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Abstract: For the manufacturing industry, exploiting the opportunities of digital transformation often implies the strategic development from being a manufacturer of pure physical products to one providing Product-Service Systems (PSS). In literature, PSS can be distinguished in different types, which differ substantially in their configuration of the underlying business model. However, since distinct PSS types require different organizational capabilities, the transformation toward a PSS provider is a challenge for managers. To provide guidance, scientific and professional literature mostly focuses on selected aspects. Though, a holistic consideration of relevant capabilities for the respective PSS type remains untapped. Against this backdrop, we developed a PSS Maturity Model (PSSMM) to guide organizations in developing appropriate capabilities. To provide an integrated view, the PSSMM refers to 5 focus areas, 20 capability dimensions, and associated capabilities. To develop and evaluate our model, we used the well-known approach of Becker et al. [1].

Keywords: Product-Service Systems, Maturity Model, Industry, Digital Transformation

1   Introduction

In the context of digital transformation in production, the development of Product-Service Systems (PSS) represents a well-established strategy for manufacturing companies to harness the various opportunities associated with digitalization. To tap new revenue pools and differentiate themselves against competitors, manufacturers are working on enriching their physical products with digital services to increase customer utility [2, 3]. PSS not only enable a higher degree of customization and product quality but also allow for novel value propositions and new data-driven business models (BM) [4]. For instance, models such as Rolls-Royce's "power-by-the-hour" for aircraft

engines [5] or Ricoh's "pay per page green" for printing services [6] are examples of successful PSS implementations. Especially for manufacturers, digitalization is a significant driver for PSS [7]. This is demonstrated by the "pay-per-part model" of the German machine manufacturer Trumpf, which provides its customers with laser sheet metal processing without having them to buy or lease equipment [8]. Digital technologies enable novel value propositions and services such as remote and automatic access to machine statuses, proactive detection of failures, and success measurement, facilitating PSS [9]. As physical products often form the core of the existing BM, especially for established companies and market incumbents, these companies are maturing toward more servitization [10].

Hence, along with the increasing degree of servitization, the literature distinguishes three established PSS types: product-, use-, and result-oriented PSS [4, 11, 12]. Challenges arise as the three types of PSS require different capabilities within the organization. The complexity of designing, implementing, and operating these integrated product-service bundles requires holistic guidance on which capabilities need to be developed across organizational departments and levels.

In order to guide organizations in the identification, prioritization, and development of relevant capabilities, Maturity Models (MM) have proven to be a useful management tool [13]. As research on PSS is mature [14], MMs dealing with PSS or service orientation already exist (e.g., Exner et al. [15], Gudergan et al. [16]). Further, MMs in the context of PSS focus on specific issues such as IS support for PSS [17], sustainability through hybrid solutions [18], or for the service development process related to PSS [19]. Nevertheless, existing literature hitherto neglects to bring together the established PSS types with corresponding capabilities. On the one hand, this makes it difficult for organizations to assess their maturity level to meet the desired PSS type. On the other hand, the existing models do not provide a holistic perspective on capabilities for a targeted PSS type.

Since the existing literature does not offer a combined view on PSS types and corresponding capabilities, we raised the following research question (RQ): *What capabilities do organizations need to develop to offer a certain type of PSS?*
To address this research gap, we developed and evaluated the PSS Maturity Model (PSSMM) and followed the well-known procedure model of Becker et al. [1]. The paper is structured as follows, in *Section 2,* we summarize relevant literature on PSS, MMs, and elaborate on related work for PSS-specific MMs. In *Section 3*, our research methodology is outlined, and in *Section 4,* we present essential design decisions and our developed PSSMM. Next, in *Section 5,* we summarize the pre-evaluation with IS scholars. At the end, *Section 6* concludes this work with our contributions, limitations, and the outlook for further research.

2   Theoretical Background and Related Work

2.1   Product-Service Systems

There are different terms for PSS in literature, e.g., Industrial Hybrid Offerings and Solutions [2], whereby PSS has become the commonly used expression [14]. Also, there are several definitions of PSS in the literature (e.g., Mont [20], Guidat et al. [21]). Yet, PSS are often defined as a type of BM that integrates bundles of products (tangible component) and services (intangible component) aiming at offering more complete solutions and thereby increasing customer utility [3, 12]. Besides, concepts such as *Servitization* and *Hybrid Value Creation* are often named in this context. Servitization describes the transformational process of moving from a product-oriented to a service-oriented BM for offering product-centric system solutions [2, 12]. In contrast, Hybrid Value Creation refers to the process of creating added value through the combination of products and services [22]. To sum up, PSS can be seen as the operational (Hybrid Value Creation) outcome and the transformational process (Servitization).

Also, PSS are often referred to as the trend of servitization in the manufacturing industry [12] and are associated with closer customer contact, more stable revenue streams, and improved resource utilization [22]. Some work on PSS follows the understanding and perspective of *Service(-dominant) Logic* [23] and focus on the co-creation of value between the service provider and customer. Consequently, they define PSS as *Service Systems* [24]. This may especially be true for mature PSS types that are close to a pure service focused BM. However, this definition neglects companies with a product-oriented PSS type. Therefore, we argue that our work's scope mainly addresses manufacturers that are driving forward service provision. The underlying definition of PSS refers to a BM perspective that defines the value proposition through a combination of the product and connected services and whereby the focus on either the product or services shifts with the responding PSS type.

For PSS, three main types are generally admitted in the literature: (a) *product-oriented*, (b) *use-oriented*, and (c) *result-oriented PSS* [10, 25]. These categories have established themselves in the literature (e.g., Raddats et al. [26], Weking et al. [12]), are used in different contexts (e.g., for BM archetypes [27, 28]), and are of importance for this work as we build our maturity levels upon them. For (a) *product-oriented PSS*, the BM is mainly focused on selling products, and only some additional services are added (e.g., maintenance services) [25]. With (b) *use-oriented PSS*, a product's use or availability is sold [10]. An example of use-oriented PSS is Hilti's fleet management offering, a global business partner offering construction tools. Here, Hilti provides a comprehensive bundle of products and complementary services instead of just selling tools. In doing so, Hilti improves fleet transparency, reduces idle time, and simplifies budgeting for customers, while Hilti profits from higher customer loyalty and interaction as a strategic enabler for growth [29]. And with (c) *result-oriented PSS*, the customer and the supplier agree in advance on the result to be delivered, and the customer only pays for that [25]. An example of this PSS-type is the cooperation of Trumpf, a German industrial machine manufacturing company, and Munich RE, a globally operating reinsurance company. The jointly developed 'pay-per-part model'

enables customers to use a full-service laser machine without buying or leasing any equipment. Instead, customers pay a previously agreed price for each part in a pre-defined quality, allowing them to avoid massive up-front investments, minimize resources for maintenance tasks, and make their production processes more flexible [8]. Moving from a product- toward a use- or result-oriented PSS, a customer's need is formulated in more abstract terms. It offers new paths for customization [25], which is enabled by developments in digital technologies (e.g., cloud and edge computing), offering a continuous connection to products and customers [20]. Further, the revenue models and pricing strategies in these PSS types are entirely different, changing from single purchases to constant payment models related to the product's use or result [22]. Therefore, the transformation from being a product manufacturer to becoming a PSS provider calls for far-reaching changes within the organization and especially for new capabilities to be developed.

2.2   Organizational Capabilities and Maturity Models

The resource-based view defines organizations as configurations of resources [30]. Competitive advantage and long-term performance enhancement can be accomplished by providing valuable, unique, inimitable, and non-substitute resources [30] that consist of both assets and capabilities [31]. In this paper, we define capabilities as an organizational entity's ability to perform certain activities to achieve a particular outcome [32]. MMs reflect how organizational capabilities develop [33] while assessing and leading the continuous improvement of various organizational capabilities [34], such as technology, practices, or knowledge in a particular domain [13]. Thus, MMs are instruments to assess the maturity in a specific area by conceptually dividing the presumed development of maturity into different phases [33]. Maturity thereby refers to the status of being ready or complete, and the respective maturity level increases with increasing capabilities [1]. In practice, MMs have high relevance and are widely utilized as a management tool [35] that facilitate planning and stepwise capability development [13] and also improve the decision-making regarding organizational development [34]. In the Information Systems (IS) and Information Technology (IT) domain, MMs are often used either as guidance for continuous improvement or as an assessment tool for self- or third-party evaluation [33, 34]. Besides, there are different types of MMs in literature, including descriptive (status quo assessment and potential target state derivation), comparative (benchmarking), and prescriptive *MMs* (enabling roadmap development and suggesting measures for achieving it). Also, combinations of these types exist, as these different model types represent consecutive stages in a MM's evolution [33, 36].

The general structure of MMs is characterized by a sequence of discrete stages [13] reflecting the expected or desired development path from an initial to a potential target state [1]. MMs are usually conceptualized as matrices, including maturity stages on the one and dimensions (e.g., capabilities) on the other axis [36]. To structure capabilities, *focus areas* can be defined, representing domain-specific capability areas that describe different aspects of the corresponding topic [34] and provide more detail by describing specific capabilities as subcategories (i.e., Capability Dimensions). On the other axis,

the maturity levels describe the phases of development arranged in sequential order from the lowest stage of maturity to the highest [36]. The number of maturity stages between the initial and target state is not prescribed and varies in existing MMs. However, most MMs use between four to six stages [36]. Also, MM types can furthermore be distinguished into staged, continuous, and focus area MMs [37, 38]. These reflect different ways of assigning capabilities to maturity stages. Thereby, staged MMs require an assignment of capabilities to exactly one maturity stage. Continuous MMs require the specification of capabilities for all maturity stages. In contrast, focus area MMs inductively derive maturity stages per capability area, where each capability area has its number of specific maturity stages.

2.3   Related MMs in the Field of PSS

As the PSS domain is a mature research area and research has been conducted here for over 20 years [14], several MMs already exist in this research field. MMs, with a focus on PSS, address the increasing service orientation in the sense of maturing from traditional product sales to PSS (e.g., Rapaccini et al. [19], Gudergan et al. [16], Karni et al. [39], Exner et al. [15]). Rapaccini et al. [19] created a MM for the new service development process related to PSS. Gudergan et al. [16] introduce their Business Transformation Readiness Assessment – a MM to assess the readiness for PSS. Karni and Kaner [39] present a Process Capability and Enterprise Maturity Model focusing on PSS. Exner et al. [15] developed a PSS capability self-assessment tool for companies named Product-Service-Change. Other MMs in the context of PSS and servitization address more specific issues concerning IS support for PSS [17, 40], service engineering [41], or sustainability through hybrid solutions [18]. There are already several MMs in the research field of PSS. Still, to the best of our knowledge, there is no MM with a holistic perspective on the organization and that combines its maturity levels with the three different types of PSS, including *product-*, *use-*, and *result-oriented PSS*. Thus, existing MMs do not allow conclusions and provide guidance on how the identified capabilities should be developed concerning an aimed, pre-defined PSS type. Our paper aims at filling this gap. Further, our PSSMM provides a multi-dimensional categorization for PSS capabilities and therefore provides guidance for capability development. Therefore, with this work, we propose a continuous MM that can be used for descriptive and prescriptive purposes [33].

3   Research Methodology and Development Process

The approach of Becker et al. [1] for the development of our MM comprises, as presented in Figure 1, eight steps that are based on design science research principles by Hevner et al. [42]. The first four phases are central to the design and development of the MM, whereas the second four cover the transfer and evaluation. All in all, this work focuses on phases 1 to 4. The other phases will be carried out in future research. In the following, we briefly explain each phase and how we executed it:
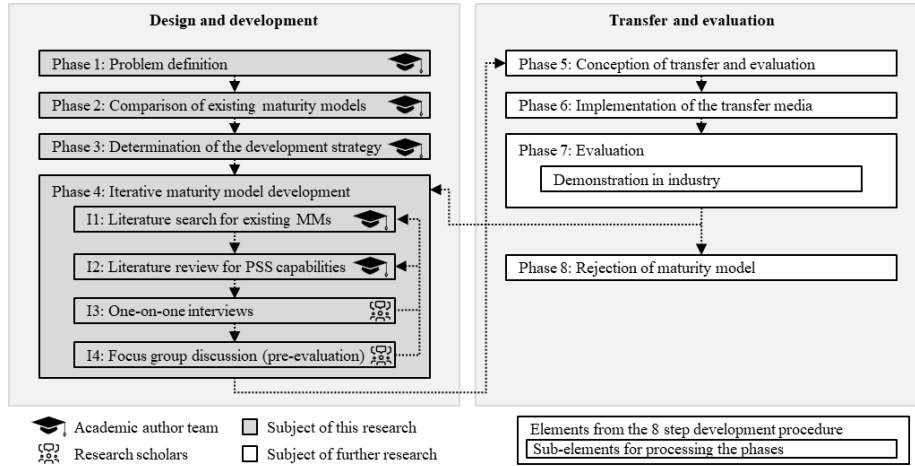
Figure 1. Applied Research Approach Based on Becker et al. [1]

Phase 1, *Problem definition*, examines the motivation for the particular MM and derives an appropriate RQ. We address this phase in our *Introduction*, where the topic's relevance and the need for management guidance, like for our PSSMM, are outlined. Thereby, the key problem is that manufacturers face significant challenges in developing toward a PSS provider. While existing MMs for PSS neglect a holistic perspective on the organization, we propose our PSSMM to fill this gap.

Phase 2, *Comparison of existing MMs,* thematizes the relevance of developing a MM by pointing toward the research gap. The lack of existing approaches is initially addressed in the *Introduction* and then outlined at the end of the *Theoretical Background (see Section 2.3.)*.

Phase 3 is the *Determination of the development strategy*. Becker et al. [1] differentiate between four strategies, i.e., (1) design of a new model, (2) enhancement of an existing model, (3) combination of models to form a new one, and (4) the transfer of existing models to new application domains. As mentioned in the *Theoretical Background*, there is no MM in the literature that addresses our purpose and RQ. In this work, we developed a novel MM (strategy 1) as an artifact based on the insights of existing MMs and additional literature, as neither an existing model was close enough to be enhanced (strategy 2) nor existing models combined (see below) could fulfill the research question.

Within **Phase 4**, the *Iterative MM development*, we – additionally to Becker et al. [1] – considered van Steenbergen et al. [43], as they recommend using a multi-methodological approach for the development of dimension-specific development paths. To assess and integrate different knowledge sources for this manifold topic, we included a literature search and interviews with research scholars [33, 43]. The following figure presents how the development phase of the PSSMM was carried out in four iterations.
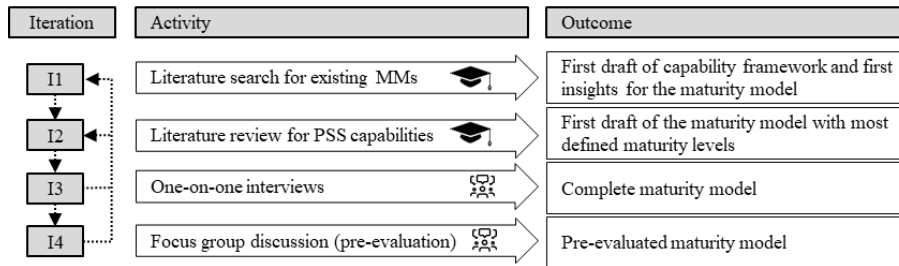
Iteration	Activity	Outcome
I1	Literature search for existing MMs	First draft of capability framework and first insights for the maturity model
I2	Literature review for PSS capabilities	First draft of the maturity model with most defined maturity levels
I3	One-on-one interviews	Complete maturity model
I4	Focus group discussion (pre-evaluation)	Pre-evaluated maturity model

Figure 2. Applied Iterations within the Development Phase

Within **Iteration one**, the literature search, we started by identifying existing MMs focused on PSS and related research streams as recommended by Becker et al. [1]. With this iteration, we identified first context-related MMs for PSS and scrutinized those for capabilities and maturity levels related to our research gap. For this, we performed a search on Google Scholar with the following search string: *"product-service system*" OR "PSS" OR "hybrid product*" OR "servitization" OR "hybrid value creation" AND "maturity model"*. As a result, we found 15 papers related to MMs for PSS, which came into consideration, e.g., Rapaccini et al. [19], Gudergan et al. [16], Karni and Kaner [39], Exner et al. [15]. To understand and build upon existing work, as recommended by Becker et al. [1], we compared the MMs and partly included them in our MM by identifying relevant capabilities for PSS. Within this bottom-up approach, we identified 180 capabilities for PSS from related MMs. After coding and clustering these capabilities, we came up with 18 capability dimensions within this iteration. We chose this approach because we wanted to develop the MM without being influenced by the different existing MMs on PSS (e.g., on sustainability) and tailor our dimensions toward our research gap, taking a PSS-type specific and holistic view. The interim result here was the first draft of a capability framework with capability dimensions and first insights for the definition of some maturity levels.

Next, with **Iteration two**, we carried out a literature review for PSS and corresponding capabilities following vom Brocke et al. [44] to ensure that the body of knowledge is covered by existing MMs on PSS but also on recent and domain-specific work. Hence, we applied this by assessing domain-related databases, i.e., ScienceDirect, EBSCOhost, and AISeL, with the following search string: *"product-service system*" OR "PSS" OR "hybrid product*" AND "industrial" AND "capabilit*"*. Thereby, we reviewed 62 articles to identify PSS capabilities. Furthermore, we finished with a forward and backward search to screen the field of research and completed the maturity levels. After carefully reading and screening these publications, we worked out and coded another 72 capabilities from this general PSS literature. Here, 19 capability dimensions were identified. As a result, the first iteration's draft was complemented with the capability dimensions and maturity levels found in literature.

In these first two iterations, all in all, 252 capabilities (= 180 + 72) were found and processed (coded and clustered), which resulted in 37 capability dimensions (18 from existing MMs and 19 from PSS literature). After reducing the duplicates and

summarizing similar ones, 20 capability dimensions were finally derived. As we developed a continuous MM, the definition of all maturity levels, including different characteristics, is required to outline each capability dimension's maturation along all stages. We proceeded by using the literature and more specified capabilities.

Iteration three - after developing the second version of the PSSMM and intensively discussing it within the author team, we conducted two interviews with scholars from the IS domain for the understanding and relevance of its focus areas, capability dimensions, as well as each level of maturity. One is specialized in MM development, and the other in digital transformation strategies for manufacturers. The interview partners are summarized in Table 1 (Int 1 and Int 2). Afterward, each proposed model adjustment was critically discussed within the author team and cross-checked with supporting work in literature before including the feedback into the PSSMM.

Iteration four - after reaching consensus among the authors about the maturity of the model, as the interviews brought no significant insights to the MM and instead helped to sharpen the identified capabilities, the MM was pre-evaluated in a focus group discussion with nine domain-specific scholars specialized on PSS and related capabilities (Int 3 in Table 1). Thereby, we used the proposed evaluation criteria of Becker et al. [1], i.e., comprehensiveness, consistency, and problem adequacy. The discussion did not lead to advanced adjustments of the model and underpinned its saturated maturity. This pre-evaluation is addressed in detail in *Section 5*.

Table 1. Interview Partner

Interview ID	Type	Expertise	Experience
Int 1	One-on-one Interview (n=1)	Transformation strategies for manufacturers	Junior researcher (1 - 2 years in this field)
Int 2	One-on-one Interview (n=1)	Maturity models and organizational capabilities	Senior researcher (> 3 years in this field)
Int 3 (pre-evaluation)	Focus group discussion (n=9)	Domain focus on Industry 4.0 and PSS BM	PhD students and senior scholars

Phases 5 to 8 are, as mentioned before, not the object of this paper and, thus, the subject of further research. After developing the model, it needs to be tested in a real-world context and evaluated with industry experts for relevance and rigor, including validity and reliability [33]. Also, for guaranteeing broad applicability, the model must be made available in a more general way to investigate its generalizability [1] (phase 5). Next, further evaluations and improvements on wider acceptance are conducted (Phase 6, 7), and finally, a decision on the acceptance or the rejection of the model is made (Phase 8).

4   Product-Service Systems Maturity Model

In the following, we present our PSSMM with its overarching structure by first elaborating on pathbreaking design decisions and afterward outlining each focus area and its associated capability dimensions. At the end of this section, we present the whole PSSMM with its corresponding maturity levels. We developed a continuous MM [33, 37] along the PSS types of Tukker [11, 25]. This design allows reflecting the non-

linearity of transformation processes (i.e., being at different maturity stages for different capability dimensions). A certain maturity level thereby describes how a capability in this capability dimension is typically developed within this step (i.e., type of PSS). For the maturity levels, we set the 'pure product' view as the initial stage (1.) that reflects a common starting point of a transformation toward PSS. The three main PSS types [10, 11] represent the remaining maturity levels of our model: product- (2.), use- (3.), and result-oriented PSS (4.). We have arranged the levels 1 to 4 next to each other according to their maturity toward servitization. In doing so, we guide organizations in further developing the needed organizational capabilities (i.e., for service deployment) toward a target type of PSS and do not refer to the commonly used generic maturity levels in existing MMs on PSS (e.g., Rapaccini et al. [19]). As with almost all MMs, the definition of a target state is not primarily dependent on the pursuit of higher levels of maturity, but rather on organization-specific (e.g., customer requirements) as well as economic (e.g., budget) factors. Also, certain PSS types can be skipped or different PSS types can be implemented within the same company, e.g., different markets or customer segments. Further, and in contrast to existing maturity models (e.g., Rapaccini et al. [19], Karni and Kaner [39], Gudergan et al. [16]), our PSSMM aims to demonstrate relevant capabilities for the respective PSS types. Thus, each column offers a detailed specification of the required capabilities for the corresponding PSS type. To take a holistic perspective on the organization and follow Cleven et al. [37], our MM addresses five focus areas: *Strategy*, *Culture*, *Structure*, *Practices*, and *IT*. Those were successfully used for other domain-specific MMs before, e.g., Enterprise Architecture Management [45] or Business Process Management [33]. Table 2 lists the focus areas' definitions based on Cleven et al. [37] and Rosemann and vom Brocke [46] and represent relevant capability areas for organizational capabilities.

Table 2. Five Focus Areas for Capability Development in Organizations

Focus Area	Definition
Strategy	*Strategy* comprises the vision of how an organization creates value and develops toward a defined target state.
Culture	*Culture* covers the collective values and behaviors of individuals and teams.
Structure	*Structure* comprises the way an organization is shaped and interacts with its environment to achieve its goals.
Practices	*Practices* cover key activities, responsibilities, methods, mechanisms, routines, competencies, and processes.
IT	*IT* comprises technical solutions that support and enable the operation of the organization but also the design, implementation, execution, and control of activities and objectives.

The five focus areas represent action fields for organizations that need to be further specified. This is achieved by assigning our *capability dimensions* to these focus areas. The PSSMM, presented in Table 3, thus provides a holistic overview of relevant capabilities, which we assign to 20 capability dimensions to evolve toward one of the three main types of PSS.

The focus area **Strategy** describes to which extent the organization focuses on enriching its value creation with services until service is at the core of their business model (*Service Focus*) [18]. This strategy shift creates the necessary foundation for an

organization to develop and implement a successful PSS. Customer centricity, therefore, becomes an essential part of business strategy and value creation (*Customer Involvement*) [15, 25]. Furthermore, a PSS-driven vision is pursued by allocating human and financial resources (*Resource Allocation for PSS)* [10, 19]. The PSS strategy determines the direction in which an organization should thrive and is, therefore, a signpost for the resulting focus areas.

As a second focus area, **Culture** comprises how employees work together (*Work Culture*) [47, 48] and how the organization's PSS vision is committed by the employees (*Employee-committed PSS Vision*) [16, 17]. This capability dimension is directly enabled by 'Resource Allocation for PSS' from Strategy and underpins that the entire workforce must support the PSS-vision. To successfully master PSS, relevant soft and hard skills need to be developed throughout the organization (*Skill Training*) [49], e.g., data analytics or leadership.

Regarding the organization's **Structure,** PSS require distinct changes in how the product or PSS is marketed and what channels are used to deliver the value (*Channels and Sales*). Here, the product itself becomes a new and essential channel, especially in mature PSS types [50, 51]. Also, through the establishment of new channels, extensive value-added networks, and the deep integration of the product into the customer's processes, the organization's boundaries become blurred as external partners are increasingly integrated into business processes (*Partner Integration*) [10, 15, 20]. As the business model depends less on the sale of the product and focuses on services, the organization must manage the change of its income, changing from one-time product purchases to continuous payments for services (*Capital Management*) [10, 25].

The focus area **Practices** consist of six capability dimensions. The first addresses how an interaction with the customer has to be initialized regarding services (*Customer Interaction and Service Initiative*) [3, 52]. Mature PSS go in line with increasing customer interaction and responsibility for the performance of the product. The next capability dimension addresses how to design and enable high quality of PSS. The specificity of the methods and tools used increases with mature PSS and gains importance for innovation and product management (*PSS Design Methods and Tools*) [53, 54]. As mature PSS have a strong focus on product availability and performance for the customer, feedback on the product and its performance are a crucial factor on the practice level. Therefore, *Product Performance Measurement and Feedback Systems* become increasingly relevant for the provision of additional services or advice, but also regarding the pricing of mature PSS [19, 25]. *Automated Service Offering* is crucial to ensure the product and service availability, especially for mature PSS [55, 56]. In this context, mature PSS also request the ability to develop and offer suitable pricing models and customer-individual prices that are increasingly distinguished by performance-oriented payment structures (*Pricing Mechanism)* [4, 57]. Also, *Life Cycle Management* becomes essential to accompany the customer holistically before, during, and after using the product [25].

IT, at the bottom of our PSSMM, acts as the foundation for enabling the development and operation of PSS. First, the *Role of IT* determines whether IT only supports business or takes over an enabling role regarding the organization's actions and objectives [58]. Due to the increasing collection and exchange of valuable data

Table 3. The PSSMM

Focus Area	Capability Dimension	Maturity Level			
		1. Pure Product	**2. Product-oriented PSS**	**3. Use-oriented PSS**	**4. Result-oriented PSS**
Strategy	**Service Focus**	Focus on the physical product; no additional services	Limited focus on PSS; additional services like consulting, maintenance, or recycling	Focus on PSS; warranty of the availability of the physical product along with services	Focus on mature PSS as core business model; highly integrated product-service bundles to offer result as a service
	Customer Involvement	No or little involvement to design and evolve the physical product	Growing involvement to design and evolve the product and additional services	Increasing cooperation with and integration of the customer into PSS design processes	Partner-like collaboration and intensive communication for PSS development
	Resource Allocation for PSS	No budget for PSS development and implementation	Little effort for creating additional services to the product; ad hoc investments in organizational changes	Medium effort for creating well-functioning PSS; continuous investments	Great efforts to achieve a high-performance PSS; substantial and continuous investments
Culture	**Work Culture**	Focus on product-related solutions; independent work or partly in homogenous teams	Focus on product-related solutions and on easy-to-implement services; occasional work in interdisciplinary teams	Solution-oriented in terms of both products and services; usually work in interdisciplinary teams	Solution-oriented for PSS; team-oriented, cross-team, -domain, and -organizational work, continuous exchange with customers and value-added partners
	Employee-committed PSS Vision	Product-oriented way of thinking; working for developing and selling physical products	Product-oriented way of thinking; working for offering complementary services to the product	Thinking in terms of customer usage; working for providing PSS solutions with a higher level of service integration	Thinking in terms of customer results; working for delivering result as a service
	Skill Training	No training or further education regarding PSS skills	Occasional in terms of PSS development, training for product-related consultation	Selective training courses on specific topics for PSS development and implementation	Structured training courses on all relevant PSS topics like development, implementation, sales, customer contact, leadership, and management
Structure	**Channels and Sales**	Traditional and web-based channels for product sales	Traditional and web-based channels for product and service sales	Traditional and web-based channels or product as point of sale	Traditional and web-based channels and product as point of sale for integrated view on results
	Partner Integration	Only suppliers as value-adding partners; clear organizational boundaries	Additional value-adding partners for service-creation and initial involvement of and cooperation with customer as partner	Blurring of boundaries between company and suppliers as well as service-creation involved partners; close cooperation with customer as partner	Strong collaboration and integration of value-added partners and customer for PSS co-creation; company is deeply integrated into customers' processes and business model
	Capital Management	Bearing all costs until point of sale; management of one-time payments for each product sale	Bearing all costs until point of sale; management of one-time payment for product and demand-driven service provision income	Bearing of production and development costs for products and services until a pre-defined point of time; continuous payments for usage	Bearing all costs for PSS until end of life cycle; continuous and success-related payments for operation of the PSS
Practices	**Customer Interaction and Service Initiative**	Interaction focuses on product purchase and emerging operation problems; customer is responsible for operations	Interaction is driven by the customer; interactions are pre-defined in the service contract; mostly topic-driven services related to maintenance	PSS provider initiates services and is responsible for ensuring the perpetual availability; planned interactions	Proactive and automated service interaction; connected through pre-defined touch points and processes; result as continuously monitored parameter for service initiative
	PSS Design Methods and Tools	No approach for service or PSS development;	General (management) approaches for product; partial use of PSS methods and tools	Selected approaches and formalized development processes for PSS; appropriate tools for development and implementation	Company-specific and individualized PSS approaches plus fast development cycles and prototyping; continuous improvement and use of methods
	Product Performance Measurement	No need for measuring product performance; only measuring product quality by internal tests	No need for measuring product performance but occasional insights through maintenance services; measuring product quality in order to provide advice and guidance to customers	Measurement of product performance and usage in order to guarantee and optimize product availability	Well-defined measures and feedbacks are systematically used for payments, maintenance, and new service development
	Automated Service Offering	No service provision	Almost no automation; rule-based or instinct-driven service provision	Partly automated or modularized services are provided	Most services with the customer or value-creation partners are automated and/or modularized; optimization toward minimizing human-interaction in the service process
	Pricing Mechanism	Fixed one-time payment (pay for product)	One-time payment for product and situational service fee (pay for product or service order)	Continuous payment like leasing, renting, or sharing (pay on availability)	Customer-specific, result-based payment based on service level agreement (pay on production)
	Life Cycle Management	Development, production, sale, and shipment; no responsibility for operation	Development, production, sale, and shipment; no responsibility for operation but reactive provision of services	Development, production, sale, shipment, maintenance, and usage phase; responsible for guaranteeing the usability of the product	Managing everything until the end of the product life cycle; responsible for delivering results and productivity
IT	**Role of IT**	IT as supporting function; intra-organizational focus	Supporting function, partly as driver of value creation and change; intra-organizational focus	IT as an enabler and diver for value creation and change; enabler of product-availability; inter-organizational focus	IT as an enabler and driver for value creation and change; enabler of enhanced product-performance, inter-organizational focus
	IT Security and Compliance	Security of highly critical assets; isolated IT security activities	Security of highly critical assets and initially also of external processes	Intra- and inter-organizational IT security activities	Intra- and inter-organizational IT security activities; security by design in product development process
	Connectivity and Data Access	No access to product after point of sale	Indirect, situational data access to customer; possible manual data exchange	Continuous interconnectivity; mainly reading rights; connectivity of the product is a substantial component	Continuous interconnectivity; full access to product; connectivity of the product is a substantial component
	Data Collection	No collection of customer's product data	Reactive and manual collection of data	Partly automated collection of data from the customer	Highly automated collection of data
	Data Analysis	No analysis of product usage or descriptive analysis of internal product testing	Descriptive and diagnostic analysis of product data; initially for service provision	Diagnostic and predictive analysis of product data; focus to keep promise of availability	Predictive and prescriptive analysis; focus on optimization of result

regarding PSS value chains and business ecosystems, *IT Security and Compliance* activities need to enable holistic IT security concepts across organizational boundaries [59]. Especially result-oriented PSS depend on a continuous connection and data availability for performance measurement or determination of payments [17, 60]. Therefore, *Connectivity and Data Access* were added as an IT-capability. To provide data-driven services, e.g., predictive maintenance, relevant product data needs to be collected (*Data Collection*) [17] and analyzed (*Data Analysis*) [57], so that, e.g., necessary key performance measures can be created that are crucial for offering PSS.

5   Pre-evaluation

As recommended in the development process of Becker et al. [1], we evaluated our PSSMM using proposed evaluation criteria. We conducted a pre-evaluation of the model to anticipate a demonstration and application of the model in practice to first assess the model's quality according to recommended criteria. A comprehensive application and demonstration of the model in practice with industry experts, as proposed by Becker et al. [1], is planned to be subject to further research. Therefore, our theoretical evaluation was carried out through a focus group discussion with domain-specific scholars of the IS discipline. We used the evaluation criteria of Becker et al. [1], which are: (1) *comprehensiveness*, (2) *consistency*, and (3) *problem adequacy*. The focus group comprised nine research scholars with experience in PSS and MM development (see also *Table 1* in *Section 3*).

(1) *Comprehensiveness:* Within the focus group, the model was perceived as comprehensive and covering essential PSS aspects. Nevertheless, we enriched several capability dimensions with some details, e.g., IT Security and Compliance with the term 'security by design' in the last maturity level of result-oriented PSS.

(2) *Consistency*: The focus group generally agreed on the overall consistency but objected to a few minor issues. Minor adjustments, such as eliminating non-uniform designations for the same term, e.g., 'teamwork', 'work in teams', and 'collaboration in teams', were made.

(3) *Problem adequacy:* The focus group discussion led to several iterations of the model, which resulted in an improved specificity for the application context. For example, we have adjusted some generic capabilities for transformational processes and specified them for the intended context of manufacturing companies that aim to offer PSS (e.g., 'project management', 'agility', and 'change management').

6   Conclusion and Outlook

This paper addresses the need for conceptual work to guide manufacturers in becoming PSS providers [61]. It contributes to the interplay between established PSS types and organizational capabilities, which has not yet been sufficiently addressed in literature. To fill this gap, we developed a MM for the transformation into becoming a PSS provider. To structure the MM, we used the well-established PSS types of Tukker et al. [11, 25] – product-, use-, and result-oriented PSS – often applied in literature for

distinguishing the different types of BMs and their implications on organization or environment (e.g., Bocken et al. [27], Yang and Evans [28]). For the MM development, we followed Becker et al.'s [1] procedure model. We first searched for existing MMs (e.g., Rapaccini et al. [19], Gudergan et al. [16], Exner et al. [15]) and second conducted a literature review for PSS-specific capabilities. After, we iteratively developed the model by building upon the literature, conducting expert interviews with senior scholars, and pre-evaluated the PSSMM with domain-specific scholars by checking for the proposed evaluation criteria (i.e., comprehensiveness, consistency, problem adequacy) of Becker et al. [1] in a focus group discussion.

Our contribution is relevant for practice and research. For the latter, the PSSMM adds to descriptive and prescriptive knowledge on PSS and supplements the current discussion on PSS (e.g., Exner et al. [15], Pigosso et al. [18]). In particular, our work represents the hitherto missing link between established PSS types and corresponding capabilities. We also contribute by summarizing, structuring, and enriching current PSS literature and providing a foundation for future research on specific PSS capabilities. This work also points out that digitalization is a driver for PSS in the manufacturing industry.

On the one hand, this offers the possibility of differentiation to overcome market pressure at the product level. On the other hand, the developed model reveals at various points how digital technologies may serve as an enabler to offer PSS (e.g., connectivity and data access, customer interaction and service initiative, automated service offering). For practice, the PSSMM guides manufacturers in transforming themselves toward a certain type of PSS. Our model supports this strategic transformation by defining the needed capabilities. For example, management can use the PSSMM to evaluate their status quo and desired target state. This makes it easier for managers to assess the necessary efforts for developing needed capabilities. For the transformation process, additional management tools such as manuals or self-assessment questionnaires are needed to complement the PSSMM [1].

As any research project, this work is beset with limitations, which stimulate future research. Although this paper followed the MM development approach of Becker at al. [1], the development of our PSSMM is limited to phases 1 to 4. To guarantee a high quality of this work, this paper built upon current and PSS-specific literature and was challenged and evaluated by domain experts in IS research. However, an evaluation with industry experts to scrutinize the PSSMM and check its completeness, real-world fidelity, and practical applicability is missing. Also, a demonstration of the PSSMM in a real-world context has not been carried out yet. Both are planned as next steps within the research project. Also, further research could provide an approach for application.

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