Characterising smart service systems – Revealing the smart value

By Julian Kurtz*, Christian Zinke-Wehlmann, Nina Lugmair, Martin Schymanietz, and Angela Roth

The increasing use of digital technologies is creating new values, which can be unfold in smart service systems (SSS). Although SSS offer multiple values in products and services, research is still struggling to fully capture the specific values of "smart" as result of digital technologies. Therefore, there is no all-encompassing value understanding of SSS. In our work, we derive values of SSS, especially the "smart" values, by a qualitative analysis of cases in an open coding approach. These cases are identified by a systematic literature review. The derived "smart" values are e.g. increasing system transparency and autonomy, increasing knowledge integration, and enabling ecological savings fostering value in context. The specific values of "smart" in SSS give rise to value in context as a representation of those specific values. In addition, the emergence of derived values in SSS is further illustrated with an SSS value continuum, which presents value in product, value in services, and value in context as characterisation of values in SSS. The derived values and the SSS value continuum developed are intended to promote a better understanding of SSS and its value manifestations, and provide a basis for further research into SSS as a theoretical lens for value co-creation.

1. Introduction

Smart service systems (SSS) highlight the increasing convergence of servitisation and digitalisation (Satzger et al. 2022). However, the smartness of these special service systems often remains unclear (Beverungen et al. 2019a; Beverungen et al. 2019b). Servitisation describes an organisational transformation in which combined bundles of products and services are offered in order to add value to core product offerings (Vandermerwe and Rada 1988). It is a key strategy to capture additional value to the existing portfolio and differentiate in commoditising markets (Schüritz et al. 2017). This leads to strategic shifts in firms (Kamal et al. 2020). Furthermore, digitalisation encompasses a firms' value proposition, enabling it to develop smart products and smart services based on digital technologies and to sell new system solutions to end customers (Leimeister 2020). This leads to improved value co-creation through data provision, data collection, data storage, data analysis, and data use (Kohtamäki et al. 2020). Through digitalisation, firms increasingly use digital technologies to deliver their value propositions

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(Ardolino et al. 2016; Raddats et al. 2022; Satzger et al. 2022). Thus, servitisation is driven by digitalisation and involves a shift from offering products to offering SSS (Kohtamäki et al. 2020; Li et al. 2020; Münch et al. 2022; Raddats et al. 2022). These SSS are service systems that control "things for the users based on the technology resources for sensing, connected network, context-aware computing, and wireless communications" (Lim and Maglio 2018, p. 118). They create value in numerous industries, such as healthcare (Valencia et al. 2015), manufacturing (Heinz et al. 2022b), smart cities (Lim and Maglio 2018), and others (Maglio and Lim 2016).

For example, a robot equipped with sensors transmits usage data to the provider about the robot's run time at the customer's facility. Based on this usage data, the robot provider can customise the maintenance contract policies, as more contextual information is known about the usage of the robot. Thus, the customer may receive an individual contract that offers better conditions than a categorical maintenance contract. However, if the robot usage is higher than the categorical average, the customer may receive an individual contract that offers worse conditions. In both cases, the robot provider would have valuable context information based on the sensor data to create the individual contract policies for the customer. This example shows that the value of SSS to customers and providers varies depending on the individual situation, but it is co-created based on the data exchange between provider and customer and the resulting context information. As another example, a supply part equipped with sensors transmits data about, e.g. its location. This allows for supply chain transparency, as the customer receives context information about the supply status of their ordered product. These examples demonstrate that SSS potentially enable better provider differentiation from competitors and higher customer loyalty by making the offerings to customers more flexible and individualised (Leimeister 2020). Furthermore, SSS offer the potential for digital value creation for customers, e.g. collecting digital records of equipment (Chowdhury et al. 2018), early warnings for maintenance (Kohtamäki et al. 2020), and predictions of expected performance (Bertoni and Bertoni 2022).

Although the servitisation research has acknowledged the role of digital technologies, studies have lacked the necessary emphasis on the role of digitalisation (Kohtamäki et al. 2020). Especially, the "smartness" of SSS leads to new value by, for example, using interfaces to technologies on the basis of digitalisation and thus realising new technology-based services (Roth et al. 2017). Nevertheless, the value of the smartness for providers and customers in SSS is rarely explored, as the "consequences of smartness received little research attention, even though they might mitigate the positive impact of perceived personalisation on customer engagement" (Henkens et al. 2021, p. 426). In this context, the smartness is often poorly considered as an independent value, but rather it is viewed as part of a smart product value or a smart services value. For example, Porter and Heppelmann (2014, p. 4) have already noted that "products have become complex systems", but "[firms] must look beyond the technologies themselves". They end their article by arguing that digital technologies lead to the "smartness" of products that enable related services, but do not explain the distinct value of "smartness" in these systems of products, services and digital technologies (p. 13). Although "smartness" will shape the customer experience and the role of business models, the "smart" value in SSS often remains unclear, as "smartness" challenges existing assumptions about the dynamics and mechanisms in SSS through its impact on innovation processes and outcomes (Heinz et al. 2022a). Furthermore, "it remains unclear how firms configure smartness characteristics when offering smart service systems to customers" (Henkens et al. 2022, p. 3). In order to fully exploit the value potential of SSS in the context of digitalisation, it is worth shedding light not only on the product value and services value but also on the smart value. This is of particular importance for understanding the value creation dynamics around SSS as well as for the further development of service science in general (Vargo et al. 2008). Especially in an increasingly digital world, a comprehensive understanding of smart value is necessary to fully exploit the future value creation potential in the digital sphere. For example, a smart value leads to higher levels of customer interaction (Henkens et al. 2021). Therefore, in order to characterise the different values and their contributions to the SSS, we propose a new perspective on SSS, as they "need to be reinterpreted according to a perspective that applies a total and all-encompassing view to the processes of value generation and to the interpretation of the information and data exchanged" (Grimaldi et al. 2020, p. 212). In particular, this paper addresses the research question: *How can SSS be characterised from a value perspective?*

The paper is structured as follows. Section 2 explains the fundamentals of digitalisation, servitisation, SSS, and the concept of value. The research design reflects the scientific approach to characterising SSS from a value perspective. The insights are presented in the results and then evaluated in the discussion.

2. Background

2.1. Servitisation, Digitalisation, and Smart Service Systems (SSS)

Servitisation is a strategic shift in capabilities to provide integrated end-to-end services using innovative technologies that add value to products (Kamal et al. 2020). It describes the trend towards offering not only products but combined products and services. Servitisation implies the offering of "fuller market packages or "bundles" of customer-focused combinations of goods, services, support, self-service and knowledge" in order to add value to core product offerings (Vandermerwe and Rada 1988, p. 1). The bundles offered are named product-service systems (PSS), which are defined as combinations of tangible products and intangible services intended to jointly fulfil the needs of customers (Tukker 2004). The use of PSS generates value for providers, such as the potential for increased profit margins (Bustinza et al. 2017; Raddats et al. 2016), customer lock-in effects (Bustinza et al. 2017; Neely 2008), product differentiation (Neely 2008; Rabetino et al. 2017), and improved service quality (Rabetino et al. 2017; Raddats et al. 2016). For customers, they generate value, such as risk reduction (Martinez et al. 2017; Rabetino et al. 2017), increased quality (Rabetino et al. 2017), and individual solutions (Fliess and Lexutt 2019; Martinez et al. 2017). The categories of a PSS between a pure product and a pure service are not selective, which is why the value can be spread differently in products or services (Tukker 2004). Depending on whether a service is added to an existing product or a product is added to an existing service, either servitisation or productisation is taking place (Beverungen et al. 2017). Productisation describes the development of a service component into a product or a new service component that is marketed as a product (Baines et al. 2007). It is a contrarian shift from servitisation, with the aim of meeting customers' needs and improving service quality and efficiency (Leoni 2015). In both cases, the share of products and services in the respective PSS can vary (Münch et al. 2022). Digital technologies are becoming increasingly important for value generation in PSS (Li et al. 2020).

Digital technologies are enabled by the trend of digitalisation, which relates to "the connectivity supported by digital technologies including machines, vehicles, buildings and the like, and is the major force driving the current industrial revolution" (Parida 2018, p. 3). On the one hand, new tools and techniques for e.g. process management become feasible, on the other hand, existing products and services themselves are digitalised (Benkenstein et al. 2017). Digital technologies decouple value from tangible products when added to them and lead to new value generation potentials (Münch et al. 2022) by moving into a digital business (Parida 2018). Through the influence of digital technologies on products, smart products arise as autonomous objects designed for self-organised embedding in different environments throughout their lifecycle (Ahram et al. 2012). They are able to use context information about themselves and about the environment in which they run, and to collaborate with other products (Gutierrez et al. 2013). Smart products can also emerge in the opposite way, such as when tangible products are added to digital technologies. This is the case, for example, with Amazon Corp., which not only offers a digital platform but also tangible products connected to the digital platform, such as Amazon Echo music speakers. In our sense, this is a shift of materialisation in which tangible objects are added to already existing digital technologies, in this case, a digital platform. Digitalisation also has an influence on intangible services in that smart services are created when digital technologies are added to them. Smart services are digital services that generate added value out of the data from smart products through continuous data collection and analysis (Reinhold et al. 2022). They can integrate physical and digital competencies in a complex sociotechnical service system (Beverungen et al. 2017). Smart services are enabled by smart products and are the application of specialised competencies, through actions, processes, and performance (Beverungen et al. 2019b). Smart services can also emerge through embodiment, which is the incarnation in the course of an interaction (Barsalou et al. 2003). This is the case when intangible services are added to digital technologies, for example when human-like attributes are added to a digital agent, such as a face (Shamekhi et al. 2018).

With the influence of digital technologies, new types of PSS, such as SSS, are being discussed. In contrast to PSS, SSS necessarily include digital technologies and a fundamental part of the value creation of SSS is data processing. SSS consist of smart products as boundary-objects and are the basis for smart services, which integrate the resources and activities of the involved actors for mutual benefit (Beverungen et al. 2019b). The essential attributes of SSS are connectivity between things and people, data collection for context awareness, computation in the cloud, wireless communication, and shared value creation (Lim and Maglio 2019). SSS are characterised by technology-mediated, constant, and routinised interaction (Beverungen et al. 2019b). They are specifically designed to prudently manage their contents and objectives, with the ability to reconfigure themselves to ensure they remain capable of satisfying all the relevant contributors over time (Barile and Polese 2010). The key to SSS is using data to foster shared value creation (Lim and Maglio 2019). In the era of digitalisation, there is a growing need for SSS based on information and communication technologies to provide a foundation for systematic and sustainable service innovations in complex environments (Barile and Polese 2010). SSS are driven by the impact of digital technologies, but in the context of servitisation, the digital dimension has not been specifically considered in the research (Münch et al. 2022).

The main motivation for research in the context of servitisation so far has been competitive motivation, demand-based motivation, and economic motivation (Martinez et al. 2017). Explanations for servitisation often rely on theories of business model innovation, as well as organisational change and capabilities (Kurtmollaiev and Pedersen 2022). As SSS represent the market proposition of manufacturing firms in the context of servitisation, there is little research on a value-driven framework for digital technology-influenced PSS (Liu et al. 2018), such as SSS. Thus, it is often unclear what value digital technologies have in the context of the SSS, besides "new value by reducing costs, increasing efficiency and improving outcomes" (Matzner et al. 2018, p. 8). Beverungen et al. (2017) highlight digital technologies as a bridge between resources and actors in SSS. In the work of Maglio and Lim (2016), digital technologies enable the identification of patterns in big data and lead to the enhancement of SSS. They state that digital technologies can create value independent of tangible products and intangible services. Shih et al. (2016) introduce digital technologies as "pseudo-actors" next to tangible products and intangible services. The respective perspectives and research indicate that there is already an understanding of the role of digital technologies in PSS, thus expanding its scope (Satzger et al. 2022), but that holistic characterisations are missing.

2.2. The concept of value

Value is a concept that has been discussed by different research communities for decades. It has no clear definition and is constructed and perceived differently by providers and customers (Grönroos and Voima 2013). In general, there is a distinction between the "value in exchange" (VIE) and the "value co-creation" (VCC) views (*Fig. 1*). Since little research exists on the VCC-frameworks for SSS (Chowdhury et al. 2018; Liu et al. 2018), a stronger consideration of the influence of digital technologies is needed to fully capture the expression of value (Grönroos and Voima 2013). Although there is no universal understanding of value and the different approaches around it, there is, however, a common understanding in service science that value is typically co-created.

Over 2000 years ago, Aristoteles depicted VCC as a customer's subjective perception of a product or service and market demand as a function of VCC expressed in the VIE (e.g. price) (Gordon 1964; Medberg and Grönroos 2020). Later, Adam Smith noted that products having the greatest value in co-creation are often worth little in exchange, and vice versa (Medberg and Grönroos 2020; Smith 2010). Although it was recognised early that the value of a product originates in its co-creation, wealth was traditionally measured in terms of exchange, which therefore became the focus of later economic philosophy (Medberg and Grönroos 2020) and understanding of value. VIE is based on the power of purchasing products, as reflected in the market price, with the customer being the passive recipient of value (Eggert et al. 2018), leading to separate provider and customer spheres (Schüritz et al. 2019). On the other hand, VCC results in shared knowledge between actors, considers the context of the wider actor group, takes place primarily in the joint sphere of provider and customer, and considers resources (Eggert et al. 2018). In contrast to VIE, the actual value-in-use is considered the primary real value for VCC (Vargo et al. 2008). VCC can only be realised by the beneficiary (Lusch et al. 2008), and it is individual, experience-based, context-dependent, and substantial (Vargo and Lusch 2008).

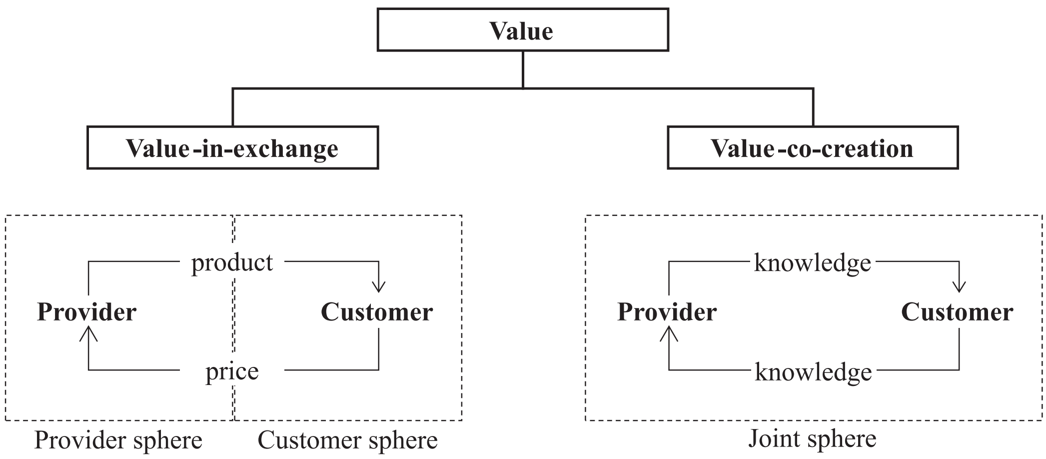

Figure 1: Concept of value (based on Eggert et al. 2018; Grönroos and Voima 2013)

The use of digital technologies improves the potential extent of value in SSS by increasing the granularity and velocity of data (Beverungen et al. 2019b; Kohtamäki et al. 2020), supporting decision-making, optimising operations, and improving system quality (Bertoni and Bertoni 2022). These technologies lead to better connectivity, interactive dialog, and greater proximity of the provider and customer (Li et al. 2020). In addition, digital technologies enable dematerialised functionalities and promote an increased focus on VCC (Pirola et al. 2020). For example, digital technologies enable providers and customers to own and share more data about each other, leading to more information and knowledge as well as a better contextual understanding of each other's situation. This fosters a greater understanding of the interrelationships between tangible products and intangible services and consequently primes the VCC for system innovations (Chowdhury et al. 2018; Leimeister 2020) through improved contextual information (Satzger et al. 2022). Despite their significant financial potential, however, many providers struggle to appropriate the value of digital technologies because of the major organisational challenges and capability demands that accompany investments in these technologies (Kohtamäki et al. 2020; Münch et al. 2022). Therefore, firms often focus on the technical aspects, such as communication standards, and neglect the potential of digital technologies for new opportunities of contextual understanding in order to create higher co-created value (Beverungen et al. 2019b).

While the technological aspects highlighted allow for an increase in smartness, practitioners and researchers lack guidance on how to influence the smartness of service systems while considering the needs of customers (Henkens et al. 2022). For example, products should be seen as part of systems, as digital technologies can create new opportunities for customers to co-create the value proposition and stimulate value-driven service innovation (Harvey et al. 2020). Reflecting the current debate on values and SSS, Leroi-Werelds and Matthes (2022) identify 15 key principles for successfully positioning transformative values as a provider to customers. However, it is not well understood how firms are changing their value proposition to customers to align with investment in SSS (Henkens et al. 2022). According to Zeithaml et al. (2020, p. 10), a systematic conceptualisation of VCC (from a social constructionist point of view) "emphasises that value co-creation extends dyadic interactions between customers and service providers [...] [and] recognises that customers are embedded in systems of social and economic actors engaged in integrating resources and exchanging services". The systematic view is accompanied by the insight that value creation and value dimensions depend on the interaction of products and services - as well as "smart" components. To summarise with Zeithaml et al. (2020, p. 17): "The value literature has largely ignored the transformative potential that smart products offer. […] How will this new context shape the customer value?"

3. Research design

In order to characterise SSS from a value perspective and to sharpen the understanding of digital technologies' impact on SSS to reveal the "smart" value, we followed a two-stage research design. In a first stage, we conducted a systematic literature review according to Webster and Watson (2002) to identify use cases of SSS in the literature. Second, we followed an open-coding approach to analyse the identified use cases and develop a descriptive characterisation of SSS. From a methodological viewpoint, scientific research has examined SSS mainly from a conceptual perspective (Barile and Polese 2010; Beverungen et al. 2017; Maglio and Lim 2016; Shih et al. 2016) and through interviews (Beverungen et al. 2019b). By analysing current use cases based on a literature review, we aimed to enrich the understanding of SSS and the "smart" value, since use cases effectively express the functional requirements of a system (Fantechi et al. 2003). As SSS, with their special focus on the "socio-technical configurations for service provision" (Anke et al. 2020, p. 3), are a specification of PSS, we have broadened the scope of the initial literature review to include all kinds of PSS. The results of the first stage of the research approach were developed over a longer period of time. The literature review was conducted end of the year 2021. This was intended to be as broad as possible in order to cover a wide range of literature from the fields of business administration, information systems and production. For this purpose, a special focus was given to "smart" in the construction of the search string. It was assumed that "smart" describes something that is digital, data-driven or IoT-based as reflected in the first substring. IoT in particular is one of the main drivers of digitalisation and a trend around smart product especially. The second and third substring are intended to cover literature on smart products, smart services and in combination with the first substring on SSS. The fourth substring served to narrow down the broad field of research. The focus should be on the innovation and development processes and the design of the various concepts. This was intended to highlight the three different areas of product, service and digital technologies in particular. The evaluation of the literature was conducted in the year 2022. All terms were searched in quotation marks to ensure precise results.

1st substring		2nd substring		3rd substring		4th substring
Smart* OR Digital* OR IoT* OR Data-driven*	*, AND	Product* OR Service* OR System* OR Hybrid*	*, AND	Product* OR Service* OR System* OR Hybrid*	*, OR	Innovation* OR Process* OR Engineering*OR Design* OR Approach* OR Technology* OR Collaboration* OR Artefact*

Table 1: Search string

The original sample included 12,849 articles. We narrowed this to 734 articles by including only journal articles with an A, B, or C ranking according to the VHB-JOURQUAL3. The VHB-JOURQUAL3 provides fundamental information about the scientific quality of journals; it is a valid, comprehensive ranking of journals that includes an adequate forum regarding the scientific quality of journals and is suitable for evaluation (Hennig-Thurau et al. 2004). The next step was to reduce the sample by removing duplicates, articles without full author information and those with titles that did not contain the words e.g. "smart*", "digital*", "data-driven*", "IoT*", "SSS", "product service system*", or "PSS". This resulted in a sample of 171 articles. After screening the 171 titles, we scanned the abstracts and removed all the articles without a link to SSS or to the terms in the 4th substring. This led to a sample of 107 articles. The next step was to review the full texts and to remove all articles that did not contain a status quo on SSS or SSS features, processes, design or innovation. This resulted in a remaining sample of 75 articles. After conducting a forward and backward search, the final sample contained 86 articles, as articles that fulfilled the previously applied exclusion criteria and were not yet included in the sample were added. We then screened the 86 articles to identify use cases of SSS that include an exposure to digital technologies. We identified 31 different use cases in 15 articles (113,782 words) of the final sample of 86 articles (see appendix).

Returning to characterisation of SSS in the second stage of the research approach, we investigated the general literature to find SSS characterisations in order to sort the 31 use cases. To the best of our knowledge, no existing framework sufficiently characterises SSS from a value perspective. Nevertheless, we were able to derive the value in products and services from the existing frameworks through an open-coding approach. For this purpose, the existing SSS-frameworks of Beverungen et al. (2019b), Beverungen et al. (2017), Maglio and Lim (2016), and Shih et al. (2016) were examined and text passages representing value in product or services were investigated in an iterative process. Text passages such as "maintenance and upgrades that are bundled with products" (Beverungen et al. 2017), or "services allow people to use products without owning the product" (Shih et al. 2016) represent value in services by e.g. adding value to product offerings or e.g. performing actions in systems (see Figure 3). Text passages such as "trash cans to collect trash" (Maglio and Lim 2016), or "acts as reference point for service interaction" (Beverungen et al. 2019b) represent value in products by e.g. performing a job to be done or e.g. providing the frame of reference (see Figure 3).

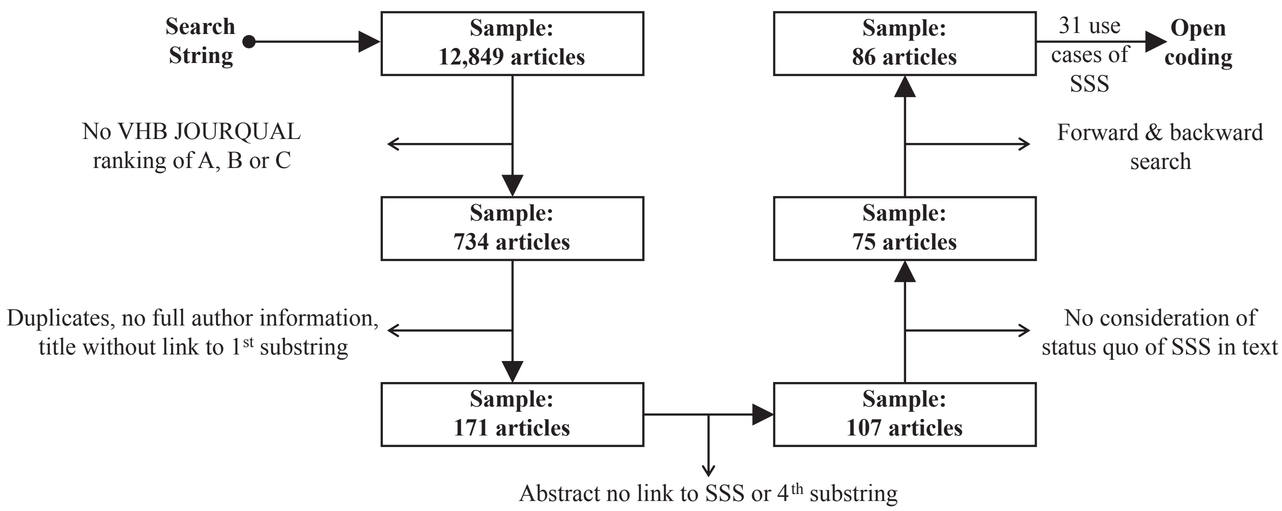

Figure 2: Research design

We could not, however, derive the value of "smart", because the existing frameworks do not provide a holistic value perspective. Therefore, we coded the 31 use cases identified from the described literature review in a descriptive multi-stage open approach to develop a characterisation of SSS from a value perspective. In open coding, concepts are extracted from raw data and later placed into conceptual categories to create a descriptive framework (Khandkar 2009). In a first iterative coding round to derive the "smart" value, we grouped the codes into 3 different groups: customer value, supplier value, and global value. In a next iterative coding round, we paraphrased the codes to 41 different "smart" values with-in the groups e.g. "maximising flexibility", "saving money", "monitoring status", "modifying new service elements", or "tracking location". In a final iterative coding round, we aggregated the 41 paraphrases from the 3 different groups into the 8 cross-group resulting first-order codes for the value in context. Herby, identified 1st order codes for the 2nd order category "increasing system transparency and autonomy" of the aggregate dimension "value in context" are, for example, "measuring performance of machine", "connecting service provider", and "detecting system status automatically". Text passages for 1st order code "measuring performance of machine" leading to 2nd order category "increasing system transparency and autonomy" are e.g. "manufacturing companies share their raw data of machines with a specific data analysis company and not for all other partners in the value network to perform certain analysis" (Olivotti et al. 2019, p. 14), "within a digitally connected production, different devices such as sensors, actuators and controllers can record the current status and values of objects" (Schönig et al. 2018, p. 2), or "applying IoT, the performance of machines can be measured during the use phase" (Zancul et al. 2016, p. 7). We iterated the coding cycles singularly and then merged and aggregated the individual coding results. This enabled us to identify patterns, effectively identify connections, and draw out themes with overlapping dimensions through a series of repetitions and comparisons (Gioia et al. 2013; Strauss and Corbin 1990).

According to our conception, a satisfactory characterisation of value creation in SSS includes an equalisation of value in product, value in services, and value in context. In the final step, we developed a descriptive characterisation and continuum of SSS that focuses not only on the products and services but also on the digital technologies and their value contributions. It needs to be mentioned that a systemic approach of VCC brings challenges: firstly, the question of "value for whom" arises with the insight that all actors create values (for themselves); secondly, within a system there are many spill-over effects of value creation when using digital technologies, services and products, which are difficult to classify. For example, increased transparency and autonomy can be a value for customers as well as for service or product providers, depending on the business model, strategy and many other factors. The paper does not aim to provide a complete answer to the question of "value for whom" and its interrelationships - we prioritise the characterisation of the SSS in terms of value characteristics.

4. Characterisation of smart service systems

In this section, we present our characterisation and continuum of SSS as the main contribution. First, we characterised the value in tangible products and intangible services according to the existing frameworks of Maglio and Lim (2016), Shih et al. (2016), Beverungen et al. (2017), and Beverungen et al. (2019b), which currently do not include a sufficient value perspective. Second, we derive and characterised the value in context from the 31 identified use cases of the 86 articles in the systematic literature review. Third, we present our continuum of SSS.

4.1. Value in tangible products and intangible services

First, tangible products create value by performing a job that needs to be done, especially when customers pay for it (Maglio and Lim 2016). Washing machines, refrigerators, cooker hoods, and other products in homes can replace human labour by performing their work. Tangible products substituting human labour for a job to be done is not only the case in homes (Beverungen et al. 2017) or in cities (Maglio and Lim 2016) but also in industry due to industrial revolutions (Obermaier 2019). They generate value by increasingly enabling the delivery of services, as "the ultimate objective of networking physical goods with information technology often is to create and capitalise on smart service as new or transformed value propositions" (Beverungen et al. 2017, p. 1). The carrying of digital technologies by tangible products creates new customer value (Shih et al. 2016); for example, wrist bands with implemented digital technologies help customers achieve personalised outcomes (Maglio and Lim 2016) by providing information about their daily movements. Tangible products generate value by providing the frame of reference when acting as "boundary objects that integrate service consumers' and service providers' resources and activities" (Beverungen et al. 2019b, p. 1). Especially when tangible products carry digital technologies, they act as boundary-objects for resource integration and interaction (Beverungen et al. 2017). In summary, the value of tangible products in SSS derives from performing a job to be done, enabling the delivery of services, carrying digital technologies, and providing a frame of reference.

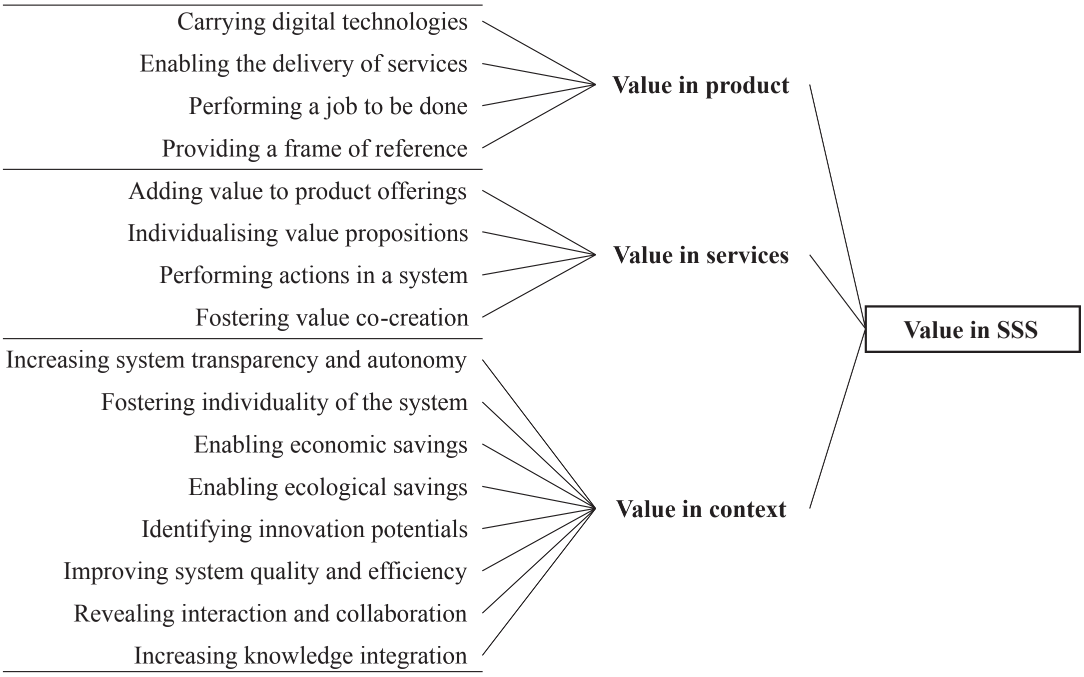

Figure 3: Value in SSS characterised by product, services, and context

Intangible services create value when added to product offerings, especially in optimising the product's operations and conditions and the entire product lifecycle by taking over activities for further development, from a pure product to a system (Beverungen et al. 2019b), e.g. through maintenance and upgrades that are bundled with products (Beverungen et al. 2017). Intangible services generate value through individualised value propositions, as they provide consumption choices for the customer (Shih et al. 2016) and create personalised experiences through tailored value propositions (Beverungen et al. 2019b). They create value by performing actions in a system, which "can be categorised as informational, physical, and interpersonal actions" according to their contribution to the system (Maglio and Lim 2016, p. 6). In doing this, they perform specialised competencies for the benefit of another or the operator (Beverungen et al. 2019b). Intangible services generate value by fostering VCC, using products to create value (Beverungen et al. 2019b). They enable people to use products "instead of actually owning them" (Shih et al. 2016, p. 1) and include all the economic activities of individuals, organisations, and technologies, which perform better together in collaboration than they do individually (Maglio and Lim 2016). Intangible services foster VCC as they amplify the interactions and business relationships between providers and customers (Beverungen et al. 2017). In summary, the value of intangible services in SSS derives from adding value to product offerings, individualising value propositions, performing actions in systems, and fostering VCC.

4.2. Value in context

Second, digital technologies create value by increasing system transparency and autonomy to enable a better understanding of the details or the needs of the job to be done. This value is generated by the introduction of digital technologies to provide customer data for higher quality services and, e.g. to be able to adapt the contract situation (Brown 2017; Gimpel 2020). For example, sensors allow for the identification, tracking, and tracing of tangible products (Gimpel 2020; Zhang et al. 2016). The application of digital technologies also enables direct machine access and connectivity, helping technicians to better diagnose problems (Rasouli 2020; Saarikko et al. 2017), and leads to automation, "contributes to a greater business context" (Saarikko et al. 2017, p. 3), and the real-time adaptation of performance (Beverungen et al. 2019b). Based on digital technologies, measuring the performance of a machine (Boldosova 2020; Zancul et al. 2016), recording and storing relevant process and equipment data in a structured reusable form (Schönig et al. 2018), and using "data to identify when repairs and service truly are needed and just as important, when they are not needed" (Gimpel 2020, p. 4) show that data and the context information generated from this data are an important source for value creation (Olivotti et al. 2019). Digital technologies also generate value by fostering the individuality of proposed systems; e.g. in the industrial context, providing a tailored transport based on real-time customer data collected through digital technologies enables personalised transport planning (Stopka 2020). Context information from real-time customer usage data enables differentiated service offerings (Beverungen et al. 2019b; Gimpel 2020), e.g. fleet management and equipment offerings (Boldosova 2020), as well as unified customer profiling, engagement (Gimpel 2020), and the satisfaction of individual customer needs (Sorescu 2017). This can be supported by digital twins that foster the offering of individualised services in value networks (Olivotti et al. 2019). In the healthcare sector, e.g. context information about patient status based on real-time data of digital technologies enables fast and precise medical intervention (Gimpel 2020; Schönig et al. 2018).

In addition, digital technologies create value by enabling economic savings through "cost reduction within the [system]" (Rasouli 2020, p. 10). The context information from the data generated by digital technologies leads to reduced capital investment, higher usage of leased equipment, and reduced operating expenses; e.g. condition monitoring and predictive maintenance improve system usage and financial returns (Gimpel 2020). In addition, digital technologies create value by enabling ecological savings, e.g. through reducing environmental footprints based on optimised resource ingredients of the system process operations (Beverungen et al. 2019b). In the transport sector, seamless mobility based on mobility-as-a-service concepts or sustainable logistic services based on the use of digital technologies leads to societal and environmental benefits (Stopka 2020; Zhang et al. 2016). Digital technologies also generate value by identifying the innovation potentials of the systems, as these technologies lead to the fundamental or incremental innovation of SSS, processes, and business models (BM) (Wiesböck and Hess 2020). The context information provided through digital technologies enables "modification in the value proposition" (Zancul et al. 2016, p. 7), investigation of system designs (Ahram et al. 2012), and adjustment of systems (Beverungen et al. 2019b). The usage of context information from the data promotes overall equipment effectiveness, improved on-time schedules, faster service, and "exploring new business models" (Gimpel 2020, p. 9). Independent market participants can thus become system participants and foster service innovation through competition (Reiter et al. 2019). Indeed, all levels of service profit through the innovations made possible by better access to data through digital technologies (Saarikko et al. 2017). Digital technologies also create value by improving system quality and efficiency, e.g. through better standardisation of processes (Rasouli 2020) and back-end platforms for multimodal operations (Stopka 2020). In addition, improved tangible products and intangible services through the investigation of dark data are a result, as are the extended life of these products and services and their reduced downtimes (Gimpel 2020).

Finally, digital technologies create value by revealing interaction and collaboration, e.g. through continuously monitoring customer status and better connecting customers and providers (Brown 2017; Reiter et al. 2019). The continuous monitoring of customer status leads to higher customer satisfaction (Gimpel 2020; Wiesböck and Hess 2020), and fundamental changes in operations based on digital technologies lead to the increased connection and faster interaction of customers and providers (Rasouli 2020; Zancul et al. 2016), with long-term commitment effects and loyalty (Reiter et al. 2019; Saarikko et al. 2017). Through this increased interaction and the possibilities of data preparation with the help of digital technologies, value is generated by facilitating knowledge integration. System design is characterised by the relationship between knowledge and technology, as the knowledge of actors can be fully "embedded in [...] the system" through digital technologies (Ahram et al. 2012, p. 2). To create value from data, it must be transformed into knowledge via information (Zancul et al. 2016), which can be supported by knowledge management systems based on digital technologies (Olivotti et al. 2019). Precise context information about the job to be done leads to higher quality of the system's output (Saarikko et al. 2017) through "goal-oriented work and protects users from information overload" (Schönig et al. 2018, p. 5). In addition, the benchmarking of existing systems is possible when knowledge is generated out of data from digital technologies (Beverungen et al. 2019b). In summary, the "smart" value created by digital technologies in SSS derives from increasing system transparency and autonomy, fostering individuality of the system, enabling economic savings, enabling ecological savings, identifying innovation potentials, improving system quality and efficiency, revealing interaction and collaboration, and increasing knowledge integration. All of this is enabled primarily because context is obtained based on a better data foundation fostered by digital technologies. The three values outlined are illustrated in *Fig. 3* with their respective characteristics, which do not always have to be fully prioritised by the provider and customer.

4.3. Value continuum of SSS

In characterising SSS from a value perspective in the third step, we frame them by the introduced trends of servitisation and digitalisation and their introduced reverse processes (productisation, materialisation, and embodiment). For individuals, a clear distinction of the appearance of the SSS values is not always clear, which is also be related to individuals' different value priorities (Tukker 2004). In some PSS, the value in tangible products, such as e.g. performing a job to be done, can prevail over the value in intangible services, such as e.g. individualising the value proposition, but also vice versa. The value of smart products derives from tangible product value and value in context created by, e.g. products carrying digital technologies and digital technologies revealing interaction and collaboration. The value in smart services derives from intangible services value and value in context created by, e.g. services fostering VCC and increasing system transparency and autonomy through digital technologies. In both smart products and smart services, the value in context creates value that cannot be seen directly as the value of the tangible product or intangible service, but as an additional value in its own right.

In the context of SSS, it is not always clearly whether the value of an SSS is due to the product or due to the service part. Furthermore, we see value in context as an independent additional value that results from the use of digital technologies. This means that the value of smart products is derived from the value in product bundled with value in context. Similarly, we see the value of smart services as derived from value in services and value in context. Which of these three value leaps is perceived depends on the individual's prioritisation. We therefore draw a continuum of the three parts to characterise SSS from a value perspective, consisting of value in product, value in services and value in context. In this continuum, it is not possible to make a clear distinction between the value of tangible products, intangible services, or digital technology, but it is possible to identify value priorities.

Hereby, the more a system develops towards digitalisation, the smarter an SSS can be and more potential value can be prioritised in context. Entering the continuum from a digitalised perspective, the more a system transits towards materialisation or embodiment, the more potential value can be prioritised in a product or a service. From a combined digitalisation and servitisation perspective (smart service), more potential value can be prioritised in context and in service. Vice versa, from a combined perspective of digitalisation and productisation (smart product), more potential value can be prioritised in context and in product. This value potential can vary, as Beverungen et al. (2019) already introduced a line of visibility between providers and customers in SSS. The different potentials and transitions can be seen in the characterisation of SSS as a continuum in *Fig. 4*. The continuum serves as a characterisation, with smooth transitions between the values on which a provider, but also a customer, can place itself according to its value priority.

5. Discussion and contributions

The value continuum of SSS extends the existing knowledge about SSS and adds a perspective by focusing especially on the "smart" value. As a result, delivering the value of an SSS to providers and customers is considered holistically, not just from the perspective of products and services. To illustrate this, we took a descriptive approach and used the existing descriptions of SSS and use cases from the literature to characterise the value of SSS. We argue that the increasing application of digital technologies in PSS, leading to emerging SSS, generates independent value beyond product value and services value.

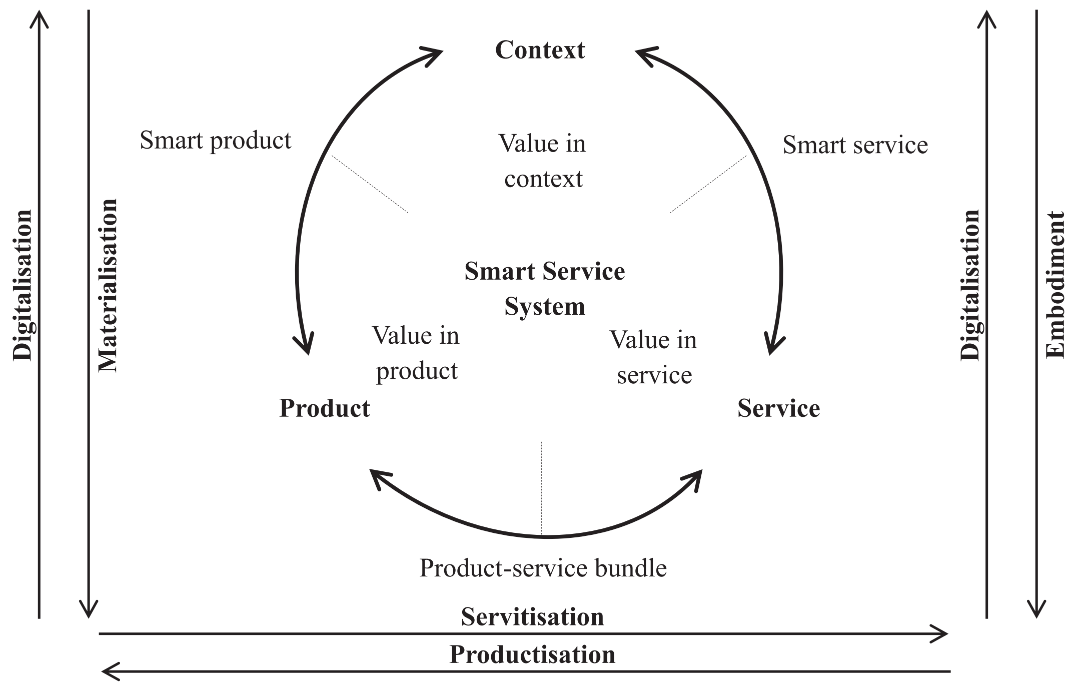

Figure 4: The value continuum of a smart service system

5.1. Theoretical contributions

The first contribution of our work is that digital technologies open up a new sphere in SSS that enables context as a new, additional value, besides the services and product value, or their bundled value. We argue that digital technologies represent this contextual value as such, as they aggregate the necessary data (Boldosova 2020), measure machine performance (Zancul et al. 2016), enable autonomous system adaptations (Beverungen et al. 2019b), and increase the asset lifetime and system availability (Gimpel 2020). The value in context can exist even without a product or service, as in the case of digital-only data providers, e.g. Oracle Database in its basic features. However, the value in context of SSS based on digital technologies does not have to be solely in the joint sphere while value co-creating. This is the case, for example, in the robot example introduced earlier, since the customer's usage data benefits the provider's contract preparation, who can also use the data for the contract preparation of other customers. In addition, the provider can use the generated value in context for other purposes that do not affect the actual customer's contract situation, e.g. evaluations of robot usage and comparison of this with other customers. This opens up a new sphere that goes beyond VCC in the joint sphere. Therefore, the direct value of digital technologies can be invisible to the customer, since on the one hand, they are generated backstage and, on the other hand, they generate value primarily for the provider. Thus, an SSS no longer consists of a complete VCC of provider and customer in the joint sphere, but of diverse actor-specific values in a complex system. For example, Beverungen et al. (2019) describe the line of visibility, separating activities of the SSS actors along the smart product. Moreover, it is not easy to differentiate where the contextual value resides, e.g. in the case of the described robot example. Here, the provider receives specific usage data and thus a contextual understanding of the use of their robot, which can be compared with the usage data of other customers with other robots. The contextual understanding of the activities of a specific robot acquired by the provider can subsequently enrich the contextual understanding of an entire robot assembly line, if this is the provider's intention. Actors may therefore have different considerations of value in context, which leads to the second contribution.

The second contribution of our work is that the different characteristics of value lead to value priorities for the different VCC actors. Due to the increased use of digital technologies, it can be a priority of providers to generate usage data (Ahram et al. 2012; Beverungen et al. 2019b; Gimpel 2020; Zancul et al. 2016). Based on these data, they can derive information about, for example, innovation potentials (Reiter et al. 2019; Saarikko et al. 2017; Wiesböck and Hess 2020). Besides this, the priority of customers can be that they gain increased system transparency and autonomy based on digital technologies (Saarikko et al. 2017; Zhang et al. 2016). In this case, the value priority of providers and customers would be equal in the context, but the characteristics of the value in context would be different. Value priorities may also differ between providers and customers. A provider can still see the value in context by generating data based on digital technologies. A customer, however, can see the value in services characterised by the performance of actions in the system (Beverungen et al. 2019b; Maglio et al. 2019). The different value priorities need to be understood and considered, especially when providers want to evolve systems and transform value propositions (Lugmair et al. 2022). In doing so, it is important to balance customers' value expectations with the generation of usable value for providers out of SSS. Moreover, digital technologies make it possible to identify innovation potential (Ahram et al. 2012; Gimpel 2020; Zancul et al. 2016), increase system quality and efficiency (Rasouli 2020; Stopka 2020), and promote interaction and collaboration (Brown 2017; Zancul et al. 2016). These technologies promote VCC because they link providers and customers and lead to increased knowledge integration (Olivotti et al. 2019; Schönig et al. 2018) and shared knowledge as a basis of VCC (Eggert et al. 2018). VCC benefits from the use of digital technologies, e.g. by enabling faster interaction (Rasouli 2020; Reiter et al. 2019; Zancul et al. 2016) and knowledge integration (Ahram et al. 2012; Olivotti et al. 2019; Saarikko et al. 2017). Consequently, with the growing prevalence of SSS, VIE represents an increasingly rare format of value creation.

The third contribution of our work is that digital technologies lead to a characterisation of value that is equal to, rather than merely being a part of, product value and services value. Presented in the value characterisation and its continuum, SSS emerge when firms digitalise during servitisation or productisation. SSS can also emerge during parallel materialisation and servitisation or parallel embodiment and productisation of the digital offerings of firms. The impact of digital technologies can be seen, for example, through their influence on the servitisation transformations of firms, leading to the rising research stream of "digital servitisation", but "only a few studies have considered the digitalisation journey and VCC alongside the PSS development" (Li et al. 2020, p. 898). Digital servitisation is referred to as the convergence of digitalisation and servitisation (Paschou et al. 2020). As seen in the analysed use cases, SSS expand the potentials for value creation by bringing new opportunities for interaction (Gimpel 2020; Rasouli 2020), contextual knowledge through data (Olivotti et al. 2019; Zancul et al. 2016), and a high degree of system individuality and system autonomy (Beverungen et al. 2019b; Boldosova 2020). For example, products become transformative through digital technologies by collecting quantifiable data about their environment, expanding the classic user-product relationships into reciprocal relationships (Pardo et al. 2020). Value is therefore created primarily through digital technologies, which also enable systems to adapt themselves and increasingly contribute to their viability and value creation (Mele et al. 2023). The value in services of SSS consists mainly in the performance of actions in the system (Beverungen et al. 2019b; Maglio and Lim 2016) and by fostering VCC in the joint sphere (Beverungen et al. 2017; Beverungen et al. 2019b; Maglio and Lim 2016; Shih et al. 2016). The product value of SSS will be reflected mainly in the function as a carrier of digital technologies (Maglio and Lim 2016; Shih et al. 2016) and by providing a frame of reference (Beverungen et al. 2017; Beverungen et al. 2019b). By co-creating value within SSS, firms become holistic solution providers of multiple values and offer value in products, services, PSS, smart products, and smart services.

5.2. Managerial contribution

Even though the focus of this paper is on theory, a contribution to improving the understanding of SSS at management level can be proposed. Practitioners in service economies need to carefully decide what investments they want to make to create value from their resources (Wirtz and Ehret 2017). The value characterisation and continuum of SSS can help practitioners determine their value priorities. In this sense, two possible applications of the continuum can be suggested. First, the continuum can be used as a strategic management tool to indicate future innovation directions. Starting with the example of the robot, innovation managers can consider whether they want to develop more in the direction of services. To do so, they can map necessary steps of this transformation from a pure product provider to a PSS provider. Alternatively, they could map necessary steps for a digitalisation of their robot towards a smart product in order to generate more value in context besides the value in product. If steps are to be taken towards both more service and more digitalisation, transformation steps towards an SSS can be mapped. Secondly, the continuum can alternatively be applied as a tool for reflecting and describing a transformation that has already been completed in a firm. This presupposes that a concrete transformation idea of a firm already exists and is being implemented. In retrospect, for example, transformation decisions can be reflected by visualising the activities on the continuum in order to generate learning effects for future transformations. This gives providers the opportunity to continuously review their value priority and to identify a change in their value priority. This may help when building resources and capabilities during a transformation.

In summary, the continuum as a management tool within a firm supports innovation decisions when it comes to creating value through products, services or digital technologies. It can be used to describe where a transformation journey should end temporarily. Future transformations can thus be managed more purposefully if there is a better common understanding of the strategic direction and the activities required to achieve it.

5.3. Limitations and outlook

The result presented in this study are not without limitations, however, as the proposed characterisation and continuum from a value perspective do not provide a complete answer to the question: “Value for whom?”. This provides another opportunity for discussion among academics. In addition, the cases studied are the result of a literature review conducted in 2021 and have a limited temporal focus. One potential research avenue could be a practical validation of the developed continuum. On the one hand, workshops could be conducted with the help of the tool to define the strategic directions of an innovation process and the necessary activities for the development of e.g. an SSS. On the other hand, evaluation workshops could be conducted with the help of the tool to reflect on completed innovation steps of e.g. SSS developments on the tool. Through these workshops, the tool could be evaluated in practice to identify any necessary additions to the tool, e.g. an actor perspective, for the practical application of the tool. A second possible research avenue could be the investigation of further use cases from practice, as this study is limited to the use cases identified in the literature. It would be conceivable to enrich the data further, e.g. with practical cases from firms that offer SSS. A possible investigation of the differences between B2B and B2C value characteristics could be conducted, as these are not distinguished in this work. The third research avenue could be the integration of the resource perspective into the tool, which is particularly beneficial for the discussion of values. The literature reviewed should therefore examine the value contributors, enrich the continuum with the respective resources of the value perspectives and examine the actors for this purpose. Finally, a fourth research avenue should be to investigate the measurability of value within e.g. innovation processes towards SSS. This would also help practitioners to sharpen their perception of their existing SSS and to measure the success of the accompanying transformation processes.

6. Conclusion

The research on SSS has so far mainly focused on their general conceptualisation (Beverungen et al. 2017; Beverungen et al. 2019b; Maglio and Lim 2016; Shih et al. 2016). To our knowledge, little research on SSS has addressed the characterisation of SSS from a value perspective, especially since not only products and services but also digital technologies generate value. Our study enriches the existing theoretical knowledge on SSS, using a value perspective to provide a basis for the further development of the "smart service system as a theoretical lens through which digital VCC by service consumers and service providers can be understood, analysed, and designed" (Beverungen et al. 2019b, p. 8). The study thus adds to the body of knowledge on SSS in the context of servitisation and digitalisation.

However, in academia, SSS are not sufficiently characterised from a holistic value perspective. Therefore, we could not characterise our identified use cases with the existing conceptualisations of SSS when considering them from a value perspective. A value perspective for SSS is necessary to further develop an understanding of them, as "the creation of value is the core purpose and central process of economic exchange" (Vargo et al. 2008, p. 145). The study provides a comprehensive overview of SSS value, characterised by product value, services value, and contextual value based on digital technologies. Digital technologies open up a new sphere that enables contextual value and characterises the "smart" value of SSS. This value is equal to the product and services value, as evident from the value characterisations of this study. The SSS value can be prioritised differently depending on the actors involved. The study contributes to further scientific understanding of SSS and underpins the existing knowledge. As there is already a general conceptualisation of SSS, researchers have the opportunity to use the results of this study to further deepen the understanding of SSS from a value perspective.

Finally, this paper develops a value continuum for SSS. Since existing characterisations of SSS mainly distinguish between product- and service-related values, we have additionally focused on value in the digital context. The result is a value continuum of SSS which stresses the call "to develop a more dynamic framework" for smart value in SSS (Henkens et al. 2022, p. 17). This continuum is intended to stimulate scholars to conduct further research on the different spheres of value and participation in these spheres of value.

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Appendix

List of use cases

#	Reference	Sector	Use Case
1	Ahram et al. (2012)	Logistic	RFID tracking
2	Ahram et al. (2012)	Airport	Ticketing kiosks
3	Beverungen et al. (2019b)	House-keeping	Smart washing machine
4	Beverungen et al. (2019b)	Mobility	Smart cars / smart planes
5	Beverungen et al. (2019b)	Manufac-turing	Steel mills
6	Beverungen et al. (2019b)	Energy	Energy grid infrastructure
7	Beverungen et al. (2019b)	Mobility	Smart cars
8	Beverungen et al. (2019b)	Manufac-turing	Production technolgy
9	Beverungen et al. (2019b)	Manufac-turing	Smart factory
10	Boldosova (2020)	Mobility	Fleet management
11	Boldosova (2020)	Other	Printing
12	Brown (2017)	Insurance	Car insurance
13	Brown (2017)	Health-care	Clinical longitudinal trials
14	Gimpel (2020)	Manufac-turing	Production technology
15	Gimpel (2020)	Manufac-turing	Asset tracking
16	Gimpel (2020)	Health-care	Patient monitoring
17	Gimpel (2020)	Safety	Weareables
18	Gimpel (2020)	Entertain-mnet	Weareables
19	Gimpel (2020)	Manufac-turing	Predictive maintenance
20	Gimpel (2020)	Manufac-turing	Fleet management
21	Gimpel (2020)	Insurance	Car insurance
22	Olivotti et al. (2019)	Manufac-turing	Digital twin
23	Reiter et al. (2019)	Mobility	E-call
24	Rasouli (2020)	Health-care	Networked clinical analy-sis processes
25	Saarikko et al. (2017)	House-keeping	Smart washing machine
26	Schönig et al. (2018)	Manufac-turing	Wearables
27	Sorescu (2017)	Logistics	Delivery service
28	Stopka (2020)	Mobility	Mobility as a service
29	Wiesböck & Hess (2020)	Mobility	Smart car
30	Zancul (2016)	Manufac-turing	Production technology
31	Zhang et al. (2016)	Logistic	RFID tracking

List of terminology

Concept	Definition
Servitisation	Describes an organisational transformation in which product-oriented firms expand their existing business model to include service offerings, e.g. from the pure sale of a robot to the additional offering of cyclical repair and maintenance of the robot.
Productisa-tion	Describes an organisational transformation in which service-oriented firms add products to their existing business model, e.g. from the pure service of passenger transport without owning a vehicle to offering the transport service including vehicle ownership.
Digitalisa-tion	Describes a socio-technical process of applying digital technologies to broader social and institutional contexts to transform traditional business models, processes, and practices into digital ones e.g. send an email instead of a text message by postcard.
Embodi-ment	Describes the process of adding human attributes to purely digital technologies to make them more accessible to the user, e.g. a chatbot that has an avatar for visualisation in addition to its text output.
Materialisa-tion	Describes the process of adding tangible product offerings to digital technologies, e.g. amazon music speaker, where physical speakers such as amazon echo are added to a digital platform offering.
Digital tech-nology	Includes a number of related technology trends such as IoT, Big Data, I4.0 and data analytics based on the internet, which are transforming operations management in a wide range of areas and industries.
Smart ser-vice	They are digitally-enabled services that generate added value from data through continuous data collection and analysis, integrate physical and digital competences into a complex socio-technical service system, and represent the application of specialised competences through actions, processes and services.
Smart prod-uct	Smart products emerge as autonomous products that are designed to self-organise into different environments throughout their lifecycle, use contextual information about themselves and the environment in which they operate, and collaborate with other products.

PSS / PS-bundle	PSSs are a market expression resulting from the trends of servitisation and productisation and are characterised by bundled products and services.
SSS	They emerge from the impact of digital technologies on PSS and are characterised by connectivity, data collection for contextual awareness, value co-creation and constant, routine interaction. The central element is the use of data to facilitate value co-creation. Synonyms for SSS are e.g. smart product-service systems, data-driven service systems or IoT-driven service systems.

Keywords: Servitization, Digitalisation, Smart Service Systems, Value Co-Creation

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