A digital servitization framework for viable manufacturing companies

Maria Vincenza Ciasullo
Department of Management and Innovation Systems, University of Salerno, Fisciano, Italy;
Department of Management, University of Isfahan, Iran and Swinburne University of Technology, Sarawak, Malaysia, and
Francesco Polese, Raffaella Montera and Luca Carrubbo
Department of Management and Innovation Systems, University of Salerno, Fisciano, Italy

Abstract

Purpose – The purpose of this paper is to understand the strategic management of a technology-enabled shift from a product-centric to a service-centric logic and to identify the sociotechnical dynamics underlying this transition. The study focuses on how manufacturers manage to create value in industrial markets through digital servitization.

Design/methodology/approach – An abductive research approach is used to investigate two manufacturing firms, and an interpretive framework is used as an analytical template. A cross-case analysis is conducted.

Findings – The case companies strategically managed sociotechnical processes of digitization to co-create value. Their service orientation delineates dissimilarity in terms of digital servitization. It reflects a viable ecosystem that moves toward datatization through adaptation in one case and a viable ecosystem that moves toward digitization through reconfiguration in the other case.

Practical implications – A theoretically grounded, empirically informed framework is proposed to detect transformational mechanisms to manage value co-creation in digitally servitized contexts, thus contributing to ecosystem viability.

Originality/value – This is the first study to adopt a system perspective such as the viable system approach combined with service-dominant logic to reconceptualize the overall sociotechnical processes and the underlying mechanisms leading to digitized value creation. In line with a systems view and a systematic process based on a transformative attitude toward digital servitization, the empirically informed framework identifies specific co-creation activities and recursive feedback loops.

Keywords Value co-creation, Manufacturing firms, B2B markets, Digital servitization, Viable system approach

Paper type Research paper

1. Introduction

The current era is marked by perpetual change, high uncertainty and growing complexity fueled by the digital revolution (Savić, 2019). Emerging technologies (i.e. internet of things [IoT], blockchain, big data, cloud computing platforms and robotics) have made possible strong connectivity among people and organizations in interactive ecosystems where unprecedented value can be created and exchanged (Ramaswamy, 2020). The transition toward digitization has generated profound changes in the managerial mindset, organizational layouts, relationship management and decision-making processes (Kowalkowski *et al.*, 2013; Breidbach and Maglio, 2016). Organizations competing in business-to-business (B2B) markets are not immune to these transformations because digitization alters value communication, appropriation, measurement and representation. Technology breakthroughs, triggering a new mindset, push digital servitization, i.e. the use of digital technology to sustain the shift from a product-centric to a service-centric logic (Coreynen *et al.*, 2017). The transition to service seems far from easy because it adds complexity that entails changes in business orientation (Sklyar *et al.*, 2019), as well as a reconfiguration of value creation processes (Hakanen *et al.*, 2017).

The literature has identified three research gaps in this research stream. First, the digital servitization of industrial companies, especially in manufacturing settings, remains under-investigated (Paschou *et al.*, 2018; Kohtamäki *et al.*, 2020). In this field, B2B is studied less than business-to-consumer (B2C) given the greater complexity of industrial markets in terms of resource heterogeneity, changes in contextual conditions, mistakes, conflicts and misalignments

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among actors (Gebauer *et al.*, 2020). Second, scholars have called for theoretical development based on conceptual pluralism and the use of well-established theories from adjacent mature fields to endow servitization-related research with higher-order components (Kowalkowski *et al.*, 2017; Luoto *et al.*, 2017; Kohtamäki *et al.*, 2019). Third, several studies have investigated dyads, neglecting the higher levels of analysis required to further develop servitization theory, as a digital transition to service not only occurs within a manufacturer and its customers but also requires involving suppliers, partners and even competitors, thus calling for multiple and interacting co-creation links (Martin *et al.*, 2019).

Such gaps inevitably increase the complexity faced by scholars and B2B organizations in identifying which theoretical approaches and practices are effective in harnessing the potential of digitization in servitization research.

Against this backdrop, the present paper aims to understand the strategic management of the technology-enabled shift from a product-centric to a service-centric logic and to identify the sociotechnical dynamics underlying this transition. Accordingly, the leading research question is *how do manufacturers manage digital servitization to create value in industrial markets?*

Theoretically, to accomplish the complexity in which digital servitization is rooted, a systems approach is adopted (Barile *et al.*, 2012a; Barile *et al.*, 2016). Accordingly, B2B is considered a system because actions depend on and influence other actors' actions, entailing mutual dependence among inter- and intra-systemic actors' interactions (Gummesson and Polese, 2009; Polese *et al.*, 2017a). This perspective is extended to the marketing literature by the viable systems approach (VSA) (Golinelli, 2010; Barile and Polese, 2010). These themes are echoed by service-dominant (S-D) logic, where value co-created by actors influences ecosystem viability (Vargo and Lusch, 2011; Polese *et al.*, 2017b). Thus, an interpretive framework of digital servitization is defined that combines VSA and S-D logic to reconceptualize the overall sociotechnical processes and the underlying mechanisms leading to digitized value creation. Empirically, we designed a qualitative study involving two B2B manufacturing systems to explore how key drivers can lead to the emergence of different digitized outcomes.

The paper contributes to the body of knowledge on both servitization and digitalization in three ways. First, this research field is endowed with a greater conceptual component, as the findings reveal the contribution of service orientation to digitization in manufacturing. Thus, we suggest that digital servitization implies changes occurring in focal firms and other actors, engaging the whole service ecosystem in transformations to achieve viability. Second, we provide a theoretically grounded, empirically informed framework to detect the transformational mechanisms needed to achieve and manage value co-creation in digitally servitized contexts. Third, we provide additional research on the micro-foundations of value co-creation, analyzing the activities co-created between interacting actors and identifying specific digital servitized pathways that revisit service exchange through new value-creating opportunities enabled by digital technology (Paschou *et al*, 2020).

The article proceeds as follows. Section 2 contains a literature review on digital servitization and describes the interpretive framework proposed to reread the phenomenon. Section 3 explains the research methodology. Sections 4 and 5 outline and discuss the research findings. Finally, Section 6 proposes the main study implications.

2. Theoretical background

2.1 Digital servitization

The interplay between digitization and servitization falls under the umbrella of digital servitization (Kohtamäki *et al.*, 2020; Paschou *et al.*, 2020). This term refers to how digital technologies enable the delivery of advanced services in innovative ways (Kohtamäki *et al.*, 2019). Digital servitization requires digitization, which means converting analog information into a digital format (Ng and Wakenshaw, 2017). Its innovativeness depends on digitalization, which refers to the combination and recombination of digital technologies to create and harvest value in new ways (Svahn *et al.*, 2017). A wide range of digital systems and interfaces (i.e. IoT, big data, artificial intelligence, cloud computing, etc.) (Rymaszewska *et al.*, 2017) need to be managed to shift from a product-centric to a service-centric logic (Sklyar *et al.*, 2019).

Previous research has highlighted both opportunities and challenges for industrial organizations in undertaking digital servitization, although this research stream is in its infancy (Kohtamäki *et al.*, 2020). Focusing on opportunities, manufacturers can exploit digital servitization to enhance both internal and external processes. Internally, manufacturers can improve operational efficiency through automation (Coreynen *et al.*, 2017). Externally, digitization enables companies to integrate their processes with customers' value processes, generating innovative solutions for competing in complex markets (Ulaga and Reinartz, 2011; Grandinetti *et al.*, 2020). To respond to challenges, companies need to reconfigure their organizational behaviors. In the cases of separate service/product units, it is a challenge to balance the interests of such units to achieve a consistent decision-making process (Vendrell-Herrero *et al.*, 2018). Another challenge concern unlearning an obsolete product-related mindset and routines in favor of service orientation and behaviors to increase customer value (Storbacka and Nenonen, 2015). This requires significant investment in Industry 4.0, coupled with the recruitment of people with the capability to harness digitalization (Kohtamäki *et al.*, 2019). Moreover, there is a need for investment in relationships because transactional product-centric relationships must be revised and adapted to interactions (Reim *et al.*, 2018). Hence, digital transformation implies boundary-spanning activities that lead to the establishment of new partnerships (Tronvoll *et al.*, 2020). Nevertheless, manufacturers seem to struggle with the deployment of digitization. Industrial marketing scholars have highlighted the need to understand the strategic configurations that industrial companies must orchestrate to achieve digital servitization (Kohtamäki *et al.*, 2019). Moreover, the literature contends that digital servitization can emerge from tightly coupled interactions among technological innovations and collaborative innovations.

On this basis, we argue that industrial organizations need to innovate both their market offerings and business processes by embracing an all-encompassing service mindset grounded on open organizational models and co-developing digital capabilities through complex patterns of coordination, cooperation and integration.

2.2 Theoretical roots of digital servitization framework

To interpret digital servitization, S-D logic and VSA are combined as the theoretical foundations.

S-D logic (Vargo and Lusch, 2008, 2016, 2017) is a scientific-cultural approach that aims for value co-creation in systems of service-for-service exchange based on the premise that service – the application of one actor's resources for the benefit of another – is the foundation of social and economic exchanges. S-D logic portrays markets as dynamic and socially constructed systems that are driven by resource integration (Akaka *et al.*, 2012). VSA embraces a holistic view halfway between viewing organizations as a set of interacting components and the willingness to explore ways to survive in evolving environments (Barile and Polese, 2010). It is based upon viable systems, as interacting service systems are dynamic configurations of resources connected internally and externally through value propositions (Maglio *et al.*, 2006; Barile *et al.*, 2012a).

On the one hand, S-D logic is used to understand manufacturers' shift from a traditional value-in-exchange product orientation to a servitized value-in-use interactional orientation. More specifically, S-D logic constitutes a revealing lens to understand value as co-created within the digital servitization context. Co-creation of value is intended as a complex, "joint, collaborative, concurrent, peer-like process of producing new value, both materially and symbolically" (Galvagno and Dalli, 2014, p. 644). On the other hand, the key theoretical insights of VSA are considered.

First, VSA embraces a constructivist view according to which each entity builds the observed reality according to its own information variety (Barile, 2009). In fact, any observed phenomenon can be investigated by analyzing the parts of a system and the whole system (how it is made) and by interpreting its dynamics as an open system (how it behaves) (Barile *et al.*, 2016). System behavior can be understood by identifying other relevant systems and the multiple influences that they exert on the focal system. Such systems shape interconnected networks that can create new entities and innovative episodes of mutual value creation.

Second, VSA refers to the conditions for viability, defined as the ability of a system to restore its point of equilibrium within a specific relational context, in which sub-systems and supra-systems are harmonically integrated, survive and co-evolve (Barile *et al.*, 2013). This implies that their expectations and goals need to be harmonized to enable effective service-for-service interactions. This aspect allows us to recall the notions of consonance and resonance that foster the viability of the system as a whole (Barile and Polese, 2010).

Third, VSA addresses the role of decision-making for system viability, which is particularly relevant in value co-creation contexts under uncertain conditions. Based on the ability of management to decide and creatively resolve intricate problems, a system can react and adapt to changes (Polese *et al.*, 2017b).

2.3 Digital servitization framework design

By integrating S-D logic and VSA in the digital servitization domain, specific dynamics are contemplated. The focus is broadening the strategic role of the value creation process in ensuring ecosystem viability (Polese *et al.*, 2018a). Thus, a holistic understanding of digital servitization is proposed to break the complexity of the phenomenon into smaller and more manageable building blocks named antecedents, viability mechanisms and outcomes (Figure 1).

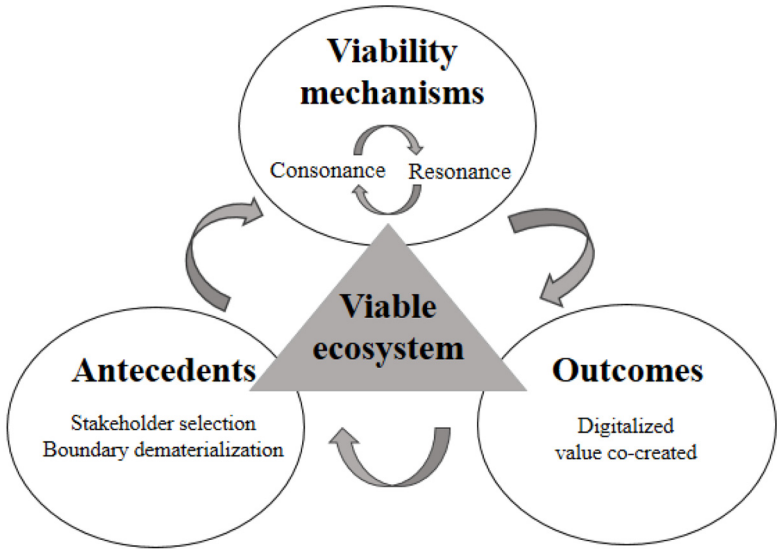
The framework represents an iterative and nonlinear process that dynamically evolves through the interplay of the building blocks. Additionally, the framework has a multidirectional nature because the building blocks exist in a state of dynamic interdependency. The conceptual foundations of the framework support this multi-directionality: S-D logic considers value co-creation a cyclical interactive process (Powers *et al.*, 2016), while VSA suggests viability mechanisms that can shape the self-adjustments of systems. Therefore, changes to any building block can ripple through the framework in a variety of directions.

2.3.1 Antecedents

Stakeholder selection consists of selecting the various supra-systems according to the critical resources they own and their influence on the system's viability (Barile and Polese, 2010). The relevant resources for viable systems are operant resources consisting of a knowledge endowment that expresses value, not in itself (objectively) but through its use (as the value in use) (Vargo and Lusch, 2011). This implies interactions with other viable systems that possess those resources to gain access to them (Barile and Saviano, 2013). Moreover, stakeholders' selection is oriented toward supra-systems that comply structurally with the organization and have a set of values that are widely shareable, fostering stable inter- and intra-systemic relationships. Once such relationships are established, the supra-systems become actors embedded in the emergent relational context as a limbo that contains potential partners such as suppliers, customers, investors and other co-makers. Sub-systems refer to the physical organizational structure, including operand and operant resources (i.e. equipment, facilities and people).

Actors are service-providing and value-creating entities that engage in value propositions with other entities leveraging digital platforms. The system embraces a diversity of actors as viable systems (Barile and Saviano, 2013) with different goals but the same need to survive in a specific context (Polese *et al.*, 2017b). These entities accommodate both human (people) and non-human (machines and technologies) actors rooted in systemic value co-creation (Breidbach and Maglio, 2016). Thus, the role of non-human actors challenges the conventional view of technology, emphasizing that digital is more than a mere mediator of B2B transactions because it gives rise to new value-creating opportunities (Kaartemo *et al.*, 2019). This mixture of humans and smart solutions open business relationships to complex and rich interaction patterns ranging from dyads to triads and ecosystems (Storbacka, 2018).

Figure 1 Digital servitization framework



Source: Authors' elaboration

When resources from multiple sources are integrated into a specific context, actors become agents of value co-creation (Vargo and Lusch, 2016). Rather than being manufactured and delivered, value is co-created by involved actors willing to collaborate to improve this integration process. Thus, value co-creation broadens two-way supplier-firm or firm-customer interactions to various relations of artifacts, processes, interfaces and persons (Ramaswamy and Ozcan, 2018). Actors provide benefits to other parties involved in the exchanges and contextually generate positive effects for the whole system to which they belong, looking ahead to results in the medium and long term (Polese *et al.*, 2017b). Service interactions foster the emergence of a viable ecosystem in which the value of the whole system is greater than the sum of the value of its parts. An actor represents the "foundation resource," the "key determinator" (Tronvoll, 2017, p. 8) in-service ecosystems because he/she/it performs roles not performed by other resources or processes. Finally, actors can be present in other actors' processes; this enables new types of organizational structures, institutions and practices that become more malleable, paving the way for ongoing innovations.

The gradual fulfillment of common value creation involving different actors blurs distinctions between focal enterprises, other enterprises and the environment (Barile *et al.*, 2016). According to VSA, boundaries can be identified only at a structural level, as they vanish at a systemic level (Barile *et al.*, 2012b). System organizations should open their boundaries to collaborate and co-evolve along with their relevant stakeholders (Polese *et al.*, 2018b). Hence, a digital transition to service requires the capacity to co-create across firm boundaries, as smart solutions must be designed to interact with the solutions of other firms used by customers, delivered by distributors, maintained by partners and operated by third parties (Sklyar *et al.*, 2019).

This leads to boundary dematerialization, referred to as open connections within and among sociotechnical systems for the exchange of resources. In addition, dematerialization is strengthened by resource density in terms of the degree to which the technology-enabled mobilization of resources takes place (Normann, 2001). The huge availability of data and advanced analytics allows new systemic collaborative structures that blur traditional actors' roles, making access to both physical and sociocultural resources relatively easier and cheaper (Storbacka *et al.*, 2012). Moreover, digitization provides endless opportunities for the liquefaction of resources, which means decoupling from their physical form, allowing them to be easily moved and accessed in any time and space (Storbacka, 2018).

2.3.2 Viability mechanisms

Consonance and resonance act as crucial mechanisms among system elements and the relational context to achieve viability (Barile and Polese, 2010). While consonance reflects the interacting actors' abilities to optimize available resources in their interaction episodes, resonance represents the virtuous orientation toward increasing returns over time (Barile *et al.*, 2012a). Consonance defines the condition for effective interaction, making entities aware of belonging to the same context with mutual goals. Moreover, it refers to the compatibility or configurational fit between systemic actors in terms of shared value categories providing resource compatibility. When different actors harmonically collaborate to achieve a common purpose, consonance emerges from the relation by ensuring stability and growth for the parties involved (Gummesson *et al.*, 2010).

Resonance is a behavioral mechanism describing interaction success that increases system viability (Polese *et al.*, 2018a, 2018b, 2018c). In the digital servitization context, actors should play an active role in jointly creating value (Sjödin *et al.*, 2020). Value is co-created when actors' interactions are based on a structural consonance that leads to value alignment for achieving shared purposes (Barile *et al.*, 2016). Key aspects are the mutual exchange and integration of resources – such as capabilities, skills, information and experience – in the actors'

reality (Vargo and Lusch, 2008). In sum, a system is viable if it is able to create and sustain inter- and intra-systemic relationships through synergic resource integration and to seek cooperation by adhering to a win–win logic, thereby facilitating a range of co-creative activities (Polese *et al.*, 2018b). Moreover, to achieve viability, the system has to preserve its stability through complementary feedback mechanisms (Batista *et al.*, 2017).

This set of viability mechanisms allows a system facing variety to preserve its stability through a range of activities related to adaptation, transformation and reconfiguration at the organizational, business and identity levels (Barile, 2009). These activities depend on actors' ability to subjectively analyze the environment and to proactively influence it. This proactive condition supports viable value co-creation because it stimulates consonance, improves co-creative activities and allows cognitive and profitable alignment (Pels *et al.*, 2014). In other words, this capability refers to decision-making under complexity (Barile, 2009). It should improve dynamic and continuous learning, in which knowledge is continually reorganized and adapted, into a higher-level learning process. Therefore, the learning process should involve other actors because the aim is not only learning within the system but also as a system (Storbacka and Nenonen, 2015). Decision-making needs to ensure a real-time and circular exchange of knowledge among all actors (Ciasullo, 2018; Polese *et al.*, 2018c) with the aim of fostering informative and cognitive alignment. Each actor should be guided by a collaborative spirit and feel that he/she is an integral part of a net of relationships oriented toward value co-creation. Harmonic and more diffuse decision-making takes place within the co-creation process because the strategic direction involves all actors in the co-development of innovations and generation of ideas for product-service integration and provision (Lusch and Vargo, 2014).

2.3.3 Outcomes

Outcomes of the co-creation process are related to the value whose systemic nature makes it subjective (the process cannot be measured as embedded in objects and is evaluated by adopting a specific perspective) and emergent (it cannot be evaluated with a static and structural perspective but needs a dynamic and systems view). In addition, the value is contextual (the process through which it is created dynamically depends on the conditions of the relational context) and interactional (implying a multi-actor process).

Outcomes for manufacturers overcome the economic value of the financial benefits due to digital servitization (Martin *et al.*, 2019). As the servitization literature states, digitization is intended to enable more effective and efficient value creation and capture through a variety of software components, thereby implementing smart platforms (Kohtamäki *et al.*, 2020). This implies that outcomes derive from multiple interactions in terms of value that are obtained from investments in digitization and captured by interacting actors according to their real expectations of growing mutual satisfaction (Polese *et al.*, 2017a). Both strategic and relational value emerge. Strategic value reinforces higher competitiveness (i.e. access to new markets) because it is based on knowledge comprising the innovation opportunities deriving from digital servitization (i.e. customer knowledge, user knowledge, and external market knowledge). As the knowledge endowment of interacting viable systems influences the outcomes of the co-creation process, such outcomes can be read as cognitive processes that characterize the functioning of viable systems (Barile and Saviano, 2013). Relational value refers to the legitimacy of the manufacturer to manage relationships with several actors, aligning their positions and activities around common value creation in a process of resource sharing aimed at developing synergies in the creation of a new value proposition at the core of the system (Barile *et al.*, 2013). On this basis, there is a need to consider value multidimensional, requiring its analysis in light of the viability mechanisms among interacting actors.

3. Methodology

3.1 Research strategy

Given the limited research on digital servitization in manufacturing companies (Paschou *et al.*, 2018; Kohtamäki *et al.*, 2020), we adopted an abductive research strategy based on an integrated approach to the theory, literature, and emerging data (Dubois and Gadde, 2002, 2014), constantly moving "back and forth between a set of observations and theoretical generalizations" (Tavory and Timmermans, 2014, p. 4). More in-depth, we used S-D logic and VSA approach as sensitizing concepts to help us set the direction of our study. These theoretical lenses enabled us to propose an interpretative framework as a general sense of reference and guidance in which the main dimensions (i.e. building blocks) are proposed. By switching from theory and empirical observations several times, we applied the framework proposed, and then enriched it through an in-depth case analysis (Gummesson, 2017). We then returned to the theory to apply our new findings to the existing literature, highlighting our contribution. This implied matching of different research activities to expand the understanding of the theory and empirical context since empirical findings and theoretical considerations are alternated and combined, providing a holistic and rich description of digital servitization in industrial settings.

3.2 Research setting and data collection

An exploratory case study research design included two B2B companies and a cross-case analysis (Eisenhardt and Graebner, 2007). Adopting the viewpoint of the focal actor, an in-depth investigation was performed to analyze how manufacturers manage digital servitization to create value in industrial markets. We relied on criterion-based theoretical sampling by defining screening parameters to identify suitable cases. The parameters were being B2B companies; belonging to the manufacturing industry; being large organizations according to the European Union (i.e. firms with 250 or more employees), with smaller firms excluded based on the assumption that they were not yet ready for a full digital transformation (Ghobakhloo, 2018); having pursued digital servitization over the previous five years; and has received awards in the digital domain. The cases were chosen through an internet search using many keywords (e.g. digital servitization, manufacturing, Industry 4.0 and service 2.0) to identify and select information-rich cases (Russo Spena and Mele, 2020). The companies selected under these criteria were identified as "Alpha" and "Beta" to preserve confidentiality. Both are multinational

manufacturers with headquarters in Europe. Alpha's core offering is based on alcoholic beverages. Beta is an original equipment manufacturer (OEM) that provides industrial and commercial vehicles (Table 1).

Data collection lasted 7 months between 2019 and 2020. Drawing on Yin (2017), multiple data sources were used to ensure construct validity through data triangulation, as recommended for industrial marketing case studies (Goffin *et al.*, 2019). Secondary sources included annual reports and internal documentation, as well as company magazines and business publications and websites. Primary sources consisted of 26 in-depth interviews with key informants across various functions and organizational levels in the two case companies to capture alternative views about the digital servitization transition. To preserve confidentiality, individual informants were anonymized (Table 1).

The primary data were collected through exploratory interviews with the help of a semi-structured interview guide aimed at ensuring a comprehensive understanding of the changes – in terms of the antecedents, viability mechanisms, and outcomes – affected by digital servitization (Appendix). The interview design included the introduction and general questions followed by specific ones to contextualize the research aim. They addressed the following insights: challenges and problems experienced by firms; factors that triggered digital servitization and how it has changed the intra- and inter-systemic relationships, i.e. within and among internal departments, customers and/or other players (such as suppliers and service providers); main changes in the structure of relational context occurring after digital servitization; practices of value creation occurring with customers and other players, and their impact on other actors' resources and activities; how these practices were managed; finally, effects generated by digital servitization.

The interviews, which lasted approximately 50 min and were conducted by Skype, were based on open-ended questions, giving to interviewees the freedom to answer, to cover a detailed description of transformations required by digital servitization, and to introduce new elements encouraging the emergence of new issues and questions. The taped interviews were transcribed verbatim and their collection and analysis took place simultaneously. Follow-up discussions by e-mail were used to clarify and validate issues.

3.3 Data analysis

We conducted a nonlinear data analysis process, in line with a systematic combining approach, in which "theoretical framework, empirical fieldwork and case analysis evolved simultaneously" (Dubois and Gadde, 2002, p. 554). Following this approach, data analysis was based on thematic analysis that provided ways to identify patterns in a large and complex data set, and effectively and accurately identify links within analytical themes and overarching dimensions (Braun and Clarke, 2006). In so doing, we performed three interrelated phases. The first phase focused on an in-depth analysis of the collected interviews. Each interview was analyzed and coded both deductively, using the sensitizing concepts to "lay the foundation for the data analysis" (Bowen, 2006, p. 14) and inductively to unfold new concepts (Gioia *et al.*, 2013). Then, codes emerged by matching empirical data and the main dimensions of our interpretative framework (i.e. building blocks) to detect the structural and systems dimensions of digital servitization and were repeatedly revised. These codes constituted the foundation for the development of the first-order categories during the second phase. The latter consisted of comparison, grouping and in-depth examination of the relationships among codes and first-order categories. During the first two phases, the authors first coded individually and then compared the coding results, thereby ensuring a high degree of inter-coder reliability. Data analysis and coding process were compared, and if disagreements occurred, discussions followed to improve coherence.

In the third phase, the first-order categories were examined and used to discover links and patterns within them. Such iterative process generated second-order themes that

Table 1 Case companies' profile and data collection

	Alpha	Beta
Main offering	Beer, wine and cider	Trucks and light commercial vehicles
Size	Employees: 266 Revenue: €26.8m	Employees: 302 Revenue: €110.4bn
Main industrial markets	Europe, Americas	Europe, Americas, Asia Pacific
Location of the unit interviewed	Spain	Italy
Number of interviews	12	14
Informant position	General manager: 1 Software specialists: 2 Tool managers: 4 Customer solution manager: 1 Regional manager: 1 Sales director: 1 Marketing manager: 1 Technology manager: 1	General manager: 1 Digital services manager: 1 Service engineers: 2 Platform development managers: 3 Vice president of customer segment: 1 Integrated operations manager: 2 Global technical support manager: 1 Embedded systems coordinators: 2 Research and development manager: 1
Interview length	45 min	50 min
Interview type	Online	Online

Source: Authors' elaboration

adequately captured the phenomena observed in the first-order categories. In this phase, the goal was to identify the enabling mechanisms and their dynamic interplay involved in digital servitization patterns. To meet theoretical aims, in the description of the findings the main mechanisms are grouped into the key dimensions, which then provided the structure for how the themes converged into dimensions of our interpretative framework. They captured the structural and systemic adjustments of investigated systems to improve value co-creation in digital servitized contexts. Thus, the key dimensions represented a theoretically and empirically grounded categorization. Figure 2 shows the entire data structure resulting from the data analysis. This step of the data analysis was conducted conjointly by the authors, who thoroughly discussed the data structure, assessing for further linkages between key dimensions, second-order themes and first-order categories across cases (Table 2). Case comparison allowed us to further refine our data structure and create an overall framework (Figure 3) to explain how the complex socio-technical processes were handled to generate innovative digitalized outcomes.

4. Findings

The following Sections 4.1 and 4.2 provide case descriptions that explain each of the key dimensions as core pillars of the transition to digital servitization. This is also supported by Table 2 that provides a summarized overview of the representative quotes for each case company.

4.1 Alpha

4.1.1 Setting the condition for value co-creation

In the predigital servitization state of Alpha, a product-centric logic dominated due to inefficiencies in the management of service activities. This logic negatively affected the overall quality of the service delivery and the opportunities for tailoring solutions offered to business clients, such as mass-market retailers and hotel, restaurant and catering (HoReCa) players. In particular, the absence of real-time information led to front-/back-end misalignment within the company's marketing and sales department, compromising waterfall-like relationships with the network of industrial clients. In fact, as the sales director declared: "an Alpha's weakness concerned an on-off coordination between frontline and backline staff whose informative exchange about purchase orders was email-based." This decoupling was based on an organizational structure in which sub-systems of the front and back ends operated fuzzily: they separately collected, prioritized and stored customer information. Thus, Alpha failed to deeply know its customers and missed opportunities to capture and add value to the knowledge stock within its ecosystem. The relational context was negatively affected: Alpha dealt with inefficient activities of inbound and outbound logistics (i.e. backline staff), while mass-market retailers and HoReCa clients faced service failures in terms of the product type, quantity received and delivery delays, thus increasing the likelihood that they would switch to other, more effective suppliers. Contextually, failure to plan service travel and optimize load capacity damaged service logistic providers that reacted by increasing their transport costs.

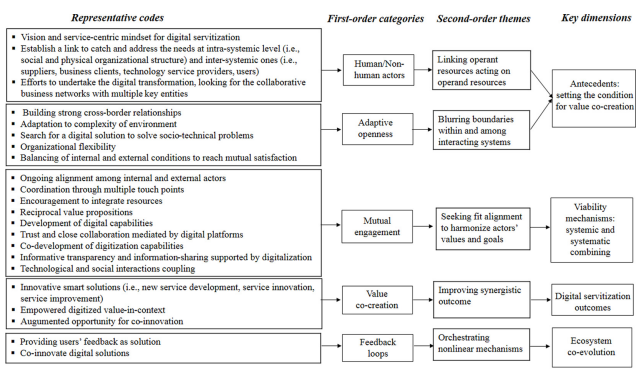
The lack of tightly coupled linkages implied the need for Alpha to move toward a digital servitization state. This shift was gradual and encouraged by the firm belonging to international industry organizations (e.g. trade-specific associations and manufacturing associations).

Alpha started to blur its boundaries by cooperating with technology service providers in the joint development of an e-commerce platform to develop customized offerings. As tool manager declared: "I think we need to work closer with the technological providers since our customers ask for tailored digital solutions." The e-commerce platform was based on an integrated system allowing the front-/back-end coupling and front-end mistakes' reduction because business clients inserted order data by accessing their user areas. At the same time, various interfaces integrated into the functionality of the platform were available to the back end, improving the integration of resources and the smoothing of activities. Furthermore, business clients were more actively engaged in purchase activity, contributing to solving the problem of a non-fluid informative exchange. Thus, a diffuse creation of value was achieved through the digital solution shared among actors: Alpha addressed internal inefficiencies and B2B clients overcame service failures.

4.1.2 Systemic and systematic combining

Alpha gradually invested further in the e-commerce platform with the aim "to systematically launch new services and functionalities based on the platform in the near future" as customer solution manager stated. An instant messaging tool was added to allow real-time interactions between Alpha and its

Figure 2 Data structure and coding process



Source: Authors' elaboration

Table 2 Case companies' transition to digital servitization

Key dimensions	Second-order themes	First-order categories	Representative codes		Representative quotes	
			Alpha	Beta	Alpha	Beta
Antecedents: setting the condition for value co-creation	Linking operant resources acting on operand resources	Human/Non-human actors	- Establishment of stable intra-systemic relationships (assignment of dedicated staff to keep track of key operational activities: front/back-end staff in marketing and sales department, data scientists in IT department) - Establishment of stable inter-systemic relationships (within and among international mass-market retailers, international HoReCa, technology service providers, service logistic providers, international industry organization) - Investments in building digital systems (e-commerce platform, instant messaging and geo-localization tools, smart cloud system, big data analytics)	- Reinforcement of stable inter-systemic relationships (within and among dealers, transportation companies, mining firms, maintenance service companies, spare parts suppliers, financing companies, consulting firms, University, research institutes, autonomous driving engineers and programmers) - Investments in building digital systems (autonomous driving platform, sensors)	- "Alpha's weakness concerned an on-off coordination between frontline and backline staff whose informative exchange about purchase orders was email-based. Thus, frontline wrote order data to backline that read in irregular ways and responded discontinuously. This behavior of salespeople increased mistakes when communicating and fulfilling an annual volume of over 40,000 orders, determining negative customer experience." (Sales director)	- "Beta does not manufacture common light commercial vehicles, trucks, buses and trailers but is a provider of mobility solutions for businesses." (General manager)
	Blurring boundaries within and among interacting systems	Adaptive openness	- Effort to maintain and upgrade digital infrastructure - Organizational flexibility to emerging strategic objectives - Boundaries' fluidity according as services and functionalities of platform grow	- Effort to react quickly to the customer needs for safety-related services - Organizational elasticity based on shared values and proactive interpretation schemes - Boundaries' openness and emergent fluidity	- "I think that a good relationship with our customers is crucial. I am working in this direction, but I do not have support from other departments. We say one thing, but we end up doing another." (Marketing manager) - "We were born as brewers, but this is half the story: at a certain point, a necessary step for us was to evolve into a service provider developing and launching innovative solutions. In a strongly competitive market, we need to differentiate our offering, going beyond the mere product to enable a holistic service experience. This was not one of our core capabilities, so we understood that our collaborations required to be extended." (Regional manager) - "We have a close communication with our industry association and regularly participate in the meetings. This is very important to share the experiences of other manufacturers and ideas for small or big changes. Moreover, there is also potential for establishing new partnerships, which allow access to new competencies." (Regional manager) - "After business clients purchase online, front-end staff visualizes incoming orders and shares them in real-time with back-end staff that manages and processes them immediately through a control panel." (Software specialist)	- "The customer is always in focus, but (the mobility solution) addresses needs from a complete ecosystem of stakeholders." (Vice president of the customer segment) - "Our efforts are not limited to simply adding services to existing products because Beta's offerings incorporate the organizational capability to design valuable solutions and clients' capability to capture the most value out of them." (Service engineer) - "The sale does not mark the end of relationships with clients because we focus on relational agreements." (Vice president of the customer segment)
Viability mechanisms: systemic and systematic combining	Seeking fit alignment to harmonize actors' values and goals	Mutual engagement	- Shift to datatization - Data-oriented mindset - Internal and external fit alignment - Coordination of service activities from the purchase order to the delivery	- Shift to digitalization - Service-centric mindset - Internal and external fit alignment - Relational agreements and outcome-based contracting	- "We wanted to systematically launch new services and functionalities based on the platform in the near future." (Customer solution manager)	- "Our net of suppliers has a high-quality expertise that we consider basic for our activities. Thus, we look for a mutual collaboration with the entire network." (Embedded systems coordinator)

(*continued*)

Table 2

Key dimensions	Second-order themes	First-order categories	Representative codes		Representative quotes	
			Alpha	Beta	Alpha	Beta
			- Real-time decision-making - From data collection and analysis to solutions	- Participative and agile decision-making - From mobility to smart mobility		
					- "Our clients looking for support or wanting to express opinions contact our smart chat robot that ensures continuous conversation without excluding dialogue with our frontline." (Tool manager)	- "Business clients require fleets of safer industrial vehicles, also considering the rigid safety rules introduced by some governments and industry organizations." (General manager)
					- "The client can see the van, where it is driving, the states of the drivers if they are available or unavailable. This means good control of the logistic partners and strong communication with the clients." (Tool manager)	- "We want to contribute to the mobility of tomorrow in the B2B context, providing a safety smart mobility solution." (General manager)
					- "To adopt the geolocalization tool, we needed to establish new and close relationships with the net of service logistic providers. Otherwise, it would not have been possible to install microchips on their vehicles for wireless data communication." (Technology Manager)	- "We and our partners have planned to reach highly or fully automated driving levels, ranging from Level 3 to Level 5 in which full autonomy is obtained." (Platform development manager)
					- "RFID enabled them to offer more competitive pricing due to the optimization of travel planning, load capacity, and reduction in fuel consumption." (General manager)	- "Our clients and partners are periodically invited to visit Beta's digital service centers because we are sure that experiencing novel offerings, developed thanks to the contributions of each of them, enhances trust relations." (Vice president of the customer segment)
					- "Logistic providers are engaged to collaborate and share solutions with us so that they are proactive channel partners for the company." (General manager)	- "Driverless vehicles are a market on its own where mechanical engineering skills have to be combined with a mix of specific knowledge in machine learning, robotics and computerized optics." (General manager)
					- "Our industrial customers perceived changed consumer behavior. They drink the beer to live an authentic experience." (Sales director)	
					- "We produce in small quantities a raw (not pasteurized) beer that preserves all the taste and freshness of the beer as freshly tapped, releasing authentic aromas and fragrances." (Sales director)	
Digital servitization outcomes	Improving synergistic outcome	Value co-creation	Service innovation	New smart solution	- "The real-time information acquired from many interactions requires being stored and managed successfully. A data center with high availability and analytics tools is employed to detect and interpret data." (General manager)	- "We are experimenting with a fleet of light commercial vehicles to be rented through a smartphone-hailed rental technology to transport equipment and bulky objects in an urban context. Our clients could significantly reduce transportation costs, using vehicles without owning them, without having to pay drivers, and parking for free in specific stalls. This avoids double or with the engine running parking." (Research and development manager)
					- "The cloud-based virtualization has provided a concrete opportunity to tailor our solutions. Clients no longer take time and costs to send teams to customize products and wait for our customized productions. Now, digitization makes our partners tightly	

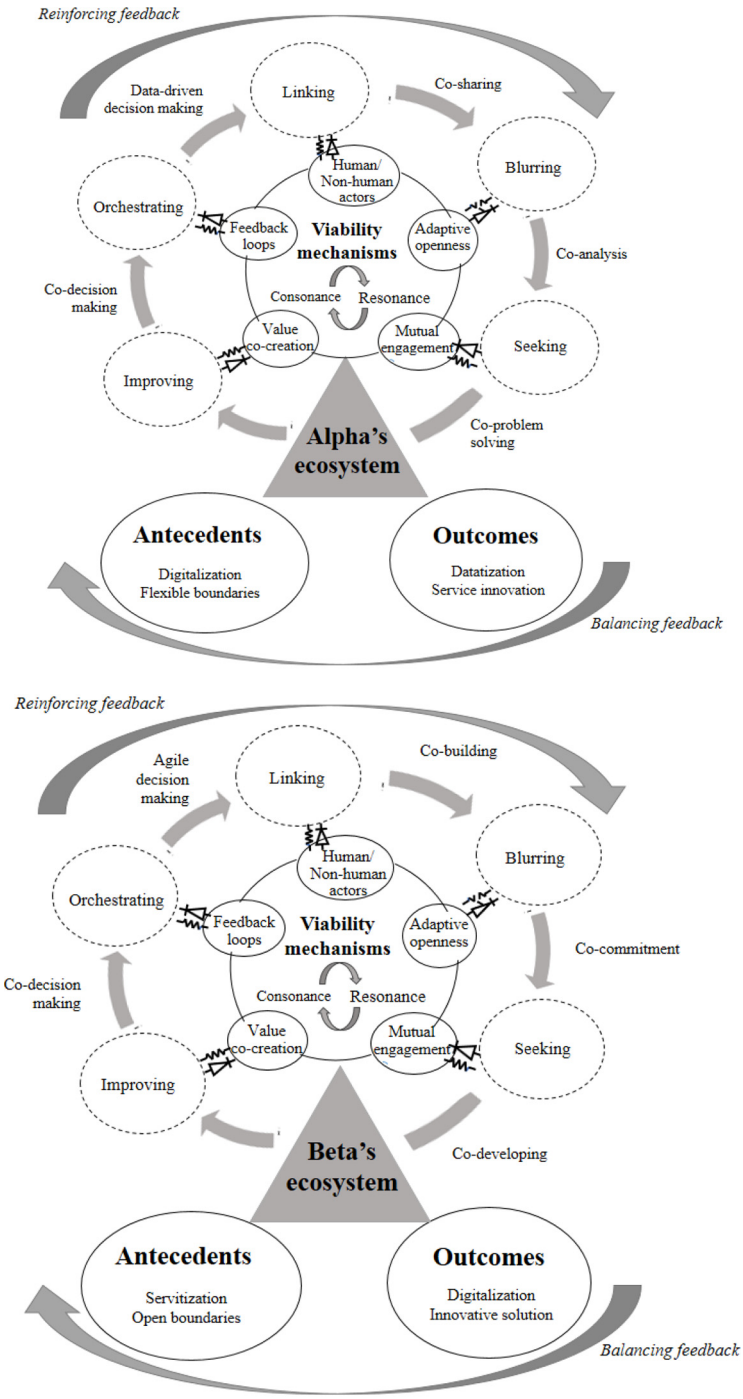
(*continued*)

Table 2

Key dimensions	Second-order themes	First-order categories	Representative codes Alpha	Representative codes Beta	Representative quotes Alpha	Representative quotes Beta
					integrated and engaged with Alpha's processes and resources." (Marketing manager) - "To reap the benefits of our technological investments, we focused on internal skill development through extensive training programs among existing staff and new recruitments of data scientists. It was important for us to organize an IT department to internalize big data analysis functions and optimize information management." (General manager) - "Business clients are drivers of advanced service provision. Thus, it is important that Alpha is aware of the services that clients demand, the services that would benefit them, and the services they are willing to develop with us and pay for. Thus, we also need the client data generated by our relational network to become a hub for the complete solution of industrial market problems." (Sales manager)	- "The relationship between autonomous vehicles and the public transportation system should not be ignored, especially in large metropolitan areas. Thus, envisioning an integrated system, we propose a hybrid transit system with on-demand autonomous vehicles as an additional service to improve metro or bus connectivity during peak hours." (Global technical support manager)
Ecosystem co-evolution	Orchestrating nonlinear mechanisms	Feedback loops	- Discover and exploitation of opportunities - Ongoing renovation of knowledge		"We need to develop innovative ideas, encouraging the network actors to collaborate for innovation according to a shared purpose. This is an important aspect triggering value co-creation and service innovation." (General manager)	"We heavily invested in alignment with partners, and informal contracts increase their cooperative behaviors, pursuing common results." (Operations manager)

Source: Authors' elaboration

Figure 3 Revised digital servitization framework through the empirical application



Source: Authors' elaboration

business clients, integrating the possibility of posting comments on the e-commerce platform. By doing so, Alpha improved its response time to the requests of geographically dispersed customers. Additionally, a geospatial tool was implemented to provide advanced delivery services, allowing clients to exactly localize their orders, visualizing on maps the service logistic providers involved in the delivery through radio frequency identification (RFID) technology. Consequently, Alpha held many face-to-face meetings with service logistic providers. Initially, these providers were hesitant about the RFID technology; then, they became aligned in a shared value proposition in which mutual increase in revenue and upgrading of capabilities were achieved through a risk-sharing agreement. In particular, Alpha was able to achieve both customization and

coupled customer interactions; moreover, the digital solution that captured information on products in real-time allowed it to manage an efficient flow of returns (i.e. reverse logistics) owing to collaboration with its service logistic partners.

On the logistic providers' side, RFID solution has allowed optimizing travel planning, load capacity and reduction in fuel consumption, also providing prices that were more competitive. Moreover, the logistic partners took advantage of the opportunity to use RFID as a new solution offering.

The e-commerce platform went beyond its exclusively commercial aim to become a web-based interactional architecture: in fact, its increasing use generated seamless and multidirectional communication flows because the actors co-shared immediate, simultaneous and continuous access to the platform and its tools. This interaction platform created a virtual connection between Alpha and other actors, enhancing the experiences of "partnering" aimed at seeking mutual alignment. For instance, owing to continuous informative exchanges via the platform, Alpha soon realized that its Spanish customers wanted to move away from mainstream beer sales. For this reason, Alpha was prepared to align the offering with the needs of its clients, investing in craft beer as a new product line.

4.1.3 Digital servitization outcomes

The interactional platform allowed the collection of data from many different sources. This proliferation of data led to the need for a centralized solution that combined and analyzed them to create advanced services. By collaborating with a platform provider, Alpha developed a cyber-physical system-related solution, such as a cloud-based big data analytics tool, that enables the actors' network to co-analyze data and be alerted to risks in terms of monitoring product lines, tracing loads, and purchasing raw materials and packaging. In this way, Alpha and its partners were jointly able to discover and exploit opportunities for service improvement and new service development, paving the way for closer relationships.

At the same time, Alpha adopted additional customer relationship management analytics devoted to transforming customer data into insight that provided grounds for market intelligence. This further evolution toward digital servitization implied that all business processes were oriented toward customer service as a result of a customer-centric logic and entailed the enrichment of data analytics skills in the whole organization, as well as adapting sub-systems to include an information technology department. This organizational stretch beyond manufacturing skills was rewarded by endless opportunities provided by the correct analysis and integration of data from the network of relationships. For instance, Alpha could leverage collaborative decision-making with reduced complexity and decision-making time because an improved understanding of business clients' needs fostered the optimization of business processes and overall service delivery. Moreover, the use of customer data increased effectiveness in recognizing and addressing customers' problems and translating their needs into new advanced service solutions in an efficient, tailored and collaborative way. Thus, service quality improved, and customer satisfaction and loyalty were positively affected.

4.1.4 Ecosystem co-evolution

Developing technologies around software compatible with hardware of the actors' network, Alpha's vision gradually oriented the strategic choices of other actors by leveraging and improving the ongoing process of resource integration that leads to knowledgeable actors and fosters overall service interactions and related outcomes.

Overall, through a constant process of adaptation, Alpha demonstrated proficiency and credibility in orchestrating value co-creation activities and their related processes within its network of relationships, paving the way for seamless knowledge endowment and ongoing digital service innovation.

4.2 Beta

4.2.1 Setting the condition for value co-creation

In Beta's pre-digital servitization state, a service-centric logic dominated as a vision that inspired the entire organization. The general manager confirmed, "Beta does not manufacture common light commercial vehicles, trucks, buses and trailers but is a provider of mobility solutions for businesses," such as dealers, service logistic providers, transportation companies and mining firms.

Following this vision, Beta put service at the basis of its competitive strategy aimed at differentiating its offerings and adapting to heterogeneous customer needs.

The product-related services portfolio consisted of after-sales services aimed at increasing Beta's revenue and customer value during the entire life cycle of the vehicles. They comprised maintenance contracts, financing schemes and consulting services customized and offered as packages that linked services together. To increase the interaction intensity and number of touchpoints with customers, Beta introduced offerings such as monitoring diagnostics and corporate credit-card services. In addition, the company's portfolio comprised use-oriented services – such as leasing, renting and sharing – which required the active involvement of customers to develop and deliver tailored solutions and satisfy on-demand requests.

Therefore, Beta designed an integrated product-service bundle in which the personnel, facilities, relational skills and capabilities of both company and customers were embedded and shared. Moreover, additional advanced services allowed Beta to increase customer engagement since service was embedded in customer relational processes. According to this logic, the company worked in close collaboration with its clients to achieve mutual business goals, paving the way for reciprocal long-term relationships based on trust. Such service centricity was achieved by organizing for mutual dependency and a shared agenda through common value creation logic adopted at each stage of the value chain owing to blurred boundaries. The effective delivery of integrated product-service solutions required both intra- and inter-systemic integration by merging operand and operant resources. Beta invested in the combination of multiple ICT-based systems (i.e. a machine-user interface) to achieve sufficient modularization and connectivity. This led to the creation of synergies among subsystems and improved collaborations among the service teams that tracked the connected products and the service engineers who performed inspections, repairs and maintenance. Moreover, Beta maintained stable connections with the suppliers of machines, equipment applications, professional

facilities, maintenance systems and spare parts supply systems, as well as financing companies and consulting firms.

4.2.2 Systemic and systematic combining

Beta quickly embarked on an important shift toward a digitalization path due to the introduction of global safety regulations to avoid industry accidents.

Beta seized this business opportunity to migrate toward digital services. The achievement of this opportunity affected the reorganization of the overall value system, depending on the objectives and activities of actors from other ecosystems.

Specifically, Beta looked for synergies with technology service providers, machine suppliers, and research institutes by establishing a "talent network" to integrate internal and external knowledge resources and increase open collaborations in the autonomous driving area. As a result, the "talent network" co-developed a platform for automated driving, allowing industrial vehicles to accomplish complex tasks ranging from driving to loading and unloading raw materials. Vehicle smartness was achieved through innovative technologies (i.e. advanced video perception and high-definition mapping, highly performant sensors and artificial intelligence) that offered the highest safety and versatility at the production sites. The platform included IoT solutions that allowed smart vehicles to communicate in real-time with each other (vehicle-to-vehicle communication) and with the central infrastructure (vehicle-to-infrastructure communication).

The co-development platform was based on the company's effort to seek external fit alignment to preserve coupled B2B relationships. Initially, many negotiations were necessary to achieve the co-commitment of all partners to goal achievement. As the general manager stated: "We are sure that regular meetings, consultations, workshops and brainstorming foster iterative exchanges bringing to an ongoing involvement in common rules and values." Beta increased its attention to co-building trust among partners and followed clear cooperation rules to ensure smooth collaborations, manage openness and sustain innovations. In this regard, it developed a partner program to provide a comprehensive set of benefits (e.g. sales and technical training, application development tools, technical support, marketing resources, legal support and business development funds). External fit alignment also enabled it to involve new actors, such as universities, research centers, autonomous driving engineers and programmers, with and from whom to co-build capabilities and learn continuously.

4.2.3 Digital servitization outcomes

Collaborative development of the platform improved benefits and created new value for the actors involved. Beta improved customer experience because the platform architecture and functions were co-designed with other actors, and its modular nature allowed high customization and operational adaptiveness to multi-actor contexts of use. Moreover, the platform allowed Beta to plan access to an emerging market of van sharing, expanding its reach in the field of pay-per-kilometer vehicle rental services. This could mean not only market innovation but also environmental sustainability in terms of the reduction of both traffic and air pollution.

At the same time, the platform reinforced the capability of industrial clients to improve their productivity because the smart vehicles performed better than human drivers in terms of perception (e.g. no blind spots), decision-making (e.g. more accurate planning of complex driving maneuvers such as parallel parking) and execution (e.g. faster and more precise control of steering, brakes and acceleration). Moreover, the platform improved the reputation of Beta's clients as sustainable companies in the eyes of their customers. In fact, switching safety-critical tasks from humans to machines demonstrated social sustainability efforts to reduce job accidents and fatalities and promote easier job accessibility for people unable to drive.

4.2.4 Ecosystem co-evolution

In the wide reconfiguration of the ecosystem, Beta acted as a knowledge-intensive solution by taking responsibility for coordinating and integrating old and new actors and shaping innovative resources, co-innovating new technical solutions. Outcome-based contracting as relevant coordination mechanisms has allowed orchestrating tighter multi-actor coupling. Finally, a mutual alignment toward a shared value proposition was the key for participative and agile decision-making in which all actors actively engaged, contributing to Beta's strategic direction.

New business opportunities emerged within the effects of service ecosystem digitization because the platform was able to enhance regulatory and systematic debate and users' feedback in relation to testing licenses, accidents between smart and traditional vehicles, and smart vehicle use on public roads. Owing to the most advanced machine-learning technologies, the platform can derive real-time information, make *ad hoc* recommendations and stimulate creative thinking to effectively address future needs.

In this regard, the platform is co-designed to represent a revolutionary future for urban mobility through the possibilities of hybridizing autonomous vehicles and public transportation, including improvements in the intermodality and individualization of the transit service.

5. Discussion

The cross-case analysis allows us to explore how manufacturers manage digital servitization to create value in industrial markets. To this end, the analysis of actors, activities and digital tools allows us to identify emergent resource exchanges, thereby exploring how they are dynamically combined to generate innovative outcomes. The findings show that both case companies strategically managed the sociotechnical processes of digitalization to enhance their competitiveness. Regardless, differences in service orientation delineated dissimilar journeys toward digital servitization. This finding is in line with a system principle of equifinality referring to a property of open systems reaching the same end state of the structure even when starting from different conditions and/or taking different paths (Barile *et al.*, 2012a). Overall, both case companies' journeys embraced digital servitization, despite Beta shaping a more viable digital ecosystem, harmonically combining service centricity and the ability to cope with contextual variety. This finding is in line with both VSA's constructivist view and the influence of servitization maturity on digitalization level (Polova and Thomas, 2020).

By interpreting the iterative and non-linearity of the framework proposed in the light of the empirical findings, the

integrated interplay of the key dimensions is discussed below (Figure 3).

Alpha gradually moved from digitalization to servitization due to the lack of tightly coupled linkages among and between front- and back-end staff and industrial clients initially viewed as exogenous recipients of a company's value proposition. The lack of internal (unskilled people) and external consonance led to the absence of real-time information exchanges, creating knowledge silos that caused inefficiencies in both human resource management and customer relationships. Thus, the e-commerce platform acted as an accelerator of market knowledge because it fostered the smoothing of informative exchanges, also disseminating market intelligence to different departments and fostering synergistic activities. In contrast, Beta quickly moved from servitization to digitalization arising from customer-centricity expressed by integrated product-service bundles and active investment in stable relationships, mediated by technological tools (i.e. from basic ICT-based systems that facilitated production processes and service operations to multiple ICT-based systems) and close collaboration on the overall value system. Thus, a crucial antecedent of digital servitization lies in the relational capability of organizing relationships, of different natures and extents, connecting relevant actors (supra- and sub-systems) and aligning activities and related processes to improve mutual understanding. This leads to different opportunities for leveraging digitalization, also affecting system boundaries. Alpha showed flexible boundaries to foster the establishment of new relationships according to the incremental use of a wider range of digital technologies to improve customers' knowledge. Boundary flexibility moved at the same pace as the flexibility of the system through adaptive behavior consisting of back- and front-end optimization. Likewise, Beta showed open boundaries characterized by emergent fluidity due to the selection and ongoing involvement of new actors (i.e. universities, research centers and scientists) with whom the company integrated and created new external market knowledge from extended partnerships mediated by platforms that enabled modularization and connectivity (Lusch and Nambisan, 2015).

The implementation of multiple digital tools allowed more open exchange of information between the involved actors and made stronger operational linkages, as well as data transparency and analysis, sustaining thereby an alignment of values and incentives to foster value co-creation. Hence, an operational and strategic alignment was achieved through the viability mechanisms that worked as relational strategies to ensure structural and systemic stability. In particular, consonance fostered the coordination of the relationships across different functions to maximize contribution coming from actor-network, paying the way to the creation of synergies and avoiding possible conflicts. Resonance reinforced the coordination and harmonization of the interactions through collaboration and cooperation aimed to synchronize shared objectives and mutual engagement between involved actors. Consequently, the synergistic exchange of resources produced the enhancement of the skills and the provision of new knowledge for the actors involved. Thus, consonance and resonance are homeostat mechanisms that ensure and allow the system viability (von Bertalanffy, 1968). Acting as variety attenuators, they absorbed variety by allowing the system to align its tangible and intangible resources with complementary resources provided by the actor-network. Thus, the viability of the ecosystem was reinforced. For instance, the provision of an advanced delivery services to Alpha's business clients was possible because of the close collaboration of service logistic providers willing to the mutual usage of RFID technology and sharing of information.

The combined effect of the viability mechanisms allowed dynamic adjustments actualized in co-created activities.

By adapting its ecosystem, Alpha shaped the service value network through the following co-created activities:

- co-problem solving, obtained through resource integration by matching managerial and technical capabilities with the identification of specific customer performance improvements and operational requirements;
- co-sharing by integrating data storage and data sharing with jointly discussed and agreed-upon greater experiences and value innovations, matching the expertise of the suppliers' network with the experience of the customers' network to reduce technical and social asymmetries and carrying out a set of collaborative rules; and
- co-analyzing, consisting of the integration of digital capabilities by technology experts and suppliers to extract information from which emergences are constantly detected in real-time, and thereby new value is obtained through big data analytics to translate customer data into data forecasts.

In contrast, strong service centricity pushed Beta to reconfigure its ecosystem, establishing cross-sectoral partnerships, allocating resources on joint activities and nurturing mutual value propositions through rule clarity for long-term cooperation. Thus, the following co-created activities were achieved:

- co-developing, obtained through resource integration by generating and suggesting a joint elaboration of new co-created solutions, scanning new technological frontiers (i.e. AI) and advanced applications (i.e. data models and analytical methods), and bringing together ideas, designs and talent from internal and external ecosystems;
- co-committing by integrating and optimizing cooperation management practices, including shared rules and standards, to jointly craft value propositions and jointly specify value perspectives; and
- co-building, consisting of new capabilities that are synergistically recombined in new knowledge, cooperating with scientific and technological partners to increase technical, managerial and relational capabilities, together with the enhancement of specific digital capabilities (i.e. intelligence, connective and analytic functions) toward new co-created customer-centric offerings.

The synergistic combining of the co-created activities affects an innovative mindset, institutionalized to actualize an ongoing value creation, involving the overall decision-making process.

In Alpha, data-driven decision-making allowed it to extract significant information and meanings from data empowering knowledge sharing. First, the provision of additional functions

of the offering by means of a wider range of digital tools (i.e. instant messaging and geolocalization tools integrated into the e-commerce platform) allowed seamless access to and sharing of information through interaction-in-use (Vargo and Lusch, 2011) and allowed it to implement integrated strategies with clients, service logistic providers, etc. Second, a cloud-based big data analytics tool sustained by a technical and analytics skills pool allowed it to store, process and extract real-time data, unlocking value from them to co-create new value propositions. This corroborates the proposition that data centricity (Svahn *et al.*, 2017), which is the synchronization of digitization, connectivity and data analytics, increases opportunities for value co-creation (Martín-Peña *et al.*, 2018).

In Beta, agile decision-making allowed digitalization to be obtained through the development of digital co-capabilities. Agility, as flexibility and continuous realignment to changes (Weber and Tarba, 2014; Bustinza *et al.*, 2018), is crucial for sustaining value co-creation for the advancement of new integrated solutions. Agility allows a timely response to the need for scalability and speed in rapidly changing environments where technologies' life cycles are short (Tronvoll *et al.*, 2020). Then, we can advance that the co-commitment to decisions acts as glue that enables swift and decisive interorganizational and business reconfigurations. Co-commitment affects the overall value architecture at the identity level due to the full inclusiveness of multiple actors as partners and leads to generate not only smart solutions but also new markets.

Consequently, and in line with the digital servitization outcomes key dimension, outcomes achieved by the two case companies are different due to the distinct degree to which decision-making copes with contextual variety and imagines protovisions (Nenonen and Storbacka, 2020). In particular, the datatization pursued by Alpha led to ongoing service innovation and data-intensive processes and supported and enhanced the quality of decision-making. The digitization pursued by Beta led to co-innovative smart service solutions for new emerging needs (i.e. cybersecurity digital services). Matching industrial, scientific, technical and academic expertise, Beta is acknowledged to have developed an institutionalized knowledge-intensive solution.

Ongoing innovative digitalized outcomes can be promoted over time owing to feedback loops to foster the constant diffusion and rearrangement of the new knowledge generated within a systematic and iterative process oriented toward discovering and exploiting new opportunities for value creation and co-evolution. This process requires the appropriate orchestration of cycles from which feedback loops arise. Thus, in analyzing the two ecosystems as a whole, we advance the existence of transformational mechanisms named reinforcing and balancing feedback loops as nonlinear and iterative mechanisms that allow outcome achievement and, ultimately, ecosystem viability and co-evolution over time (Peters *et al.*, 2020). More specifically, reinforcing feedback is a perceptive mechanism based on the capability to discover and exploit untapped opportunities. It requires the orchestration of co-monitoring activity and related processes by multiple short planning and execution cycles based on user feedback, as well as regular meetings and follow-ups among actors to gain a fluid understanding of their resources and interests (Paluch *et al.*, 2020). Instead, balancing feedback is a responsive mechanism acting based on the orchestration of co-learning activity and related processes that renovate knowledge in a continuous cycle of sensing, responding and adapting. In doing so, resourcefulness increases since each knowledge resource become able to support other knowledge resources in achieving innovative outcomes (Koskela-Huotari and Vargo, 2016). An effective and harmonic orchestration of cycles from which feedback loops arise sustains an update of the iterative process of value co-creation since the outcomes obtained in a given time represent improved antecedents that reinforce the re-start of the cycle. Thus, the human-mediated integration of digital resources, platforms and tools turns into strategic assets actualizing improved value co-creation that sustain an enduring digital innovation. Hence, viability and co-evolution of the entire ecosystem are fostered over time.

6. Implications, limitations and further research

The paper contributes to enriching and extending the emerging body of literature on digital servitization (Tronvoll *et al.*, 2020; Kamalaldin *et al.*, 2020), thus stimulating further scholarly work in value co-creation implementation and simultaneously providing guidelines to facilitate the attainment of value co-creation in digitized B2B markets. The work advances a theoretically grounded, empirically informed framework to detect transformational mechanisms to manage value co-creation in digitally servitized contexts, contributing to ecosystem viability and co-evolution in the long run. Co-created activities are identified, and five higher-order categories are conceptualized to make sense of digital servitization in line with a systems view and a systematic process based on a transformative attitude toward digital servitization.

Therefore, the study can be considered a further step in extending knowledge on digital innovation emergence in B2B manufacturing systems by categorizing different viability mechanisms and proposing transformational ones that foster innovation. Thus, it confirms the disruptive aspect of digital servitization that leads to significant transformations in how integrated solutions are designed, produced and delivered, involving changes in strategies, activities and the value network (Vendrell-Herrero *et al.*, 2018). In addition, the study encourages the consolidation of a research orientation that expands its scope to the systematic integration of investigating interdependencies among actors by detecting specific co-created activities. Thus, it provides additional research on the micro-foundations of value co-creation (Storbacka *et al.*, 2016).

At the same time, the paper offers direct implications for managers from the manufacturing industry who drive digital servitization initiatives in B2B markets. The practical stance lies in the identification of specific digital servitized journeys that research findings indicate are value-driven and partnership-focused. Thus, organizations that plan similar endeavors can benefit from this study and more effectively and efficiently manage the necessary transformational shifts, choosing more suitable transition routes between datatization supporting servitization and servitization supporting digitalization. Consequently, managers can collect insights into the proper combination of technology and human interactions to manage strategic value co-creation that can allow, in turn, the

harmonization of complex innovation processes. Managerial implications also underlie the conceptual framework. First, executives can rely on practical mechanisms when designing innovation projects that are consistent with digital servitization plans. For instance, the co-monitoring required by reinforcing feedback can be implemented through smart decision support systems that enhance the capability to collaboratively discover and exploit untapped opportunities. Additionally, the co-learning required to balance feedback can be achieved through strategies based on the valorization of the multiple contributions of ongoing upskilled actors within the process of value generation and inspired by survival in the long run. Relying on practical mechanisms would lead to the definition of managerial models that highlight digital servitization with greater potential for companies according to contingency factors, such as industry, company size and supply chain position. Second, our framework represents a valuable solution for practitioners and industry groups seeking a more contemporary managerial framework that, by being receptive to the ecosystem view, enables practitioners to see beyond the firm boundaries and perceive multiple tiers of suppliers, customers, and users that directly and indirectly provide information and resource flows. This change in perspective may represent a relevant contribution to B2B industrial management, helping understand decision-making in conditions of complexity. In particular, the set of processual dynamics underlying specific co-created activities can be amplified or reduced according to the contextual circumstances, supporting decision-making to better adapt to internal and external contextual variety.

Although the study offers valuable contributions, some limitations must also be recognized, suggesting directions for future work. First, the adoption of the case-study methodology, scarcity of case companies and low number of interviews do not allow a consistent generalization of the results. Regardless, the paper proposes exploratory research that is a first qualitative step toward addressing future quantitative studies on a higher number of firms. Second, our attention is focused on manufacturing, although the literature has started to investigate the phenomenon in other industries. Thus, future studies can explore servitization beyond the boundaries of manufacturers to compare results obtained in other organizational contexts. Third, all the interviews were conducted in the two focal firms. In the future, respondents from both sides of the interactions (i.e. both the customer and the provider view) could be involved to provide validation and contextual richness for the analysis, enabling a deeper understanding of the phenomenon. Moreover, future studies could deepen the longitudinal nature of digital servitization, extending the search for how the transformational efforts of manufacturers develop over time in accordance with changing circumstances and conditions. Finally, future research could adopt a system dynamics lens, which may offer interesting insights into the narrative of digital servitization.

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Appendix. Interview guide themes

General questions:

- What is your role in the company?
- What are the company's main activities?
- What was the company's revenue over the last year?
- Who are the company's most important business customers geographically?
- How many employees does the company currently have?

Framework-related questions:

- Why has the company undertaken the digital servitization?
- Which are actors involved in the shift to digital servitization?
- What are the main resources and capabilities required by digital servitization?
- What are roles of organizational units, internal and external customers and other actors in the digital servitization project?
- How do relations occur within the companies and across other actors?
- How are relations managed within the companies and across other actors?
- What activities are needed for the company to offer advanced services?
- What activities are critical in facilitating digital servitization?
- How do digital technologies work to support service implementation?
- Are there advantages/disadvantages of adopting digital technologies for advanced service development and implementation?
- What is the strategic vision of the company toward technology-enabled service implementation?

About the authors

Maria Vincenza Ciasullo is an Associate Professor in Business Management at the University of Salerno, Italy, since 2005. She received the PhD degree in management from the University of Naples, Italy, in 2004. She is also an Affiliated Professor in Management at University of Isfahan, Iran. Her current research focus on: Digital Transformation and Business Models, Sustainability management, Service innovation and value co-creation. On these topics, she has published in International journal such as *International Entrepreneurship and Management Journal, Business Strategy and Environment, The TQM Journal, Studies of Higher Education, Current Issue in Tourism, Futures and Land Use Policy*. She has been awarded by Emerald (Highly Commended Paper Award, 2018; 2019). orcid ID 0000-0003-2052-551X. Maria Vincenza Ciasullo is the corresponding author and can be contacted at: mciasullo@unisa.it

Francesco Polese is a Full professor of Business Management at the Dept. of Business Studies – Management & Innovation Systems in Salerno University where he teaches Service Management, Marketing, Healthcare Management. He is Director and founder of Interdept. Centre Simas (Innovation Systems and Healthcare Management) and author of several books dealing with networks and management in healthcare environment. With a system thinking perspective, his research interests cover the Viable Systems Approach, Service Science, Complexity. Since 2009 he is co-chair, along with Evert Gummesson and Cristina Mele, of the Naples Forum on Service (www.naplesforumonservice.it)

Raffaella Montera is Adjunct Professor of Economics and Business Management at University of Salerno (Italy) – Department of Management & Innovation Systems and Adjunct Professor of Management and Marketing of Cultural Heritage at University of Salerno (Italy) – School of Specialization in Archaeological Heritage. She is engaged in training activities in the master's degrees and advanced training courses. She is also a Teaching Fellow in Business Strategies at University of Salerno (Italy) – Department of Management & Innovation Systems. She holds a PhD in Marketing and Business Communication at University of Salerno (Italy) – Department of Business Studies. Her researches are focused on Strategic Management, Marketing Management, Sustainability, Internationalization, Tourism and Hospitality. She is author of a monograph, contributions in Conference proceedings and in national and international journals.

Luca Carrubbo is in charge of Department of Business Studies, Management and Innovation Systems since 2020 as Assistant Professor (RTD-B) in Business Management. He is graduated cum laude in Business Management at University of Naples "Federico II", PhD in Business Management since 2011 and Licensed as Associate Professor in Business Management since 2018. Since 2012 he is Visiting Professor at Masaryk University of Brno (CZ) for the course of Marketing strategies in service business within the T-shaped international educational program of sponsored by SSMED. He is Member of AIDEA, SIM and SIMA Associations since 2017, ASVSA Member since 2011, Council Member of SIMAS Interdepartmental Research Centre focused of Innovation Systems and Healthcare Management since 2019.