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EXPLORING HOW DIGITIZED PRODUCTS ENABLE INDUSTRIAL SERVICE INNOVATION – AN AFFORDANCE PERSPECTIVE

Matthias M. Herterich
University of St.Gallen, matthias.herterich@unisg.ch

Alexander Eck
University of St. Gallen, alexander.eck@unisg.ch

Falk Uebernickel
University of St Gallen, falk.uebernickel@unisg.ch

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Research

Herterich, Matthias M., University of St.Gallen, St.Gallen, Switzerland, matthias.herterich@unisg.ch

Eck, Alexander, University of St.Gallen, St.Gallen, Switzerland, alexander.eck@unisg.ch

Uebernickel, Falk, University of St.Gallen, St.Gallen, Switzerland, falk.uebernickel@unisg.ch

Abstract

This paper explores the impact of digitized products on industrial service innovation. Digital technologies equip physical products with versatile material properties that create a multitude of opportunities for value co-creation. In particular, product-complementing service offerings are an obvious field for investigating service innovation that leverage digitized products. We contribute to research on digitally enabled service systems that progressively emerge in industrial settings. Anchored in a revelatory case study in the intra-logistics industry, we explore how digitized products are put to innovative uses. Specifically, we take an affordance perspective to identify goal-oriented action potentials that arise from material properties of the digitized product and organizational use contexts in service systems. Interpreting case data, we show how original equipment manufacturers create the potential to (1) monitor and control industrial products remotely; (2) empower technical customer service; (3) manage, optimize, and integrate product operations; and (4) offer performance-based contracting of industrial products. Besides identifying affordances and demonstrating how digitized products enable novel configurations in service systems, we contribute to theory by (1) proposing a framework to conceptualize affordances of digitized products for service innovation and (2) linking the service-dominant logic with affordance theory.

Keywords: Service innovation, Servitization, Service-dominant logic, Digitized products, Generativity, Affordance theory.

1 Introduction

The traditional goods-dominant logic that relies on the exchange of industrial products for cash has come under tremendous competitive pressure. Original equipment manufacturers (OEMs) have realized that they need to intensify value co-creation in innovative service systems to meet their customers' genuine needs (Baines and Lightfoot, 2013; Lightfoot et al., 2013; Neely, 2008; Ulaga and Reinartz, 2011). Against the backdrop or pervasive digitization, physical products increasingly become augmented with digital technology (Woodard et al., 2013; Yoo, 2010). Whereas digitized consumer products rather have a hedonic value (Tuunanen et al., 2010) or increase convenience in our private daily lives, the arguably larger economic value lies in industrial contexts (Manyika et al., 2015). To address shrinking margins and growing competition, OEMs beginning to identify digitized industrial products as promising resources to intensify value co-creation with equipment operators. Their aim is to unlock the next level of service innovation on their servitization journeys.

Recent studies estimate that global spend by OEMs on digitizing industrial products and associated digital infrastructure will exceed US$-500 billion by 2020 (Accenture, 2015; Annunziata and Evans, 2012). Particularly in the context of the industrial service business that is geared towards long product lifecycles, digitized products afford “dramatic new opportunities for service innovation” (Barrett et al., 2015, p. 135). OEMs, however, struggle in leveraging these opportunities (Herterich et al., 2015, 2016). The information systems (IS) domain recently turned to study how digital technology is put to innovative uses (Barrett et al., 2015; Lusch and Nambisan, 2015; Lyytinen et al., 2015; Nambisan, 2013). Scholars call for exploratory, yet theory-rooted research to better understand the generative capacity of digitized products and how it can be harnessed to gain competitive advantage (Barrett et al., 2015; Lusch and Nambisan, 2015; Yoo et al., 2012). First attempts exist that investigate the impact of the physical and digital materiality of digitized industrial products on value co-creation in industrial service system configurations (Kees et al., 2015; Tuunanen et al., 2015; Zolnowski et al., 2011). However, to the best of our knowledge, no research focuses on affordances of digitized industrial products and resulting opportunities for service innovation. The purpose of this paper is to examine how digitized industrial products afford service innovation. We therefore formulate the following research question: *How do digitized products afford service innovation in industrial service systems?*

Based on a revelatory single case in the intra-logistics and materials handling industry, we identify potential uses of digitized industrial products for service innovation. To comprehensively conceptualize the arising potentials for service innovation, we draw upon affordance theory (Majchrzak and Markus, 2012). Affordance theory allows us to focus on both technology features and the organizational use context.

The contribution of our work is threefold. We (1) identify four affordances of digitized industrial products in the context of the industrial service business. We (2) propose a framework for conceptualizing affordances of digitized products. We apply this framework by operationalizing *performance-based contracting of industrial equipment* as an exemplary affordance in the context of the industrial service business. We inform affordance theory and advance research on the generative capacity of digital technology, based on work on digital product innovation (Yoo, 2010; Yoo et al., 2012) and socio-technical-systems (STS) theory (Bostrom and Heinen, 1977) to conceptualize affordances in the context of service innovation. We (3) link S-D logic with affordance theory by describing potentials for service innovation based on digital technology as affordances taking into account both technological and organizational aspects. Thus, our work emphasizes the relevance of digitized products as operant resource for value co-creation in industrial service systems. We find that the service-dominant (S-D) logic needs to be extended by taking greater account of digital technology as operant resource for value co-creation.

This paper proceeds as follows. In Section 2, we provide the relevant theoretical background on digitized products, conceptualize service innovation by drawing on the S-D logic and introduce affordance theory. In Section 3, we describe the research methodology and introduce the case context. In Section 4, we present the identified affordances and go into detail for one exemplary affordance. Sections 5 and 6 discuss limitations, theoretical and managerial implications, as well as potential avenues for further research.

2 Theoretical foundation

2.1 The generative capacity of digitized products

Our world is increasingly affected by pervasive digital technology (Yoo, 2010; Yoo et al., 2010). A key characteristic of this trend is the incorporation of digital technology into objects that previously had a purely physical materiality (Yoo et al., 2010). Especially when incorporated in industrial equipment with high requirements in terms of availability and utilization, digital technology seems to open infinite avenues for service innovation. Since the operations phase in the lifecycle of industrial products often spans decades (Ulaga and Reinartz, 2011), OEMs expect significant benefits from digitized products for their service business. Among scholars, different conceptualizations exist that address digital augmentation of physical products. Table 1 provides an overview on relevant concepts describing the digitization of physical objects.

Concept	**Constituting elements**	**Sources**
Digitized products	Physical products augmented with digital technology resulting in new properties, namely programmability, addressability, communicability, memorability, sensibility, traceability and associability.	Yoo, 2010; Yoo et al., 2010, 2012
Cyber-physical systems	Integrate physical processes and computing; employ sensors and actuators; save and evaluate recorded data; interact with physical/digital world; connect with each other; use globally available data and service; have multimodal human-machine interfaces; represent an evolution of embedded systems; feature system of systems characteristics.	Lee, 2008; Park et al., 2012
Smart objects	Possess identity and store data; sense physical condition and environment; send actuation commands to other devices; possess decision-making capabilities; reach and receive information through networking.	Kortuem et al., 2010; López et al., 2011
Smart, connected products	Consist of physical components, smart components (i.e., sensors, microprocessors, data storage, controls, software), and connectivity.	Porter and Heppelmann, 2014, 2015

Table 1. Relevant concepts describing the digitization of physical objects

Acknowledging the different aspects of the above-mentioned notions, we draw on the concept of *digitized products* shaped by Yoo et al. (2010, 2012) as the most comprehensive and scholarly recognized vocabulary for describing the phenomenon. Digitized product innovation deals with digital and physical materiality of products and the impact of digitization on product architecture (Leonardi and Barley, 2008; Yoo, 2010, 2013). The properties of physical products that incorporate digital components can be described comprehensively by drawing on the layered modular architecture as a well-established framework (Yoo et al., 2010).

Digitizing physical objects gives them new properties that facilitate anticipated and unanticipated opportunities for product and service innovation (Barrett et al., 2015; Nambisan, 2013; Yoo et al., 2010). Hence, the (re)combination of a specific set of properties affords to produce novel products and services (Barrett et al., 2015). The term generativity describes this capacity of (digital) technology to be malleable by diverse groups of actors in unanticipated ways (Zittrain, 2008). Recent studies provide first insights on how digitized products change value co-creation in an industrial context (Chowdhury, 2014; Tuunanen et al., 2015; Zolnowski et al., 2011). However, examples that illustrate the generative capacity comprehensively in the light of service innovation are largely missing. Anchored in a revelatory case study, this work illustrates how the generative capacity of digitized products can be leveraged for service innovation in an industrial context.

2.2 Service innovation and S-D logic

Innovation of physical products is no longer relevant to be addressed individually (Barrett et al., 2015; Lusch and Nambisan, 2015; Sawhney et al., 2006), since physical products are rather seen as distribution mechanisms for service provision (Vargo et al., 2008; Xu and Ilic, 2014). The traditional goods-dominant logic fails to explain value co-creation in interwoven service systems with various actors (Vargo et al., 2008). Vargo and Lusch (2004, 2008) therefore proposed an S-D perspective that is widely accepted by scholars in various disciplines such as operations management, marketing and information systems (Bardhan et al., 2010; Beverungen, 2011; Maglio and Spohrer, 2008; Rai and Sambamurthy, 2006). According to S-D logic, value is co-created based on the beneficial application of operant resources by actors in actor-to-actor networks or service ecosystems (Lusch and Nambisan, 2015; Vargo et al., 2008). With the rise of the service business in the manufacturing industry (Lightfoot et al., 2013; Oliva and Kallenberg, 2003; Ulaga and Reinartz, 2011), S-D logic took root for also investigating the phenomenon of servitization (Ulaga and Reinartz, 2011; Vargo and Lusch, 2004). Servitization describes the shift of OEMs from a pure product focus to more integrated service offerings that can be conceptualized as service systems (Barrett et al., 2015; Lightfoot et al., 2013; Ulaga and Reinartz, 2011). Following the S-D logic, service systems are generic value co-creation configurations of people, technology, and value propositions connecting internal and external service systems (Maglio et al., 2007; Maglio and Spohrer, 2008).

Böhmann et al. (2014) argue that service systems increasingly rely on digital technology. In particular, they call for research that aims at investigating the impact of physical and digital materiality of products on service system configurations. Barrett et al. (2015) likewise recognize digital technology as a key resource for service innovation describing the "rebundling of diverse resources that create novel resources that are beneficial [...] to some actors in a given context" (Lusch and Nambisan, 2015, p. 161). Digital technology is no longer exclusively understood as an *operand resource* (facilitator or enabler), but is also becoming an *operant resource* (initiator or actor) (Lusch and Nambisan, 2015). Hence, digital technology shifts from a supporting role to a vital role for value co-creation. A great number of service systems are termed as *digital* or *digitally enabled*, since they draw on both the physical and digital materiality of digitized products as well as the expanded role of information technology as an operant resource (Yoo et al., 2010). Although the generative capacity of digitized products is identified as an essential driver for service innovation (Barrett et al., 2015), scholars and practitioners struggle to understand and describe how digitally enabled generativity is leveraged for service innovation (Lusch and Nambisan, 2015; Nambisan, 2013; Yoo, 2013).

To explore how digitized products impact service innovation, we draw on the S-D logic for three major reasons. First, S-D logic takes into account both tangible products and intangible services (Grönroos and Helle, 2010), since the service concept is employed as a "common denominator of all economic and social exchange" (Barrett et al., 2015, p. 142). Second, it focuses on value co-creation in service ecosystems and thus abstracts from interests of singular commercial actors. Third, it avoids the dyadic distinction between consumer and producer since it takes a network-centric perspective.

2.3 Affordance theory

Based on the ideas of *gestalt* theory, affordance theory has its origins in perceptual psychology (Gibson, 1986). In its basic understanding, it describes how humans can interact with objects as a result of their material properties (Leonardi, 2011). In recent years, IS research has increasingly focused on the mutually reinforcing and constituting relationship between social and technical forces (Leonardi and Barley, 2008; Markus and Silver, 2008; Seidel et al., 2013; Volkoff and Strong, 2013; Yoo, 2013) with the goal to better understand the generative nature of digital technology. This interest resulted in a renewed interest in affordance theory among IS scholars (Fayard and Weeks, 2014; Leonardi, 2011; Majchrzak and Markus, 2012; Strong et al., 2014; Volkoff and Strong, 2013; Zammuto et al., 2007).

According to affordance theory, digitized (industrial) products have a physical and digital materiality (Leonardi and Barley, 2008; Yoo, 2013) and thus feature specific *material properties.* These include physical material properties, referring to hardly changeable, visible and touchable properties (e.g., sensors and actuators), as well as digital material properties, referring to "what the software incorporated into an artifact can do by manipulating digital representations" (Yoo et al., 2012, p. 1398). An example for a digital material property of a digitized industrial product is an event-processing engine that continuously analyzes sensor data streams for pattern detection. Whereas the exclusive focus on material properties only results in describing technology characteristics, the relational nature of the affordance concept creates an understanding for the potential contextual value arising from the relationship between *material properties* and the *use context* (Majchrzak and Markus, 2012; Markus and Silver, 2008; Volkoff and Strong, 2013). Although affordance theory in perceptual psychology originally focused on actors at an individual level (i.e., humans), the theory did undergo adaptations and extensions and thus serves as a valuable lens to investigate potentials for goal-oriented behavior at an organizational level (Seidel et al., 2013; Strong et al., 2014; Zammuto et al., 2007). While Markus and Silver understand affordances as "possibilities for goal-oriented action afforded to specified user groups by technical objects" (2008, p. 622), Zammuto et al. (2007) see affordances as capabilities of organizational actors when using a system. We follow the well-established conceptualization of Markus and Silver (2008) and understand affordances as *potential* behaviors (i.e., possibilities for action) of an actor for goal-oriented behavior to achieve an immediate concrete outcome (Majchrzak and Markus, 2012).

We choose an affordance lens as a theoretical foundation to analyze the generative capacity of digitized products for service innovation for three reasons. First, it takes into account both the material properties of technology (technical subsystem) as well as the particular use context (social subsystem) (Majchrzak and Markus, 2012; Yoo et al., 2012). Second, its focus on a particular use context is compatible with the contextual nature of the service innovation concept (Lusch and Nambisan, 2015). Finally, it is able to take a consistent perspective on how actors are conceptualized in the S-D literature and literature on service innovation (Barrett et al., 2015; Lusch and Nambisan, 2015). On that score, affordance theory is a valid theoretical lens for investigating how the generative capacity of digitized products fuels service innovation.

3 Research design and method

The goal of this research is to explore how the generative capacity of digitized products affords service innovation in an industrial context. To investigate the arising affordances in detail, we draw on an interpretive research design and apply a qualitative single case study approach because of three major reasons (Eisenhardt, 1989; Myers, 1997). First, we aim at investigating a novel phenomenon with yet undefined boundaries (Silverman, 2010; Yin, 2008). Second, qualitative research allows to generate a deep understanding of complex real-world phenomena within their social or organizational embedded contexts (Orlikowski and Lacono, 2001). Third, we follow the principles of interpretive case study research (Klein and Myers, 1999; Walsham, 1995, 2006) and conduct a revelatory single case study (Yin, 2008) to harness the full strength of human sense-making to explore the qualitative relational nature of affordances (Leonardi, 2011; Pozzi et al., 2014).

3.1 Case context

Since affordances are highly contextual (Volkoff and Strong, 2013), we briefly outline the setting of our case and present the organizational goals of the case organization as focal organizational actor of this study. The case organization is a leading multinational intra-logistics and materials handling organization mainly focusing on industrial trucks and warehouse equipment. It is split up into a manufacturing division and a sales & service division. In 2014, the case organization generated revenues exceeding US$-4 billion with around 20,000 employees. Comprising more than half of the staff, the service business is responsible for more than 45% of total revenue. Organized regionally, sales and service is occasionally performed by affiliated dealer organizations that exclusively focus on the products of the OEM, but can be considered as independent actors in the service ecosystem. Collectively, regional sales & service subsidiaries focus on selling and leasing new and refurbished industrial products to equipment operators. By far the largest share of revenue is generated by leasing products to equipment operators as beneficiary actors. Furthermore, the OEM offers product-related maintenance and repair services for its products as 'ad hoc service' or 'full service'. Whereas 'ad hoc service' implies that equipment operators are invoiced for discrete maintenance or repair activities based on actual costs, 'full service' comprises routine maintenance and default repair activities based on defined service level agreement for a fixed service fee. Based on the data that we collected and analyzed, Table 2 provides an overview of main *organizational goals* for the service business.

Organizational goal (code frequency)	Exemplary evidence
Incrementally increase efficiency of existing service activities (48)	*"I think we are not efficient. That's why I'm currently running a project to change completely the maintenance that we do on short term rental, starting from a totally different point of view than we are doing today." (#03, Head of full service business)*
	"In service, it's all about maximizing efficiency. That means we need to improve the well-known first-time fix rate." (#09, Director service marketing)
Intensify value co-creation with beneficiary actor organization (25)	*"We need to get rid of this thinking in terms of steel and iron. We need to sell more services instead of machines. We need to address our customers' needs." (#07, Director new business and product digitization)*
	"The customer wants to say: 'Okay, you take care. I just want my truck run, work properly, have no down time, and that's fine'. We need to sell this as a chargeable service." (#03, Head of full service business)
Radical service innovation (57)	*"If I notice that a driver always presses the wrong buttons [...] then I sell him a driver training." (#04, Managing director technology)*
	"Based on a cross-functional innovation initiative our goal is to offer entirely new services. [...] Today we can barely imagine the potential of our products augmented with digital technology." (#09, Director service marketing)

Table 2. Organizational goals for the service business

3.2 Data collection

This study is part of a larger multi-year research program in which we accompany the case organization in their service innovation efforts. Thus, we had extensive access to experienced personnel with sound knowledge on service innovation initiatives within the case organization and its broader service network. Senior managers helped us to conduct snowball sampling and identify the right persons to discuss divergent perspectives on service innovation enabled by digitized products. Between 05/2015 and 11/2015 we conducted 14 formal interviews with managers responsible for service business, service innovation, and product digitization as well as with executives from group IT of the case organization. Formal interviews were based on an interview guideline, which we structured along the dimensions of STS theory, taking into account capability areas of digitized products (Sanislav and Miclea, 2012) as well as existing frameworks and foundational work on value co-creation (Tuunanen et al., 2010, 2015; Vargo and Lusch, 2008). We aimed at examining how the case organization leverages digitized products in its industrial services business. The interviews were designed to collect appropriate and sound data for later identification of affordances as relations between material properties of the organization's digitized industrial products and the specified use context of its service business. Supplemental activities within the larger research program allowed us to gather additional data by attending meetings, calls, and focus group workshops (Tremblay et al., 2010). We furthermore consulted internal documents and archival data for triangulation purposes (Yin, 2008); all relevant data for this study is presented in Table 3.

Data source	General information	Detailed information	Duration
Formal interviews	14 formal interviews Interview statistics: - ∑ 17:56h - μ: 1:17h - σ: 22:48min	#01, Managing director product marketing and communication #02, Vice President Sales & Service #03, Head of full service business #04, Managing director technology #05, Director of after-sales service region A #06, Managing director innovation management #07, Director new business and product digitization #08, Head of product marketing #09, Director service marketing	84 min 60 min 105 min 99 min 64 min 54 min 65 min 50 min 101 min

	- 328 pages of text	#10, Director of after-sales service region B #11, Global Head of IT Operations #12, Director service standards #13, Director of after-sales and customer service #14, Head of competence center IoT platform architecture	79 min 30 min 93 min 109 min 83 min
Focus group workshops and meetings	4 full-day workshops and 2 meetings	Digitized equipment 2.0 proof-of-concept kickoff workshop Milestone review workshop I Milestone review workshop II Smart service systems innovation workshop Strategic meeting on servitization and service innovation Foresight workshop on flexible pricing models and outcome-based offerings	Full day Full day Full day Full day 4 hours 2 hours
Internal documents and archival data	Strategic service innovation concepts, technical documentations	Presentation on strategic service innovation clusters; 2x innovation board status presentations: project brief on business model transformation project (usage-based industrial equipment offerings and servitization), Internet of Things/telematics platform architecture proposal, sensor data payload calculations, target data model: operational industrial product data, network and connectivity requirements documentation	-

Table 3. Overview of collected and analyzed data

3.3 Data analysis

Two researchers analyzed the collected data line by line in an interwoven three-stage process of *open*, *axial* and *selective* coding following the recommendations of Strauss and Corbin (1990; 1997). For analyzing interview transcripts and internal documents, we used the software NVivo 11 as a computer-assisted qualitative data analysis tool. Figure 1 provides an overview on how we performed data analysis.

In the *open* coding stage, we aimed at identifying recurring concepts in the data with the goal of addressing concepts that guided us when compiling the interview guideline. At the same time, we tried to remain as open as possible to identify salient concepts from collected data. To corroborate our findings, we constantly compared the emerging codes coded by two researchers to identify common codes and harmonize different perspectives based on different codes.

In the *axial* coding stage, we condensed categories by drawing on the affordance concept. This theoretical lens let us distinguish between material properties of digitized products and the organizational use contexts. We structured our analysis of affordances by drawing on the four dimensions of technology, structure, people and task originating from STS theory (Bostrom and Heinen, 1977). STS theory is appropriate as a meta-framework, because it is simple, extensive, sufficiently well-defined, and anchored in existing literature (Seidel et al., 2013). Analogously to Seidel et al. (2013), we related the technology dimension to material properties, while the structure, people, and task dimensions helped us to specify organizational use contexts. Following the recommendations of Lusch an Nambisan (2015), we furthermore drew on the four dimensions of layered modular architecture to comprehensively describe the material properties of digitized products, namely device layer, network layer, service layer, and content layer (Yoo et al., 2010).

In the *selective* coding stage, we finally took affordances and STS theory as lenses to sharpen our focus on the relations between material properties and manifold use contexts that express arising affordances in the context of the industrial service business. In total, 850 codes were captured related to affordances (720 codes) and to organizational goals (130 codes).

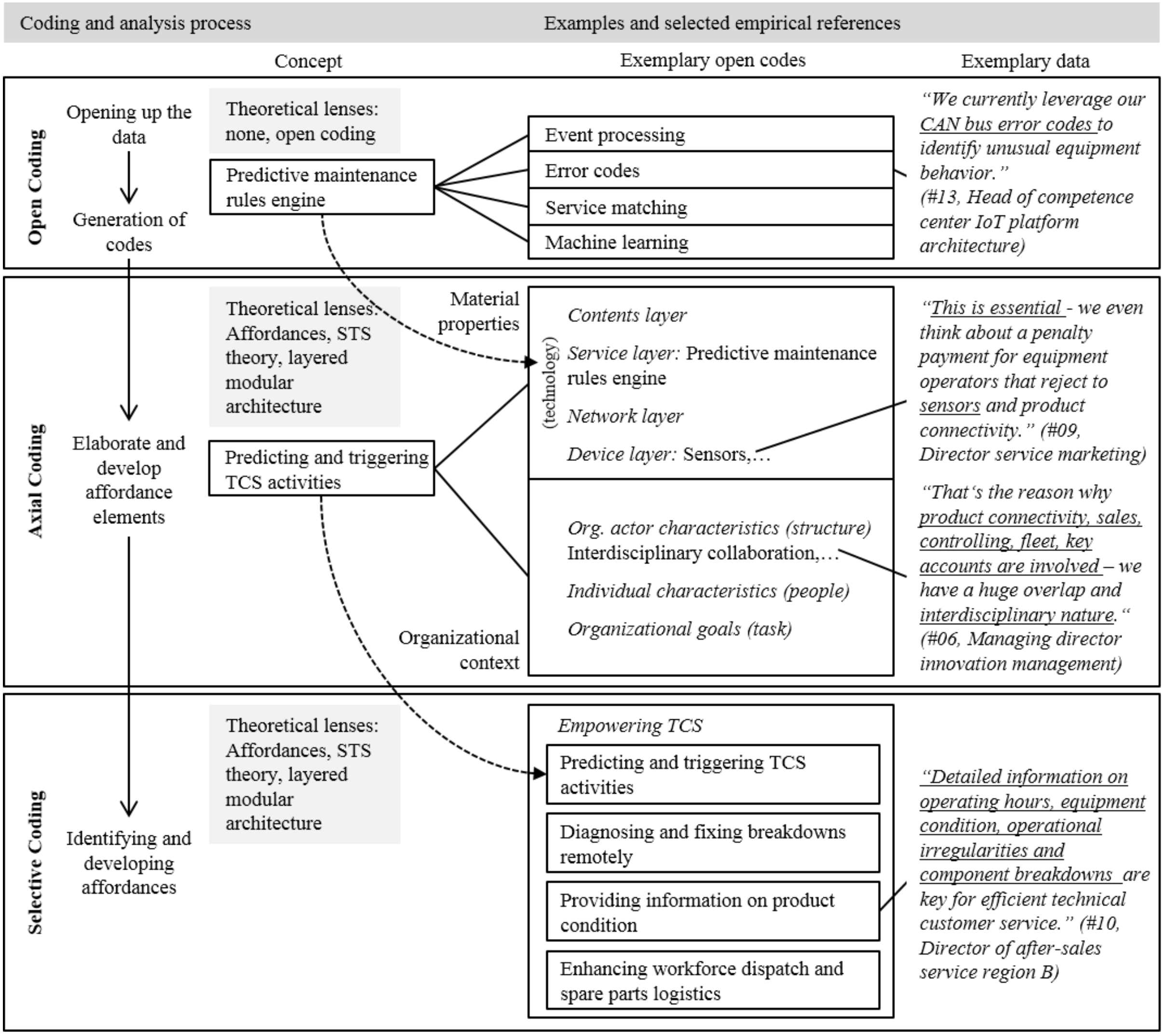

Figure 1. Coding process with illustrations

4 Results

In the following, we describe affordances that arise from digitized products. We center our analysis on the OEM as our focal organizational actor. Although we cannot claim to identify an exhaustive set of affordances based on a single case study with sufficient claim for rigor, Table 4 provides an illustrative overview of affordances related to the service business identified in our data. Due to the focus of this work on service innovation and value co-creation, we exclusively address affordances in the context of the industrial service business. Hence, affordances that do not address value co-creation with other actors (e.g., using operational product data to engineer better products) are not regarded in this study.

Due to the limited space, we thoroughly discuss *performance-based contracting of industrial equipment* as an example to (1) provide evidence how affordances emerge based on our case and (2) give an illustrative example of how the generative capacity of digitized products lead to service innovation in the specific case of our case organization.

Affordance	**Description**	**Code frequency**
Monitoring and controlling industrial products remotely	Monitoring and controlling industrial products remotely allows the OEM to generate operational visibility on their products in the field. The affordance furthermore allows controlling, updating, and resetting industrial products remotely. Transparency on product utilization and downtimes enable the OEM to determine the actual value generated by its products in value co-creation with the equipment operator as beneficiary. This affordance builds the foundation for other affordances.	152
Empowering TCS	Empowering technical customer service (TCS) allows to improve value co-creation in existing TCS systems. Harnessing the material properties of digitized products such as condition monitoring technology, TCS activities can be triggered and predicted based on operational data. At an individual level, service technicians can be empowered with rich information on equipment status aiming to increase TCS efficiency. In the same context, actuators allow that dedicated faults can be resolved remotely.	167
Managing, optimizing and integrating product operations	Managing, optimizing and integrating product operations allow the OEM to intensify value co-creation with other actors in the service ecosystem. OEMs can disseminate operational data from their own products or exploit data from other actors as a resource to co-create value in the service ecosystem. Exemplary immediate concrete outcomes are more adequate capacity scaling of the product fleet/installed base or vertical and horizontal integration in the service ecosystem resulting in innovative service offerings.	190
Performance-based contracting of industrial products	Performance-based contracting enables the OEM to change its product-dominated business models towards service-dominated offerings. By fully understanding how the beneficiary is using the products for value creation, flexible pricing mechanisms can be implemented that draw on contextual product usage data. Value co-creation and thus the relationship between OEM and equipment operator is intensified, since the OEM takes ongoing responsibility for product operations.	211

Table 4. Affordances for service innovation focusing on the OEM as organizational actor

In the notion of S-D logic, “there is no value until an offering is used” (Lusch and Vargo, 2006, p. 44). Shifting from goods-dominant product sales to offering industrial products based on fixed leasing rates was a first step of our case organization towards addressing evolving expectations of beneficiaries. Because of fluctuating production, usage of industrial products is rather volatile. Hence, equipment operators demand for flexible pricing models of industrial products. Triggered by this need, the organizational goal of the OEM arises to intensify value co-creation and in the process to offer more flexible usage-based offerings based on actual usage of the products.

> *“We no longer can just give the customer our equipment and then bill a monthly leasing rate. The customer wants to pay according cargo turnover or the number of transshipped tons or pallets. Digital technology is needed to monitor the equipment.” (#04, Managing director technology)*

> *“Our current key focus area is to sell our products as service offerings to dig deeper into the value creation of our customers. Therefore, we are in the middle of changing our business model towards dynamic pricing models, pricing on cargo turnover, per hour or per dedicated customer application.” (#01, Managing director product marketing and communication)*

> *“Do I have clean, dusty, moist conditions, abnormal environmental temperature on the shop floor? [...] We can no longer rely on checkboxes in some half-baked self-assessment questionnaires about operating conditions. Therefore, we start to leverage digitized equipment.” (#06, Managing director innovation management)*

We conceptualize the affordance of *performance-based contracting of industrial products* by focusing on the relation between material properties of digitized products (*technology*) and the use context described by organizational actor characteristics (*structure*), individual characteristics (*people*), and organizational goals (*task*). To comprehensively describe the material properties of digitized products, we furthermore draw on the dimensions of the layered modular architecture (Yoo et al., 2010). Following this structure, Table 5 presents a detailed overview on the constituting elements of this affordance.

Affordance: Performance-based contracting of industrial products	
Material properties (technology)	**Use context**
Contents layer: Digital product twin, contextual information to interpret operational product data, on-demand billing information *Service layer:* Contextual pricing engine integrating operational product data, operator peculiarities, product application cost models *Network layer:* Bi-directional reliable and secure product connectivity with sufficient bandwidth *Device layer:* Physical products augmented with sensors and actuators	*Org. actor characteristics (structure):* Adequate organizational culture, incentive systems linked to goals of beneficiary and intensified value co-creation, partnerships with other actors for holistic value co-creation *Individual actor characteristics (people):* Individuals understand products as services; are able to identify and understand cost drivers based on operational product data, collaborate among various disciplines and organizational functions *Organizational goals (task):* Comprehensively addressing equipment operators' (beneficiary) needs, value-in-use instead of value-in-exchange, superior value co-creation and stronger relationships with beneficiaries

Table 5. Offering industrial products as a service (outcome-based offerings) affordance

Focusing on the physical elements, industrial products need to be augmented with sensors and actuators that are required to be protected against on-site fraud or manipulation (*device layer*). For data transmission, bi-directional, reliable and secure product connectivity with sufficient bandwidth (*network layer*) is necessary to securely transmit various kinds of sensor data to a digital platform in the service layer.

> *"We decided […] to consequently equip every forklift truck […] with our connect kit." (#04, Managing director technology)*
>
> *"Hardware security is super important. [...] We do not have any interest that a third party can access that raw operational product data in any manner." (#08, Head of product marketing)*
>
> *"We use different technologies for ensuring a reliable connectivity based on the surroundings of the equipment. Wireless network or Bluetooth are two options [...] but the most widespread technology is 3G. More than 12.000 digitized, connected products result in around 350 GB of compressed mobile traffic per year." (#14, Head of competence center IoT platform architecture)*

Based on historic usage data and contextual information (i.e. information on customer relationship or external data), pricing models can be generated. Based on a contextual pricing engine that draws on these models, actual costs for using the industrial product can be calculated. Resulting on-demand billing information needs to be fed into existing accounting systems of the OEM to bill the equipment operator (*service layer*). All information that is relevant for a specific truck is unified in a digital product twin – representing a holistic picture on the product condition at any point in time (*contents layer*).

> *"The crux of the matter in this topic is the level of detail that can be achieved on customer operations, actual equipment usage and performance, wear and tear, utilization, and finally availability. Visibility is the foundation for billing according to actual equipment performance. […] We need both data about the utilization and accurate cost models, to be able to bill the customers based on the added value our products created in their operations". (#06, Managing director innovation management)*

Besides material properties of digitized products *(technology),* the use context among the dimensions of *structure*, *people* and *task* give rise to the affordance of performance-based contracting of industrial products. First, an organizational culture that aims at a unique and phenomenological determination of value by the beneficiary actor (i.e., equipment operator) needs to be established. Incentive systems that are linked to goals of the equipment operator need to be set up at an organizational and individual level. For instance, need-oriented goals that are related to scale the truck fleet of the beneficiary by anticipating seasonal ups and downs in product usage might contradict traditional goals of the OEM such as selling the maximum number of products to the equipment operator.

> *"Changing the business model results in higher requirements in terms of product uptime, since we optimize existing equipment surpluses, which our customers had paid in the past. The absolute number of trucks that are used for the same intra-logistics operations will decrease; customers can do the same with less equipment." (#09, Director service marketing)*

> *„Flexible pricing and performance-based contracting means to optimize equipment utilization in swaying demands such as seasonal peaks in agricultural applications. The equipment might then be smartly swapped to another equipment operator with full order books. However, we have to be aware that we sell less products. And this is not a bad thing." (#06, Managing director innovation management)*

Performance-based contracting furthermore calls for interdisciplinary collaboration and draws on the employees of various organizational functions; intra-organizational collaboration between product engineering and service innovation division must be ensured.

> *"Part of this flexible price model team is of course the IoT connect team but also sales, controlling, customers, fleet managers and key account managers are involved." (#06, Managing director innovation management)*

The organizational self-conception of the OEM must focus on value co-creation with other actors in the service ecosystem to comprehensively address the needs of other actors in the service ecosystem (*structure*).

> *"This transformation is complex and difficult to handle. We have to think about the fact that the entire organization is not trained for this – we are not computer scientists. And this will be the reason why we probably fail." (#10, Director of after-sales service region B)*

Performance-based contracting means that individuals in various organizational functions understand products as services. They need to be able to identify and understand cost drivers based on operational product data, and collaborate among various disciplines and organizational functions *(people).*

The affordance of performance-based contracting of industrial products allows the OEM to address the needs of the beneficiary more comprehensively and enables superior value co-creation resulting in stronger relationships with beneficiaries. In this way, the OEM focuses on value-in-use instead of value-in-exchange of their industrial products *(task).*

> *"Offering flexible pricing models and selling products as services require a high degree of interdisciplinary collaboration: we need digitization experts, IT experts, sales guys, controllers and marketing people work closely together. Furthermore, this involves in-depth research with key customers, fleet managers and key account managers. This results in organizational challenges such as cultural aspects, [...] reorganization of existing functions, and greater responsibilities for our organization. "(#06, Managing director innovation management)*

5 Discussion and future research

We discuss the results of this paper in light of the existing body of knowledge on (1) S-D logic and service innovation, and (2) affordance theory and the generative capacity of digitized products. We furthermore (3) state major limitations of this work and propose how we would plan to continue our research.

S-D logic and service innovation. IT has been considered as an enabler and operand resource for value co-creation (Maglio et al., 2007; Maglio and Spohrer, 2008; Vargo and Lusch, 2004). Recent studies on servitization mainly recognize cultural aspects or organizational characteristics (e.g., size, competitive situation) as key drivers for service innovation (Eggert et al., 2011, 2014; Gebauer et al., 2005; Mathieu, 2001). Service systems, however, increasingly rely on digital technology (Barrett et al., 2015; Böhmann et al., 2014). In line with existing work, this study illustrates how digitized products enable OEMs to gain transparency of their products as a prerequisite for flexible service offerings of any kind. OEMs as actors in service ecosystems are now able to leverage remotely monitored and controlled digitized products as *operant* resource. Thus, they are able to quantify how industrial products contribute to value co-creation. The actual value-in-use of industrial products augmented with digital technology can now be metered and billed adequately. Our work contributes by conceptualizing the generative capacity of digitized products as operant resource for digitally enabled service innovation (Lusch and Nambisan, 2015).

We furthermore identify operational product data of digitized products as an additional operant resource for value co-creation in service systems.

Affordance theory and the generative capacity of digitized products. As suggested by Zittrain (2008, p. 78) and Yoo et al. (2012), this work illustrates how the affordance concept can be used as an effective lens to understand the generative capacity of digitized products for service innovation. We contribute to IS-specific theory development in three ways. We (1) link affordance theory with S-D logic by discussing affordances from an S-D perspective. In particular, we demonstrate how digitized products are put to innovative uses by drawing on the value-in-use concept (Vargo et al., 2008; Vargo and Lusch, 2008). In addition, we exemplify that an affordance lens is suitable to investigate service innovation fueled by digitized products (Barrett et al., 2015; Lusch and Nambisan, 2015). By taking an organizational perspective, we (2) extend the body of knowledge on affordance studies in IS at an organizational level (Blegind Jensen and Dyrby, 2013; Glowalla et al., 2014; Strong et al., 2014; Volkoff and Strong, 2013). We (3) contribute to the theoretical discussion of how affordance theory is used in IS research on digital technology (Fayard and Weeks, 2014). We therefore combine an affordance lens with the dimensions of STS theory and the layered modular architecture of digitized products as a meta-framework for a detailed conceptualization of arising affordances. The resulting structure can be used as an organizing framework in future affordance-related research, since it describes service systems based on loose couplings between the individual layers of digitized products and the use context in a comprehensive way. In particular, the framework takes into account (1) the physical and digital materiality of digitized products as well as (2) the use context at both an organizational and individual level.

Limitations and future research. The results should be viewed in light of the study's limitations. First, we have to note that partially different affordances could arise in other organizational settings or industries. Second, the identified codes and derived affordances might be interpreted differently by a different team of researchers. However, we aimed at developing a clear chain of evidence by taking into account multiple data sources. Nonetheless, we suggest to conduct additional studies in other industries than the intra-logistics industry to corroborate our findings. Despite those limitations, our explorative findings provide valuable insights and serve as an adequate conceptual grounding for further affordance-based studies on digitized products for service innovation. In particular, we plan to extend this work substantially aiming to (1) contribute to the body of knowledge on affordance dependencies, (2) affordance actualization, and (3) quantify the value of arising affordances.

First, our data suggests that *monitoring and controlling industrial products remotely* seems to be an essential affordance serving as foundation for other affordances. Volkoff and Strong (2013) coined the term 'basic affordances' to describe such foundational affordances. Similarly, TCS processes empowered by digitized products (i.e., condition monitoring) are fundamental for performance-based contracting, since highly efficient TCS processes allow OEMs to ensure product uptimes in a profitable way (Herterich et al., 2015). Strong et al. (2014) discuss how affordances seem to cascade, and introduce 'affordance dependencies' as a potential extension to affordance theory for describing this phenomenon. Volkoff et al. (2013) have a similar understanding and refer to 'basic affordances' and 'thematic affordances'. First studies exist that draw on the concept of affordance dependencies (Glowalla et al., 2014). Since the generative capacity of digitized products affords a multitude of opportunities to use the same material properties in different use contexts, we plan to extend the work at hand with follow-up research. Similar studies might find it worthwhile to further investigate affordance dependencies and thus advance affordance theory as proposed by Strong et al. (2014). For practitioners, insights on basic affordances as foundations for other affordances could be generated.

Second, this study in its current form exclusively focuses on affordance existence and perception (Bernhard et al., 2013; Glowalla et al., 2014; Pozzi et al., 2014) in the specific context of our case organization. Affordance actualization, however, deals with the "actions taken by actors as they take advantage of one or more affordances through their use of the technology to achieve immediate concrete outcomes in support of organizational goals" (Strong et al., 2014, p. 70). Extending the research towards affordance dependencies and affordance actualization might be an interesting lens to investigate the digital transformation journey of organizations. Such research might identify critical success factors as well as technical and organizational challenges that arise in the course of such endeavors.

Third, most of the current research taking an affordance perspective, including the study at hand, is either qualitative or conceptual. First ideas for quantitative research approaches on technology affordances have been proposed (Carte et al., 2015). Even more than in a consumer context, we argue that industrial service innovation fueled by digitized industrial products might serve as adequate settings for quantitative affordance research, since actors in industrial service ecosystem mostly focus on quantifiable utilitarian value themes as immediate concrete outcomes (Tuunanen et al., 2015). From a S-D logic perspective, we plan to draw on the value–in-use concept of digitized products in industrial service systems.

6 Conclusion

Drawing on a revelatory single case study, we explored how the generative capacity of digitized products enables service innovation and affects value co-creation in industrial service systems (Barrett et al., 2015). Our work is a first attempt to investigate how digitized products are used as an operant resource for service innovation in industrial service systems. In particular, we identified (1) *monitoring and controlling industrial products remotely*; (2) *empowering technical customer service*; (3) *managing, optimizing, and integrating product operations*; and (4) *performance-based contracting of industrial products* as four affordances of digitized products in the context of the industrial service business.

This study, however, goes beyond solitary affordance perception and contributes to theory-rooted knowledge on service innovation as an emerging and critical area for the IS discipline (Barrett et al., 2015). The identified affordances illustrate the generative capacity of digitized industrial products. Depending on the organizational use context, similar material properties of digitized products can be used differently. Furthermore, we propose a conceptual framework for describing affordances of digital technology. We instantiate this framework by operationalizing *performance-based contracting of industrial equipment* as an exemplary affordance in the context of the industrial service business. The framework takes into account existing work on digital product innovation (Yoo et al., 2010, 2012) and socio-technical-systems theory (Bostrom and Heinen, 1977) to comprehensively describe affordances in the context of service innovation. Hence, our work addresses current research gaps (Volkoff and Strong, 2013; Yoo et al., 2012) and provides an adequate conceptual grounding for further affordance-based studies on digitized products for service innovation. In particular, our findings serve as a foundation to identify dependencies between affordances of digitized industrial products for adequate affordance actualization.

Finally, we wish to outline two managerial implications. First, our findings show that digitized products the way OEMs will co-create value in innovative service systems fundamentally changes. Various affordances arise based on the generative capacity of digitized industrial products. The emergence of performance-based contracting as an exemplary affordance results in extensive managerial challenges for OEMs. Instead of maximizing ad hoc service revenues, OEMs must reevaluate organizational goals and establish highly efficient and proactive service operations to offer such performance-based contracts competitively and profitably. Second, fully harnessing the generative capacity of digitized products has extensive socio-technical implications. OEMs can harness the generative capacity of digitized products only when taking into account both technological and organizational aspects. Affordances such as outcome-based offerings require adequate organizational culture, adjusted organizational structure to increase interdisciplinary collaboration, and building up powerful service ecosystems to co-create value and meet the needs of the beneficiaries.

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