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An Affordance-Actualization Perspective on Smart Service Systems

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Abstract. Smart physical products increasingly shape a connected IoT world and serve as boundary objects for the formation of 'smart service systems'. While these systems bear the potential to co-create value between partners in various industries, IS research still struggles to fully capture the phenomenon to support successful digital innovation in IoT settings.

In our work, we analyze the phenomenon of smart service systems taking an affordance-actualization perspective. Based on a qualitative content analysis of a multi-case study, we identify elements and propositions to build mid-range theoretical knowledge for smart service systems. We suggest that providers and users of smart products not only realize their own affordances via their actions but might also affect the immediate concrete outcomes of partners. The developed theoretical framework and six distinct propositions should build the theoretical base for further research into the phenomenon in IS research.

Keywords: smart service systems, Internet-of-Things, affordances, actualization processes, digital innovation.

1 Introduction

As everyday physical objects surrounding us become increasingly data-driven, connected, and communicative (i.e., 'smart' [1, 2]), it becomes more and more evident how technological advancements in the context of the 'Internet-of-Things' (IoT) might have a transformational impact on our work, our daily lives, and our participation in society [2, 3]. An example of the impact of increasingly smart products is the rapidly ongoing transformation of manufacturing industries ('Industry 4.0') [4]: Digital technologies allow the integration of processes across the value chain and enable to servitize previously product-focused business models [5]. These novel offerings blend the physical and virtual world by analyzing data collected via sensor-equipped connected physical objects and create value-in-use through contextual and preemptive services [1, 6].

As it is crucial to understand both social and technological influence factors on this phenomenon, Information Systems (IS) research as an interdisciplinary field is predestined to unify the primarily technically focused research in computer science and engi-

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neering disciplines with the rather benefit- and value-oriented studies in fields of economics [7]. Thus, Beverungen et al. [8] pinpoint how digital technologies manifested in smart products are transforming service systems into *smart service systems.* They provide a widely recognized conceptualization of this new phenomenon and have already sparked a vivid discussion among scholars [e.g., 9–12]. In our study, we follow their understanding of smart service systems, where "smart products take the role of boundary objects that digitally mediate the interactions of service providers and service consumers and enable the co-creation of individualized value propositions" [8, p. 8]. Despite the concept's rising popularity in practice and related disciplines, smart service systems yet lack a thorough theoretical grounding and linkage to common constructs and concepts. By emphasizing a systems perspective (cf. general systems theory [13, 14]) or by examining the dual nature of smart products either managing or increasing the system's complexity, IS research has great potential to enhance our scientific understanding of smart service systems [7, 10, 15]. In particular, investigations into the dynamics and mechanisms underlying smart service systems allows building mid-range theoretical knowledge explaining *how* and *why* the advent of 'smartness' challenges existing assumptions [16, 17]. Studying the impact of smart technologies on service systems is also relevant as it potentially provides implications on the digitalization of innovation processes and outcomes, thus contributing to the study of digital innovation management [18, 19]. As one of four new theorizing logics for this endeavor, Nambisan et al. [18] suggest technology affordances (and constraints) [20–23] as a promising lens to build new theory–as the use of digital technology offers new sets of affordances for innovating actors. Consequently, we ask: *How do smart products give rise to affordances for actors in smart service systems, and how can this potential be realized?*

As we outline in this article, the theory of affordances provides means to better grasp and operationalize the complex reciprocal relationship between technology and organizational actors in smart service systems from a critical realist perspective [24]. In particular, we apply Strong et al. [25]'s *affordance-actualization* lens to revisit the concept of smart service systems and to extend existing theoretical knowledge. We build on insights from a multi-case study and claim that the purposeful design or 'engineering' of smart service gives rise to *affordances.* In simple terms, an affordance is a 'potential for goal-oriented behavior in interaction with an artifact' [21, 25, 26] whereby in this context a smart product is the 'artifact'. Further, we differentiate between an affordance and its realization through *actualization*, i.e., "the actions taken by actors as they take advantage of affordances through their use of the technology" [25, p. 70]. Our results contribute to the body of knowledge on smart service systems by presenting a conceptual framework and propositions towards a mid-range theory from an affordance-actualization perspective. Also, our work holds value for practitioners by allowing them to analyze the potentials of smart technology and by providing a vocabulary to consciously articulate the expected outcomes of participating in smart service systems.

We present our study as follows: The next section elaborates on the theoretical foundations of smart service systems and affordance theory, followed by the description of our methodology. Then, we present our conceptual results applying an affordance-actualization lens on smart service systems. Our concluding section wraps up our study by discussing the limitations of our study and its implications for theory and practice.

2 Theoretical Foundations

2.1 Smart Products, Smart Service, and Smart Service Systems

The idea of ‘smartness’ emerged along with technological advancements in sensing, monitoring, analyzing, and controlling physical objects [27], which enabled building intelligence–i.e., awareness and connectivity–into products [3]. These smart products offer the potential for innovating business models [2, 28] and play an increasing role in service delivery as their abilities allow them to take an active role in service systems [1, 27]. We understand service systems as “a configuration of people, technologies, and other resources that interact with other service systems to create mutual value” [14, p. 395]. Smart products offer transformative potential on how value is co-created and captured in service systems. This gives rise to the phenomenon of *smart service system*s [8], defined as “service systems in which smart products are boundary objects that integrate resources and activities of the involved actors for mutual benefit” [8, p. 12].

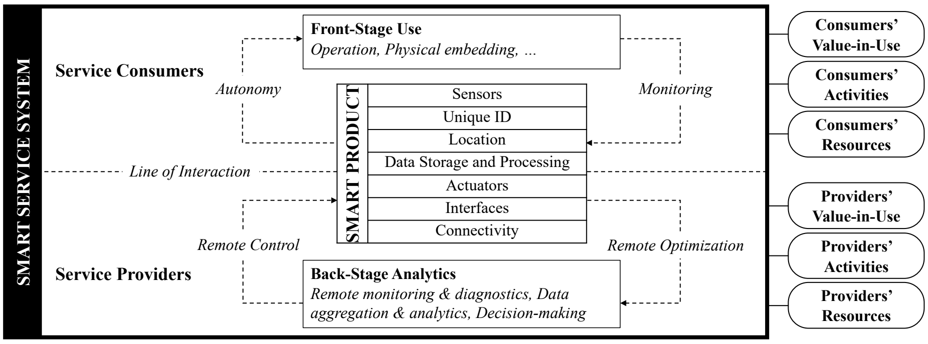

Figure 1. Conceptualization of smart service systems, based on [8].

As boundary objects, smart products act as a reference point for service interactions maintaining a single shared identity across all interacting communities. However, they also provide the required flexibility to be interpreted differently by the involved actors to extract different utilities from it [8, 29]. In their conceptualization of smart service systems, depicted in **Figure 1**, Beverungen et al. [8] explain how smart products reside at the interface (‘line of interaction’) between the basic roles of a service consumer and service provider recognizing their built-in features ‘sensors, unique ID, location, data storage and processing, actuators, interfaces, and connectivity’. Further, they assign widely recognized capabilities [2, 30] of smart (connected) products partly to the ‘frontstage’ (monitoring, autonomy) and partly to the ‘backstage’ of a smart service system (remote control and optimization). In the ‘frontstage’, the smart product is used to create and capture value-in-use [31] for the user of the product. However, in the ‘backstage’ (i.e., outside its immediate physical context), the product can provide data to monitor, diagnose, or optimize the product’s usage [8, 32, 33]. Further, retrieving data from a smart product can also be used to provide additional value via services to an ecosystem of third parties [34] or even to the product’s provider itself. All in all, the properties of smart products give rise to various types of *smart service,* which we define as "the application of specialized competencies, through deeds, processes, and performances that are enabled by smart products" [8, p. 12].

2.2 Affordance Theory and Affordance-Actualization Framework

The theory of affordances originates from the seminal work of the ecological psychologist Gibson [20, 35]. Following his view, goal-directed actors do not perceive objects as a set of characteristics or material features. Instead, they rather recognize how the objects can be used (i.e., what it 'affords' the actors in terms of action possibilities for goal-oriented behavior) without requiring a cognitive analysis of the object [20, 36]. For example, a reasonably sized chair affords a person the possibility to either sit down or reach something on a high shelf (according to her goals) without depending on the conscious analysis of the chair's material features (e.g., height or stability) [36].

The concept of 'affordances' holds great potential as a lens for looking at a variety of IS topics [23, 37]. However, some important themes should be recognized when applying affordance theory to explore how technology is perceived and used by an individual or organizational actors: first, affordances only arise from the relationship of technology and its user–and not from the technology itself [36, 38]. Thus, a technological artifact has not any affordances except concerning a specific or archetypal actor with a set of tasks related to the actor's goals [25, 36]. Second, affordances should be used to describe action *possibilities* for goal-directed actors–not actual actions, objects, or states [25, 36]. In contrast, the actualization as the action itself relates to the structure, i.e., the actual configuration of behaviors making up the action [25, 36]. These actions then lead to a state reached after realizing an affordance, which we call 'immediate concrete outcome' as opposed to affordances as the potential action [25].

When applying the theory of affordances in an IS context, several frameworks have been used (e.g., functional affordances [21, 39, 40] or technology affordances and constraints [22, 23, 41]). This is also reflected in an ongoing debate on a few conceptions of applying the theory [36, 37, 42]. However, regarding our research question, an affordance-actualization perspective as introduced by Strong et al. [25] (**Figure 2**) seems particularly promising. In addition, our study considers the principles for examining affordances in IS research presented by Volkoff & Strong [36]. In Strong et al.'s [25] study on the implementation of electronic health records (EHR), the authors describe how the EHR features, the characteristics of individual actors and the organization's goals give rise to multiple affordances. Further, they identify necessary goal-directed actions to actualize the affordances, e.g., creating and using EHR templates and following standard procedures (action) to realize the potential of standardizing data, processes, and roles (affordance). They deduce how individual-level immediate concrete outcomes aggregate to an organizational level and how affordances are interrelated and interact. These relationships can be described in two ways: 1) as a temporal relationship (e.g., realizing the affordance of capturing and archiving digital data gives rise to the affordance of accessing information remotely) or 2) as a feedback loop (cf. **Figure 2**) so that immediate concrete outcomes affect actors, their organizational context or artifact features to give rise to further affordances that can be actualized [22, 25].

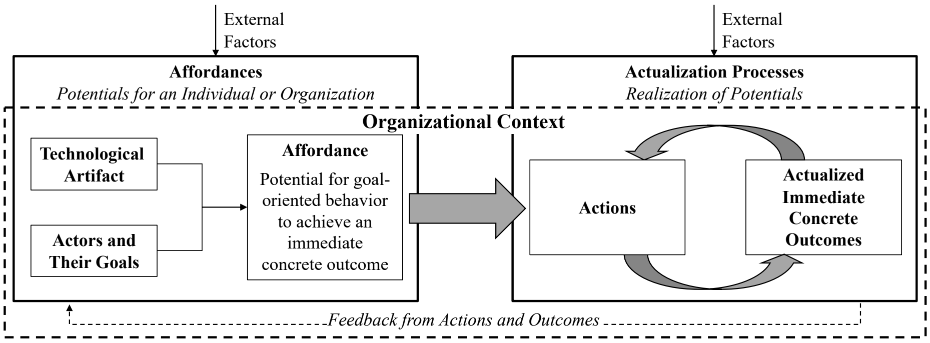

Figure 2. Affordance-actualization framework, based on [25].

A few articles already apply affordance theory in the context of smart service (systems). Knote et al. [40] take a functional affordance perspective to develop propositions on how different types of smart personal assistants (e.g., Amazon's Echo products) afford value co-creation. Effah et al. [41] examine affordance and constraint processes in smart service systems with a focus on applying smart products in seaports. These applications underline the growing interest in translating insights from affordance theory to smart service systems. However, existing research yet lacks a thorough analysis of how the specific characteristics of smart service systems can be reflected and how utilizing affordance theory as a lens can change how we look at the phenomenon.

3 Methodology

To explore affordances and actualization processes in smart service systems, we conduct a multi-case study by interviewing senior decision-makers of 10 companies. Following a generic purposive sampling approach [43], we apply pre-defined criteria to identify suitable cases [44]: the company already has deployed a smart service system at least in a mature prototype version, the interviewees are business or technical experts, and they play a significant role in shaping or running the smart service system [45]. Further, the selection is guided by the intention to consider cases of different industries, company sizes, and levels of maturity. For example, we include cases in the machinery and plant engineering industry but also providers of medical equipment and products for the chemical industry (cf. **Table 1**) [46]. The interviews range between 39 and 67 minutes and were conducted between May and July 2021 via video-conference software. All interviews are recorded and transcribed before being coded and analyzed using MAXQDA software. To reduce the subjectivity of interviewing only one person per case, we verified and supplemented the interview data with information available from public sources (e.g., online descriptions of smart service applications).

Throughout the conversations, we follow a semi-structured interview guideline to ensure comparability among the cases, which is particularly important as the interviewees hold different roles within their respective companies. The overarching goal of each interview is to understand the smart service system, i.e., to determine critical value-creating actions, technological features of the smart product, and relevant characteristics of the involved actors. For this purpose, we ask questions to obtain both retrospective and current perceptions from those experiencing and actively shaping smart service systems in practice [43]. After conducting 7 interviews, we already began with analyzing the data. Despite the topic of affordances in smart service systems being far from exhaustively covered, including 3 additional cases did not substantially challenge our elaborated conceptual understanding. Therefore, we interpret the sample of 10 cases as a sufficient level of theoretical saturation for this study's purpose, which seems appropriate to balance between empirical evidence and the volume of data in the context of theory-building case study analyses [46].

Table 1. Overview of 10 interviews with smart service system providers.

Case (mm:ss)	Description of Smart Service System	Role
CarCo (65:43)	Digital innovation unit of a global car manufacturer providing an intermodal mobility platform	CEO/CTO
ChipCo (60:18)	Provider of semiconductor software and chips and further wireless technology solutions	Vice President Technology EMEA
DriveCo (59:48)	Provider of integrated electric drive systems with IIoT-based automation services	Head of IIoT & Service
FilterCo (61:33)	Provider of filter systems and pressure vessels, equipped with IoT-technology	Managing Director
GearCo (67:05)	Provider of electromechanical drive systems for machines with IoT-based monitoring services	Business Developer Digitalization
HealthCo (47:39)	Provider of medical devices with subscription-based software packages	Managing Director DACH
IoTCo (41:07)	Subsidiary firm of a technology company focusing on AI-powered solutions for IoT ecosystems	Product Manager Track & Trace
LaserCo (43:53)	Provider of production machines and software solutions to implement IoT-based smart factories	Product Manager Digital Service
PrintCo (39:28)	Provider of printing machines integrated with cloud-based performance services	Global Head Subscriptions
ValveCo (55:12)	Provider of control valves for hydraulic systems complemented with digital service apps	Director Engineering

After the interviews, we apply qualitative content analysis [47, 48] to our data to identify the actors' goals and organizational context, smart product features, affordances, actualization actions, and immediate concrete outcomes. In a second step–similar to Strong et al. [25]'s analysis of EHR implementation–we synthesize our findings: Aiming for an appropriate and consistent level of granularity, we arrange the coded items as affordances and corresponding actualization processes [36]. Interviewing only one person per case does not allow for claiming completeness of the identified affordances. However, comparing the heterogeneous set of cases allows us to abstract and theorize how smart products give rise to potentials of goal-oriented behavior (affordances) and how actors realize these potentials (actualization processes). Despite a wide variety of additional potentially interesting questions to analyze the data (e.g., interrelations of the affordances), we restrict our analysis to the general mechanisms of affordances and actualization processes in smart service systems as presented in the following section.

4 Affordance-Actualization Processes in Smart Service Systems

In this section, we build on our multi-case study to propose a conceptual framework (**Figure 3)** incorporating affordance-actualization theory [25] as a lens to further evolve the concept of smart service systems [8]. By presenting and discussing six theoretical propositions (P1-P6), we underline certain aspects of the framework and make its implications for the conceptual understanding of smart service systems more tangible. For the most part, these propositions result directly from the combination of the two established frameworks presented in section 2 (cf. **Figure 1** and **Figure 2)** and are further supported by evidence from our case study (cases given in parentheses). Greater adjustments based on empirical findings are mainly made regarding P5. In the subsequent section, we, first, describe affordances in smart service systems (left side), and then present findings regarding the actualization processes in smart service systems and their implications for the conceptualization of smart service (right side).

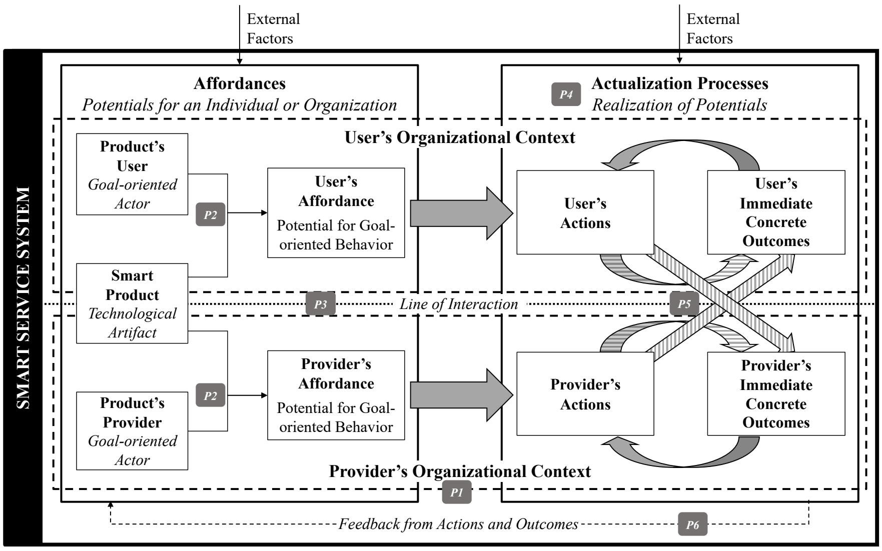

Figure 3. Affordance-actualization framework and propositions for smart service systems.

Past studies on affordances typically only consider the direct user of an artifact. However, "smart products can be interpreted differently by service consumers and service providers, subject to the value proposition that they offer" [8, p. 12]. The interview data arranged as affordances and actualization processes support this as we found that smart product providers increasingly seek to interact with the product during its usage. For example, PrintCo connected most of its customers' machines with a customer spanning IoT-cloud network. Having access to usage data made them "recognize that many customers remain below their potential machine productivity" (PrintCo). They understand this as an affordance to support their customers in using their products, primarily realized through analytics-based service offerings. Hence, we propose that in smart service systems, multiple dimensions of organizational contexts and the contained affordances and actualization processes should be reflected. To illustrate this approach, we consider a product's provider and its user as a basic service system, akin to the conceptualization of smart service systems (**Figure 1**)–acknowledging that smart products can give rise to affordances for 'third parties' as well.

P1: *Multiple organizational actors interact with smart products as they allow for remote access and reconfiguration giving rise to multidimensional affordances (CarCo, FilterCo, GearCo, HealthCo, IoTCo, PrintCo, ValveCo).*

4.1 Actors and Their Affordances in Smart Service Systems

As discussed in section 2, affordances generally arise from the technology-user relationship and are not mere reflections of the technology itself. This ontological theme offers a useful perspective on smart service systems: As the product manager of IoTCo's track and trace solutions points out, making a 'thing' smarter, i.e., increasing its technological capabilities, is not an end in itself. It is rather the combination of these features with an actor's goals and organizational context that might give rise to goal-oriented behavior. During the journey of learning about the user's goals and context, his team came to realize that the offered artifact fits better for tracking load carriers than the asset itself, as this provides more potential for decreasing costs and increasing transparency in the business context of the product's users. Multiple interviewees referred to the importance of turning this view into action by deliberately approaching well-trusted customers with suitable goals and organizational context to pilot smarter versions of their product to understand which affordances are perceived. This early-stage feedback process helped the companies to purposively promote the potential of these identified affordances–regardless of whether they were anticipated or not.

P2: *Desirable potential actions enabled by smart technology arise from the technology-user relationship, not only the smart product's features itself. (CarCo, ChipCo, DriveCo, FilterCo, GearCo, HealthCo, IoTCo, PrintCo)*

Next, we examine whether the formation and perception of affordances take place at the intersection of multiple organizational contexts. As our conceptual framework serves as a rather static portrait of a smart service system's mechanisms of perception and action, we argue that affordance as a potential for action is separated by the line of interaction spanned by the smart product as a boundary object. However, the actions in actualization processes, then, can and often do cross the line of interaction. Few of the examined cases emphasize dividing even the overall affordance-actualization process along the distinct organizational contexts, thus using the smart product as a true boundary object. This allows the product's provider to "standardize their offerings allowing for a better scalability of the smart product business model" (IoTCo). In our interview sample, we see tendencies for the more mature a solution is, the more independently different actors interact with the smart product (e.g., PrintCo, HealthCo and IoTCo). In contrast, companies who still extensively explore technological possibilities typically closely collaborate with their smart products' users (e.g., FilterCo, DriveCo, ValveCo).

P3: *Actors interacting with the smart product perceive affordances largely independently as smart products serve as a boundary object at the line of interaction. (GearCo, HealthCo, IoTCo, PrintCo)*

4.2 Smart Service as an Actualization Process

We now turn towards the actualization processes as mechanisms to realize the discussed affordances. First, the multi-case study substantiates our assumption that a distinction between affordances and their actualization seems appropriate. The interviewees in our sample name multiple actualization actions such as identifying a suitable combination of hardware and software packages for the individual customer (HealthCo), installing the smart product at the user's site (IoTCo), handling and processing the accessible data (LaserCo, CarCo) or making value-adding suggestions for improvement of the user's processes based on analytical insights (PrintCo). This extension of the conceptualization of smart service systems provides a clearer description for theory and practice, as it further clarifies distinctions between potentials, actions, and outcomes.

P4: *Due to the artifact's complexity, affordances enabled by smart products require coordinated actions, i.e., actualization processes, to realize their potential. (CarCo, DriveCo, FilterCo, HealthCo, IoTCo, LaserCo, PrintCo)*

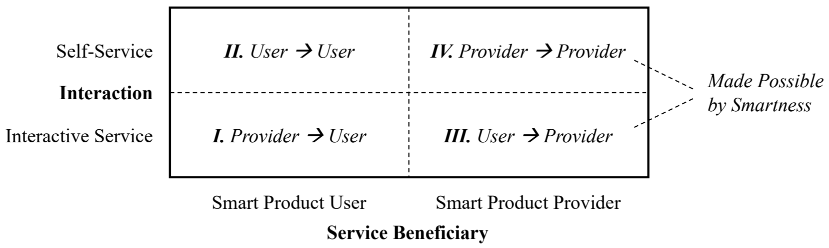

Figure 4. Classification of smart service constellations in smart service systems.

We identify cyclic processes of actions and immediate concrete outcomes in smart service systems: In the case of CarCo, increasingly connected cars drive the transition in the industry's development practices from multi-year lifecycles towards a continuous improvement via software updates. One of our most promising findings builds on this insight: separating the action potential from its realization operationalizes the conceptual understanding of 'smart service'. Comparing different cases, we found that some affordances can be realized within an actor's organizational context ('self-service') whereas others require crossing the line of interaction ('interactive service'). Further, by looking at the outcomes we observed that not only the smart product's user but also its provider can obtain 'value-in-use'–and not only value-in-exchange [49]. This notion challenges existing categorizations in 'service providers' and 'service consumers' (cf. **Figure 1** [8]). Hence, in this study, we instead distinguish between the smart product's provider and the user. In the examined cases, we find examples of all potential combinations resulting in four constellations of smart service in dyadic smart service systems, as illustrated by the hatched arrows in **Figure 3** and the matrix in **Figure 4**.

As an illustration, one case now experiments with a "shadow mode" where the user initially gives his consent to the provider (III) to autonomously collect usage data to improve their analytical models and understand the customers' processes (IV). After some time, the provider leverages this knowledge by creating customized offerings and rewards the user by offering performance-improving service free of charge for a limited amount of time (I). Besides these individualized offerings, the user can use standardized service offerings enabled by smart technology such as monitoring the condition of the product and accessing historical sensor data without further interaction (II). While this notion is in line with the definition of 'smart service' given in section 2, we acknowledge that this simplified classification neglects important aspects such as the co-creation of value for both actors and the role that third parties might play. Thus, we suggest further research to critically examine and potentially extend this classification.

P5: *Both actors can be the beneficiary of smart service by achieving an immediate concrete outcome. Further, both can actualize affordances for their own benefit (self-service) or some other actor's benefit, thus, crossing the line of interaction (interactive service). (Combined evidence from all cases to develop the classification)*

Finally, the immediate concrete outcomes achieved through actualization do not only trigger further actions to realize already existing affordances but can also change the initial agencies and affordances via feedback loops–at least across a larger time frame: After the initial release of their smart product, ValveCo understood that the built-in memory space severely constrained value-adding activities, which led them to replace the initial hardware with an electronic interface card, and ultimately, realize multiple new smart service potentials. This proposition might be particularly interesting for research on smart service systems when taking a dynamic perspective to better understand how consecutive actions iteratively shape the configuration of smart service systems by adjustments of the actors' goals or the smart product's features.

P6: *The actions and outcomes of actualization processes provide feedback affecting the actors, their organizational context, and the smart product's features, giving rise to new affordances. (CarCo, DriveCo, FilterCo, GearCo, IoTCo, PrintCo, ValveCo)*

All in all, our qualitative analysis supports the proposed conceptual framework and demonstrates how an affordance-actualization perspective may contribute to an understanding of the smart service system phenomenon. The heterogeneity of our sample allows us to highlight different aspects as discussed along the six propositions. Particularly the different levels of maturity between cases have a large impact on the richness of information regarding the discussed topics. However, this qualitative conceptual research only serves as an initial step towards theorizing affordances in smart service systems and should be complemented by additional empirical research.

5 Discussion and Conclusion

Smart physical products increasingly shape a connected IoT world and serve as boundary objects for the formation of smart service systems. While these systems bear the potential to co-create value between partners in various industries, IS research still struggles to fully capture the phenomenon to support successful digital innovation in IoT settings. In this work, we analyze the phenomenon of smart service systems taking an affordance-actualization perspective. Based on a qualitative content analysis of a multi-case study, we identify elements and propositions towards a mid-range theory for smart service systems as a basis for further research in the IS discipline. We suggest that providers and users of smart products not only realize their own affordances via their actions but also may affect the outcomes of other actors in the service system. In this final section, we point out the limitations of our study, discuss the theoretical and managerial implications of our findings, and highlight avenues for future research.

The results presented in this article certainly are subject to *limitations*. First, our case study lacks considering multiple perspectives within each case: we restrained our sampling approach to providers of smart products and only interviewed one person per case. Adding more interviewees to the sample would enhance a better understanding of the organizational context(s) and collective actions in each case. However, to reduce this subjectivity, we verified and supplemented the interview data with information available at public sources. Further, conducting only one interview per person–despite asking for the case's historical development–somewhat impedes understanding the dynamics within each case. Thus, having multiple sequences of interviews per case at different stages of maturity would certainly improve the findings on affordances, their actualization and feedback loops, and particularly how they influence each other over time. Finally, the framework was developed after conducting most interviews, which is why this article does not provide a critical evaluation of the framework with practitioners.

These limitations at the same time leave the potential for *future research* that can contribute to answering our research question. Particularly, testing and extending the proposed findings by conducting an in-depth longitudinal case study could be a useful extension [50], which we aim to conduct in the future. By examining a chronological timeline of events in a real-world case, one could not only further illustrate the general utility of affordance theory in the context of smart service systems but could also further develop our proposed framework. It seems particularly promising to examine the interrelations and interactions of affordances that are characteristic of smart products. This could provide valuable insights to analyze and understand the 'imbrication' of human and material agencies shaping smart service systems over time [22].

Our study offers *theoretical implications* to the ongoing debate on co-creating and realizing value through digital innovation. We underpin and extend Beverungen et al. [8]'s conceptualization of a smart service system. By taking an affordance-actualization perspective, we explain how smart products give rise to affordances for multiple actors in the system and how these potentials can be realized. With this mid-range approach, we hope to inspire further conceptual research on this relevant phenomenon. Moreover, our work underlines the scientific potential of examining smart service systems, as technology rapidly advances, and more mature cases can be subject to empirical research.

To establish a theory of affordances in smart service systems, we want to point out some *unresolved theoretical issues* beyond our research question. First, in line with current discussions in service science [51, 52], we ask whether a dyadic juxtaposition of a 'provider'/'producer' and a 'user'/'consumer' accurately reflects prevalent actor constellations in smart service systems. Today's service research increasingly turns to rephrasing these constellations as 'actor to actor' networks. As a first step towards this notion, we replaced Beverungen et al [8]'s service-focused role names for smart service system actors with names describing the actors' relation to the smart product., as our data suggest that both actors can be a beneficiary of smart service (cf. **Figure 4**).

Second, the taken dyadic micro-level perspective does not adequately reflect the complex organizational actor networks forming smart service systems. Thus, we encourage future research to extend our model by applying a (service) ecosystem perspective. A more detailed case study considering affordances and actualization processes of multiple actors in a smart service system could be a fruitful starting point (e.g., a smart product provider, smart product user, third-party service providers and beneficiaries, support service providers). Another possibility would be to investigate shared affordances of closely intertwined smart products like in smart manufacturing networks.

Third, our study neglects the potential of multiple actors aligning their actualization actions, which might be a valuable perspective to operationalize the understanding of value co-creation in smart service systems. Hence, it might be interesting to further investigate the interaction in the joint sphere of smart service systems and how such interaction can be purposefully promoted–e.g., by building trust among actors or formalizing governance mechanisms [49, 53]. If all these research issues can be resolved, the results might also contribute to general affordance theory by adapting and expanding the theory's implications from an organizational towards an (eco-)system-level where multiple actors and technologies jointly give rise to and realize affordances. However, this theoretical transition requires interdisciplinary research efforts in the future where IS research seems highly suitable to integrate different perspectives.

Finally, we consider our results also as useful for *practitioners*. First, a differentiation between affordances and their realization can be a valuable construct for decision-makers to analyze possibilities presented by smart technology. Further, consciously articulating expected outcomes of participating in smart service systems supports more efficient management of digital innovation within and beyond the organization [18, 54]. Particularly, our understanding of smart service can inspire practitioners to rethink traditional roles of providers and consumers, as smart products and their connective capabilities allow novel value-creating actor constellations. Overall, applying affordance theory and the presented affordance-actualization perspective to the relevant phenomenon of smart service systems holds great potential for researchers to create meaningful theory and artifacts to support managers in solving practical problems in the future.

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