Model", another critical requirement, refers to the different technology-enabled business models that facilitate firms to achieve a competitive advantage by providing customer knowledge-based digital service offerings during the entire product life cycle [27, 28]. In addition, "Digital Service Offering" applies to the enrichment of the existing but also the creation of totally new service offerings enriched by digital technologies that bring digital and physical systems together creating customer value and revenue streams [20]. The last requirement of this dimension is the "Digital Service Ecosystem" and makes reference to the relationship between the company and business partners (R&D organizations, technology incubators, startups), enabled by platforms, which aims at gaining access to resources such as technology intellectual property, or people to increase the organization's ability to improve, innovate and grow, balancing security and privacy needs with the ability to flex capacity according to business demand [9, 29].

Customer Experience focuses on the necessity of considering customers' needs and interests as the basis for developing digital service offerings. The first requirement,

that we identified is the "Customer Centricity" and deals with a set of procedures and practices for assessing closer customers' preferences and continuously evolving needs on digital service offerings, to enhance the competitive position and strengthen customer relationships [13]. Experts stressed the "Customer Trust", which refers to how the customer's trust is build and how the perceived risks (functional, psychological/ safety, privacy) are evaluated by them [30].

The dimension of **Business Processes** contains the way of executing and evolving a company's operations by using digital technologies aiming at driving strategic management and enhancing service business efficiency and effectiveness. The first requirement is "Production" and indicates the way processes are executed, monitored and managed. It consists of internal processes (the way inputs are transformed to outputs, products and services are integrated through digital technologies to create value for the customers and end users), supply chain orchestration (the way the firm employs digital technologies to manage the value network of all actors and individuals that interact to deploy resources and applied competences in order to create value) and digital innovation (practices based on digital technologies that support research, design, and development of new product-service offerings) [8, 10]. "Marketing" requirement include the pricing, the process whereby a business sets the price at which it will sell its digital service offerings and value co-creation, which occurs through interactions among providers and customers by integrating resources and applying competences [31]. "Human Resources" requirement depicts to services provided by an HR department to business operations. HR operations include administrative services, recruitment, job analysis, and employee relationship management [15].

Organization and Culture dimension defines and develops an organizational culture with governance and talent processes to support progress along the digital servitization maturity curve, and the flexibly to achieve growth and innovation objectives. "Digital Service Business Mindset and Culture" describes the diffusion within the companies of a mental model that is oriented towards digital service culture: the company needs to change mental model to view digital service offering as a business logic and perspective on value creation [15]. Furthermore, "Governance and Leadership" refers to the efficient and effective decision making processes which define the expectations, systems and management of projects related to digital servitization [8]. Another significant requirement is the "Organization Design and Talent Management" and cites the transformation of the internal organizational structures by establishing dedicated team/roles/persons for the development of digital service offerings in light of new competitive pressures [15]. The final requirement is the "Competences", which treats higher and diversified competences that employees need to develop by acquiring new knowledge and ways of working to encounter increasingly interactive tasks, take data-driven decisions, understand customer's problem and interpret its real needs [32].

4.2   Maturity Levels

To define the digital servitization MM phases we used as main reference the MM processes of [19]. For simplicity in this study, we use three maturity stages (see Tables 3a, b and c), which were deduced from the items in each dimension.

Table 3. Maturity model for digital servitization.

Dimension	Requirement	Level 1 – Beginner	Level 2 – Experienced	Level 3 – Leader
Strategy	Strategic orientation	Limited vision of digital servitization, no documented implementation target. Strategy initiated and developed. Low investment	Incremental vision of digital servitization, not fully defined implementation target. Strategy implemented and occasionally reviewed. Investment and Innovation management established in multiple areas	Transformational vision, clearly defined implementation target. Strategy implemented and regularly reviewed. Enterprise-wide Investment and Innovation management established
	Business model	Add-on business models use DTs (ICT, IoT) to enable additional functions or adding personalized services to the existing physical products or service to facilitate service provision	Usage-based business models use DTs (IoT, cloud computing, big data) to measure the amount of product usage and allow customers to pay for or subscribe to the plan, based on their actual usage and needs (pay-per-use)	Solution-oriented business models use DTs (IoT, artificial intelligence) to enable the provision of solutions to customers. With the aid of IoT technology, providers are able to offer integrated solutions to customers' needs (subscription availability)
	Digital service offering	Low usage level of DTs is used to provide obligatory product-related services (base services), such as installation or maintenance and repair	Moderate usage level of DTs (IoT, Cloud computing, Big data, Advanced manufacturing Solutions) is used to provide intermediate services (e.g. remote monitoring)	High usage level of DTs (IoT, Big data, Advanced manufacturing solutions, Artificial Intelligence) provides value for both customer and the companies' internal processes creating novel services (advanced services)
	Digital service ecosystem	Company has partnerships with a few stakeholders; low level collaboration. No flexibility, no additional integration; limited understanding today, no future shared view	Company has partnerships with some of stakeholders; medium level of collaboration. A moderate level of flexibility, integration and understanding	Fully digitized, integrated partner ecosystem; open system built on a flexible and integrity architecture; clear shared view, today and in the future
Customer experience	Customer centricity	None customer preferences and needs are collected. Interaction between customer and company is not existent/distant. No feedbacks from the customer are collected. Impersonal customer communication	No standard approach of preferences/needs collection. The customer is integrated in the early design process in order to align the product to the customers' needs. Formal feedback is collected after technical assistance interventions	Formal procedures and rules drive customer preferences and needs, used for future strategical decision. Customer and interaction data collected through different channels. Feedbacks are discussed with the client and are explicitly considered in the continuous improvement process by creating common platforms. Intimate relationship
	Customer trust	No documentation; customer does not know when/how the service provider access the equipment; uncertain about which activities are performed on the machine. Service technician can access private/confidential information beyond the service agreement; no control	Some documentation; customer does not know when/how the service provider access the equipment; certain about which activities are performed on the machine. Service technician can access some private/confidential information beyond the service agreement; little control	Documentation; customer knows when/how the service provider access the equipment; certain about which activities are performed on the machine. Service technician cannot access private/confidential information beyond the service agreement; control
Business Processes	Production	Operation process traceability is provided partially; low level end-to-end visibility and production customization. Standard agile methods in project execution (e.g. Scrum); no clear integration and standardization. Integrated supply chain processes between company, suppliers and customers in terms of basic data sharing and communication; few	Operation process traceability is provided at production line level; medium level end-to-end visibility and production customization; integration and standardization are at a medium level. Integrated supply chain processes between company, and key strategic suppliers/customers in terms of data transfer; some software systems in use and	Operation process traceability is provided at factory level; high level end-to-end visibility and production customization; high level of process standardization. Supply chain systems are fully integrated between company, suppliers and customers which provide real-time planning; lots of software systems in use and production systems are

Table 3. (*continued*)

Dimension	Requirement	Level 1 – Beginner	Level 2 – Experienced	Level 3 – Leader
		software systems in use and production systems are partially automated. No activities supporting the digital service innovation, apart from observations. Data usage in service innovation is at low level	production systems are automated at production line level. Systematic approach for digital service innovation; company is aware of the process but some activities are still incomplete or inconsistent. Data usage in service innovation is at medium level	automated in factory level. Quality management and continuous improvement activities are formalized in the procedure. Data usage in service innovation is at high level
	Marketing	A few analytics studies are conducted and data obtained from environment is not used in product pricing and dynamic pricing. The customer has little control over the contribution process and the provider offers the digital services that chooses	Analytics studies are conducted and data obtained from environment is used in product pricing and dynamic pricing. The customer has some control over the contribution process and the provider offers the digital services that customer also needs	Analytics studies are conducted and data obtained from environment is used in product pricing and dynamic pricing. The customers are tightly integrated and engaged with the provider's processes and resources. They are jointly able to discover opportunities for value creation
	Human resources	Data is used in a few areas, but company does not share real-time data with field workers. Traditional recruitment and training, e-learning is not an option	Data is used in some areas; company shares real-time data with field workers. Traditional/Digital recruitment, e-learning is an option	Data is used in lots of areas; company shares real-time data with field workers. Special training (mixed reality, internal academy) for re-qualification of the employees. Digital recruiting
Organization & Culture	Digital service mindset & culture	Low attitude towards digital servitization. Mistakes and lessons from failed projects not secretive, digital competences are not critical, the development of new digital service offerings by customers is not actively promoted. Low level of knowledge sharing and no/in limited area collaboration across company. Home office for employees for whom it makes sense	Promote attitude towards digital servitization in a medium level. Evaluate errors, identify the importance of digital competences, the development of new digital service offerings is promoted. Encouragement of knowledge sharing and structured and consistently performed cross-functional collaboration	Promote digital servitization vision. Evaluate errors to improve processes, digital competences are critical, customers suggest systematically improvements for the digital service offerings. High level of knowledge sharing and sophisticated forms of cross-company collaboration in value creation networks. Great experience on mobile working and little regulations are needed
	Governance and leadership	De-centralize decision making process. Low quality/transparency/availability and accuracy of data used for decision-making processes	Promote central decision making process. Medium quality/transparency/availability and accuracy of data used for decision-making processes	Re-centralize decision making process. High quality/transparency/availability and accuracy of data for decision-making processes
	Organization design & talent management	Organization structure is not suitable for transformation. No formal or informal roles are created. Limited interaction between departments	Organization structure is suitable for initial projects. Some roles are being created. Departments are open to cross-company collaboration	Well-structured for transformation. Formal roles responsible for strategic planning, which are well connected within business units. Departments are open to cross-company collaboration to drive improvements
	Competences	Only technology focused areas have employees with digital skills that are not allocated to specific digital servitization projects	In most areas of the business digital skills have been well developed that are allocated to specific digital servitization projects in different units	All across the business, cutting edge digital and analytical skills are prevalent and allocated to specific digital servitization projects in same units

Level 1 – Beginner is a maturity level where a company has some pilot strategy initiatives and offers base services. The usage level of digital technologies in business processes (production, marketing, HR) is low. Flexibility, integration and collaboration

with partners are at low level as well. The customer interaction is distant, while there is a low attitude towards digital servitization. The organization structure and people are not prepared enough for this transformation.

Level 2 – Experienced is a maturity level where a company is implementing digital servitization and offers intermediate services. Digital technologies are used in a moderate level in the different business processes the ecosystem is getting digitized while the collaboration is becoming closer. The customer is integrated in the design phase already and the general attitude is encouraged towards the new transformation. The organization structure is suitable for initial projects and people for specific units that have digital servitization projects have the necessary competences.

Level 3 – Leader is a maturity level where a company has implemented digital servitization, has a comprehensive vision and offers advanced services. The usage level of digital technologies is high both in the business processes and business models. There is a fully digitized, integrated partner ecosystem built on a flexible and integrity architecture. There is an intimate relationship and personalized communication with the customer while the attitude is comprehensive and promotes digital servitization. The organization structure is well structured and digital competences are prevalent in the whole company.

5 Discussion and Conclusion

Although, evidence show that manufacturing companies struggle with comprehending the impact of digital servitization and how to master it, little attention has been devoted so far in developing a tool that can be used from practitioners. This study presents the development of a new maturity model, that based on specific requirements identified in digital servitization literature and expert interviews, can be used as a management instrument to analyze the current set-up, by assessing the maturity level of strategy, business processes, customer experience, organization and culture. Three levels of maturity have been outlined, and the model constitutes the main contribution of our research, since, to the best of our knowledge, no such kind or model exists for digital servitization in manufacturing.

Coping with the challenges of digital servitization is of considerable interest to both researchers and practitioners. Initially, it provides a theoretically grounded, methodologically rigorous development of a maturity model for digital servitization in manufacturing companies. The value of the presented model, in research, resides in the combination of scientific rigor, practical relevance, and direct applicability. The tool is also directly applicable because of its extensive documentation and it describes its scope, purpose of use, and structure (maturity levels, dimensions, requirements). Even if the model has little normative power, it can favor the identification and prioritization of the improvement actions, as they emerged from literature and interviews.

The developed maturity model for digital servitization can be used by managers to inspire, establish trust, build consensus and communicate. First, managers can use the model by asking what they could learn from the others' experiences in different organizational contexts. The objective is to avoid mistakes already made by others and

benefit from accumulated experiences identified in literature. The maturity model, in this way, supports managers to identify their requirements with low maturity that they need to be improved and provides them with inspiration on how to incrementally improve digital servitization. Second, the development of digital servitization requires significant high investments, for which the approval of top management is mandatory. To receive such approval, it is essential to convince decision makers that these investments are urgent and will pay off. Therefore, the model can help to create trust, that investments in digital servitization will pay off, and gain top management's support. Third, the success of fundamental business transformation depends on the existence of a strong consensus and a clearly defined and well-executed digital servitization strategy. The basis for consensus and a shared assessment of the as-is situation is a shared language and consolidation of diverse perspectives. The maturity model encompasses a number of dimensions and requirements, along with their definitions. Hence, it provides a shared language that facilitates the structure exchange of perspectives. Finally, tangible evidence of the current state of digital servitization is needed both at the corporate level but also by those who are responsible for developing this phenomenon. By capturing the maturity stages at different times, the model provides the means for continuously communicating any improvements. Consequently, the developed maturity model is a tool which enables internal awareness not only for the strengths but also the areas that need improvement. The model shows what has already been achieved and allows to track back success to understand the contributions of each individual.

Although this paper produced some interesting and useful finding, we would like to point some limitations that need to be considered when interpreting the results. The maturity model was developed to be applied in manufacturing sector. Thus, it cannot be applied across various industries. Furthermore, it is based exclusively on literature and a number of expert interviews, which makes it conceptual and for that reason, further research could involve more experts, divided into academics and practitioners, aiming at completing the requirement list considering different perspectives. We also acknowledge that even though the maturity stages have been carefully developed, based on literature and interviews, a testing and final evaluation of the tool with empirical cases are missing.

References

1. Lerch, C., Gotsch, M.: Digitalized product-service systems in manufacturing firms: a case study analysis. Res. Manag. **58**(5), 45–52 (2015)
2. Grubic, T.: Remote monitoring technology and servitization: exploring the relationship. Comput. Ind. **100**(3), 148–158 (2018)
3. Holler, J., Tsiatsis, V., Mulligan, C.: Toward a machine intelligence layer for diverse industrial IoT use cases. IEEE Intell. Syst. **32**(4), 64–71 (2017)
4. Rymaszewska, A., Helo, P., Gunasekaran, A.: IoT powered servitization of manufacturing – an exploratory case study. Int. J. Prod. Econ. **192**(5), 92–105 (2017)

5. Ardolino, M., Rapaccini, M., Saccani, N., Gaiardelli, P., Crespi, G., Ruggeri, C.: The role of digital technologies for the service transformation of industrial companies. Int. J. Prod. Res. **56**(6), 2116–2132 (2018)

6. Adrodegari, F., Saccani, N., Kowalkowski, C., Vilo, J.: PSS business model conceptualization and application. Prod. Plan. Control **28**(15), 1251–1263 (2017)

7. Porter, M.E., Heppelmann, J.E.: How smart, connected products are transforming competition. Harv. Bus. Rev. **92**(11), 64–88 (2014)

8. Vendrell-Herrero, F., Bustinza, O.F., Parry, G., Georgantzis, N.: Servitization, digitization and supply chain interdependency. Ind. Mark. Manag. **60**(1), 69–81 (2017)

9. Sklyar, A., Kowalkowski, C., Tronvoll, B., Sörhammar, D.: Organizing for digital servitization: a service ecosystem perspective. J. Bus. Res. **104**(11), 450–460 (2019)

10. Belvedere, V., Grando, A., Bielli, P.: A quantitative investigation of the role of information and communication technologies in the implementation of a product-service system. Int. J. Prod. Res. **51**(2), 410–426 (2013)

11. Becker, J., Knackstedt, R., Pöppelbuß, J.: Developing maturity models for IT management. Bus. Inf. Syst. Eng. **1**(3), 213–222 (2009)

12. Rabetino, R., Harmsen, W., Kohtamäki, M., Sihvonen, J.: Structuring servitization-related research. Int. J. Oper. Prod. Manag. **38**(2), 350–371 (2018)

13. Coreynen, W., Matthyssens, P., Van Bockhaven, W.: Boosting servitization through digitization: pathways and dynamic resource configurations for manufacturers. Ind. Mark. Manag. **60**(1), 42–53 (2017)

14. Opresnik, D., Taisch, M.: The value of big data in servitization. Int. J. Prod. Econ. **165**(1), 174–184 (2015)

15. Bustinza, O.F., Gomes, E., Vendrell, F., Shlomo, H.: An organizational change framework for digital servitization: evidence from the Veneto region. Strateg. Change **27**(2), 111–119 (2018)

16. Paschou, T., Adrodegari, F., Perona, M., Saccani, N.: Digital servitization in manufacturing as a new stream of research: a review and a further research. In: Gallouj, F., Djellal, F. (eds.) A Research Agenda for Service Innovation, pp. 148–165. Edward Elgar Publishing, Cheltenham (2018)

17. Ostrom, A.L., Patrício, L., Voss, C., Voss, C.A., Patrı, L.: Service research priorities in a rapidly changing context service research priorities in a rapidly changing context. J. Serv. Res. **18**(2), 127–159 (2015)

18. Wendler, R.: The maturity of maturity model research: a systematic mapping study. Inf. Softw. Technol. **54**(12), 1317–1339 (2012)

19. Paulk, C., Curtis, B.: Capability maturity model. IEEE Softw. **10**(4), 18–27 (1993)

20. Baines, T., Lightfoot, H.W.: Servitization of the manufacturing firm: exploring the operations practices and technologies that deliver advanced services. Int. J. Oper. Prod. Manag. **34**(1), 2–35 (2014)

21. De Bruin, T., Freeze, R., Kaulkarni, U., Rosemann, M.: Understanding the main phases of developing a maturity assessment model. In: Proceedings of the Australasian Conference on Information Systems, ACIS 2005, pp. 8–19. ACIS Press (2005)

22. Alvarez, R.L.P., Martins, M.R., da Silva, M.T.: Applying the maturity model concept to the servitization process of consumer durables companies in Brazil. J. Manuf. Technol. Manag. **26**(8), 1086–1106 (2015)

23. Hevner, A.R.: A three cycle view of design science research a three cycle view of design science research. SJIS **19**(2), 87–92 (2004)

24. Neff, A.A., Hamel, F., Herz, T.P., Uebernickel, F., Brenner, W., Vom Brocke, J.: Developing a maturity model for service systems in heavy equipment manufacturing enterprises. Inf. Manag. **51**(7), 895–911 (2014)

25. Becker, J., Knackstedt, R., Janiesch, C., Pfeiffer, D.: Configurative method engineering – on the applicability of reference modeling mechanisms in method engineering. In: Proceedings of the 13th Americas Conference on Information Systems, AMCIS 2007, pp. 1–12 (2007)
26. Bustinza, O.F., Bigdeli, A.Z., Baines, T., Elliot, C.: Servitization and competitive advantage: the importance of organizational structure and value chain position. Res. Manag. **58**(5), 53–60 (2015)
27. Kohtamäki, M., Parida, V., Oghazi, P., Gebauer, H., Baines, T.: Digital servitization business models in ecosystems: a theory of the firm. J. Bus. Res. **104**(5), 380–392 (2019)
28. Frank, A.G., Mendes, G.H.S., Ayala, N.F., Ghezzi, A.: Servitization and industry 4.0 convergence in the digital transformation of product firms: a business model innovation perspective. Technol. Forecast. Soc. Change **141**(1), 341–351 (2019)
29. Cenamor, J., Rönnberg, D., Parida, V.: Adopting a platform approach in servitization: leveraging the value of digitalization. Int. J. Prod. Econ. **192**(11), 54–65 (2017)
30. Paluch, S., Wunderlich, N.V.: Contrasting risk perceptions of technology-based service innovations in inter-organizational settings. J. Bus. Res. **69**(7), 2424–2431 (2016)
31. Valencia, A., Mugge, R., Schoormans, J.P.L., Schifferstein, R.: The design of smart product-service systems (PSSs): an exploration of design characteristics. Int. J. Des. **9**(1), 13–28 (2015)
32. Paschou, T., Rapaccini, M., Adrodegari, F., Saccani, N.: Competences in digital servitization: a new framework. In: Proceedings of the 23rd Summer School "Francesco Turco" – Industrial Systems Engineering, pp. 381–387. Press (2018)