Exploring Capabilities for the Smart Service Transformation in Manufacturing: Insights from Theory and Practice

Christian Koldewey
Paderborn University
christian.koldewey@hni.upb.de

Timm Fichtler
Paderborn University
timm.fichtler@hni.upb.de

Michel Scholtysik
Paderborn University
michel.scholtysik@hni.upb.de

Jan Biehler
acatech
biehler@acatech.de

Nick Schreiner
Fraunhofer IEM
nick.schreiner@iem.fraunhofer.de

Franziska Sommer
FIR at RWTH Aachen
franziska.sommer@fir.rwth-aachen.de

Maximilian Schacht
FIR at RWTH Aachen
maximilian.schacht@fir.rwth-aachen.de

Jonas Kaufmann
Industrie 4.0 Maturity Center
jonas.kaufmann@i40mc.de

Martin Rabe
Fraunhofer IEM
martin.rabe@iem.fraunhofer.de

Joachim Sedlmeir
acatech
sedlmeir@acatech.de

Roman Dumitrescu
Paderborn U. & Fraunhofer IEM
roman.dumitrescu@hni.upb.de

Abstract

Digital Servitization is one of the significant trends affecting the manufacturing industry. Companies try to tackle challenges regarding their differentiation and profitability using digital services. One specific type of digital services are smart services, which are digital services built on data from smart products. Introducing these kinds of offerings into the portfolio of manufacturing companies is not trivial. Moreover, they require conscious action to align all relevant capabilities to realize the respective business goals. However, what capabilities are generally relevant for smart services remains opaque. We conducted a systematic literature review to identify them and extended the results through an interview study. Our analysis results in 78 capabilities clustered among 12 principles and six dimensions. These results provide significant support for the smart service transformation of manufacturing companies and for structuring the research field of smart services.

Keywords: Digital Servitization, Transformation, Capabilities, Maturity, Smart Services

Introduction

The manufacturing industry has traditionally been a driving force behind innovation and prosperity. It is currently being impacted by multiple major trends, i.a., digitalization and servitization (e.g., (Frank et al., 2019)). Digitalization refers to the integration of digital technologies into broader organizational contexts affecting organizational structures, strategies, architectures, methods, and business models (Legner et al., 2017). The resulting increasing amount of data and potential for automation extend the design leeway for service innovations (Böhmann et al., 2014). Digitalization, hence, opens up new pathways for servitization (Coreynen et al., 2017). Servitization describes the shift from selling physical products to selling services and solutions that complement those products (Vandermerwe & Rada, 1988). In that way, manufacturing companies react to unfavorable market developments like outsourcing trends, saturation of markets, or commoditization of products (Reinartz & Ulaga, 2008). The intersection of digitalization and servitization is called digital servitization. At the heart of digital servitization in goods-dominant industries are digital services that build on data from smart products – smart services (Koldewey et al., 2021).

Smart services allow manufacturing companies to realize a plethora of functionalities to create new value propositions for their customers (Koldewey et al., 2020). However, such data-driven services differ significantly from established products and services (Schüritz et al., 2017), leaving manufacturing companies struggling to adopt them (Kowalkowski et

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al., 2022). They must build the necessary smart service capabilities. Building on (Bharadwaj et al., 1999), we conceptualize those capabilities as technological and organizational facets reflecting a firm's overall ability to engage in, sustain, and restructure a smart service business. Nevertheless, to the best of our knowledge, no comprehensive catalog of capabilities for the smart service transformation exists, representing a significant gap in theory and practice.

This leads to the two research questions this paper seeks to answer: 1) *What capabilities are necessary for the smart service transformation?* And 2) *How can these capabilities be structured for meaningful analysis and management?*

Answering these research questions, the study contributes to the understanding of smart services and their implementation in the manufacturing industry by providing a structured collection of capabilities. This allows companies to reflect on their current capabilities and the ones they need to build up. Furthermore, the capabilities structure the multiple facets of smart services in manufacturing and pave ways for further research into distinct capabilities.

The paper unfolds as follows: After describing the scientific background and the research methodology, the capabilities for the smart service transformation are presented. The findings are then discussed. The paper closes with a brief conclusion.

2. Scientific Background

To understand what deems to be necessary for a manufacturing company to become a smart service provider, the conceptual basis of smart services, their business logic, life cycle, perspectives, and transformation processes must be understood.

Comparing definitions for smart services concludes that smart services are digital services that are based on the data of smart products and form a system of systems with them (Koldewey et al., 2021). Smart products consist of smart and connectivity components in addition to physical ones, amplifying their capabilities and especially allowing for information exchange with their environment (Porter & Heppelmann, 2014). Smart products act as boundary objects in smart service systems, integrating resources and activities of the involved actors (consumer and provider) for mutual benefit (Beverungen, Müller, et al., 2019).

This mutual benefit occurs during the use of the smart service, which aligns with the emphasis on the value-in-use concept in the service-dominant logic theory (SDL) (Vargo & Lusch, 2008). The SDL centers around the exchange of services, i.e., the application of specialized competencies or capabilities through deeds, processes, and performances for the benefit of others or oneself (Vargo & Lusch, 2004).

Smart services traverse through different stages in their lifecycle. According to (Dreyer et al., 2019), the Information Technology Infrastructure Library (ITIL) service lifecycle phases can be applied to smart services: strategy, design, transition, operation, and continual improvement (ITIL, 2007). Within each phase, companies must solve smart service-specific challenges and build respective capabilities.

Smart services are emergent in a multitude of industries (e.g., healthcare, smart home) and are investigated by many disciplines (e.g., information systems, mechanical engineering) (Beverungen, Breidbach, et al., 2019; Lim & Maglio, 2018) leading to a multitude of perspectives and peculiarities.

In manufacturing, services are traditionally seen as an add-on to the core-product (Gebauer et al., 2005). The industry is deeply rooted in a goods-dominant logic focusing on tangible resources, embedded value, and transactions (Vargo & Lusch, 2004). Engaging in this shift towards digital services (i.e., digital servitization) for their products requires companies to make significant transformational efforts (Tronvoll et al., 2020). They must make the transition from products to digital services, which requires them to change old systems and heuristics (Zaki, 2019). The transformation occurs in processes, capabilities, and offerings for digital servitization (Sjödin et al., 2020). These shifts are also subject to major barriers (Klein et al., 2018) and must be engaged consciously. Unsurprisingly, manufacturers struggle to adopt digital servitization (Kowalkowski et al., 2022). Hence, in this paper, we tackle the transformation towards smart services from the manufacturing industry's perspective, considering its' peculiarities while also choosing an interdisciplinary, holistic view to integrate knowledge from different domains.

3. Research Methodology

The research design consists of a data collection and a data analysis phase (see Figure 1). First, the data for answering the research questions are collected utilizing a systematic literature review and an interview study. The data is then analyzed using qualitative content analysis and a workshop to derive and cluster capabilities for the smart service transformation. Below, the procedure is described in greater detail.

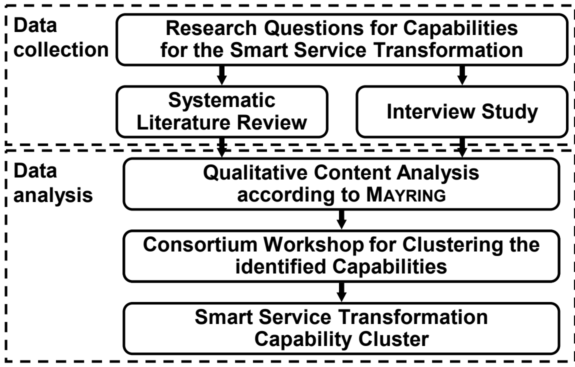

Figure 1: Research Design

3.1. Data collection

Since the smart service transformation of most manufacturing companies is far from complete and explorative in nature, we chose to triangulate data from the body of knowledge with up-to-date empirical data. For data collection in exploratory research, an extensive review of previous research and semi-structured interviews are especially suited (Saunders et al., 2019). Therefore, a systematic literature review and an in-depth interview study with sixteen experts were conducted.

3.1.1. Systematic Literature Review (SLR). The systematic analysis of the literature was based on the guidelines according to (Webster & Watson, 2002) and (vom Brocke et al., 2009). There are four successive phases to the underlying process: selection of the database (I), definition of the search string (II), conducting the search (III), and paper analysis (IV). As part of the selection of a database, four existing smart service literature reviews (Burzlaff et al., 2022; Dreyer et al., 2019; Götz et al., 2018; Romero et al., 2020) were checked to get an overview of suitable databases. The most popular databases (ACM, IEEE, SpringerLink, Science Direct, JSTOR, and AiSel) were selected for further analysis. The literature research focused on two aspects, and thus, two search strings were derived. The first string concentrates on the fields of action of the smart service transformation. Through iterative improvement, the following search string was formed: [„smart service*“ or „digital service*“ or ((“IoT” or “Internet of Things”) and “service*”) or “data-based service*”] AND [“transformation” or “barrier*” or “driver*”]. The focus of the second string was on maturity models in the broader context to identify elements that might be transferrable. The string was: [“digital transformation” or “servitization” or “IoT” or “Internet of things”] AND [“maturity model” or “assessment method” or “readiness index” or “capability index”]. The search resulted in 1653 articles, which were screened on a title and abstract basis. A total of 133 papers with an assumed focus on smart service transformation capabilities remained. After reading these papers and conducting a backward and forward search (Webster & Watson, 2002), 42 papers contained answers to our research questions; the other papers were sorted out.

3.1.2. Interview Study. Qualitative, semi-structured interviews were carried out parallel to the SLR. For data collection, an interview guideline containing open-ended questions was created (Saunders et al., 2019). The interview guideline consists of the topics of organization, people, technology, maturity, and specific changes regarding smart service transformations. It is based on the results of an initial structuring of the SLR results. A total of 16 experts were interviewed by the consortium, working for small and medium-sized enterprises, large corporations, and renowned research institutions (see Table 1). All experts either work directly in the manufacturing industry or have a strong connection to it through their activities and cooperations. The interviews were conducted virtually with one interviewee and two or three interviewers. Each interview lasted between 45 and 60 minutes. For the subsequent analysis, all interviews were recorded. After the interviews, each recording was transcribed word by word (Saunders et al., 2019).

Table 1: Participants of the interview study

	Organization	Industry	Position
I1	PLC	Production	Head of Service Europe and Asia
I2	Startup	Fintech	Chief Operating & Finance Officer (COO & CFO) & Founder
I3	SME	ICT	Chief Executive Officer (CEO)
I4	Corporate Group	Insurance	Business Development Manager
I5	PLC	Machinery	Head of Division for Digital & Technical Services
I6	Corporate Group	Mobility	Sales & Service Manager for Telematics & Digital Services
I7	PLC	Mobility	Sales & Product Management for Digital Services
I8	Subsidiary of a PLC	Monitoring	CEO
I9	University	Science	Professor of Quantitative Infonomics
I10	PLC	Healthcare	Leader of Digital Health Strategy Projects
I11	SME & University	IoT	CEO & Professor of Mechatronic System Design
I12	PLC	Machinery	Director Transformation and Strategy
I13	University	Science	Head of the Industrial Information Technology Department
I14	SME	Machinery	Director Business Development
I15	SME	Machinery	Product Manager Digital Services
I16	Large Enterprise	Housing	Head of Digital Strategy

3.2. Data analysis

For the detailed analysis, the selected articles and transcripts were analyzed using qualitative content analysis (QCA) according to (Mayring, 2022). The QCA encompasses three phases, which are explained using a continuous example: *1) Summary:* Using text analysis software, three project staff members searched the database for text passages that contained answers to our guiding question: “What is a possible capability for smart service transformation?” For example: “Technical immaturity […] and incomplete support infrastructure are among the key reason preventing case companies from providing smart services.” (Töytäri et al., 2017). *2) Explication:* The relevant statements were marked and paraphrased into consistent aspects of smart service transformation capabilities. For example: “Technological infrastructure that supports smart services.” *3) Structuring:* Based on the paraphrases, an inductive category system was created, e.g., the given example and other related paraphrases were summarized as the capability "Tailored Infrastructure" and initially clustered with similar capabilities (e.g., “Technology”). This formed the basis for the subsequent expert workshop.

The developed category system was then revised in a consortium workshop. A total of 11 experts contributed their domain and application knowledge to intensively discuss and finalize the developed categories using the research world café method (Schiele et al., 2022). Three groups were formed, each discussing two of the initial clusters formed and the capabilities included. After each round, the participants switched to another set of clusters and discussed them and the insights from the prior group discussion(s). Then, the final category system was presented. As a result, 78 relevant capabilities for smart service transformation were chosen. These capabilities are disjunctive and exhaustive. Furthermore, they were structured thematically and grouped into the final clusters for a better overview. Six selective clusters (dimensions) with two principles each were defined.

4. Results

The six dimensions are introduced in the following sections, structured along the principles. The capabilities are highlighted in *italics*. The results are summarized in Figure 2. Due to space limitations, only selected sources for the capabilities are listed.

4.1. Product & Connectivity

The Product & Connectivity dimension includes all relevant capabilities that are necessary for the smart product and its connectivity to provide a smart service. In total, there are ten capabilities, which are explained below and structured according to the namesake two principles: product and connectivity.

4.1.1. Capabilities regarding “Product.” The technical basis for the successful delivery of a smart service is a smart product. Five essential capabilities have been identified in this context. First, comprehensive *product intelligence* is required to collect and process data and information (Schumacher et al., 2019; Wolf, 2020; Yezhebay et al., 2021). The necessary sensor technology will enable *data collection from the product* so that, for example, customer-specific process data can be captured in real-time and processed to provide value (Schumacher et al., 2019; Yezhebay et al., 2021). However, the insights gained from real-time data often require the product to react quickly. Consequently, providing a smart service requires sufficient *product autonomy* (Heinz et al., 2022; Schumacher et al., 2019; Yezhebay et al., 2021). In order to guarantee the performance of the smart service in the long term, it is also necessary for the product to be able to be *updated* (Gimpel et al., 2018). For

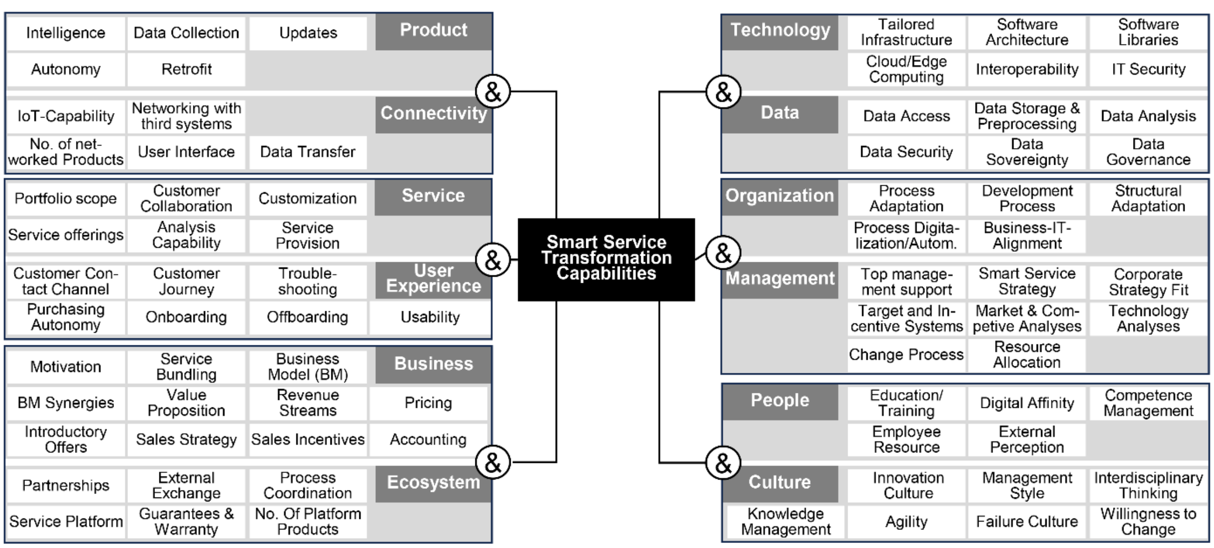

Figure 2: Collection of Smart Service Transformation Capabilities

companies to be able to offer smart services for legacy products, a *retrofit* solution is needed to add intelligence to the product (Töytäri et al., 2017).

4.1.2. Capabilities regarding "Connectivity." Connectivity encompasses all capabilities that enable the smart product to communicate with other systems and devices. The prerequisite for this is the *IoT capability* of the smart product (Baiyere et al., 2018). This enables smart products to *network with surrounding systems* and access their knowledge (Anke, 2019; Heinz et al., 2022; Schumacher et al., 2016). The resulting ecosystem can open entirely new possibilities, such as automatically increasing the efficiency of a production line. Another capability is the *proportion of networked products* that indicates how many products can be serviced (Anke, 2019; Schumacher et al., 2016). To realize the potential of networking, the smart product must transfer data to the cloud or other systems to draw new conclusions from the insights and information (Heinz et al., 2022; Koppe & Islam, 2021). Finally, a suitable *user interface* integrates and visualizes the results for the customer (Schumacher et al., 2019).

4.2. Service & User Experience

The core of the service and user experience dimension is the set of capabilities required to design the smart service portfolio and to evaluate the user experience along the smart service product lifecycle. To this end, 13 capabilities have been identified.

4.2.1. Capabilities regarding "Service." In order to provide the benefits of a smart service to a broad range of customers, the *scope* of the planned s*mart service portfolio* must be defined (Anderson et al., 2021). This includes determining which types of smart services (e.g., diagnostic or predictive services) will be offered (*service offering*) (Berger et al., 2020; Klötzer & Pflaum, 2017). This should be done in direct *collaboration with customers (co-creation)* so that general customer needs can be incorporated early (Alt et al., 2019; Berger et al., 2020). Based on these requirements, a specific *analysis capability* of the smart service must be created, which forms the basis for the technical design of the smart service (Heinz et al., 2022). Due to the sometimes complex use cases with different customers, companies must ensure that the smart service can be customized for each customer (*Customization*) (Berger et al., 2020; Gimpel et al., 2018). In order to operationalize the *service provision*, companies need to define the underlying conditions for the service level (Noz, 2021).

4.2.2. Capabilities regarding "User Experience." As part of the user experience, the smart service business defines and evaluates *customer contact channels* (Gimpel et al., 2018; Kreutzer et al., 2018). In parallel, extensive market research is required to develop a deep understanding of the customer. The insights gained from this are used to create a *customer journey* for the smart service (Kreutzer et al., 2018; Wulf et al., 2017). This enables companies to identify potential problems and errors (*troubleshooting*) with the customer at an early stage (Wulf et al., 2017). That opens up the possibility that the purchase process of a smart service can be carried out by the customer himself (*customer autonomy in the purchase process*) (Schumacher et al., 2016). Smart services are often complex applications. For this reason, a defined *onboarding* (workshop result) process is needed. To make this as intuitive as possible, companies need to analyze and design the *usability* of the smart service separately (Ghazawneh, 2019; Gimpel et al., 2018). In addition, an *off-boarding* (workshop result) process is required to terminate the service contract, taking into account, e.g., data storage policies.

4.3. Business & Ecosystem

In addition to the technical specification of the smart product and the smart service, the focus of this dimension is on the development of a data-based and service-oriented business ecosystem. This requires aligning the business towards that aim and building an ecosystem for dynamic collaboration with external partners, suppliers, etc. This dimension consists of 17 capabilities, which are explained below.

4.3.1. Capabilities regarding "Business." For the principle business, the first step is to define the *motivation for developing a smart service business* (Kaltenbach et al., 2018). This involves determining the business objectives, such as increasing revenue or expanding the customer base. Based on this, the expected *service bundling* of smart products and the smart service to be offered, such as predictive maintenance, must be defined (Berger et al., 2020). Based on the insights gained, a *smart service business model* is required to describe the basic business logic of the smart service (Anke et al., 2020; Danuso et al., 2022). This logic is used to identify *business model synergies* with existing service business models that the company can build on, such as existing customer channels or customer segments (Berger et al., 2020). In the course of the subsequent concretization of the smart service business model, the specific *value proposition* (Kaltenbach et al., 2018; Töytäri et al., 2017) of the smart service and a synergetic *revenue stream* must be described (Anke et al., 2020; Berger et al., 2020).

However, the revenue stream must also be compatible with the existing possibilities of a company to *account for a smart service* (I6; I14). An important aspect of this is the generation of automated invoices, e.g., for monthly accounting. In addition, concrete *pricing* (Berger et al., 2020; Koppe & Islam, 2021) and *introductory offers* (I13; I16) for smart service are decisive design factors, especially in lowering the customer's threshold. As smart services are based on data-based and service-oriented business models, they require a new *sales strategy* (Akkaya & Hepp, 2020; Töytäri et al., 2017). Additional *sales incentives* ensure that salespeople are both capable of selling smart services and intrinsically motivated (Töytäri et al., 2017).

4.3.2. Capabilities regarding "Ecosystem." Due to the considerable complexity of a smart service, a dynamic ecosystem is a prerequisite for development. The realization of a smart service requires the existence of new skill profiles, such as data analytics. However, it is often a challenge to cover these skills internally. Therefore, *partnerships* are crucial in delivering a smart service (Koppe & Islam, 2021; Müller et al., 2019). Companies can integrate current knowledge from research and industry in the early stages of smart service transformation through *external exchanges* with institutions such as universities or consultancies (Gollhardt et al., 2020). The resulting interactions between partners comprise the value creation system, which is characterized by a high degree of complexity. As a result, the *coordination of business processes* is required to ensure the delivery of the smart service (Gimpel et al., 2018). In addition, the *service platform* is a crucial factor for communicating with customers and making the smart service accessible to them (Bilgeri et al., 2017). The platform also enables the agreement and processing of *guarantees and warranty claims* (Koppe & Islam, 2021; Schumacher et al., 2019). To quantify the success of the smart service transformation, it is important to monitor the *share of products connected to the platform* (Heinz et al., 2022; Koppe & Islam, 2021).

4.4. Technology & Data

The technology and data dimension includes all capabilities that deal with developing and providing information systems and data processing for the smart service business. It specifies the basic infrastructure for transferring data and information to enable smart service delivery. To this end, 13 relevant capabilities have been identified.

4.4.1. Capabilities regarding "Technology." The core of these capabilities lies in developing and operationalizing a suitable information system for the smart services business. A key requirement is a specific *technological infrastructure tailored to smart services* (Töytäri et al., 2017). For this, smart service-specific aspects and processes, such as billing and service development, need to be synchronized with the existing infrastructure. In order to develop such an information system in a systematic and structured way, it is advisable to develop a suitable *software architecture* (Berger et al., 2020). The concretization of the software architecture can be supported by the use of *software libraries (I5)* in order to use proven solutions for such an architecture.

In addition, many smart services are based on real-time data, which requires a suitable *cloud and edge computing* solution (Bilgeri et al., 2017). In order to integrate the insights from the data analysis of one product into other systems, a high degree of *interoperability* between different systems and products is required (Berger et al., 2020; Wulf et al., 2017). It should be noted, however, that the data analyzed may sometimes contain sensitive information, so sufficient *IT security* must be ensured in the technical infrastructure (Koppe & Islam, 2021). To successfully implement the required technologies, *specific IT-skills* must be built within the organization (Berger et al., 2020; Koppe & Islam, 2021).

4.4.2. Capabilities regarding "Data." Besides providing the technical infrastructure, a clear definition of how to handle the required data is needed. A critical capability here is *data access* for the smart product (Gimpel et al., 2018; Schumacher et al., 2019). Depending on the technical infrastructure, the generated and collected data must *be stored and pre-processed* (Heinz et al., 2022) within the infrastructure in order to perform targeted *data analysis* (Berger et al., 2020; Gimpel et al., 2018; Schumacher et al., 2019). Furthermore, organizations need to ensure that both the insights from data analytics and the raw data itself are subject to *data security* regulations (Gollhardt et al., 2020). In addition, *data sovereignty* must be defined to describe the scope and handling of customer data collected and used (Gimpel et al., 2018; Töytäri et al., 2017). The associated processes and responsibilities should be operationalized in an appropriate *data governance* structure (Wulf et al., 2017).

4.5. Organization & Management

In the context of smart service transformation, the focus so far has been on the capabilities for technical implementation and the design of the associated smart service business. However, that requires defined strategic goals, adjustments to existing organizational processes, and embedding in the existing organizational structure. This is the core of the organization and management dimension, comprising 13 capabilities.

4.5.1. Capabilities regarding "Organization." As smart services often involve innovative products and services, this requires a *company-wide adaptation of existing processes* (e.g., production, purchasing, or training) (Klötzer & Pflaum, 2017; Wulf et al., 2017) and the integration of smart service-specific *development processes* within the company (Bilgeri et al., 2017). For example, new processes for the development of data-based pattern recognition need to be developed, communicated, and established. As the smart service-specific processes differ significantly from the existing ones, this requires a *structural adaptation* of the company structure (e.g., creating a new business unit) (Anke et al., 2020; Baiyere et al., 2018). Due to the high degree of digitalization, companies have the opportunity to structure the relevant processes digitally or in an automated way in order to make the development and delivery of smart services more efficient (*digital and automated processes*) (Gollhardt et al., 2020; Kaltenbach et al., 2018). These, in part, disruptive changes to business processes must be synchronized with existing IT processes to ensure compatibility between smart service-specific processes and IT (*business-IT alignment*) (Gollhardt et al., 2020).

4.5.2. Capabilities regarding "Management." *Top management support* is a key success factor for a successful smart services transformation *(Schumacher et al., 2019)*. This support ensures, among other things, transparent communication of the potential of smart services and their development at all hierarchical levels of the company. It occurs as part of a defined *change process* (Danuso et al., 2022; Schumacher et al., 2019). To make this possible, on the one hand, a dedicated *smart service strategy* is required, which defines the direction of the smart service business (Koldewey et al., 2021). On the other hand, this strategy must *fit the corporate strategy and mission* to avoid potential conflicts with existing business areas (Baiyere et al., 2018; Schumacher et al., 2016). Implementing the defined strategic goals requires an increased *allocation of resources,* such as human capacity and financial means (Schumacher et al., 2019). A clearly defined *target and incentive system*, such as special bonuses for smart service-related achievements, promotes motivation for the smart service transformation at all hierarchical levels (Gimpel et al., 2018; Schumacher et al., 2019). *Market, competitive* (Wulf et al., 2017), *and technology analyses* (Gimpel et al., 2018) must be used continuously, enabling early adjustments to the strategic direction.

4.6. People & Culture

Behind innovative smart services' development and delivery are creative-thinking people embedded in a corporate culture that promotes innovation. The capabilities required for this in the context of smart service transformation are the focus of the final dimension people & culture, including 12 capabilities.

4.6.1. Capabilities regarding "People" Smart services require new employee skills. On the one hand, companies can close these skills gaps through appropriate *education and training concepts* (Berger et al., 2020; Kreutzer et al., 2018), thus increasing the *digital affinity* of the employees in the organization (Gimpel et al., 2018). On the other hand, relevant skills gaps can be closed by recruiting external employees on the basis of defined positions through *competence management* (Klötzer & Pflaum, 2017). The resulting development of *employee resources* supports smart service transformation, as specific responsibilities can be transferred to employees more efficiently (Kaltenbach et al., 2018; Yezhebay et al., 2021). However, this requires an *external perception of the company* appropriate for the target group to attract suitable talents (Kreutzer et al., 2018).

4.6.2. Capabilities regarding "Culture." A *culture of innovation* is needed within the company to give employees the freedom to develop innovative ideas (Klötzer & Pflaum, 2017; Schumacher et al., 2016). Combined with a service-oriented *management style* (Berger et al., 2020; Bilgeri et al., 2017), this encourages *interdisciplinary thinking* (Kreutzer et al., 2018) and an *agile* way of working (Danuso et al., 2022). It enables employees to develop various smart service ideas and test their feasibility. A strong *failure culture* allows employees to pursue ideas without fear of failure (Müller et al., 2019). By changing the corporate culture towards innovation, the fundamental *willingness of employees to change* is promoted, which can be expected to increase the durability of the transformation (Schumacher et al., 2019). In addition, the knowledge gained from idea generation and implementation needs to be transferred into appropriate *knowledge management* to secure the knowledge base within the organization (Anke, 2019; Yezhebay et al., 2021).

5. Discussion

In this paper, we identified 78 capabilities that manufacturing companies must consider when engaging in the shift toward smart services, answering our first research question. We found that they can be structured across 12 principles and six dimensions for meaningful analysis and management, providing an answer to research question 2. By providing such a holistic view of the smart service transformation, the results show that introducing smart services in a manufacturing context is a highly interdisciplinary endeavor. It requires companies to also look beyond industry boundaries for collaboration and inspiration. This supports the findings of (Beverungen et al., 2019) and (Lim & Maglio, 2018). Two capabilities were neither mentioned in the interviews nor the literature but stem from the workshop within the project team. It surprised us that *on-* and *off-boarding processes* were not mentioned since they were significant discussion points in our applied research practices.

Our approach can be differentiated from existing collections of capabilities – most in the form of maturity models. For example, the IMPRESS Smart Service Quick-Check is a tool to identify the relevant fields of action for value creation and to guide more in-depth analyses. For that, it employs 43 questions structured with the dimensions strategy, market offering, and business model. The questions are answered with yes or no and evaluated regarding relevance (Reinhold et al., 2020). The Smart-Product-Service Maturity Model considers smart products, smart services, and business integrations according to four criteria each (Heinz et al., 2022). Another maturity model that considers smart products and smart services delivering fields of action is proposed by Klötzer and Pflaum. It provides nine fields of action for both smart product realization and application (Klötzer & Pflaum, 2017). Compared to the existing literature, our transformation capabilities, principles, and dimensions are the most comprehensible and clearly structured.

Nevertheless, naturally, our research is subject to certain limitations. This includes our choice of databases and search string for the literature review, which may have led to some papers being missed. Also, our choice of interviewees might be a limitation since only one person from each institution was interviewed, and all interviewees came from Germany. Integrating experts from other countries or conducting more interviews in each company might have led to further insights. Lastly, our coding and structuring process is subject to personal biases, so it is possible that third persons would derive different capabilities and clusters.

For practitioners, the results may help prepare and reflect their transformation processes, create workstreams, and identify potentials and weaknesses. The evident challenges and gaps with regard to smart services are thus also apparent across departments, and synergies can be uncovered and extracted. They also help raise awareness about the complexity of introducing smart services and, therefore, mitigate the risk of engaging in this endeavor with insufficient resources. Thus, the results help to stay competitive in the digital age.

For researchers, the comprehensive landscape of dimensions, principles, and capabilities collection and structuring of capabilities contributes to a holistic understanding of smart services in theory and practice. It allows them to contextualize their research, identify gaps, and derive further research questions.

Possible pathways for further research are manifold. Firstly, the results are valid for manufacturing companies in general and could, therefore, be adapted to more specific industries. Narrowing the focus allows for considering certain individual characteristics, e.g., heavy regulation and complicated revenue structures in medical technology (MedTech). Secondly, the research could be further quantified. The systemic overview of the capabilities for smart service transformation is a good foundation for a survey to determine the status quo of manufacturing companies. With a sufficient quantity of recorded data sets, certain archetypal types of companies within the smart service transformation might be identified. This, in turn, could be used to develop generic strategies for the smart service transformation based on current capability patterns of manufacturers. Thirdly, the capabilities are also very suitable as the basis for a maturity model, which is the topic of our next publication. A maturity model would allow manufacturing companies to determine their status quo, choose a target maturity, and derive strategies and measures to achieve it. Hence, it enables a conscious smart service transformation.

6. Conclusion

Becoming a smart service provider requires manufacturing companies to undergo a major transformation. Our study proposes 78 distinct capabilities structured along 12 principles and six dimensions to consider when engaging in this transformation. The dimensions show that the transformation is a socio-technical endeavor spanning human, organizational, and technological aspects. Given the number of capabilities, our results further indicate that the smart service transformation is fundamental in nature and hard to comprehend as a whole.

7. Acknowledgement

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