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Creating value in servitization through digital service innovations

Highlights

- Servitization investigated using digital service innovations (DSIs)
- Experts in 20 manufacturers interviewed to provide a comprehensive study
- Nine DSIs identified from incremental to radical modes
- A new service innovation framework developed based on innovation mode and impact
- DSIs mainly have business enabling or service enablement manufacturer roles

Abstract

Servitization increasingly requires the use of digital technologies such as the Internet of Things (IoT), cloud computing, and predictive analytics. This paper investigates digital service innovations (DSIs) that use these technologies. Using a service innovation lens, it is distinguished from most prior servitization research through specifying DSIs from incremental to radical modes, rather than measuring service innovation on self-reported scales. Data were collected using expert interviews and secondary sources from 20 manufacturers from four sectors. Using changes from baseline service offerings, the study identified nine DSIs with varying degrees of innovativeness. The paper develops a framework within which each DSI can be placed, with two axes representing innovation mode (incremental, intermediate, radical) and impact of innovation (customer, manufacturer, hybrid). This latter dimension addresses concerns about the lack of focus on customer value in prior service innovation research. The study also develops a new typology of DSI groupings (Business enabler, Service enhancement, Digital service offering) demonstrating that DSIs have mainly enabling or service enhancing roles for manufacturers rather than one that is predominantly designed to create digital service offerings. The exceptions are 'predictive maintenance' and 'process improvement', which are radical/intermediate DSIs respectively and provide strong value for both manufacturers and customers.

Keywords

Digital service innovation; Digital Servitization, Incremental, Radical, Service innovation, Servitization

1. Introduction

Servitization involves product-focused companies (manufacturers) adding ancillary service offerings to their product offerings or transforming the product offerings into service offerings to deliver more value to the customer (Baines and Lightfoot, 2013). As part of this process, manufacturers are increasingly utilizing digital technologies in the delivery of their service offerings (Martín-Peña et al., 2019). For example, lift manufacturer Otis has developed an Internet-of-Things (IoT) service platform, whereby it collects real-time performance data, aggregates, and analyzes it to prevent lift failures. Similarly, GE Power uses IoT technologies to provide real-time monitoring of its power plants to support preventative maintenance activities. This has been termed 'digital servitization', which can be conceptualized as the development of new services and/or the improvement of existing ones using digital technologies (Pashou et al., 2020). These new or improved service offerings include the application of technologies such as the IoT, cloud computing, and predictive analytics (Ardolino et al., 2018). However, it is the combination of these technologies, rather than the use of specific ones, which often enables value creation (Gebauer et al., 2021).

In this paper, we are interested in exploring the spectrum of 'digital service innovations' or DSIs (Kolagar et al., 2022; Sjödin et al., 2020a; Soto Setzke et al., 2021); that is, innovations in manufacturers' service offerings from using digital technologies that create value for manufacturers and their customers. For manufacturers, the benefits of DSIs include revenue enhancement (Gebauer et al., 2020) and improving existing offerings (Grubic, 2018), while for customers they include having information about the operational performance of their equipment (Ross et al., 2019) and making improvements to this performance (Allmendinger and Lombreglia, 2005). In this paper, we use a service innovation lens, which appears appropriate given that digital technologies are often a driver of service innovation (Toivonen and Tuominen, 2009), and manufacturers' digital service offerings require highly innovative management processes (Lerch and Gotsch, 2015). Although DSIs have been largely overlooked by the mainstream service innovation literature, they provide important benefits to manufacturers and thus, should be included in this research stream (Opazo-Basáez et al., 2021). By identifying DSIs in this study, we seek to develop a better understanding of service innovation in a servitization context.

The paper addresses three main gaps in the extant literature. First, while several recent studies have identified digital servitization archetypal pathways (e.g., Coreynen et al., 2017; Hsuan et al., 2021) and business models (e.g., Gebauer et al., 2020; Paiola and Gebauer, 2020), there has been no attempt to develop such a typology of DSIs or groupings of DSIs. While archetypal pathways and business models may signal strategic intent, they do not necessarily provide a perspective on the range of DSIs that a manufacturer may develop, despite DSIs being important aspects of many manufacturers' servitization efforts. Second, while existing studies often show a progression of value with outcome-based offerings at the pinnacle (e.g., 'value servitization' - Coreynen et al., 2017), it is unclear whether these are typical of the DSIs most manufacturers develop. In the same way that advanced services (Baines and Light, 2013; 2014) garner most research attention, yet non-advanced services appear most prevalent (Raddats et al., 2019), not all DSIs are focused on this vanguard and uncovering the value from a range of DSIs will provide great utility for theory building and practice. Third, some prior studies in this field (e.g., Johansson et al. 2019) investigate service innovation using self-reported Likert scales based on the degree of change from existing offerings (incremental to radical), whereby minor changes to the service's characteristics are categorized as incremental, while major changes with a new set of characteristics are categorized as radical (Gallouj and Weinstein, 1997). However, such work does not attempt to explore what the innovations are. For example, Johansson et al. (2019) find that radical innovations have a greater impact on manufacturers' performance than incremental ones, yet it remains unexplored what these radical innovations are. Indeed, what radical innovations are in a servitization context is a moot point, with most new offerings incremental to prior ones. For example, even the seminal example of Rolls-Royce's 'power-by-the-hour' is arguably not a radical service innovation since it provides engine availability as a managed service, so incrementally builds on several other services and technologies (Smith, 2013). Equally, an incremental innovation for a manufacturer may be perceived as radical by the customer or vice versa, so innovativeness is a relative concept. Therefore, only measuring innovation in terms of changes to a service offering's characteristics does not fully capture its value for the manufacturer or customer.

This paper aims to investigate DSIs as part of manufacturers' servitization efforts. We identify two research questions (RQs) for the study: 1) Which DSI groupings do manufacturers develop? 2) How do DSIs create value for manufacturers and their customers? The paper answers the call from Pashou et al. (2020) for further research about this topic that includes a wide range of manufacturers and sectors (20 manufacturers in four sectors in this study). The paper makes three main contributions aligned to the identified gaps in the literature. First, it develops a new framework based on innovativeness (incremental through to radical) and impact (manufacturer and/or customer) that locates the DSIs identified in this study, addressing concerns about the lack of attention to customer value in prior work. Second, the paper explains how value is created by DSIs for manufacturers and customers by combining DSIs to create different groupings; 'Business enabler', 'Service enhancement', 'Digital service offerings'. While digital service offerings are (potentially) chargeable offerings, the former two are likely to be most important to many manufacturers, thus challenging the linear progression of value, with digital service offerings often not manufacturers' main focus. Third, it specifies DSIs based on their innovativeness compared to baseline service offerings, including radical ones (e.g., predictive maintenance as a digital service offering), addressing the lack of specification in prior work about what radical service innovations are. To be digital service offerings, DSIs need to not only be innovative but also provide significant value for both manufacturers (e.g., a new revenue stream) and customers (e.g., improve an operational process).

The paper continues with a literature review, which addresses DSIs and service innovation more generally in manufacturers (section 2). This is followed by the methodology (section 3), findings and research propositions (RPs) (section 4), and discussion (section 5), which sets out the paper's theoretical contributions, managerial implications, and limitations/future research areas.

2. Literature review

2.1. Digital Service Innovations

The application of digital technologies in a servitization context has received a lot of recent attention in the literature. Several papers focus on how digital technologies can help to develop innovative services and new digital business models (DBMs), which are required to capture value (Hsuan et al., 2021; Kohtamäki et al., 2019). Although digital technologies have been around a long time, with recent improvements in computing power and the widespread availability of cloud computing, large complex data sets (often termed 'big data') can be converted into valuable information to enhance competitive advantage (Opresnik and Taisch, 2015). Moreover, information or knowledge is a key component of DSIs alongside products and services (Ardolino et al., 2018; Cenamor et al., 2017), setting them apart from earlier technology adoption in terms of innovativeness.

In terms of developing innovative services, remote monitoring is a key enabler of digital transformation (Kamalaldin et al., 2020; Naik et al., 2020). It is a way to assess the effectiveness and efficiency of the service delivery (Baines and Lightfoot, 2014; Grubic, 2018; Oliva and Kallenberg, 2003). Rymaszewska et al. (2017) see IoT technologies providing manufacturers with the opportunity to advise customers on a variety of product-related matters, such as how products are currently used and solutions for better utilization. The ability to remotely monitor equipment leads to so-called 'smart' services, developed through networking and the management of connected devices (Allmendinger and Lombreglia, 2005; Porter and Heppelmann, 2014; Porter and Heppelmann, 2015; Ulaga and Reinartz, 2011). In particular, Porter and Heppelmann (2014) highlight cumulative innovation from 1) the remote monitoring of a product's condition and operation, 2) the remote control of product functionality to align to user requirements, 3) the optimization of product operations using predictive analytics, and 4) autonomy in product operations, which combines monitoring, control, and optimization and requires little human intervention. Meanwhile, Lerch and Gotsch (2015) define offerings created by remote monitoring as 'IT-based services' and conceptualize more advanced digital service offerings, namely 'pure digital services' (e.g., virtual or augmented reality) and 'digitalized product-service systems' (PSS) (e.g., availability offerings). These digitalized PSS were also conceptualized by Coreynen et al. (2017) as a 'value' servitization pathway, situated at the radical end of the innovation spectrum, with 'industrial' and 'commercial' as more incrementation servitization pathways.

DBM innovation requires high levels of strategic agility and new ways of working (Tronvoll et al., 2020). Thus, DBM innovation can facilitate the provision of advanced service offerings (e.g., availability- or outcome-based) (Ehret and Wirtz, 2017; Sjödin et al., 2020b). For example, in a longitudinal case study, Chen et al. (2021a) investigate a firm offering remote monitoring and servicing using artificial intelligence (AI), underpinned by IoT technologies. Equally, IoT technologies enable manufacturers to extend monitoring and control activities over customers' products from other vendors and operating processes, rather than just their products (Paiola and Gebauer, 2020). In this regard, a digital platform approach has received recent attention in terms of developing innovative service offerings (Eloranta et al. 2021). Innovation mechanisms are used to develop digital platform archetypes, from product platform (basic monitoring) and supply chain platform (advanced data analytics) to platform ecosystem (AI-driven data analytics and open interfaces to diverse partners) (Jovanovic et al., 2021). The authors see the latter approach as the most innovative using a 'recombination mechanism' to explain how micro-services are (re)combined to form novel solutions. DBM performance has started to receive some attention in the literature, with some authors proposing a 'digital paradox', whereby investments in digital technologies do not lead to expected financial returns (Gebauer et al., 2020; Kohtamäki et al., 2020). While the study of this paradox is at an early stage, to help overcome it manufacturers are recommended to ensure that DBMs address true customer needs, align with internal strategies, and maintain a balance between risk and reward (Linde et al., 2021).

In order to assess innovativeness, it is necessary to consider how DSIs align with manufacturers' existing service offerings. Prior work has tended to not relate DSIs to particular offerings, so, for example, Favoretto et al. (2022) compare traditional PSS versus digitally-enabled PSS without considering the specific offerings nor the changes from the former to the latter which make them innovative. However, given that service innovation is often conceived as the degree of change from what existed before (Snyder et al., 2016), understanding the baseline service offering seems imperative to assess innovativeness. Two of the most extensive categorizations of service offerings are by Baines and Lightfoot (2013) and Partanen et al. (2017). Baines and Lightfoot (2013) set out the service categories 'base', 'intermediate' and 'advanced', with an increasing value from base through to advanced offerings. *Base services* include equipment delivery, spare parts provision, and warranty; *intermediate services* incorporate installation, maintenance, technical helpdesk, and condition monitoring; *advanced services* encompass risk and reward sharing contracts, revenue-through-use contracts, and rental agreements (Baines and Lightfoot, 2013). Partanen et al. (2017) identified five dimensions of manufacturers' services: *pre-sales* (e.g., product demonstrations and customer seminars), *product-support* (e.g., warranty, customer consulting, and telephone support); *product lifecycle* (e.g., installation, maintenance, and spare parts); *R&D* (e.g., prototype design and feasibility studies); *operational* (e.g., product operations, process operations). While there is not a like-for-like match between the typologies, there are close links between the operational dimension and advanced services.

DSIs from the literature have been identified across multiple service categories and dimensions and are shown in Table 1. The table also shows the 'baseline' service offering; that is, the starting point that the DSI changes.

Baseline service offering (dimension)*	Digital service innovation	Indicative paper
Customer consulting and support by phone (Product support)	Advise customers on how products are performing and solutions for better utilization	Rymaszewska et al. (2017)
Maintenance (Product lifecycle)	Remote monitoring to create more proactive maintenance	Grubic (2018)
Prototype design and development (R&D)	Software-based simulations, virtual or augmented reality applications, and digital technical analyses	Lerch and Gotsch (2015)
Service for operating the product sold to the customer (Operational)	Optimization of product operations using predictive maintenance	Porter and Heppelmann (2014)
Service for operating the product (Operational)	Facilitate outcome-based services	Sjödin et al. (2020b)
Service for operating the customer's processes (Operational)	Monitoring and control activities over customers' products and operating processes	Paiola and Gebauer (2020)

* Partanen et al. (2017)

Table 1: DSIs aligned to service offerings

Considering Table 1, DSIs are mainly relevant to the operational dimension (advanced services). This supports the progression of value (base – intermediate – advanced service offerings) found in much servitization work, including that which focuses on digital servitization pathways (Coreynen et al., 2017). Despite this prior work, it seems appropriate to consider whether this established progression of value with advanced services at the pinnacle is appropriate for DSIs or whether other approaches are required.

2.2. Service innovation in manufacturers

This paper uses a service innovation lens that builds on Schumpeter (1934) who proposes that economic development is driven by innovation. Schumpeter theorized that innovation progresses through three stages: invention (the first demonstration of an idea), innovation (the first commercial application of an invention in the market), and diffusion (the flow of the innovation throughout the market). Focusing on the second stage of Schumpeter's (1934) theory, service innovation has been defined as the development of a new service offering or the renewal of an existing one (Toivonen and Tuominen, 2009). The process of developing a new service offering is termed new service development (NSD) in which the outcome is service innovation (Witell et al., 2016); and in this paper, we class DSIs as outcomes. Snyder et al. (2016), through a systematic literature review, identify four main categories of service innovation that are based on: degree of change (e.g., radical or incremental), newness (e.g., to the market or the firm), type of change (e.g., service or process) and means of provision (e.g., technology or organization). There is a strong correlation between the degree of change and newness, so a radical service innovation is new to the market while an incremental service innovation is new to the firm (Snyder et al., 2016). Degree of change (radical and incremental) is the most common categorization (Ordanini & Parasuraman, 2011), with Ostrom et al. (2010) noting the need for more research on the processes that lead to radical and incremental innovations.

Digital technologies have been closely linked to service innovation (Toivonen and Tuominen, 2009). For example, Lusch and Nambisan (2015) note that these technologies have led to greater value co-creation with customers. Thus, service innovation through digital technologies has not just a technical dimension (i.e., innovativeness related to technical complexity) but also a customer dimension (i.e., innovativeness related to what customers do with technology-enabled services). Other work considers the strategic roles of IoT technology, which can be aligned to innovativeness; that is, *smoothing* (i.e., a service offering enabler), *adaption* (i.e, a provider of additional value for the service offering), and *innovation* (i.e., the main value driver of the service offering) roles (Gerpott and May, 2016). Treating digital technologies holistically (rather than considering individual technologies such as the IoT) allowed Chen et al. (2021b) to propose that IT exploration (i.e., exploring new IT resources) facilitates both radical and incremental service innovation while IT exploitation (i.e., exploiting existing IT resources) improves radical service innovation. We concur with Chen et al. (2021b) in the utility of treating digital technologies holistically and their application can lead to different levels of innovativeness in service offerings. So, it is not necessarily the complexity of the technology that drives innovativeness but its application in the customer environment as part of value co-creation.

Despite the widely used radical versus incremental dichotomy, service innovation can be viewed as a spectrum, with varying degrees of innovativeness, with incremental and radical modes at extreme ends and less extreme modes in between (Story et al., 2014). In addition to the 'degree of change/newness' category, some service innovation research has included the customer dimension. For something to be innovative, it should be new to both the supplier *and* other actors, including customers (Ordanini et al. 2014; Story et al. 2011; Witell et al., 2016). Thus, an innovation changes the way customers co-create value with the firm (Michel et al., 2008), and innovativeness is the extent to which a new or enhanced service offers meaningful benefits to customers (Heirati and Siahtiri, 2019). Despite some exceptions, Snyder et al. (2016) note that considering customer value as part of service innovation has been poorly addressed by the literature.

Turning to service innovation research in a servitization context, the literature predominantly uses the 'degree of change/newness' categories (9/11 papers). Equally, most research identifies some aspect of customer value as an important part of service innovation (see Table 2).

Paper	Service innovation category *	Customer value perspective	Method
Chen et al. (2021b)	Degree of change (Radical/Incremental)	Service innovation creates value for customers	Survey (n = 121)
Eggert et al. (2015)	Newness (Introduction of new service innovation)	Focusing on a few key customers with service innovations enables close relationships	Survey (n = 348)
Ettlie and Rosenthal (2012)	Newness (An offering that is new or significantly improved over existing offerings)	New services are co-produced with customers and are hard to standardize	Case studies (n = 9)
Gremyr et al. (2014)	Degree of change (Different service innovation modes)	Recombinative innovations address customers' role Ad-hoc innovations solve customers' immediate problems	Case studies (n = 3)
Johansson et al. (2019)	Degree of change (Radical/Incremental)	Customer knowledge development is important for service innovation	Survey (n = 239)
Kindström et al. (2013)	No service innovation categories identified	Well-established service delivery organization helps seize service innovation opportunities and create customer value.	Case studies (n = 8)
Kowalkowski et al. (2012)	Degree of change (Incremental, Ad-hoc)	Service innovations are often customer-driven	Case study (n = 1)
Markovic et al. (2020)	Newness (New or significantly improved services introduced)	None mentioned	Survey (n = 16,062)
Santamarìa et al. (2012)	Newness (New services introduced/Existing services improved)	Service innovation leads to closer customer links	Secondary data (n = 12,334)
Sjödin et al. (2019)	No service innovation categories identified	Service innovation leads to higher customer value	Survey (n = 50)
Schaarschmidt et al. (2018)	Newness (A firm's innovativeness)	Customer interaction is beneficial for service innovation	Survey (n = 146)

* Snyder et al. (2016)

Table 2: Service innovation as part of servitization research

Most prior research in this field uses surveys or secondary data to assess the degree of change/newness and does not set out to identify specific service innovations. Of those that use a case study approach to explore service innovations, Kowalkowski et al. (2012) demonstrate how service innovation in manufacturers centers on making incremental changes to existing offerings. Gremyr et al. (2014) use Gallouj and Weinstein's (1997) six service innovation modes (radical, improvement, incremental, ad-hoc, recombinative, and formalization) to discuss three service innovation trajectories, with a single innovation mode insufficient for the presented case companies. Ettlie and Rosenthal (2012) identify two organizational strategies to develop service innovations; an engineering culture brings about innovations new to the firm (incremental) while an entrepreneurial culture is for innovations that are new to the industry (radical). Thus, there is little research in a servitization context seeking to develop an understanding of specific service innovations, in particular, radical service innovations. Moreover, customer value has been incorporated heterogeneously into existing DSI research, which predominantly considers the degree of change/newness category of service innovation.

3. Methodology

3.1. Research method and case selection

As this is a rather complex and underexplored topic, a qualitative multiple-case study approach was adopted (Beverland and Lindgreen, 2010; Miles and Huberman, 1994). Such an approach is appropriate to address a general lack of understanding of a phenomenon and to conduct exploratory research (Yin, 2014). The study followed Seawright and Gerring's (2008) case selection objectives for exploratory multiple-case research, with the need to ensure that the resultant theory is generalizable to other contexts (Eisenhardt, 1989). To ensure reliability (Yin, 2014), we adopted a 'stratified' purposive sampling approach for case selection (Bryman, 2008) to discover DSIs across a range of servitizing manufacturers. This facilitated the identification of cases containing relevant information on the focal topic (Kemper et al., 2003). Our case selection focused on identifying: (a) manufacturers that (b) offer DSIs (c) to industrial customers. Criterion (b) is motivated by the particular nature of the first research question (i.e., Which DSI groupings do manufacturers develop?). Criteria (a) and (c) come from investigating manufacturers of varying sizes (Baines and Lightfoot, 2014; Rymaszewska et al., 2017), providing an opportunity for our findings to relate to wider research and practice. Within this scope, we sought to select companies from different sectors to ensure the representation of a wide range of industries currently developing DSIs (Mastrogiacomo et al., 2019). In addition, documentation such as websites, brochures, news articles, and videos enabled us to further shortlist the suitable cases.

To gather interest in participation and verify eligibility, we approached senior executives through emails and/or phone calls, with 30 manufacturers considered suitable for the study. Out of the initial pool, 23 responded to our initial contact, from which 20 agreed to participate in this study at a senior executive level. Table 3 provides an overview of the 20 anonymized cases, their industry, main products, size, and the interviewee who agreed to take part. We collected data from four main industries that had between three and seven companies within each. Equally, the range of manufacturers in the study was wide, with two micros, five small and–medium-sized enterprises (SMEs), and 13 large ones. Here, the unit of analysis, in line with the research questions, is the DSIs developed by these manufacturers.

Industry	Case	Main products	Size (global turnover in £K/£M/£B)	Interviewee
IT and telecommunications	Foxtrot	Commercial printed materials	SME (500K)	Managing Director
	Yankee	Printing machinery	Large business (2.6B)	Business Specialist, Logistics
	Zeta	Printing and optical machinery	Large business (7B)	Head of Field Services
	Theta	Printing machinery	Large business (7B)	Director of Technical Services
	Victor	Industrial IT equipment	Large business (28B)	Head of Delivery, Strategy & Service Improvement
	Oscar	Communication systems	SME (10M)	Director of Operations
Machinery and process equipment	Golf	Heat exchangers	Large business (550M)	Director of Digital Solutions and Services
	Alpha	Domestic heating equipment	Large business (300M)	Vice President, Innovation
	Echo	Cereal milling machines	Micro business (200K)	Managing Director
	Zulu	Heavy construction machinery	Large business (41.4B)	Vice President of Marketing
	Hotel	Industrial transit packaging	SME (10M)	Manager of Business Development
	Charlie	Medical equipment	Large business (2.3B)	Director of Connected Solutions
	Gamma	Air filtration machinery	Large business (500M)	VP Innovation
Automation	Sierra	Plant automation equipment	Large business (4,3B)	National Service Manager
	Delta	Packaging automation machinery	Large business (1B)	General Manager of Advanced Services

	Lima	Ventilation automation equipment	SME (90M)	Managing Director
	Beta	Industrial press automation	Micro business (500K)	Director of Operations
Industrial surface treatment and sanitation	Kilo	Surface treatment equipment	SME (2M)	Managing Director
	Mike	Industrial surface cleaning machinery	Large business (1B)	VP Global Services
	Lambda	Powder processing equipment	Large business (105M)	Managing Director

Table 3 – Manufacturers in the study

3.2. Data collection

We used interviews to collect data about which DSIs were being developed and their value. The interviewees were selected based on their knowledge and exposure to the DSIs inside the case organizations. Therefore, data collection took place using expert interviews (Bogner and Menz, 2009), where experts are defined as individuals that stand out for their knowledge, designation, education, practice, or experience on a particularly complex topic (Meuser and Nagel, 2009; Littig, 2009). This approach to interviewee selection is commonly used in servitization research (e.g., Matthyssens and Vandenbempt, 2008; Naik et al., 2020). As a result, the interviewees were senior executives and middle managers that could present rich insights into how servitization is driven by different innovations.

We developed a semi-structured interview guide (see Appendix A) to steer the interviews and encourage the interviewees to focus on describing different innovations that enabled their organizations' servitization initiatives. For example, the guide included questions about manufacturers' service offerings, experiences with the development and delivery of those offerings, and the digital technologies that are particularly key for them. These questions were adapted to reflect the context of the case organizations and the interviewees' expertise around DSIs. The interviews lasted between 45–60 minutes each and were audio-recorded, transcribed, and then shared with respondents to sense check and ensure that their views were correctly represented. Interview data was complemented by secondary data, which included the researchers' interview notes and additional documentary material (provided or separately sourced), such as web pages, brochures, news articles, and videos. This data was used to supplement the interviews, with additional details on the service offerings, thus expanding the scope and depth of data available for analysis. In summary, Creswell and Miller's (2000) measures of validity were adopted for this study, which concern the credibility of the inferences drawn from the data. Processes such as peer review, triangulation through secondary data, and reflection of the interpretations were followed to ensure the credibility of the inferences presented (Creswell and Miller, 2000; Hirschman, 1986).

3.3. Data analysis

All of the researchers involved in data collection also participated in parallel data analysis and triangulation (Bryman, 2008). The respondents were re-contacted to discuss preliminary results, and any gaps in the information and incongruence were specifically discussed. The interviews and secondary data were analyzed to find descriptions of digital innovations, in line with the research questions. A total of 74 different descriptions of digital innovations were found across the 20 cases. Final categories were reached when the analysis by the researchers brought forward no new descriptions; that is, theoretical saturation was reached (Bryman, 2008).

To further categorize these descriptions, the data was analyzed using a three-order coding method (Corley and Gioia, 2004) where these descriptions were compared to identify similarities and differences. This process yielded 25 first-order categories, each of which was assigned a label in the form of a phrase or sentence, retaining the terminology used by the experts where possible. These categories were essentially different innovation characteristics found in the services offered by the manufacturers. In the next step, we further examined these characteristics to identify common overarching DSIs that possess these characteristics. This step resulted in nine second-order categories: 3D printing, AI applications, customer app/web portal, logistics management, performance advisory, predictive maintenance, performance advisory and remote maintenance, remote monitoring.

Following this, we analyzed the identified DSIs based on their degree of innovativeness (e.g., radical or incremental). This analysis was conducted by the research team as innovativeness is a relative concept and it would not be possible to reach a consensus with the interviewees about the degree of innovativeness of each DSI. Our approach was guided by Gallouj and Weinstein (1997), whereby minor changes to the service's characteristics are categorized as incremental, while major changes with a new set of characteristics are categorized as radical. We also categorized some DSIs in an intermediate position, between incremental and radical. Such a judgment requires a common set of baseline service offerings that the innovations can be compared against, so we used that by Partanen et al. (2017) (see Table 1). We set out this categorization in Table 4, which includes an explanation for the proposed innovation level of the DSI. Interestingly, for DSIs classed as radical, there was clear evidence of the case companies partnering with (or even acquiring) specialized technology companies to develop these new service characteristics. The innovation level, thus, formed the third-order coding, with this three-tier data structure presented in Figure 1.

Innovation level (DSI)	**Service offering ***	**Explanation**
Incremental		
Remote maintenance	Maintenance	Maintenance can be provided remotely online by helpdesk service engineers and enhanced onsite provision.
Logistics management	Spare parts	Using digital technologies to improve the efficiency of spare parts management.
Customer app/web portal	Customer consulting and support by phone	Digitalizing access to information and logging requests to enhance phone-based support.
Intermediate		
Process improvement	Service for operating customer's process	Support other aspects that might affect the customer's process performance, such as other manufacturers' products and consumables.
Remote monitoring	Customer consulting and support by phone	Significantly enhanced 'visibility' that helpdesk service engineers have of a customer's equipment.
Performance advisory	Customer consulting and support by phone	Provides a major enhancement on the type of consultancy provided to customers but the formats and channels to provide these could be the same.
Radical		
Predictive maintenance	Maintenance	Use algorithms to predict equipment failures by identifying casual symptoms to reduce the number of product failures.
AI applications	Service for operating product sold to the customer	Use AI technologies to help customers manage the document workflow and improve other aspects of their operations.
3D printing	Repair service	Printing failed parts for fast-track replacement.

***** Partanen et al. (2017)

Table 4: Categorizing the innovation level of DSIs

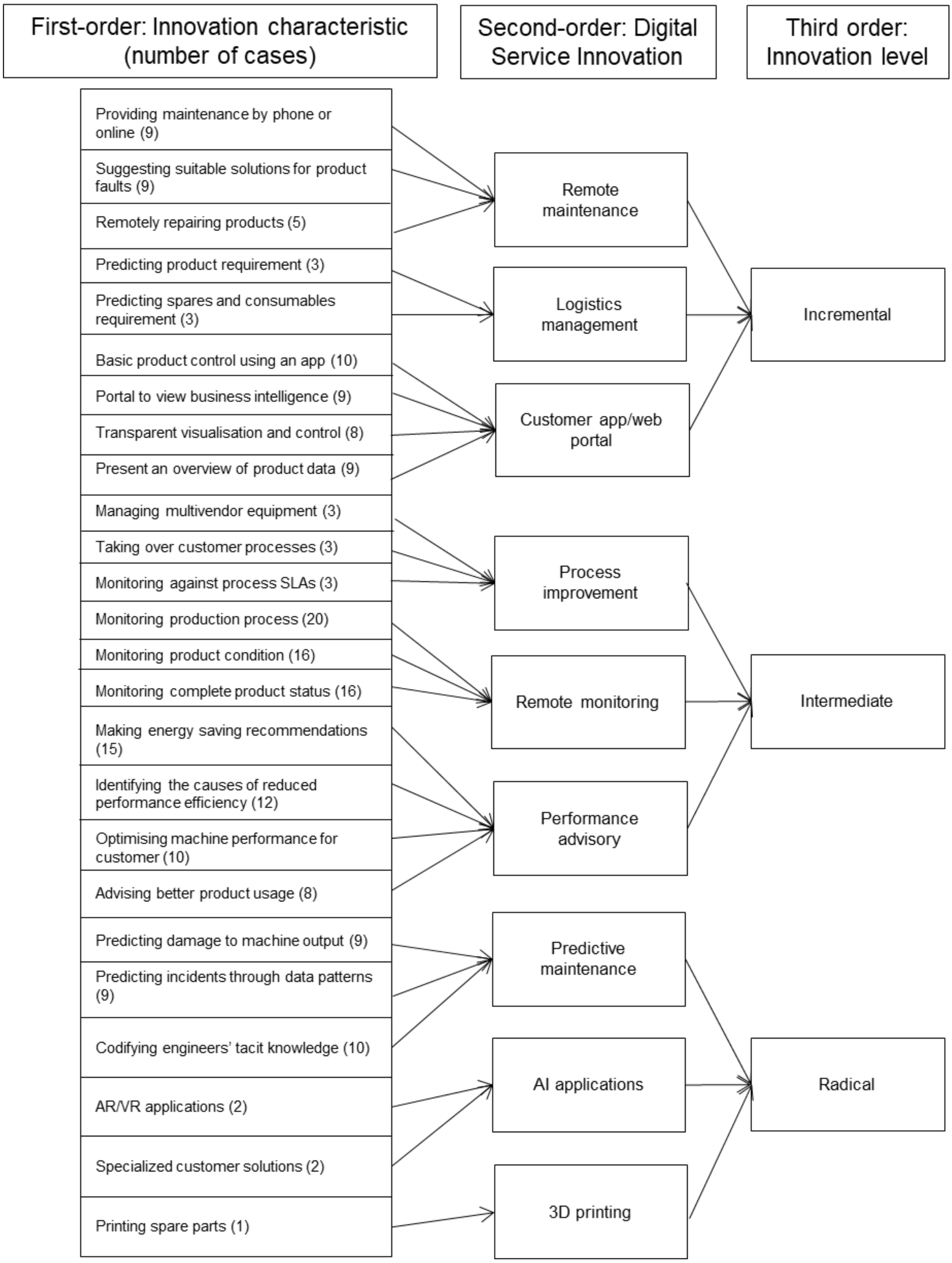

Figure 1: Three-tier data structure

4. Findings

4.1. Which DSI groupings do manufacturers develop?

This section addressed RQ1 and presents the DSIs according to innovation level (4.1.1 – 4.1.3) and their groupings (4.1.4). The prevalence of each DSI in our sample is shown in Appendix B, while indicative quotations from the interviewees about each one are provided in Appendix C.

4.1.1. Incremental DSIs

Remote maintenance includes advising customers remotely about maintenance issues, suggesting suitable solutions for product faults, remotely repairing products, etc. Several interviewees viewed this DSI as a means to improve existing service offerings rather than develop something completely new. Indeed, there was a view that having a digital component to a service offering meant that customers might expect it to be provided at a lower price, since fault diagnostics and equipment repair can be undertaken by telephone or online with less need for a service engineer to visit a site, so potentially lowering the cost (Lima). The study identified several instances of how manufacturers use remote maintenance to improve fault diagnostics and equipment repair. For example, helpdesk service engineers at Zeta guide customers through the required corrective steps they need to take to fix equipment faults. Customers provide real-time video of the printers via their mobile phones and the service engineers receive data from sensors in the printers, so helping helpdesk service engineers to be able to suggest suitable solutions for fault resolution.

Logistics management concerns using digital technologies to improve the efficiency of managing and transporting products and spare parts. In this case, DSIs are not directly linked to manufacturers' service offerings but are primarily for internal process improvement (Foxtrot). Using digital technologies, a manufacturer can have an accurate picture of where its installed base of equipment is, which can provide it with strong internal benefits, such as not having to fast-track spare parts to customer sites in the event of a part failure (Hotel, Zulu). Thus, it is important to specify the unique contribution of this DSI to internal process improvement and in some cases, this may be the main driver of developing it.

A *customer app/web portal* is used to provide customers with greater information about the status of their products. This could include aspects of product control, viewing business intelligence, transparent visualization, and an overview of product data. The potential benefits for customers to use apps/web portals were recognized by many of the interviewees. For example, Yankee developed a digital interface allowing customers to see real-time data on how their products were performing, together with information about their service contracts and stock levels. Although the Yankee digital interface provides customers with information that the manufacturer already possesses, it has an important impact on customers' businesses by providing them with greater visibility of what is going on with the products and consumables. As such, a customer app/web portal provides critical business intelligence to help customers manage their businesses more effectively. Indeed, greater functionality of the app/web portal can allow customers to control certain operational parameters of the product estate, escalate faults, and order consumables (Delta, Sierra). Manufacturers also benefit from customers using an app/web portal in terms of self-service activities that may reduce the volume of service-desk inquiries (Victor).

4.1.2. Intermediate DSIs

Process improvement concerns deploying solutions to enhance customers' operational processes, rather than just the supplied products (Paiola and Gebauer, 2020). Thus, process improvement may need to include support for products from other manufacturers and consumables and requires a deep understanding of how customers deploy these supplied products in an operational environment. For example, Lambda's primary DSI is a software platform that is designed to help optimize customers' process operations to improve efficiency. By monitoring and analyzing multiple data points in the process against its optimal parameters, process improvement can be delivered. Oscar's primary DSI involves a managed communications service, taking responsibility for an array of products, software, and systems, thereby offering customers process improvement through higher quality services, aligned to service level agreements (SLAs). Equally, Victor developed a 'multi-cloud' go-to-market offering, managing its customers' legacy data systems with public Cloud solutions, enabling Victor's customers to optimize their IT processes. Thus, the solution to deliver process improvement is often an important service offering in its own right.

Our research confirmed that for many manufacturers, *remote monitoring* is foundational (Kamalaldin et al., 2020). It involves identifying fault sources remotely, monitoring product performance, identifying possible failures, monitoring the production process, monitoring product condition, monitoring complete product status, etc. Many interviewees noted its relevance to their businesses (e.g., Kilo). For example, many of Zulu's vehicles have telematics capabilities operating through the IoT, with information on the performance of customers' vehicles provided as part of a 'data wrapper' alongside other services. Remote monitoring allows the captured information to be used for improving product design (Lima), as well as potentially being part of a revenue-generating service (Gamma). However, the interviewee from Delta was rather skeptical about the revenue-generating potential of remote monitoring, remarking on the lack of quantifiable benefits for both his company and customers. Remote monitoring can provide customers with the security of knowing that they can access high levels of support and be alerted to product failures, even if they are reducing their maintenance capability (Delta). This can help field service engineers to be better prepared for customer site visits, carrying the correct spare parts to repair faults quicker to maximize the uptime of the machine (Delta).

Performance advisory includes a range of solutions to help customers improve their business performance; for example, identifying the causes of reduced performance efficiency, optimizing machine performance, advising about better product usage, etc. For example, Alpha helps its customers improve their energy efficiency. Charlie uses the Cloud to store customers' documents, rather than these customers having to store them securely for up to 25 years, either physically or on their servers. Meanwhile, Foxtrot uses third-party proprietary technology to provide a stock management system for public sector clients, helping them to reduce print costs. Improvements in customers' operational performance may also be brought about by a comparison of how similar products are performing in different locations, or how their products are performing compared to those of other customers (Zulu). Thus, the DSI is about helping customers to use products more efficiently, rather than necessarily being about deploying the latest technologies.

4.1.3. Radical DSIs

The importance of *predictive maintenance* has been previously noted (Porter and Heppelmann, 2014) and it enables companies to be able to predict and prevent product breakdowns, rather than just react to them (e.g., Beta, Theta, Zulu). Some companies were in the process of developing this DSI; for example, the Yankee interviewee explained that companies have to be highly innovative to offer predictive maintenance because of the need to capture all the necessary data and build an algorithm, and they were not at this stage yet. Equally, Delta noted that the remote monitoring of customers' products was for reactive purposes, as they did not have the necessary performance data to establish the product failure trends and product reliability parameters required to develop a predictive maintenance algorithm. Golf developed the first predictive maintenance offering in the market in response to its customers losing experienced personnel through retirement who might have been able to predict product failures without an algorithm. Thus, Golf sold predictive maintenance separately from other service offerings and marketed it as a way to maximize equipment uptime, enabling customers to save costs and make money. That said, even radical innovations such as predictive maintenance may be viewed as part of a wider service contract, rather than a separate offering, focused on maintaining the product condition (Mike).

The use of *AI applications* was identified by Chen et al. (2021a) and these are used by Theta to provide value-added printing solutions. For example, Cloud-based applications to intelligently manage print workflow for companies with complicated or specialized requirements such as solicitors. Lambda is using AI to help customers visualize plant design through virtual reality and augmented reality (AR/VR) applications and then supply information about the chosen design to computer-aided design and manufacturing (CAD/CAM) systems. These applications are innovative for the manufacturers, with the focus on improving the customer's propensity to procure and use their products. Finally, a DSI employed in the printing sector is *3D printing*, which can be used to provide parts at short notice (Theta). The DSI enables the company to assess the parts that might break and prevent the customer from printing. These parts may be difficult to source at short notice and can be produced using 3D printing and rapidly fitted as a temporary fix until the original part is available.

Building on section 4.1.1 – 4.1.3, DSIs can be categorized based on their level of innovation from baseline services (see Table 4). While Table 1 shows various DSIs from the literature, these have not been systematically classified according to their innovativeness (incremental to radical). We, therefore, propose:

RP1: DSIs can be classified according to their level of innovativeness depending on the extent of change to their characteristics from a baseline offering.

4.1.4. DSI groupings

Based on the findings in sections 4.1.1 – 4.1.3, our study highlights three archetypal DSI groupings. We concur with Sjödin et al. (2020a), who see DSI development activities as highly iterative occurring in parallel or variable order, so we do not necessarily find that a manufacturer only develops one grouping at a time. This study confirms the foundational role of remote monitoring (Naik et al., 2020; Porter and Heppelmann, 2014); that is, it is used to underpin several other DSIs.

The 'Business enabling' grouping combines remote monitoring and logistics management to provide support for core operations. While improving core operations could ultimately lead to improvements in service offerings, this is an indirect relationship with the focus on internal improvements. The 'Service enhancement' grouping combines remote monitoring with one of several other DSIs (remote maintenance, customer app/web portal, performance advisory, AI applications, or 3D printing) to improve a range of existing service offerings; for example, remote maintenance improves 'maintenance' (Partanen et al., 2017) through helping field service engineers to understand the fault diagnostic reports before arriving on a customer's site to undertake remedial action. The 'Digital service offerings' grouping combines remote monitoring with either process improvement or predictive maintenance. There was some evidence of digital service offerings being created by a more extensive grouping of DSIs. For example, Lambda combines remote monitoring capability with AI applications and process improvement to offer customers process and people optimization. Existing literature has developed different pathways for digital servitization (e.g., Coreynen et al., 2017; Hsuan et al., 2021); however, DSI groupings have not previously been identified in the literature. Hence, we propose:

RP2: DSIs are combined in particular groupings: business enabler, service enhancement, and digital service offering. Different groupings may be undertaken simultaneously in an iterative, non-sequential manner.

4.2. How do DSIs create value for manufacturers and their customers?

In answering RQ2, our analysis shows that the value from DSIs is not equivocal between manufacturers and customers. Thus, table 5 shows the primary impact of each DSI identified in this study based on our analysis of the interview data. In this table, we specify where the *primary* value of each DSI lies, although there may be value creation opportunities for the other party too. So, for example, 3D printing primarily provides value to the manufacturer but also to the customer in the sense that it can help prevent the customer's equipment from breaking down if a critical part fails. However, we contend that the manufacturer would have to replace this part anyway as part of the SLA, be it through 3D printing or maintaining a stockpile of critical spare parts, so the primary impact of 3D printing is on the manufacturer.

DSI (primary impact)	Value derived from the DSI
Remote maintenance (hybrid)	Customer value comes from keeping equipment operational for longer as faults can be fixed without the need for an engineer's site visit. Manufacturer value comes from requiring fewer field service engineers since many remedial activities can be performed remotely.
Logistics management (manufacturer)	Value comes from using data to better plan its logistics through knowledge of which spare parts may be required and where they should be located.
Customer app/web portal (customer)	Value comes from having greater visibility of activities related to the operation of its products, such as fault alarms and spare part levels. Such information can provide confidence that the products are operating efficiently and that the risks of outages due to part shortages are minimized.
Process improvement (hybrid)	Manufacturer value comes from being able to offer customers a more holistic solution beyond its products. Customer value from requiring fewer suppliers to monitor multi-vendor equipment and/or operational processes.
Remote monitoring (manufacturer)	Value comes through providing a high level of product performance and uptime. For advanced services, manufacturers are responsible for achieving the agreed outcomes, be this through remote monitoring or having a team of field engineers maintaining the equipment and fixing faults. The former may provide a more cost-effective and efficient approach to achieving this end.
Performance advisory (customer)	Value comes from receiving expertise to help improve operational processes. This expertise may be lacking in the customer organization, and it is supplied by the manufacturer using its knowledge of how customers use their products in an operational environment.
Predictive maintenance (hybrid)	Manufacturer value comes from the provision of a new service offering that is distinct from existing offerings that creates a new revenue stream. Customer value comes from reducing the risk of critical equipment failures and, thus, maximizing equipment uptime.
AI applications (customer)	Value comes from having an AI system that can help to improve an operational process based on machine learning. AI can be targeted on specific customer requirements to create value.
3D printing (manufacturer)	Value comes from being able to supply critical parts to customers at short notice to achieve SLA targets without needing to keep these parts in a locally-held stock.

Table 5: Primary impact of and value from DSIs

The literature has identified several benefits from DSIs for manufacturers (e.g., Grubic, 2018) and customers (e.g., Allmendinger and Lombreglia, 2005). Our study has aligned these benefits to particular DSIs, allowing the following RPs to be proposed:

RP3: Manufacturer value from DSIs centers on servicing supplied products in a timely and cost-effective manner.

RP4: Customer value from DSIs centers on applications that enhance, or minimize the downtime in, operational processes.

Building on Table 5, we can see that two dimensions are important for conceptualizing DSIs. First, innovativeness, from incremental, through intermediate to radical mode. In section 3.3 we explained the allocation of each DSI to a specific mode. While innovativeness does not necessarily equate to newness, we concur with Snyder et al. (2016) who see a close correlation between the two concepts, with a radical innovation one that is likely to be new to the market. Second, the primary impact of the DSI, depending on whether this is mainly on the manufacturer or customer, with a hybrid position where the impact is equally important for both parties. This dimension draws on literature that considers the value that the customer derives from a service innovation (Heirati and Siahtiri, 2019; Ordanini et al. 2014). Figure 2 brings two dimensions (innovation level, primary impact) together in one framework, within which each DSI can be located.

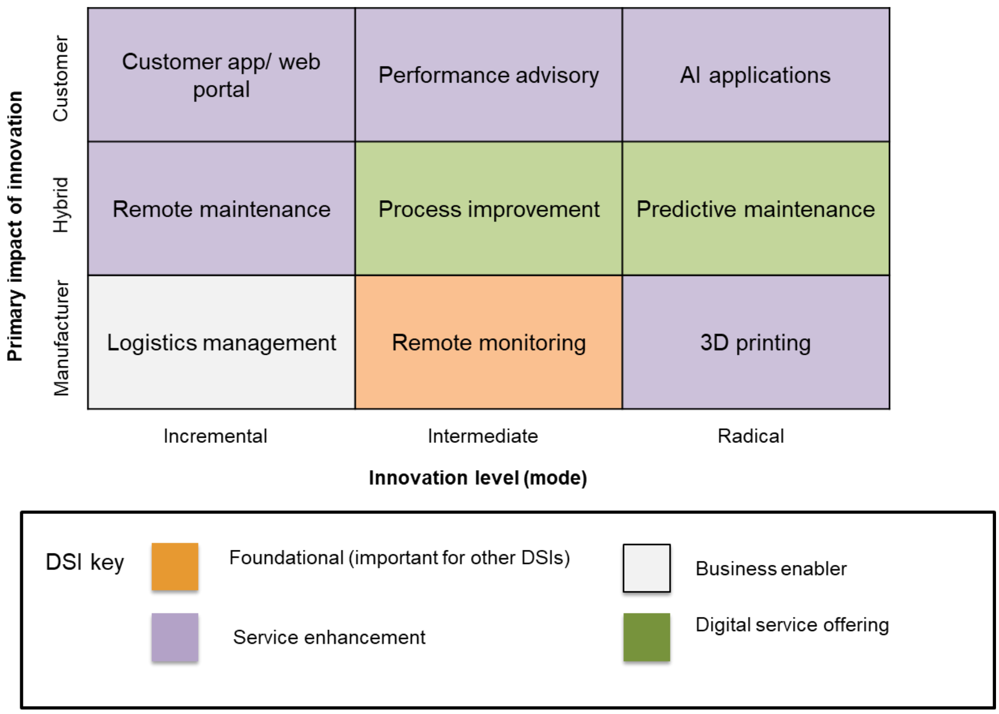

Figure 2 – DSI framework

While much of the literature discusses the revenue potential of digital service offerings (e.g., Gebauer et al., 2020), this study finds that creating a new revenue stream is not the priory of digital servitization for many manufacturers. Equally, the progression of value espoused in much servitization (e.g., Baines and Lightfoot, 2014) and digital servitization (e.g., Coreynen et al., 2017) work is not supported by our study. We, therefore, propose that:

RP5: DSIs have no hierarchy of value, so business enablement, service enhancement, digital service offering groupings can each be the most important for a manufacturer.

5. Discussion

5.1 Theoretical contributions

The paper makes three main contributions. First, while prior research investigated digital servitization archetypal pathways or DBM typologies, this study proposes DSI groupings (business enabler, service enhancement, digital service offering). This typology extends the strategic roles of IoT proposed by Gerpott and May (2016) (i.e., 'smoothing', 'adaption' and 'innovation'). For example, our framework considers remote monitoring and logistics management (grouping 1) as a business enabler of core operations, while Gerpott and May (2016) view 'smoothing' as a pre-sales activity. The typology proposed in our study also provides a different interpretation of value creation through DSIs. Unlike other studies that align to the Baines and Lightfoot (2013; 2014) typology, with advanced services at the pinnacle of value creation (e.g., Coreynen et al., 2017; Sjödin et al., 2020b), our typology does not propose a similar progression of value, with each DSI potentially valuable in its own way. Indeed, most DSIs are not digital service offerings in the sense that they are not separate saleable entities. This study, thus, provides a different interpretation to work that primarily envisages DSIs at the offering level (Gebauer et al., 2020; Lerch and Gotsch, 2015). As a consequence, we question whether the so-called 'digital paradox' (Gebauer et al., 2020; Kohtamäki et al., 2020) is likely to be as important as the seminal 'service paradox' (Gebauer et al., 2005). Services are a distinct type of offering for many manufacturers, independent of product sales to some extent, while digital technologies are usually embedded in manufacturers' core operations and existing service offerings.

Second, the paper contributes to digital servitization literature by developing a new framework within which DSIs can be positioned. The framework extends existing research that focuses on innovativeness (e.g., Porter and Heppelmann, 2014) by also accounting for customer value, which is lacking in many studies about service innovation (Snyder et al., 2016). In this framework, remote monitoring is foundational (Kamalaldin et al., 2020; Naik et al., 2020) and is combined with other DSIs to create the DSI groupings. Equally, some DSIs primarily impact manufacturers (e.g., 3D printing) while others primarily impact customers; for example, customer app/web portal, which provides visibility of a product's operational performance (Ross et al., 2019). For some DSIs, the impact is equivalent between manufacturers and customers (e.g., remote maintenance). Using this framework, it is possible to revisit existing work to include the 'customer' dimension. So, from Porter and Heppelmann (2014), we align 'monitoring' to manufacturer impact /intermediate innovation (similar to remote monitoring); 'control' to 'hybrid impact/intermediate innovation since it requires the personalization of the user experience (similar to process improvement) and 'optimization' to hybrid impact/radical innovation (similar to predictive maintenance).

Third, in this paper, we link DSIs with mainstream service innovation literature, which has so far not addressed DSIs (Opazo-Basáez et al., 2021). Our study contributes to service innovation research by being one of a small number of papers that attempts to specify what incremental and, particularly, radical innovations are in a (digital) servitization context. Most prior studies use self-reported scales that ask respondents about service innovation without attempting to specify what these innovations are (e.g., Chen et al., 2021b), or discuss service innovation without specifying the degree of change from what existed before (e.g., Favoretto et al., 2022). While Gremyr et al. (2014) make the most thorough attempt to classify service innovation modes as part of servitization, they only specify re-combinative innovations, so this paper is the first to specify radical service innovation in a servitization context despite these being considered strong drivers of firm performance (Johansson et al., 2019).

In this paper, we set out which DSIs extend the corresponding baseline service offerings using Partanen et al.'s (2017) service offering typology. We specify three DSIs as radical service innovations (AI applications, predictive maintenance, and 3D printing) since they fundamentally extend the characteristics of existing service offerings. Other DSIs extend the corresponding service offerings, but not to the same extent. Prior work has also noted that incremental to radical service innovation is a spectrum (e.g., Story et al., 2014). This study builds on this notion and aligns some DSIs to an 'intermediate' position, so creating a framework to allow more structured investigations of this topic. Moreover, innovativeness is more than just the incremental/radical spectrum, with high customer impact also an important determinant of value (Lusch and Nambisan, 2015). Our study only revealed two DSIs as digital service offerings (i.e., predictive maintenance and process improvement) and so we conclude that to reach this stage, DSIs must not only be innovative (radical or intermediate) but also provide significant value for both the manufacturer and customer.

5.2 Managerial implications

DSIs have important implications for company managers since digital technologies have the potential to strengthen manufacturers' servitization efforts. In this study, we identify several DSIs that are innovative to varying degrees. In addition to innovation level, the impact of a DSI should be assessed depending on whether it predominantly provides value for the customer or manufacturer (or impacts both equally). By considering the impact of the DSI on both manufacturers and customers, the value of each DSI can be better assessed and to whom. The study shows that developing radical DSIs that primarily create value for the manufacturer does not always translate directly into value for the customer. For example, 3D printing might be a radical DSI, but its primary value is for the manufacturer and the customer may be unconcerned about how a faulty part is fixed, be it by 3D printing or by the manufacturer having a stock of critical spare parts. Conversely, AI applications are DSIs that are both radical and perceived as valuable for the customer if they enhance their operational processes. However, by making major changes to its service characteristics, the manufacturer moves away from its traditional service business. In this situation, the value of AI applications is questionable, particularly if they are bespoke and only saleable to a few customers without major modifications.

Some DSIs such as performance advisory make a clear impact on customers' operational processes whereas others such as remote monitoring can help the manufacturer to provide its services more effectively. While the development of some innovations may be only incremental to the customer, they may require radical changes in a manufacturer's capabilities; for example, the recruitment of data engineers, to ensure that data and information management is as important in the company as products and services. Predictive maintenance is a radical service innovation for many manufacturers, requiring new data-focused capabilities. Through predictive maintenance, the manufacturer benefits from having a greater understanding of its supply chain requirements and, indeed, may benefit from improved product design through better assessing product failures. The customer may have greater certainty in its operational processes when relying on a proven algorithm to predict product failures, rather than relying on reactive maintenance or engineers' tacit know-how.

DSI groupings facilitate *business enablement* to support core operations such as logistics planning and product design; *service enhancement* to support the provision of existing services and *digital service offerings* to provide new revenue streams. While some DSIs may result in new offerings, it should be appreciated that many will not, and digital technologies will mainly have enabling or enhancing roles. In this regard, it is unlikely that a significant new revenue stream will be created by DSIs and indeed customers may seek price reductions if they believe the supplier's costs have been reduced, for example, through having fewer field service engineers.

5.3. Limitations and future research

This study is not without limitations, and we discuss them here with possible future research avenues. The purposive sampling approach used means the findings cannot be generalized to the population. However, the paper answers the call by Paschou et al. (2020) for research that considers a wide range of manufacturers and sectors. The heterogeneity in the sample provides an opportunity to consider how the study's findings differ across firms of different sizes and sectors. For example, small and medium-sized businesses appeared able to react quickly and employ DSIs to exploit new business opportunities while larger firms had greater resources to develop DSIs in-house. While the analysis for this research was not based on firm size or sector, examining the difference in DSI adoption is a useful future research avenue. Thus, using the framework established in this paper, researchers can identify which DSIs are most likely to be adopted by firms of different sizes and in different sectors and the opportunities and barriers they face in doing so.

We only interviewed one respondent per company since we were careful to identify company experts on this topic. It is possible that interviewing other people in each company might have elicited different findings, although the interview data was carefully cross-checked with secondary data, so we do not believe this to be a major issue. This study involved interviewing manufacturers, yet it discusses the impact of innovations on customers. We justify this approach, given the need to address DSIs in a wide range of manufacturers of different sizes and various industries. However, interviewing customers about DSIs would provide first-hand insights into their impact, and this would strengthen the study's framework. Finally, although this study was focused on creating a typology of DSIs, other approaches would also be beneficial, such as understanding the mechanisms by which DSIs are developed.

Acknowledgements

We would like to thank the Special Issue editors for their guidance and support during the review process and the anonymous reviewers who provided many insightful comments to help improve this paper. We would also like to thank the respondents to this study and Nick Frank at the Service Community who facilitated some of the introductions.

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Appendix A – Interview guide

What is your job title?

What is your role in the company?

How much involvement do you have with developing or delivering service offerings within your company?

How important is digitalization in developing new service offerings within your company?

How important is digitalization in improving existing service offerings within your company?

Can you provide examples of DSIs that your company has developed?

How do these innovations compare to those that other companies in your industry develop?

What are the benefits of DSIs for your company and customers?

What technologies are particularly important for new service development, e.g., IoT, cloud computing, big data?

Appendix B - DSIs in the case companies

Case		Remote maintenance	Customer app/web portal	Remote monitoring	Performance advisory	Predictive maintenance	Logistics management	AI applications	Process improvement	3D printing
1	Alpha	X	X	X	X					
2	Beta			X		X				
3	Charlie	X	X	X	X	X				
4	Delta		X	X	X					
5	Echo	X	X	X	X					
6	Foxtrot			X	X		X			
7	Gamma		X	X	X	X				
8	Hotel			X			X			
9	Kilo	X	X	X	X					
10	Lima	X	X	X		X				
11	Mike		X	X	X	X				
12	Oscar		X	X					X	
13	Sierra	X	X	X	X	X				
14	Victor		X	X	X				X	
15	Yankee		X	X						
16	Zulu	X	X	X	X	X	X			
17	Lambda		X	X				X	X	
18	Golf			X		X				
19	Zeta	X	X	X		X				
20	Theta	X	X	X	X	X		X		X

Appendix C – Indicative quotations for each DSI

DSI	Quotation	Interviewee
Remote maintenance	One of the critical points, and now we're getting down to the economics of it is, as technology improves you need to offer more functionality for the same or a lower price. What you can't do is go to market with something that's fantastic, with lots of features, but it's twice the price of what people have got already.	Managing Director, Lima
	I think there is the speed of how quickly customers will adopt this, which is going to drive the investments that people are willing to make. The more likely customers are willing to pay for it, the more it's going to accelerate. If they're not willing to pay for it then, there's going to be less investment.	VP Marketing, Zulu
Logistics management	We know when customers are roughly going to run out of things, and we can print just in time. Some of the bigger items that they use frequently like consent forms, which hospitals are using all the time, instead of printing 100k we know they use about 30k a month so we can print 30k every month and that helps us manage the workflow well but also not create too much stock on the shelf which creates cash flow problems.	Managing Director, Foxtrot
	I want to have better forecasting; I want to know where the machines are working in the world so I can distribute my parts close to where they're needed. And in this case, it is desirable for a company to have as many connected assets as possible out there. I'll make my money in cost savings and internal process improvement.	Vice President Marketing, Zulu
Customer app/web portal	We had a digital interface to the customer, which was a browser-based product where they could see the live data from what they were working on, and a vendor-managed inventory (VMI) app gave them a warehouse management tool as well.	Business Specialist Logistics, Yankee
	Zulu has an app which allows any customer to do inspections on their machines. That data then gets aggregated in terms of how we can look at all of the digital information from telematics and the visual inspections they have done.	VP Marketing, Zulu
Process improvement	The machines can go out with a template of how that they should operate and what 'good and bad' looks like. And we remotely monitor against that. So, we can give early advice as to the failure of components, failure of parts, system not working as it should, so anomalies. For example, we can detect exceptions. We can actually look for these on an hour-by-hour, day-by-day basis. Then when we tie it into the processes, we need process sensors already there to make the process work, as we need to be able to get that process to be stable and to produce good quality products.	Managing Director, Lambda
	We provide 'boxes' that go into vehicles, software that runs on the products into the vehicle. And then we install those software and boxes into the vehicle and provide back-office communication connectivity and then we run a service for the emergency service so that they can use us as their partner for comms for emergency calls that route to the vehicle and then and follow the process of that communication all the way to the person being cared for.	Director of Operations, Oscar
Remote monitoring	Customers want us to tell them they've got problems, not for them to tell us they've got problems. So, for example, we now understand what toner has gone through the machine so that we can say your magenta bottle is going to run out at the current usage, three weeks next Tuesday.	Head of Field Services, Zeta
	What we might need is training, and there's always a massive cultural shift. Everyone who works here has been used to just making a	Business Development

	product, they've not been used to putting sensors in it. So, I think they might not need the full technical knowledge of how a sensor works but they still need training on how to put a sensor in because they've never done that before.	Manager, Hotel
Performance advisory	We kept hearing about (organization) and they were struggling with space, they were struggling with overheads of people and having the manpower to do it. So, one of the trusts we were close to, we said what if we took it on and you wouldn't need that space for printing, you wouldn't need the people and they could do something else, so it gambled from there really and print management has become quite a global thing now.	Managing Director, Foxtrot
	We can see that those machines have been used only 50% of the time during the last two weeks. Or, if we compare the usage of your machines across your region, across your fleet, we see that these machines are really very heavily used, and the other ones are not. Let's look into this, is this the optimal situation, can we help you to optimize?	VP Global Services, Mike
Predictive maintenance	We can already predict that something is about to happen fairly clearly and with a high probability. Unfortunately, we're not fully sure what it is that we're predicting, we're just predicting something will happen. So, that's the next step to understand what it is that is going to happen.	Director of Connected Solutions, Charlie
	Ours was the only company having predictive maintenance in the field and it was a solution where you install sensors to monitor the equipment and to see vibration, temperature, and pressure. We could monitor and tell the client whether their pipes were corroding, and they needed to change them, and that was the solution to prevent breakdowns of the whole plant and non-planned breakdowns.	Director of Digital Solutions and Services, Golf
AI applications	We can create VR and AR mock-ups of what we're going to build for somebody, how it will work, and we can also put in predictive technology to that. When it goes out of that, it then goes into CAD/CAM, so into manufacturing. In theory, what comes out of our design can be automated and put in place.	Managing Director, Lambda
	We employ different types of AI and sell the software that will do that, digital rights software for example, for lawyers who can scan documents in and look for particular phrases or word sets in 'tons' of legal documents and produce a summary for a lawyer before the case goes to trial.	Director Technical Service, Theta
3D printing	We started to look at some parts which were always a 'pain in the backside'. They could be simple parts by the way, a cog or a gear or a bearing but invariably they were in the wrong place at the wrong time. So, we started to take a look at which of those parts, that can bring a big three-million-pound machine 'down to its knees', could you make it locally (by 3D printing) this afternoon instead of flying one in overnight?	Director Technical Service, Theta