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Smart sensing technology and self-adjustment in service systems through value co-creation routine dynamics

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A B S T R A C T

Self-adjustment processes are crucial for ensuring service system viability in the light of emerging adoption of digital technologies that shape value co-creation. This article offers a novel conceptualization of self-adjustment to explain the process that a service system performs to adapt to changing conditions to remain viable or improve the system's viability. In doing this, we draw on service-dominant logic and routine dynamics theory and zoom in on how self-adjustment emerges in value co-creation routines. We show the usefulness of our conceptualization in a case of an elderly care home that introduced smart sensing technology, which triggered self-adjustments in that service system through value co-creation routines. The case study explicates the deployment of self-adjustment when sensing solutions become integrated with other resources and applied by engaged actors as resources-in-use, creating novel value co-creation outcomes. It is argued that routine dynamics contribute to self-adjustment by initiating processes whereby the involved actors' schemas, resources, and value co-creation performances become integrated and aligned after the technological change.

1. Introduction

Smart sensing technology is reshaping value co-creation in various industries (Mele et al., 2021). Whereas the acronym "SMART" refers to self-monitoring, analysis, and reporting technology (Mele, Spena, & Kaartemo, 2022), the general notion of a smart technology implies any "electronic device or system that can be connected to the internet and used interactively" (Fouroudi et al., 2018, p. 271). The actors connected by smart technology share intentions to achieve better experiences, with the assistance of sensor devices that capture and combine simple data to gain deeper insights (Fouroudi et al., 2018). The adoption of such technologies thereby affects value co-creation in service systems, which represent configurations of people and resources "that interact with other service systems to create mutual value" (Maglio et al., 2009, p. 395). As Barile et al. (2017, p. 826) note, "actors and technology provide new dynamic institutions, self-adapting and self-adjusting the system to improve the coordination mechanisms and … to find ways to coordinate and survive." Organizations form loosely coupled and self-adjusting systems centered on value co-creation among multiple actors, often enabled by digital technologies (Meynhardt et al., 2016).

Despite the relevance of the topic, self-adjustment is rarely analyzed in detail in service systems in relation to their viability. It is argued that we need to know more about how service systems stay viable through a process of self-adjustment and how such adjustment manifests itself in adaptive behaviors (Barile et al., 2016). In this vein, digital technologies make it easier for actors to share information quickly and gain advantage through better IT-based sense-and-respond strategies (Lusch & Nambisan, 2015). Explaining self-adjustment in service systems can help advance the service-dominant logic by offering a conceptualization of value co-creation and service system viability. Therefore, the aim of this article is to explain how self-adjustment emerges in value co-creation routines, following the introduction of smart sensing technologies in service systems. With a focus on value co-creation routines, we analyze adjustments in the recognizable, repetitive (or institutionalized) interactions through which resources are integrated and value is co-created among multiple engaged actors. Our goal is to answer two

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research questions: How can we define and conceptualize the self-adjustment of a service system, and how does the introduction of smart sensing technology affect a service system's self-adjustment through value co-creation routine dynamics?

Drawing on service-dominant logic as the substantive theory, as well as on routine dynamics (Feldman & Pentland, 2003), we detail the case of an elderly care home (understood as a service system) that introduced smart sensing technology, which triggered self-adjustment in the service system's value co-creation routines. We define self-adjustment as the process a service system performs to adapt to changing conditions to remain viable or improve its viability. The self-adjusting behavior holds on the plasticity of service system in terms of fluidity and stability (Nenonen et al., 2014). With a case study, we clarify how self-adjustment occurs through resource integration when the engaged actors integrate sensing solutions with other resources and apply them as resources-in-use to achieve value co-creation outcomes. Furthermore, we specify how routine dynamics contribute to self-adjustment by aligning actors' schemas, resources, and value co-creation performances after the introduction of new smart technology (Feldman, 2004; Tuominen et al., 2020). We see self-adjustment as the forerunner of service system's adaptation and innovation: adaptation refers "to instances of adapting behaviours in response to disturbance and change and innovations referred to something new" (Lyng et al., 2021, p. 5).

After reviewing service systems, self-adjustment, routine dynamics theory, and smart sensing technology concepts in the next section, we present the case study and the methodology applied to contextualize the self-adjustment processes. Finally, we discuss the theoretical and managerial implications of the findings, along with some limitations and research directions.

2. Theoretical framework

2.1. Self-adjusting service systems

Service systems can adapt relatively easily and rapidly to changing circumstances, with the potential for both positive and negative outcomes (Lusch & Nambisan, 2015; Lusch & Vargo, 2014). This self-adjustment capability is described in terms of *plasticity*, referring to the capacity of the service system to take or retain form when molding attempts have stopped (Nenonen et al., 2014). As Chandler et al. (2019, p. 77) explain, "fluidity and stability are not opposite; rather, they are interdependent. They influence how systemic components react to new ideas, whether they maintain an existing form or catalyze a different form." Being plastic, for a service system, means it can self-adjust its behavior to take form (manifesting fluidity and innovation) or retain form (manifesting stability and resilience) and thus remain viable. Self-adjusting processes result from the service system's underlying survival (viability) objective, in that the engaged actors focus on creating value for themselves and others, even in changing circumstances (Barile et al., 2016; Polese et al., 2017). To remain viable, the system should exhibit openness to integrating new resources, which affects value co-creation that is enabled or inhibited by shared institutional norms. Self-adjustment processes also include exploring and exploiting new opportunities to integrate resources and co-create value, which may lead to innovative outcomes. However, self-adjustment processes typically result in minor or ongoing changes in resource integration practice, including actors' behaviors. Such service system adjustments are not innovations but are nevertheless crucial processes in changing circumstances.

Service systems self-adjust through multiple changes, including adopting new or improved routines (Akaka et al., 2013; Frow et al., 2016). In an ongoing adjustment process, involved actors share some common goals and intentions (Taillard et al., 2016). Therefore, changing routines also requires actors to adjust their "behaviors, efforts, cognitive, or emotional investments that create, maintain, or disrupt institutions" (Chandler et al., 2019, p. 76). The alignment of actors' work (and integrated resources) with external constraints and opportunities depends on "changing equilibrating conditions" (Barile & Polese, 2010, p. 34). For example, resource integration demands structural consonance and dynamic resonance, implying the need for actors to adjust their value co-creation routines as "a prerequisite for harmonic interactions that characterize resonance" (Polese, 2018, p. 32) and that in turn can ensure service system viability.

We see potential in deepening these insights using the theory of routine dynamics. This theoretical perspective helps to conceptualize how the processes by which self-adjusting service systems remain viable require aligning components such as schemas (a subset of institutional arrangements in S-D logic), resources, and performances (as related to performativity in S-D logic) in the system's value co-creation routines. Therefore, integrating service-dominant logic with the theory of routine dynamics enables zooming in on self-adjustment in value co-creation processes. In this paper, we next address self-adjustment processes triggered by external forces, such as the infusion of smart sensing technology, as predicted by routine dynamics theory. With this approach, we can study adaptions in actors' resource integration and value co-creation routines, to better understand self-adjustment and how actors in service systems co-create value for themselves and others.

2.2. Value co-creation and routine dynamics theory

The theory of routine dynamics (Feldman & Pentland, 2003; Feldman et al., 2016; Feldman, 2004) is a version of practice theory that addresses how collective routines, defined as repetitive and recognizable patterns of interaction among collaborating actors, evolve through their internal dynamics. It provides a useful conceptual tool for explaining self-adjustment of service systems, because it predicts interconnected changes in the elements of a service system that likely take place during self-adjustment. These adjustment processes may continue cyclically until the elements of a service system become aligned, that is, until structural resonance takes place (Feldman, 2004; Tuominen et al., 2020). We regard value co-creation processes as intertwined routines and use routine dynamics theory to suggest that the elements of a service system can be conceptualized as three different aspects of routines—ostensive, performative, and artifactual—and that these elements adjust through their dynamic interplay (D'Adderio, 2011; Feldman & Pentland, 2003; Feldman, 2004). The ostensive aspects, which we refer to as *schemas,* involve partially shared understandings and informal rules and norms about value co-creation. Schemas that guide value co-creation performances in an individual routine can be seen as a subset of institutional arrangement, that is, the interrelated institutions that "together constitute a relatively coherent assemblage that facilitates coordination of activity in value-cocreating service ecosystems" (Vargo & Lusch, 2016, p. 18; see Tuominen et al., 2020, p. 578). The performative aspects involve *situated performances* through which value is co-created and resources are integrated. Daily performances comprise actor-to-actor interactions that maintain or revise the routine (i.e., the performative stance, see Vargo & Lusch, 2018). Finally, artifacts refer to formal *resources* applied in value co-creation, such as checklists or digital tools (Feldman & Pentland, 2003; Tuominen et al., 2020). Resourceness (to be able to become) is recognized when a potential resource become a useful one (Feldman & Worline, 2011; Vargo & Lusch, 2018).

At the individual routine level, this theory further suggests that the three aspects are interrelated, so new resources can trigger changes in all of them, such as altering schemas and inspiring new types of performance (Bertels et al., 2016; Feldman & Pentland, 2003; Feldman, 2004; Feldman & Worline, 2011). For example, new technology applications that enable online grocery shopping (new resources) fundamentally change consumers' ideas of grocery shopping (schemas), the actors with whom they interact, when and how they make purchases decisions (performances), and the value created, but those changes may take place gradually and cyclically as the consumers adapt to new routines in their daily lives. For new resources to affect value co-creation, they thus must be (1) integrated with actors' other resources, such that they modify the resource aspect of routines; (2) applied repeatedly in value co-creation encounters, which modifies the performative aspect of a routine; and (3) perceived as useful by the actors, thereby affecting the schemas that underlie value co-creation (Pentland & Feldman, 2008). Previous service research suggests similar connections among the different elements (Mele, Spena, Kaartemo, & Marzullo, 2021; Nysveen et al., 2020; Sklyar et al., 2019), but routine dynamics theory explicitly can map their interplay, by suggesting that a change in one aspect of a routine triggers adjustments in the other aspects; otherwise, the routine does not change.

However, the processes are not necessarily accepted or institutionalized. Rather, self-adjustment in service systems results only if the three elements of routines (schemas, resources, and performances) align within the system. Furthermore, because new resources may affect several interconnected routines, we anticipate that system-level adjustment requires adjustments between routines. These adjustments among routines may depend on how the routines are interconnected, through actors, resources, or schemas (Sele & Grand, 2016) and interdependent actions (Kremser et al., 2019). It is likely that changes caused by new resources—such as smart sensor technology—spread more if routines are tightly rather than loosely coupled: in the latter case change in one routine would not necessarily affect the others. These insights from routine dynamics theory provide a basis for our conceptual model of self-adjustment, with which we depict what happens within service systems following the introduction of a smart sensing technology, as a new resource.

2.3. Smart sensing technology

Service research literature typically conceptualizes technology as an operant resource that is critical to system (re)formation (Akaka & Vargo, 2014). Operant resources denote broad categories of resources, including smart sensing technology, that activate, operate on, or use other operand and operant resources. Smart sensing technology, such as sensors, robots, Internet-of-Things [IoT], and artificial intelligence, can prompt a camera to take a picture, turn on a lamp, or transmit information about heart rates or blood pressure, as examples. In addition, actors can activate smart technology devices to access individualized information in real-time, including data being stored in databases. As a key source of capabilities for service systems, smart sensing technologies provide a network infrastructure for connecting and revealing service system dynamics, such as self-adjustment in real time (Barile et al., 2016). Moreover, smart technology can affect value co-creation by changing actors' resource integration, such as by enabling automation, connectivity, or the creation of new routines (Mele, Spena, & Kaartemo, 2022; Wirtz et al., 2018). Sensing technology in particular can fundamentally alter team structures and inspire new modes of collaboration (Kim et al., 2012) or non-verbal communications among actors (Pauser & Wagner, 2019). Thus, smart sensing technology represents a key resource for initiating new processes (Mele, Marzullo, et al., 2022; Ng & Wakenshaw, 2017), because it can facilitate wireless communication with a remote site, communication among sensors, automated data processing, extraction of relevant features, and so forth (Hamrita et al., 2005). In this sense, it also provides opportunities to analyze rich information about actors' experiences (Anderson & Bolton, 2015).

However, Mele et al. (2021) argue that smart sensing technologies cannot co-create value in service systems by themselves; instead, they enable or promote augmented behaviors, such as an enhanced capacity for self-adjustment, remote control, or monitoring. Such outcomes might result from smart nudging, which refers to the use of cognitive technologies to affect people's behavior predictably, without limiting their options or altering their economic incentives. Choice architectures and nudges in turn affect value co-creation by widening resource accessibility, extending engagement to more actors, or augmenting actors' agency. In line with our conceptualization, researchers also suggest that smart sensing technology must be integrated with distinct configurations of actors, resources, and activities to facilitate the transformation of service systems by modifying resource integration (Beverungen et al., 2019). Specifically, the technology interacts with system changes by facilitating coordination, especially when digital connectivity in real time "improves the effectiveness of resource integration" (Sklyar et al., 2019, p. 985). Nysveen et al. (2020) also propose that contemporary technologies affect routines that become materialized through the interaction of several actors (end-users) by changing their behavior over time.

In summary, smart sensing technology may affect resource integration and value creation in service systems in several ways; beneficial outcomes precede the service system's self-adjustment to the opportunities and limitations provided by the technology. However, we know of no research that analyzes the dynamics resulting from the introduction of smart sensing technology into service systems. Therefore, using routine dynamics theory, we theorize about and map self-adjustment within service systems as processes that dynamically align central aspects—resources, schemas and performances—within and among interdependent value co-creation routines.

3. Research methods

To contextualize and illustrate how self-adjustment processes take place, we adopt an embedded case study design (Stake, 2005) and analyze value co-creation routines as they occur in a real-world service setting, an elderly care home. This service system is managed by an Italian cooperative organization, which provides social care services to assist residents with senile dementia, critical diseases such as Parkinson's and Alzheimer's, or mental degeneration. With a longitudinal investigation of the adoption of smart sensing technology in this elderly care home, we identify how the adoption affects extant routines. A project launched in 2017 in this elderly care home introduced IoT sensing solutions and wearable devices into the care facilities, supported by various data analysis activities. These two technologies affected several value co-creation routines: A central adjustment process occurred in a monitoring routine, where environmental sensors and wearable devices were applied to care for wandering residents, and this change subsequently affected two other routines: data management routine and individualized care routine. These routines are essential for ensuring the safety and well-being of the elderly residents and thus are key in the value co-creation process. We analyzed self-adjustment in the first routine and their influences on subsequent routines, in terms of changes in the engaged actors' schemas and resources, in their tactics for integrating resources, and in the value co-creation outcomes for different actors.

3.1. Data collection

From May 2019 to March 2021, one of the authors conducted 52 open-ended interviews with 10 types of actors involved in the service system: managers (CEO, quality manager, innovation manager), technology partners, staff members (doctors, therapist, and psychologist),

Table 1
Interviewed actors.

Actor	No. of interviews (total time in brackets)
1 CEO	3 (3 h)
1 Quality manager	2 (2.15 h)
1 Innovation manager	2 (4 h)
2 Technology partners	3 (2 h)
3 Doctors	2 × each doctor (4 h)
3 Therapists	2 × each therapist (3 h)
3 Psychologists	2 × each psychologist (3 h)
5 Nurses	2 × each nurse (5 h)
6 Residents	1 × each resident (5 h)
5 Family members	1 × each family member (4,5 h)

nurses, family members, and residents (see Table 1). We sought out informants who were deeply involved in value co-creation processes and could provide relevant perspectives and detailed information about both the processes and the outcomes. We first contacted the CEO and technology partners, then used a snowballing technique and asked these initial informants for the contact information of other people who could offer further insights (Parker et al., 2019). Residents of the facility were interviewed with the help of staff members. We also gathered secondary data, such as internal reports and documents.

The interviews, conducted through Skype and Google Meet, lasted between 20 min and 2 h. To ensure reliability, the author who conducted the interviews used a consistent protocol (Denzin & Lincoln, 1998) that specified five key interview objectives: (1) to analyze extant routines, (2) to examine the objectives and process for introducing sensing technology, (3) to understand the problems and challenges experienced by key actors, (4) to identify positive versus negatives outcomes, and (5) to identify new routines. Accordingly, prominent interview questions included “What was the daily routine for residents, nurses and doctors before technology adoption?” “Why did the organization choose to implement sensing technologies?” “Who was in charge?” “What was the role of different actors?” “How did nurses perform their activities?” “What were nurses’ tech literacy and their attitude towards technology?” “What were the main problems?” “Were there positive outcomes? If so, what were they?” “How were residents involved?” and “How were families involved?” The interviews were recorded and transcribed verbatim into separate documents.

In addition to interviews, the researcher engaged in five observation days at the elderly care home: one in September 2019, two in July 2020, and two in February 2021. Field notes taken during observations were expanded and detailed soon after. By putting interviews into specific contexts, the researcher obtained rich descriptions (Geertz, 1973).

Table 2
Coding process.

Selective coding	Actors’ **schemas** leads to the use of new resources in: Monitoring routine Data Management routine Individualized care routine	**Resources** are applied and integrated in new performances in Monitoring routine Data Management routine Individualized care routine	**Performances** allows to enact new **value co-creation** in: Monitoring routine Data Management routine Individualized care routine
Axial coding	Mindset and knowhow to sensing technologies	Sensing technologies as resources	Use of sensing technologies in activities
Open coding	Tech literacy Problems Attitudes Fear vs trust Opportunities Stress and turnover Resistance to change Openess to newness	Paper documents Sensors, wearables and remote devices Drugs IT architecture Dashboard Diagnostic theraupeutic plans	Types of routines Manual control and visual inspection ICT-based control Falls, diseases and hospital accesses Training for new use Recreational activites Quality control procedure
Raw Data (interviews and observation)	Nurse 4: *I was fear of technology and thought it ould replace my job* Nurse 2 *I enjoyed new devices* Family member 3: *I had some doubts in the chnages promoted by the elderly care home* *Nurse 3: It was so stressful to check patients that I used to sitting outside the room when a patient was particularly agitated*	Nurse 1: *I get an alert from sensing devices* Nurse 3: *I gave drugs to calm down patients before smart wearables* Technology partner 2: *We showed how to overcome difficulties in applying devices* Innovation manager: *We implemented a dashboard to get key performance indicators.* CEO: *we decided to adapt the devices into jewels to foster patients’ acceptance* Patients 1: *My jewels are so nice*	Nurse 2: *I visualed check patients every 15 min now I uremotly monitor them.* Doctor 1*: By reducing drugs we organized new recreational activities* Innovation manager: *tech-based data allow to reorganize the care routines* Nurse 3*: I can focus more care activites and less on control*

3.2. Data analysis

With a constant comparative analysis of the data from interviews and observations, we combined “systematic data collection, coding, and analysis with theoretical sampling in order to generate theory that is integrated, close to the data, and expressed in a form clear enough for further testing” (Conrad et al., 1993, p. 280). This method involves comparing each interpretation, as it emerges from the data analysis, with existing findings (Glaser & Strauss, 2017), to identify different aspects of the studied routines and how they changed after the introduction of smart technology. The coding process, through which we sought a clearer view of the central phenomena, involved three levels of analysis: open, axial, and selective coding (Corbin & Strauss, 2008), shown in Table 2. With open coding, we identified patterns among the responses, which we refined through ongoing analyses of new data (Boeije, 2002). We continued until the new data supported the existing codes and did not require adding information—that is, until we reached theoretical saturation. Then we initiated the axial coding through continuous comparison and “pieced together” the data (Kolb, 2012). Finally, during selective coding, we chose core categories theoretically informed by routine dynamics theory (i.e., schemas, resources, and performances). Following the completion of the coding process, we organized meetings with the CEO, technology partner, quality manager, and innovation manager to obtain and compare their views, which affirmed a shared understanding of the results.

4. Findings

To demonstrate how the routines changed and contributed to and enabled self-adjustment in the service system, we present the adjustments in the studied routines in three steps. First, we discuss changes in the focal monitoring routine according to a temporal bracketing strategy (Langley, 1999), such that we organize the findings into distinct phases to map adjustments to the routine after the introduction of the smart sensor technology. As Banoun et al. (2016, p. 2992) define it, a phase exhibits “continuity and coherence in the actions taken by primary actors and discontinuity at its frontiers.” Second, we identify the effects of these adjustments on the broader service system, including adjustments of two other routines, namely, data management and individualized care routines. Third, we assess how these adjustment processes contribute to system-level viability.

4.1. Self-adjusting the monitoring routine

The monitoring routine involved nurses’ continuous daily actions to ensure that the residents were in a good overall condition and that everything was in order. Table 3 reveals how schemas, performances, and resources in the monitoring routine changed along the three adjustment process phases. The first phase characterizes how the actors performed the established routine manually before the technological change. The second phase features efforts to alter the focal routine by introducing smart sensing technology. In this phase, new technology-enhanced ways to perform routines co-exist with the previously established approach. The third phase pertains to the formation of a shared

Table 3
Changes in the monitoring routine.

	Phase 1. The established routine	**Phase 2.** Two ways of performing the routine	**Phase 3.** New technology-enhanced routine
Change action		Introduction of smart sensing technology, Training for new actions	Formal adoption of smart sensing technology
Schemas	Control as usual	Trust in technology, resistance to change Anxiety, Uncertainty, Openness, Curiosity	Confidence in sensing solutions Technology-oriented mindset Tech literacy
Resources	Restraints. Documentary evidence Nurses' knowhow	Manual control. documentary evidence and Sensing devices ICT-based documentation	Sensing devices ICT-based documentation New nurses' knowhow
Performances	Manual activities, detailed instructions, periodic and constant control	Manual activities and check of sensing devices	Use of sensing devices
Implications on value co-creation	⬇ Several falls, access to hospitals, physiotherapy, stress	⬇ Stress spent to compare two methods Anxiety about the correct use of devices Fear about adopting the correct procedure	⬇ Falls reduction, Faster intervention Better quality of life Enhanced well-beingfor actors

understanding of the technology-enhanced routine, which enables actors to perform it fully.

4.1.1. Phase 1: Established monitoring routine

The elderly care service system operated in a five-story building, so monitoring represented a major challenge. Nurses had to perform a visual check of residents in their rooms every 15 min, both day and night, to avoid falls and erratic behaviors.

> I always felt very stressed and worried about residents. The building is significant, and 15 min were too few to control every room. In the most complex cases, I sat on a chair outside the patient's bedroom (Nurse 4, interview).

The monitoring routine was internally aligned, in the sense that the staff and management shared schemas about to how to monitor residents using shared resources such as restraints, documentation, and drugs. However, the routine performances were time consuming and resulted in quality problems and mistakes due to human error. Furthermore, they imposed stress on nurses. Difficulties arose if residents needed to be restrained to their beds or required the administration of drugs to reduce their anxiety and wandering tendencies. In addition, nurses had to fill out several reports and document a wide range of detailed information, which then had to be checked and signed by doctors. The number of printed documents had grown over the years and become a burden, without much use value; managers could not perform effective data analyses with them. These challenges indicate that the service system had inadequate or not useful resources for creating value for involved actors, which led to resource integration problems in routine performance.

4.1.2. Phase 2: Introducing the sensing technology and dual ways of performing the routine

Managers decided to introduce smart sensing technology to improve both staff performance and residents' well-being. Various environmental sensors were installed throughout the nursing home to detect movement, position, and other parameters for each resident. These sensors included motion detectors in corridors, flow sensors in toilet tanks, and sensors to detect bed movements. Furthermore, some residents received wearable devices equipped with sensors, which then enabled them to move freely throughout the nursing home. These sensors and wearables acquired and sent data to a central system in nearly real-time, and this central system alerted staff if residents' daily activities deviated from the norm.

In this phase, two ways emerged to perform the monitoring routine: established and technologically enhanced. They involved different resources and performances and invoked conflicting schemas about the benefits of the new technology for value creation. Strong debates arose among staff, managers, technical providers, residents, and families, all of whom sought to understand the challenges and advantages of smart sensing technology. These debates indicate that it was not easy to identify how the new technology could be integrated with existing resources to improve performances. Two key challenges included ensuring that staff members internalized schemas that supported new ways to create value and that they were equipped with sufficient resources, such as expertise, to enact new technology. The former required that they were happy and motivated, in terms of their evaluations of the suitability and usefulness of the new technology. Technology consultants and trainers carried out intense training and motivational activities for personnel who would apply the technology. These activities aimed to overcome technical obstacles related to the use of the devices, as well as address cultural concerns and suspicions that the technological resources might threaten to replace them:

> Guaranteeing employees [had enough] time to understand the context, strengths and limitations of the technologies was fundamental for their implementation, to remove prejudices. Such an endeavor was fostered through clear narration and communication, developed in collaboration with consultants (Innovation manager, interview).

Residents and families also expressed initially skeptical responses to the wearable devices, indicating that they had difficulty changing their value co-creation schemas and identifying the usefulness of the new technological resources. Notably, the use of the wearables was minimal, due to negative schemas that some residents attached to sensing technology:

> I do not want to be controlled. And the wearable is really ugly. I asked my family to change the care home (Patient 2, interview).

To overcome residents' negative schemas, management proposed introducing the devices as "smart jewelry"—ornaments and accessories equipped with the appropriate sensors but with a less obviously high-tech design, to reduce the chances that residents perceived themselves as being under constant surveillance and instead would express more positive views, as in the following quotations:

> Two weeks ago, I got this necklace and it is not my birthday. Don't you think it's wonderful! And it's also magic as I can call my guardian angel [referring to the nurse] (Resident 4, interview).
> The idea to put the sensor into a wearable jewelry was the key to facilitate the acceptation by the residents. It was not an enigmatic technological tool, but a beautiful present to wear and show to other residents (Psychologist 1, interview).

In summary, through discussions and managerial interventions, previously shared schemas gradually shifted, resulting in new attitudes of various actors toward smart sensing technology as a potentially useful resource for value co-creation. Performances were gradually adjusted as actors struggled to find and perform new ways of interacting by exploiting the novel resources and integrating them with the existing ones, as well as aligning their schemas (consonant alignment) with the renewed resources and routine scripts.

4.1.3. Phase 3: New technology-enhanced monitoring routine

The third phase features the adoption of the smart sensing technology to perform and control the monitoring routine, without any alternative. Nurses and other staffers abandoned visual control as a way to perform the monitoring routine and halted their collection of documentary evidence. The new technology-enhanced monitoring routine became established and supported by additional resources, such as formal documents and dashboards of results. Nurses were equipped with a personal smartphone or device connected to an internal API (application programming interface), through which all information about residents was channeled and digitally saved, enabling individualized monitoring without their physical presence. Nurses thus perceived greater control over their work situation and less anxiety. Furthermore, their capacity to take care of residents in need of more attention grew as they received more information and time for individual discussions and support. When such improved performances became possible, the nurses' fears about being replaced by the technology were also dispelled:

> Even if I am on another floor or wing, I could make my rounds while still remotely monitoring other residents. If they experienced some critical or unexpected event I can reach immediately and help them. My work is really improved with these devices. (Nurse 2, interview).

Growing knowledge of sensing devices in turn improved the actors' technical literacy. Supported by new shared schemas, they adjusted their routines by experimenting with the new technology and by trying out new activities, interactions, problem-solving processes, and reporting methods. In addition, once residents accepted the sensors and devices, they experienced a significantly improved value co-creation process. They were no longer restricted to their beds, and their need for drugs (key resources in the old routine) decreased, both of which reduced their stress and anxiety and improved their well-being. Thanks to the smart control, residents' falls and hospital visits also decreased.

> The reduction in drug consumption by 25 % is made possible by the internal 'zero restraint' policy that now encourages the residents to leave their beds and, therefore, even those who suffer from diseases such as Alzheimer's and wandering tendencies are able move around the facility (Doctor 1, interview).

In summary, the introduction of smart sensing technology ultimately created several positive changes for actors' value co-creation process. In particular, the nurses experienced less stress in monitoring and caring for residents, because they could spend less time monitoring the residents.

4.2. Self-adjusting in other routines: Data management and individualized care

The dynamic adjustment of schemas, resources, and performances in the monitoring routine had broader effects within the system when actors found new roles and resources to fuel their interactions and value co-creation:

> Thanks to the installation of sensors and the provision of wearable devices, there is an increase in effective predictive and preventive assistance by nurses. Again, there has been a change of mentality on the part of social and health workers, who are now much more open to innovation and to the use of technology as an active component of their work (Quality manager, interview).

Most important, we observe interdependencies among core routines, revealing the dynamic alignment of schemas and resources that enables the wider service system to self-adjust. In particular, changes in the monitoring routine created further changes in the data management and individualized care routines.

4.2.1. Data management routine

The smart devices acquired and sent data to a central system in nearly real-time. This change in available resources enabled managers to conduct deeper analyses, which prompted additional changes in the planning and organization of care activities. To support such changes, the organizational chart was revised, and a new professional position, "Innovation Manager," was created to oversee the information process and the use and dissemination of new technologies. The innovation manager defined new rules, trained new staff, and encouraged technology acceptance, thus facilitating self-adjustment. A newly created IT architecture reflected the design and location of the sensors, along with different provisions within the elderly care home, which in turn inspired new performances:

> Our decision-making process has much improved thanks to data coming our devices and platform. Devices, in near-real-time, acquire and send data flows to a central system, based on Artificial Intelligence Health technology. Such a technology not only has the task of alerting the socio-health personnel when a daily activity of residents deviates from the norm but is also capable of identifying new models useful for improving the planning and organization of activities (Innovation manager, interview).

At first, the introduction of the new sensing technology required the constant presence of technological consultants, but the managers and employees soon gained proficiency to respond immediately to critical issues and reduce idle times. In this sense, the adoption of smart sensing technologies changed their schemas, resources, and performances. It also required teamwork and new activities, many of which were initiated by the innovation manager. These efforts led to a 15 %–20 % increase in the operational efficiency index, measured by the joint analysis of several key performance indicators (KPIs), such as the degree of concentration of health workers on main activities, idle time, and estimates of latent difficulties.

4.2.2. Individualized care routine

Before the introduction of the smart sensing technology, the elderly care home had adopted diagnostic therapeutic assistance plans, which involved standardized approaches to treatment for certain patient categories. But the collection and analysis of real-time data enabled the development of individualized care routines and plans, based on information related to residents' needs. In this way, resources deriving from the monitoring routine and data management routine triggered subsequent adjustments in individualized care routine. The individualized plans aimed to specify the best possible health and well-being outcomes achievable for each patient. The routine involved clinical, welfare, social, psychological, and linguistic-communicative evaluations, which were shared with families, who then collaborated with caregivers to ensure the greatest possible empowerment for residents:

> This new info-technological system is specially designed to help older people to live safely and independently. By having a better understanding of a person's daily routines and living spaces, we can identify potential risks, personalize care, and provide precise recommendations that improve their quality of life. Furthermore, all of this becomes a formidable system to improve the level of our assistance activities, providing operators with the most advanced tools to personalize aid interventions (Innovation manager, interview).

The changes triggered by smart sensing technology modified performance profoundly by allowing families to become more involved in the provision of the care service, as well as improving their relationships with nurses and staff members. To encourage perceptions of the "warmth" of the technology, professionals actively described the residents' greater awareness and safety and noted that their experience within modern smart data structures did not create a sense of invasiveness or control. In turn, trust increased among residents' family members, who usually represent the real decision-makers who choose care facilities for their loved ones.

4.3. Summary of the findings

Fig. 1 depicts how the service system adjusted though cyclical adjustments within and among value co-creation routines. The intertwined adjustments in the monitoring routine not only influenced the value co-created in that routine but also created resources and schemas that energized further adjustments in other interconnected routines. New resources and schemas such as time, data, and novel attitudes toward smart technology provided opportunities for new performances in data management routine, which then established novel resources for adjusting the individualized care routine. In addition to the adjustments in the core routines shown in Fig. 1, the changes evoked minor modifications in recreational activities for residents and training activities for employees. We argue that, through such cyclical and evolving adjusting processes, the system as a whole adjusted and took a new shape to remain viable.

5. Discussion

This article responds to calls to extend understanding of service system dynamics, with a focus on self-adjustment processes (e.g., Edvardsson & Tronvoll, 2019; Koskela-Huotari et al., 2016). Self-adjustment is a core characteristic of service systems, necessary for their viability (Barile et al., 2016; Vargo & Lusch, 2017). Previous research has described how digital platforms, for example, enable self-adjustment in service systems (e.g., Edvardsson & Tronvoll, 2019), but the dynamic nature of self-adjustment in service systems is poorly understood. To address this knowledge gap, we focus on two research questions: How can we define and conceptualize the self-adjustment of a service system? How does the introduction of smart sensing technology affect the service system's self-adjustment through value co-creation routine dynamics? The conceptualization we propose thus contributes to studies of self-adjustment and the viability of service systems, as we detail next. We also offer some theoretical and practical implications, along with an assessment of the limitations of our study that invite further research.

5.1. Conceptualizing self-adjustment in value co-creation routine dynamics

We define self-adjustment as the process a service system performs to adapt to changing conditions to remain viable or improve its viability. The plasticity of the service system therefore becomes manifest through self-adjusting behaviors. By drawing on Feldman and her colleagues' work (Feldman & Pentland, 2003; Feldman et al., 2016; Feldman, 2004), we conceptualize routine dynamics as manifestations of self-adjustment behaviors that contribute to the service system's viability (Chandler et al., 2019; Edvardsson & Tronvoll, 2019). The case study demonstrates how self-adjusting behaviors can unfold via cyclical change efforts, through which schemas, performances, and resources become aligned after the introduction of smart technology, which in turn influences the value the actors co-create.

As our illustration shows, the introduction of smart sensing technology, originally intended to reduce nurses' workloads and improve residents' safety, also influenced the schemas and performances of these

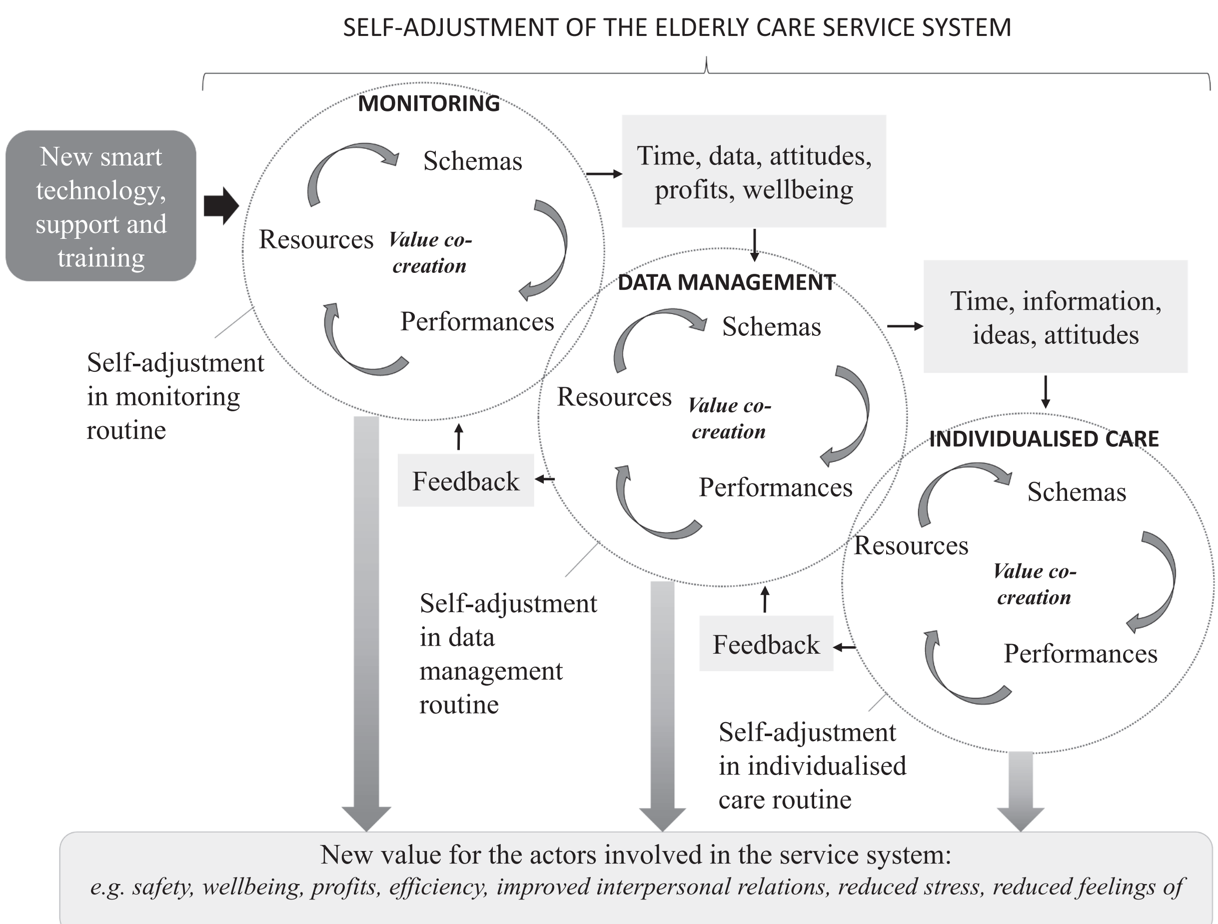

Fig. 1. Self-adjustment of the service system.

and other actors in deeper ways, creating trust, knowledge, acceptance, and time. Nurses could focus on other care aspects, such as social interaction and individualized attention. Families could interact with residents in a more positive way, with reduced feelings of guilt. In this sense, the introduction of smart sensing technology improved different routines and enabled the service system's self-adjustment, by offering consonant and resonant ways to integrate resources and conduct care activities and data management and analysis.

In line with our theoretical and empirical analysis, Fig. 2 summarizes the conceptualization of how smart sensing technology triggers processes of self-adjustment within and across value co-creation routines to ensure service system viability. For simplicity, the figure illustrates these processes in a system composed of two routines only, though service systems often entail complex configurations of multiple interconnected routines. We acknowledge that being plastic and aiming to stay viable and innovate a service system needs to self-adjust to both internal and external conditions and changes. External contexts put pressure on internal routines and their aligning and thus on all components of the service system (e.g., Edvardsson et al., 2018). Drawing on routine dynamics theory, we show how self-adjustment within and across routines occurs when smart sensing technology sparks cyclical adjustments to align and integrate resources, schemas, and performances to enable new ways to co-create value, as experienced by the involved actors. If routines involve shared aspects (Sele & Grand, 2016), these adjustments may spread across the service system, manifesting its internal dynamics. However, service system changes do not emerge suddenly but through cyclical adjusting processes, during which collaborating actors may struggle to maintain the viability of the system (i.e., adaptation and innovation). Thus, service system self-adjustment emerges step-by-step, as a process of progressive, consonant alignment, in which actors integrate resources and other elements to find a harmonic resonance of routine aspects and improve value co-creation (Tuominen et al., 2020). Even if self-adjustment can be a continuous process, the system may adjust by responding to a specific change when routines are aligned internally, with one another and with the context of the service system.

5.2. Theoretical implications

Our conceptualization of self-adjustment has several implications for advancing the service-dominant logic and service research in general. It connects to studies of service system viability by enabling researchers to analyze self-adjustment behaviors as cyclical adjustments that take place within a service system, as our case study demonstrates. It also shows researchers how to detail the dynamic nature of processes through which planned and unanticipated effects may emerge in value co-creation routines after introducing new elements into service systems (Tuominen et al., 2020) and reveals the role of performances in these processes.

These insights contribute to the understanding of performativity in S-D logic by providing means for empirically investigating how novel service models and resources are made to matter in specific situations, and how they change the system. Vargo and Lusch (2018, p. 168) suggest that the performative view of service context helps to understand "how a specific context is enacted for a specific service exchange". This paper argues that routine performances fuel the dynamics through which new concepts and resources are applied so that they enable not only situated value co-creation but also system-level adjustments, that may lead to the institutionalization of new value co-creation performances and revise the institutional arrangements. Thus, by drawing on routine dynamics theory, we reconcile with both performativity and institutional arrangements being key concepts in S-D logic.

Furthermore, the conceptualization can be used to explain how resource integration can be coordinated through smart sensing technology, providing actionable information to coordinate routines through signaling and screening (Dehling et al., 2022).The conceptualization supports viewing resource integration as an embedded process in

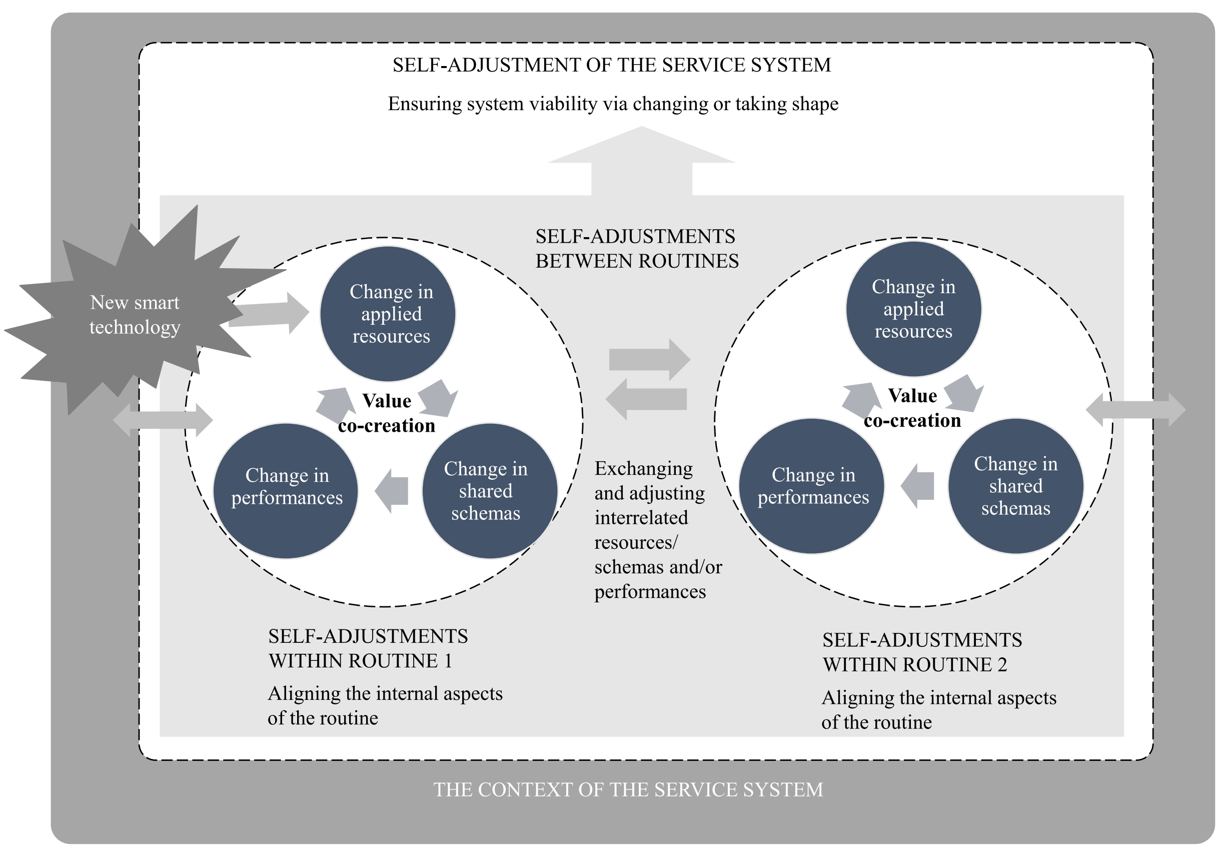

Fig. 2. Self-adjustment through value-creation routine dynamics.

service systems (Carida et al., 2018; Mele et al., 2021) and extends understanding of changes in resource integration (Findsrud et al., 2018; Vargo & Lusch, 2016).

Finally, the proposed conceptualization has implications for service innovation research related to the diffusion of innovations in existing service systems (e.g., Di Pietro et al., 2018; Vargo et al., 2020). Routine dynamics can enable or inhibit innovations from scaling up, so they might explain breaking, making, or maintaining institutionalized rules for resource integration (Koskela-Huotari et al., 2016). The empirical findings extend research in healthcare service systems (Beirão et al., 2017; Mele, Marzullo, et al., 2022); and the conceptualization may be applicable to system dynamics in different empirical contexts, ranging from local service systems to broader networks and service ecosystems.

5.3. Managerial implications

For practitioners, our conceptualization suggests ways to improve value co-creation in changing situations. First, the suggested definition of self-adjustment and the conceptual framework shown in Fig. 2 may help managers to reflect on and analyze value co-creation in their service system, then manage the integration of new resources (beyond smart sensing technologies) into the system. The conceptualization directs attention to assessments of how and to what extent established routines and schemas may or must change. At the same time, other actors may grasp the advantages and inspire or help one another adapt their routines and thereby institutionalize new ways of co-creating value.

Second, as self-adjustment processes in a service system unfold, the intended new performances and value outcomes might be traced back to interrelated alignments of schemas, the integration and use of resources, and performance in the focal and other routines. Managers can identify alignment and misalignment when monitoring changes in their value co-creation routines. They should keep in mind that self-adjustment relates to breaking, making, and maintaining institutionalized schemas and other aspects of routines; in many cases, only some routines or parts of the system are changing.

Third, the empirical findings suggest that managers should focus on explaining the benefits of new resources in a way that helps different stakeholders understand the specific value being created for them, as well as the need to change and align their activities with engaged actors' activities and thus self-adjust the service system as a whole. Prior findings similarly highlight the key role of actors' mindsets, willingness, and ability to enable alignment (e.g., Pentland & Feldman, 2008). It is important for managers to promote shared schemas to change value co-creation routines to support the performance and viability of the whole system. These managerial efforts can evoke both short- and long-term benefits.

In summary, the paper provides a framework for managing challenges when renewing value co-creation in an organization, with implications for a wider service system. With suitable KPIs, organizations can identify change outcomes and areas for improvement over time. Managers can introduce new resources, such as smart sensing technology, to enact and feed continuous self-adjusting processes and ensure that service systems remain viable. Such ongoing self-adjustment can be managed by focusing on the interdependences among changing resources, schemas, and performances.

5.4. Limitations and further research

This study assesses the proposed conceptualization in a single service system setting. Further research is needed to elaborate on the conceptualization in other service system contexts. Comparative empirical studies of service systems in different sectors—such as education, financial, and travel services; systems embedded in different cultural contexts; and systems whose internal elements are loosely and tightly coupled—could offer wider insights into self-adjustment processes and enable testing and further developing the suggested conceptualization.

Furthermore, in our case study setting, no strong restraints arose among actors. Therefore, the study does not extensively address the self-adjustment challenges or opportunities resulting from the introduction of smart sensing technology in value co-creation routines. In organizations with strong professional identities, resistance might be greater and routine dynamics might be different, leading to different value co-creation outcomes (Pentland & Feldman, 2008). Comparisons of successful and failed smart technology introductions might reveal when and how dynamics among shared schemas, resources, and performances constrain changes to service systems. Research that combines theoretical perspectives such as routine dynamics, group dynamics, social construction, and system dynamics theories could be insightful.

Further research also should explore misalignments among schemas, resources, and performances in service systems to outline how self-adjustment proceeds when alignment exists between two aspects but not the third or if the consonant process is not also resonant. Research into misalignment processes could reveal hindrances to self-adjustment, as well as compare different types of self-adjustment processes and outcomes in service systems, including analyses of plasticity in terms of the interdependencies among routines when some routines are stable but others change, as often occurs when service systems self-adjust (e.g., Koskela-Huotari et al., 2016). Furthermore, the role of various digital and service platforms (Edvardsson & Tronvoll, 2019) should be covered, to explore their usefulness for aligning the changes in routines in self-adjusting service systems.

Another stream in future research could deepen the link between self-adjustment, adaptation, and innovation to better explain radical self-adjustments. This could help to understand the balance between continuous, incremental aspects and radical, innovative aspects affecting resilience and innovation in service ecosystem (Lyng et al., 2021). Scholars need to identify and analyze the different mechanisms needed to redesign value co-creation routines for service systems to stay viable. Future research may zoom in on different types of self-adjustment processes, such as incremental and radical changes in service systems over time. In such research, the innovation literature can inform the understanding of self-adjustment beyond theory of routine dynamics used in this paper.

Finally, we investigated smart sensing technology exclusively; continued research might address other forms of technology, such as social robots, artificial intelligence, the blockchain, and the metaverse and their effects on service systems' self-adjustment, as agents, resources, and processes that can foster novel dynamics in value co-creation routines.

CRediT authorship contribution statement

Cristina Mele: Writing - original draft, Writing - review & editing. **Tiina Tuominen:** Writing - original draft, Writing - review & editing. **Bo Edvardsson:** Writing - original draft, Writing - review & editing. **Javier Reynoso:** Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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