Article:
Kreye, Melanie (2026) Implementing circular practices through supply-chain configurations of service offerings for consumer products. IEEE Transactions on Engineering Management. pp. 1224-1239. ISSN: 0018-9391

https://doi.org/10.1109/TEM.2026.3651889

Implementing circular practices through supply-chain configurations of service offerings for consumer products

Melanie E. Kreye

Abstract

This research investigates how the supply-chain configurations of service offerings in Business-to-Consumer (B2C) markets enable manufacturers to implement circular practices. We differentiate offerings by service complexity as relevant starting points for this purpose. Following best practices in methodological rigour, we provide empirical evidence from five cases in the household-appliances industry. We detail the respective supply chain configurations of service offerings and of circular practices. In addition, we identify three mechanisms by which the supply chain configurations of service offerings connect to the supply chain configurations of circular practices: complement, enable, and undermine. This research contributes to the debate on the connections between servitization and circularity in B2C markets. Specifically, we identify the supply-chain configuration of service-based business models and circular practices showing their downstream and upstream effects. This enabled us to identify the mechanisms connecting service offerings to circular practices via their respective supply-chain configurations.

Keywords: servitization; case study; secondary data; circular economy; B2C

Managerial relevance statement: This research investigates the creation of circular supply chains from existing supply-chain configurations. We distil implications for service managers and policy makers. Service managers who aim to achieve circularity are advised to follow the following steps. They should review their current supply-chain configurations of their service offerings based on the three identified mechanisms. Here, managers are advised to avoid service-based supply-chain configurations that undermine the implementation of circular practices. Instead, service offerings in B2C markets can be viewed in terms of their dynamic development of related supply-chain capabilities. This may in turn reduce the undermine-mechanism and instead emphasise the complement or enable mechanisms between service-offerings and circular practices. In turn, policy makers are advised to review existing regulations based on the incentives they provide for circularity. In addition, new regulations may create unintended consequences where the supply-chain configurations of service offerings (especially product-oriented services) can undermine the implementation of some circular practices. Instead, new regulations should emphasise service offerings based on their enabling or complement mechanism for circular practices. This paper also contributes to the following SDGs: SDG 9, SDG 12 and SDG 17.

I. Introduction

Manufacturers of complex consumer products, such as user electronics, household appliances, or automobiles, have long explored the ability to servitize their businesses and provide service support for these products [1], [2]. Servitization defines a trend when manufacturing firms 'offer fuller market packages or bundles of customer-focused combinations of goods, services, support, self-service, and knowledge' [3, p. 314] and can contribute to sustainable outcomes [4], [5], [6]. Servitization can offer such sustainability benefits particularly in business-to-consumer (B2C) markets [1], [7]. A drive for manufacturers in B2C markets to consider these benefits arises from increasing pressures to transform their businesses and create circular supply chains (SCs) [8]. This is often driven by regulations and legislation such as Extended Producer Responsibility[1] and the European Commission circular economy action plan[2]. In addition, there are increasing societal pressures. For example, consumers increasingly demand extended product life cycles through repairing and service provision [9]. Implementing circularity is typically motivated by environmental sustainability, including resource scarcity, environmental degradation, and climate change and aims at reducing waste and enabling material reutilization [10], [11]. Circular SCs create effects, such as replace the use of virgin materials [12], reduce products and materials [13], and enable product reuse by different customers [14].

While servitization can play a central role in achieving sustainability, its positive impact on circularity is not clear and often disputed [15], [16], [17]; especially in B2C markets [18]. The effect of service offerings on achieving circularity goals depends on whether the

[1] See UK regulation as an example: https://www.gov.uk/guidance/extended-producer-responsibility-for-packaging-who-is-affected-and-what-to-do

[2] See https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

product use life is extended [19]. For example, while service-based offerings can enable access to used products, it may not necessarily lead to reduced material flows in SCs or extended product life spans [18]. Here, service complexity can play an important role as different types of services require more (or less) operational complexity, including the level of engagement between provider and customer [18], [20]. Existing studies highlight the potential of complex result-oriented services, such as leasing, as they contribute to dematerialisation [21]. Such argumentations are based on the ability to create closed-loop SCs through service provision, where circular practices are controlled and often enacted by the manufacturer [22]. Other studies emphasise that such sustainability benefits of complex service offerings are only realised if they relate to circular practices in the SC [18]. While complex service may enable access to used products and offer the possibility for recirculating them [13], the ability to do so depends largely on available circular SC capabilities, including repair, remanufacturing or recycling of such returned products and their redistribution [18], [23]. Such insights emphasise the need for further research connecting servitization and circularity in B2C markets.

We approach this connection between servitization and circularity indirectly via the respective SC configurations, showing the actors in the SC and their relationships [24]. This is based on recent findings highlighting the role of SCs in the circularity effects of servitization [25], [26]. The provision of services of different complexity levels affects the respective SC configurations [27]. For example, product-oriented services, such as spare part provision, typically requires relatively simple SC configurations between provider and customer [28]. In comparison, more complex offerings, such as pay-per-use models (e.g., city e-bikes) often require additional actors creating more complex SC configurations [29]. Similarly, different SC configurations may enable circular practices. For example, product

reuse requires connections between two end users, while recycling involves product circulation deeper into the SC [30]. Some SC configurations may also hinder the implementation of circular practices. For example, the lack of drop-off points for used or broken consumer products or inability to access repair capabilities may encourage purchases of new products instead of prolonging or reusing existing products. To study this connection between servitization and circular SCs, we formulate the following research question (RQ): How do the supply-chain configurations of service offerings in B2C markets enable manufacturers to implement circular practices?

To study this RQ, we build an initial conceptual framework, connecting service offerings of varying complexity levels indirectly to circular practices via their respective SC configurations. We investigate this conceptualisation using empirical evidence from five case studies in the household-appliance industry. Our study reveals three main insights. First, we identify the SC configurations of service offerings differentiated by their level of service complexity showing particularly the downstream effects of product-oriented and result-oriented services observed in our empirical cases. Second, we identify the SC configurations of circular practices, including their downstream and upstream SC effects. Third, we identify three mechanisms by which service offerings indirectly connect to circular practices via their respective SC configurations: complement, enable, and undermine. These mechanisms are summarised in a framework and explain the observations of our empirical cases. This research contributes to the debate on the connections between servitization and circularity for consumer products [15], [24]. This research shows how these connections unfold via the three identified mechanisms. In addition, we discuss the contributions of this research to the B2C servitization [1], [31] and circular SC literature streams [22], [30].

II. Literature review

B2C markets define the setting when consumers are the users of products or services [32]. B2C markets are characterised by a large set of consumers with heterogeneous needs [33]. This typically results not only in a variety of different products and services [34] but also in differences in consumer relationships [1], [7], [35]. Especially for services, consumer interactions can be both transactional (one-off) and relational (planned and administered) [32], [36]. Consumers are geographically dispersed often spanning wide areas of both urban and rural settings [37]. This requires a wide range of retail outlets and potential contact points [38] and can create logistical challenges for delivering services and products to the level and when they are needed [39]. As a result, B2C markets typically involve intermediates, such as product installers, to provide the front-line service [33]. The central role of consumer involvement has been highlighted for both circularity [16] and servitization [1], [11]. This suggests distinct insights for B2C markets.

A B2C servitization and related supply chains

Adding services to product-focused business models is understood to increase complexity of the resulting operations and offerings [3], [18], [40]. Service complexity is difficult to define because of the dynamic nature of services leading to constant adaptation to context and conditions [41]. We hence study service complexity via a useful approximation based on the agreed service output and level of interdependence between provider and customer during service provision driving the resulting operational considerations of both provider and customer [20]. This understanding enables us to differentiate service offerings comparing relatively simpler offerings, such as product-oriented services to more complex ones, such as outcome-oriented services and derive relevant insights.

The varying sustainability and circularity effects of servitization often arise from the SC and other institutional surroundings of the service offering [25], [26]. The SC implications of servitization can be viewed in terms of the product and service SCs. Product SCs relate to the provision of the physical elements of the offering, including product, spare parts and other materials to enable availability within the provider network through integrating inputs from various suppliers and partners [42]. Such product SCs can further require integration with a potential digital product SC, to ensure functioning and security of the digital product elements [43]. Service SCs, in comparison, are characterised by staff, affected by their skills and knowledge [44] as well as motivation [45]. Dyadic dynamics between the service supplier and customer affect value perception [25], [46] and are largely driven by the operational complexity of the service offering [18]. Table 1 details initial thoughts on the SC implications of service offerings based on their service complexity.

Table 1: Supply-chain considerations for service offerings based on the level of service complexity

	Product-oriented services	**Result-oriented services**	**Outcome-oriented services**
Service offering	Offered as an add-on to the sold product to improve operational up-time and includes spare part provision, preventative and corrective maintenance [18]. An example is the repair of a washing machine.	Offered as availability of a product for its use by the consumer through, for example, lease arrangements [25]. Examples are phone as a service [18]. An example is the lease of a washing machine based on regular or use-based payments.	Offered as the outcome of product use, where the provider takes over whole operational functions of their product to ensure outcome [47]. An example is clean laundry.
Supply-chain implications	Product-oriented services require limited interactions between provider and customer and are typically initiated (ad hoc) by the customer. Related product and service SCs can be managed separately. For example, spare-part availability for repairs can be handled separately from customer support via call centers. This results in relatively simple SC configurations [28].	Result-oriented services require regular and often planned contact between provider and customer based on a pre-agreed service interval, initiated by either provider or customer and typically result in a long-term service relationship [48]. Consequently, there are many connection points between product and service SCs and more complex SC configurations.	Outcome-oriented services require a close provider-customer relationship with regular planned exchange of information, including product use patterns [49]. This often results in complex SC configuration with additional actors for service delivery [47] or parts supply [50].

B Circular supply chains

While the specific definitions surrounding circular SCs have evolved significantly as the understanding about their structure and inter-organizational relationships and value creation increase, two main concepts are typically distinguished: closed and open loop SCs. Closed-loop SCs focus on the *"design, control, and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time"* [22, p. 10]. In closed-loop SCs, the manufacturer takes primary control of returning products into reverse flows for reuse, remanufacture etc based on direct customer contact [51]. Hence, forward and reverse SC actors are typically the same as pre-used products are used within the same industry sector and the same application [52]. In contrast, open loop SCs *"arise where the original company loses business control of its components after sale"* [53, p. 580] and consequently other SC actors take on the responsibility of looping used products back into the SC. As a result, a variety of actors can be found in open-loop SCs beyond those involved in forward SC activities, including remanufacturers, product maintenance and resale shops and brokers [51].

The difference between these circular SCs in B2C markets arises particularly based on the characteristics of the consumer links (Section II.A). The enactment of circular practices aimed at *"the recovery of added value by reusing the whole product or part of it (…) and are ultimately concerned with the reduction (or the delay) of unintended negative impacts on the environment"* [54, p. 345] often falls on third parties. For example, the provision of sharing-economy services aimed at product reuse through maximising the value of products, is often done by a purposeful provider, such as Airbnb (accommodation sharing), Thule (e-bike or e-scooter sharing), and Enterprise (car sharing) [29]. This would favour an open-loop SC configuration for circularity in B2C markets. Conversely, examples such as

Apple's recycling robot for used iphones, show examples of manufacturers taking responsibility for the circular practices of their consumer products [18]. This suggests that both open and closed-loop SCs are found in practice.

The related SC configurations differ between circular practices [30], [55]. Reuse enables value retention for the whole manufactured product and consequently the related SC configuration requirements may be less complex [56]: in its simplest form, product reuse requires engagement between two product users through a second-hand market [27]. In comparison remanufacturing enables value retention for components and requires a multitude of further steps before a component can be utilised again [57]. The SC configuration for remanufacturing becomes more complex as used products are circulated deeper into the SC for inspection, disassembly etc before being redistributed to secondary customers [30]. This suggests that the implementation of different circular practices requires different SC configurations (Table 2).

Table 2: Exemplar circular practices for consumer products

Circular practices	Product level effects	Potential supply chain configurations
Reduce and Repair	Reduce the number of resources needed in the system by extending product use phases [21].Reduce can involve a reduction in consumer product on the market, reduction in resource use for operating the product or reduction in material used in each product. Repair can result in reducing the number of products on the market as individual products are in use longer [21].	Limited effects on supply chain configurations. With a reduction of consumer product sales affects a change in the economic valuation of product-based business models along the upstream supply chain as fewer components and parts are needed [58].
Reuse	Value retention of the manufactured product through extending its use phase. A used product is redistributed to another consumer for continued use after inspection for its functionality. In consumer settings, such reuse typically happens through second-hand marketplaces, including online platforms [29].	Multiple consumers through potentially providers and matching services to match supply and demand [10]
Refurbish and Remanufacture	Value retention of product components and parts as these are integrated into new products. End-of-life products are cleaned, disassembled, and inspected for the operability of key components [59]. From these, the product is either restored for a new use cycle (refurbishment, [60]) or a new product is manufactured, combining partially used components with replacements for wear and tear parts [61]. Pre-	Requires circulation of used products deeper into the up-stream supply chain [30] creating increased complexity of the supply chain through participation of collectors of used products, logistics providers [63], and remanufacturers [30].

	used components can also be integrated into a new product design to enable the functionality of comparable new products with previously used parts and components [62].	
Recycle	Value retention of materials, which are extracted from the product and its components to be reintegrated into new products. After product disassembly and inspection, the components are further separated into their base materials, such as metals or plastics. These materials are then further processed through, for example grinding to product pellets of plastics, or metal scraps, which can then be reintegrated into the supply stream as recycled raw materials.	Requires circulation of used products even deeper into the up-stream supply chain [30] through participation of distributors of waste streams [33], suppliers and sub-suppliers, and the manufacturer. Due to relative maturity of waste collection and transformation systems, product recycling may by-pass actors participating in the forward supply chain and involve waste-stream actors only [18].

C Initial conceptualisation

The aim of this study is to connect service provision in B2C markets with the implementation of circular practices. Existing studies indicate that such connections should exist even though there remains disagreement regarding their nature. For example, complex services, such as result-oriented services (e.g., product leasing) and outcome-oriented services (e.g., product availability), are described by some studies as particularly suitable for implementing circularity [17], [21], [55], [64]. Regular engagements to ensure product functioning and often also the retainment of product ownership offer the opportunity for the manufacturer to take control of the product post use. However, the realisation of circularity often depends on whether these used products are looped back into the SC suggesting that this positive connection between servitization and circularity is not automatically achieved [18]. Services of low complexity may also offer the opportunity for circularity due to their simpler SC configurations. For example, offering spare parts enables other SC actors to perform product repairs and hence prolong product use phases [21]. This is often a stated goal of initiatives related to right-to-repair [65].

We aim to build the connections between service offerings and circular practices via the related SC configurations as these enable us to explain how circular practices can be implemented in relation to different service offerings. In other words, we aim to link the SC configuration of service offerings to those SC configurations of circular practices. While existing studies disagree about the potential connections between servitization and circular practices [17], [66], they highlight that any realised circularity effect of service offerings depends on the wider SC configurations [6], [18], [64]. The reason for this is the usual limited visibility of individual actors in relation to the value realisation through services and circular practices [25]. For example, less complex services, such as spare part availability or product repair can often be provided by external SC actors [65] potentially enabling an open-loop SC. In contrast, complex service offerings may enable closed-loop SCs as the manufacturer can implement product reuse or remanufacturing [21]. This suggests that SC configurations created by service offerings drive how circular practices *can* be enacted. Based on these evaluations, this research has two research objectives that enable us to answer our research question (Figure 1): This research aims to (1) identify the SC configurations of service offerings differentiated by their level of service complexity, and (2) identify the SC configurations of circular practices. In combination, these two objectives will enable us to answer our research question and allow us to identify the mechanisms by which service offerings connect to circular practices.

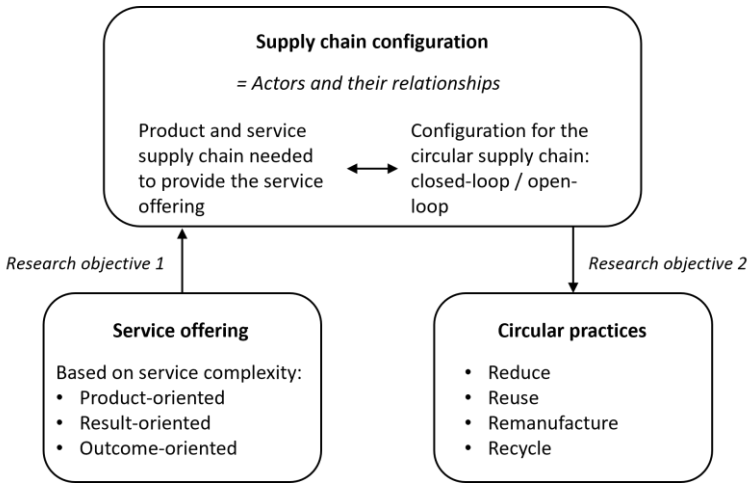


Figure 1: Initial conceptual framework linking service offering and circular practices via supply chain configuration

III. Method

To answer our RQ and two research objectives, we use theory elaboration, which aims at *"developing new theoretical insights by contrasting, specifying, or structuring theoretical constructs and relations to account for and explain empirical observations"* [67, p. 441]. We draw on the literature on (B2C) servitization and circularity in SCs to support our initial conceptualisation and provide a more nuanced and detailed description through our empirical study. The multi-case study approach is appropriate for theory-elaboration for three main reasons. First, disagreement exists on the connections between servitization and circular practices driving a need for in-depth insight in support of theory elaboration [68]. Existing works are detailed in Section II and shaped our initial conceptualisation (Figure 1). Second, a variety of connections may exist as outlined in the initial conceptualisation section. A multi-case approach offers an ideal basis for investigating these and distilling underlying mechanisms from across settings [68] while allowing contextual embeddedness of the topic [69] and enabling the researchers to identify the empirical evidence needed to improve understanding and elaborate theory [68]. Third, case study methodology has

formed the foundation for seminal studies of B2C servitization [1], [70] and circularity implementation [25] due to the importance of context. Hence, our approach allows for comparison to, and theoretical elaboration from, these prior works.

A Case selection

The empirical study offers insights from five nested industrial cases within the white goods and household appliances sector. We focused on one specific industry sector with products of similar levels of complexity as product complexity can affect the ability for servitization [1]. The household appliance sector has received significant attention of sustainability-based investigations by making the use of these products less resource intensive [71] with recent developments into circularity in this sector [72]. Furthermore, it offers a meaningful basis for investigating B2C servitization as product-support services are widely applied and studied [18]. Finally, focusing the empirical study on one industry sector enabled the researchers to control the findings for institutional settings that affect the external pressure on companies to implement circularity through regulations and societal drive [25], [26].

We present insights from five cases based on a selection process driven by theoretical sampling criteria in three main steps. First, we included companies with a wide range of household appliances on offer, both large (including washing machines, fridges, freezers, and dishwashers) and small appliances (including vacuum cleaners). This enabled comparability between case companies in terms of their product portfolio, related product-innovation practices and supply and distribution networks [1]. Second, we included companies that provided support services with their products and have a history of doing so. Specifically, companies providing repair or maintenance services, or similar kinds of service offerings were included in the sample [18]. Here, we excluded any companies without a clear service portfolio or service strategy. Third, we included companies that have

a sustainability strategy for their business with circularity as part of their efforts [13], [31]. As a result of this sampling strategy, we present evidence from five industrial case companies (Table 3). Conjointly, the five cases represent 52.9% of the revenue generated globally from household appliances in 2022. The cases included in this analysis hence form a high coverage of leading firms of globally operating household appliance manufacturers relevant to this research as they provide services for their appliances and implement circularity in their operations.

B Data collection

Data were collected from a range of secondary sources that provide a rich picture of the business strategy, including services, and sustainability efforts, such as circularity implementation of the case companies. Secondary data provides a unique source suitable to answer our RQ and research objectives for the following reasons. First, the breadth of collected secondary data (multitude of sources) as well as their depth (detail of reporting) provides in-depth insights into the concepts studied in this research. In particular, the detailing of service offerings offers insights into the core customer markets, intentions with service offerings and related SC configurations. Similarly, the reporting of circular practices and other circularity-related efforts with related SC configurations offer detailed insights that enable us to identify insights into both research objectives and our research question. This is enabled through the increasing tendency of companies to describe such sustainability and circularity efforts in their publications motivated by regulatory requirements or positive company image. Due to the increasing reporting of sustainability data especially by listed companies, a rich set of data is available for these organisations providing a record of their sustainability and circularity initiatives and considerations. Furthermore, such records give annual insights over an extended time horizons (often multiple years or even decades).

Table 3: Overview of case companies and collected data (abbreviations: HQ – headquarter)

	Case company A	**Case company B**	**Case company C**	**Case company D**	**Case company E**
Global spread	HQ in Europe, production sites in 6 countries	HQ in Europe, production sites in 11 countries	HQ in Europe, production sites in 7 countries	HQ in North America, production sites in 11 countries	HQ in Asia, production sites in 11 countries
Revenue globally 2022	12.94 bn US $	17.02 bn US $	5.81 bn US $	19.27 bn US $	23.62 bn US $
Employees globally 2022	Ca 51,000	Ca 63,000	Ca 23,000	Ca 61,000	Ca 75,000
Collected data	***Internal***: Annual company report 1998 - 2022 Annual environmental or sustainability report 1995 - 2022 Annual review 2018 - 2019 Websites on company strategy, climate goals, circularity efforts, sustainability strategy, sustainability strategy for 2030, Sustainability reporting framework for suppliers, sustainability blog news articles, future targets, services, circular products and services, science-based sustainability targets, Company policy documents on human trafficking and modern slavery Notes and observations from academia-industry events ***External***: Science-based target website, UN World Waster Development reports, OECD Environment Policy paper	***Internal***: Annual reports 1998 – 2022 Sustainability reports (annually from 2011), data and targets 1998 – 2022 Company policy documents, including code of business conduct, principles of social responsibility, policy for conflict raw materials, code of conduct for business partners, reporting rules) Website on repair services, sustainability, carbon neutral strategy,, sustainable supply chain, modern slavery, circularity advice and practices ***External***: UN World Waster Development reports, European Union Papillon Project website, GHG protocol	***Internal***: Business reports and fact and figures Sustainability reports (published every two years) company policy on supplier management Company websites on services and service offerings, company philosophy, sustainable strategy and vision, sustainable projects, waste management, green logistics, green materials, including green steel, sustainable services and products, news blog with articles about recent developments, 3D-printing offerings, energy efficiency ***External***: Sustainability assessments, product return statistics, APPLiA Press release and responses, Science-based target website, reports on household appliances from third party organisations	***Internal***: Annual reports 2001 – 2022 Sustainability reports 2012 – 2022 CSR reports 2015 – 2020 (no report published in 2019) Company policy documents (including supplier code of conduct and integrity manual) Company websites on services, service plans for different appliances, service scheduling, service support, service troubleshooter, extended service provision, internal, sustainability, social responsibility, self-service instructions, improving appliance use, circularity projects, governance integrity ***External***: Website national recycling blog, UN Global Compact, Science-based targets website	***Internal***: Annual reports 2004 – 2022 Sustainability reports 2020 - 2022 Company policy documents, including inclusion policy, code of ethics, net zero reporting. Company websites on services, repair requests, right to repair, troubleshoot support, sustainable practice, press releases on services and sustainability, self-service guides on YouTube channel ***External***: Conflict material industry association website, Responsible business alliance website, UN Report Peace and Business, cited research paper on water consumption
Total collected data	5700 pages (internal) 622 pages (external)	5556 pages (internal) 361 pages (external)	850 pages (internal) 842 pages (external)	3246 pages (internal) 203 pages (external)	2804 pages (internal) 94 pages (external)

The data sources give detailed insights into services and circular practices being trialled and consequently further developed or dropped from following reporting. Such insights go well beyond the experience of organisational managers accessible via primary data collection. The collected data set hence gave us the opportunity to answer our RQ from broad insights across the case organisations, both in terms of organisational activities (e.g. geographic spread) and temporal extent. In addition, secondary data has the advantage of prior verification through internal and external channels, providing a robust basis for this research. We complemented this further by complementing case company reports with external data sources to further increase the robustness of our study. Our study hence aligns with similar studies reported in the literature e.g., [73]. Collected data was based on a wide range of sources, including annual reports, sustainability reports, websites (Table 3). After initial analysis, explicitly referenced external documents, including reports, research papers or third-party organization websites, were included in the collected data providing a rich picture for each case. Comparably less data was available for Case company C as unlike the other case companies, this is not publicly listed and hence not required to publish regular reports, such as annual reports. However, this type of documentation – even though high in recorded page numbers – was relatively low in insight density for the purpose of this research. Thus, despite the lower page numbers collected for this case, the available depth and breadth of insight for the purpose of this research was comparable across cases.

C Data analysis

This study focuses on the supply network as the unit of analysis, nested within which we analyse the service offering and circular practices. Data were analysed through qualitative coding using a three-step process supported by the coding software NVivo. First, descriptive coding was performed using an inductive logic to achieve data reduction. This was initially

based on a broad understanding of circularity resulting in a variation of codes emerging from the data. These codes were subsequently merged and divided to ensure internal consistency and their meaning throughout the large data set [74]. For example, pay-per-use services were coded separately for some cases while for other cases they were included in the code related to sharing and leasing services. Such instances of inconsistencies were resolved through a subsequent iteration of the codes. The service offerings were coded based on the level of service complexity using the descriptions in the collected data and categorising them based on the definitions shown in Table 1. To ensure consistency, a list of codes including description of each individual code was created as well as a list of notes and initial within-case observations kept as a separate document. Alongside this process, a visual representation of the individual case supply networks was created based on the described services and circular processes. This was used for the following steps of the data-analysis process.

Second, the codes were refined and further abstracted through an abductive logic by utilizing the code descriptions and insights from the coding notes in iteration with the collected data and the literature in the field. Codes were restructured based on emerging insights. For example, initially first-order codes were grouped into second-order codes based on their respective level of analysis (supply-chain or service-dyad level) or based on the level of service complexity (product-oriented, result-oriented etc). Through iterative inclusion of the literature, these codes were then regrouped based on reframing and iteration of this research. This process was complemented by a network analysis of the SC configurations for service offerings and circular practices. The case-specific supply network graphs were then merged into graphs with similar or overlapping characteristics. This analysis using the network graphs enabled us to specify the second-order codes by showing

the supply-chain configurations for service offerings and for circular practices, and via their comparison identifying the second-order codes for connecting service offerings and circular practices related to research objectives 1 and 2 specifically. This combination of coding and network analysis resulted in a list of codes that were consistent across cases as well as with descriptions in the literature regarding services and circular practices. Third, we connected the initial conceptual framework (Figure 1) to the codes based on a deductive logic. This enabled us to explicitly connect the conceptual framing of our research (visible in the aggregate themes) to the developed insights (first-order and second-order codes) and create a coding structure (Figure 2). In this step, the three mechanisms for connecting service offerings and circular practices via their respective SC configurations (second-order codes in the third aggregate theme) emerged. Within-case and cross-case comparison were combined throughout this three-step process with initial coding steps focusing more on within-case insights while later coding steps considered relatively more cross-case comparisons.

To present a rigorously conducted research study, we followed a structured case study approach [75] and addressed issues of validity as follows. For construct validity, insights were based on triangulation among multiple sources of data [76] especially in the first coding step. This included triangulation across multiple company-based data sources and across internal and external sources of data. In addition, we use the longitudinal nature of the available sources to focus on successful implementations of service offerings, circular practices and their related SC configurations, discounting descriptions that were presented in earlier documents but ultimately rejected. This ensured rigour of the derived conclusions. For internal validity, data analysis matched the empirically identified patterns with the insights from the literature and utilised a conceptual framework (Section II) [74]. This was

applied especially in steps two and three of the coding process. For external validity, results were derived from multiple cases enabling analytical generalisation [76]. Finally, reliability was ensured throughout the data collection and analysis processes by following a case-study protocol, creating a case-study database, and detailed recording and description of the analysis process [75].

Figure 2: Coding tree

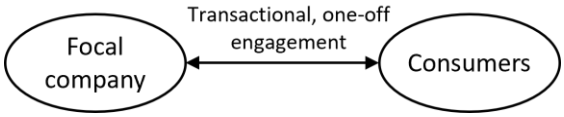
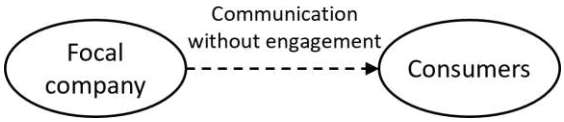
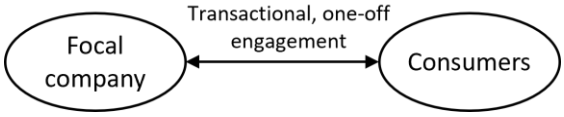
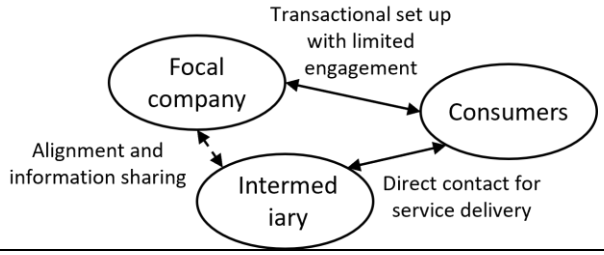
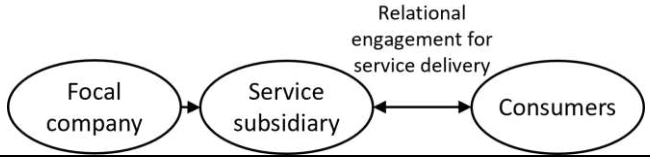
IV. Findings

A Supply chain configurations for service offerings

Product-oriented services were offered by all case companies. For example, Case company B operated *"Seven logistics centers in proximity to the production locations house more than 200,000 replacement parts – and for a period of over ten years after the end of production"* (Case B, Sustainability report 2021). Such offerings suggest a direct connection to consumers, who can order replacement parts as they need them, effectively circumventing retailers (Table 4 second row). Another product-oriented service offering was to provide maintenance information about their products, which could enable self-service by consumers. For example, Case company E hosted a YouTube channel where they offered videos on *"how to check a thermistor"* or *"how to check the aqua lock"* (Case E, YouTube page). Similarly, Case company C offered *"care tips, information at retail locations (via QR codes, for example) and online tutorials on social media"* (Case C, Sustainability report 2021). While such information was made available directly to consumers, it did not require direct engagement. Other providers offered direct communication channels with consumers to support self-service. This offered a richer engagement as described by Case company B: *"The high-quality service that the [Case company B] call center provides also includes working with the customer to troubleshoot problems. A number of issues can be resolved right over the phone"* (Case B, Annual report 2015). Finally, extended warranties enable case companies to provide services, including free repairs as detailed in Case C: *"For continued peace of mind, customers have had the chance to extend the two-year manufacturer warranty to five or ten years (…) This service now comprises comprehensive protection for appliances that are ten years old or more. Be it a material, production or operator defect, force majeure or wear: the repair remains free of charge for customers"* (Case C,

Sustainability report 2019). This enabled repeated interactions for delivering product repair with richer consumer engagements and was often delivered in collaboration with local retailers, who provide front-line service delivery. Table 4 (row 1) summarises these product-oriented services and their respective SC configurations for all cases.

Table 4: Supply chain configurations of service offerings observed in cases

Type of service	Service offering	Supply chain configuration	Provided by case companies
Product-oriented services	**Spare part provision and self-service support**	The service is typically delivered directly to consumers, circumventing intermediaries, and involves transactional engagement for spare part provision, initiated by consumer: 	A, B, C, D, E
	Self-service support through providing information	Direct connection between focal company and consumers for one-way communication without direct engagement: 	C, E
	Self-service support through call centres	Service delivery directly to consumers through transactional engagement initiated by consumer: 	B
	Extended warranty and product repair	The focal company collaborates with intermediaries who deliver the service directly to the consumer (service triad). This intermediary can be the product retailer or an independent service technician: 	A, B, C, D, E
Result-oriented services	**Pay-per-use or subscription**	The service supply network involves the creation of a purposeful subsidiary who provides the service to consumers, including shared households, such as student housing. The purposeful subsidiary provides service sale, delivery and administration: 	A, B, C, D

Three case companies (A, B and C) also provide result-oriented services, where the provider typically retains product ownership and provides a combination of product use, maintenance, and replacement (Table 4, row 2). One example was the pay-per-use subscription service that enables use of the household appliances in shared households. This offering makes efficient appliances available to consumers, who would otherwise not invest in them. Such offerings are in the early stages of provision as described for Case C: *"[We] developed the [shared use] concept for shared use of (Case company) washing machines and tumble dryers, including online reservations and cashless payment. The idea of using [the concept is] to make it easier and more flexible to use and manage appliances provided centrally – in larger apartment complexes or student housing, for example"* (Case C, Sustainability report 2021). These pay-per-use services required rich and regular consumer engagement across the service contract period. Another result-oriented service is product leasing to underprivileged consumer households. Here, Case company B collaborated with a locally operating non-governmental organization (NGO) to rent *"resource-efficient appliances [… which] lower the households' energy and water bills"* (Case B, Sustainability report 2019).

B Supply chain configurations for circular practices

The cases indicate a range of circular practices, including reduce, reuse, remanufacture, and recycle with varying implications for the SC configurations. Reduce aimed at reducing the material within the SC of household appliances and created much discussion and research in the sector based on the trade-offs between reducing material use in new products (through extending product use life) and reducing used resource in appliance use (through pushing more efficient appliances on the market). Case company A, for example, initially prioritised increased product sales *"to accelerate the replacement of old products. Due to long product*

life cycles, there is a gap between the energy efficiency of appliances currently used by households and those that are available on the market" (Case A, AnnR 2006). This strategy shifted as case company *"is embracing the circular economy - where resources are used as long as they possibly can and then recovered to ensure they get a new life"* (Case A, SustR 2018). Case companies B, C, and D, in contrast, prioritised extended product use lives and engaged in parallel investigation into the trade-offs with use efficiency of new products as exemplified by Case company C: *"The exceptional durability of [Case company C] products is the result of sturdy construction, the use of high-quality materials and demanding load and endurance tests"* (Case C, Sustainability report 2017). Eventually, all case companies came to prioritise extended product use life due to the proven higher sustainability benefits. The reduce-based SC configurations involved the same downstream actors and eventually involved new upstream relationships to new material suppliers. For example, Case company C formed a long-term supply relationship with a provider of green steel, where carbon emissions "by the manufacturing process are reduced by more than 66% in this material by harnessing climate-friendly energy sources and reusing steel scrap" (Case C, website). This also applied to Case E.

Reuse practices enabled new consumers to access the case companies' products: *"The idea is to promote the use of resource-efficient refrigerators, washing machines, and dryers"* (Case B, SustR 2020). To access such new consumers the case companies engaged with intermediaries. Here, they engage particularly with an external provider that *"enables household arrangements such as people sharing apartments, who could not otherwise afford high-quality and efficient appliances, to save resources [Case company C]"* (Case C, SustR 2019). This enabled access to customers for product reuse. In sum, reuse had

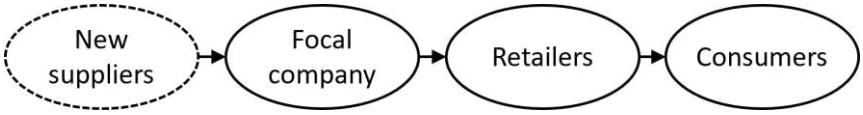
particularly downstream implications for the case companies' SCs, introducing new intermediaries and new consumers.

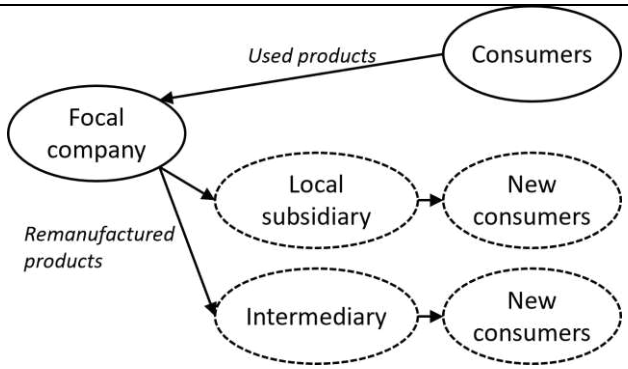
Remanufacture required repeated engagement with consumers (for first-use cycles) for returning products: *"when a customer is finished using the product, most of the products are returned to us, refurbished and provided to another customer. In some cases, we reuse the parts, or, if not possible to reuse, we properly dispose of the unit"* (Case D, SustR 2020). Remanufacturing also created downstream effects on the case companies' SC configurations. Remanufactured products are introduced to new consumers groups that would not purchase new products. These new consumers were reached via a specifically created local subsidiary that enabled contact to these new consumer groups: *"As part of a pilot project launched in Austria in 2022 and running until March 2023, [Case company B] offers refurbished washing machines for sale with manufacturer's warranty – at prices that can be as much as 50 percent lower than for a comparable new model"* (Case B, SustR 2022). These new customer groups were also reached via new intermediaries, such as locally operating NGOs to facilitate donation of remanufactured products: *"The Maytag Feel Good Fridge also uses refurbished refrigerators placed at select BGCA {youth] Clubs across the country along with a grant to keep it stocked with healthy food for Club members and their families to take when in need"* (Case D, SustR 2021).

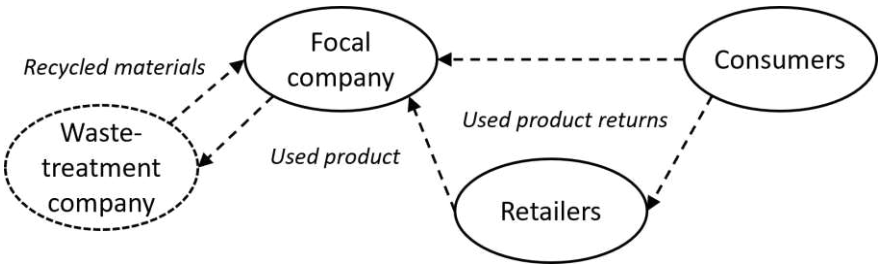
Recycle created substantially new SC configurations with system implications both up and downstream. To enable use of recycled materials in new products, the focal companies partner with national waste management firms creating new upstream configurations. This is exemplified by Case A: *"on the new 'Circular Initiative' where we shared good practice with other leading companies and demonstrated a smart robot that dismantles old (…) vacuum cleaners and collects recyclable fractions"* (Case A, Interview Vice President for

Sustainability Affairs, quoted in Sustainability report 2019). These changes to upstream SC configurations are complemented by downstream changes enabling access to waste products. For Cases A, B, C, and D, case companies support the creation of these new supply network arrangements by supporting relevant industry consortia to manage the return of end-of-life products and processing for closing the loop. For example Case company D described the existence of trade-in programmes: *"When new products are delivered to a consumer, the consumer has the option to have the delivery service haul away their old unit"* (Case D, Sustainability report 2019). In comparison, Case company E developed the relevant capabilities for end-of-life product collection and recycling in-house: *"We collect discarded refrigerators, washing machines, air conditioners, and others in one place. (…) After disassembling the components of collected e-waste, we shred them into uniform sizes"* (Sustainability report 2022). Table 5 summarises the SC configuration implications of these circular practices.

Table 5: Cross-level connections arising from the implementation of circular practices

Circular practice	**Supply-chain configurations**	**Provided by case companies**
Reduce material through extended product use-lives	Engagements with new upstream connections: New supply relationships for new materials that allow material use reduction in new products. 	A, B, C, D, E
Reuse of products	Engagement with new downstream actors to provide access to new consumer groups. 	A, B, C
Remanufacture used products for new customers	Engagement with new downstream actor to give new consumers access to remanufactured products. This included either a local subsidiary or external intermediaries:	A, B, C, D



Recycle	Engagement with new actors and in new relationships up stream and downstream: 	A, B, C, D, E

C Connecting services and circular practices

The SC configuration of service offerings (Table 4) enabled direct comparison to the SC configurations of circular practices (Table 5). This allowed us to (indirectly) connect service offerings to circular practices and explain how different service offerings connect to the implementation of specific circular practices. Product-oriented services enabled reduce practices only because the related SC configurations locked-in linear actors and hence undermined the implementation of other circular practices that require the creation of loops. We discuss this insight in relation to prior studies in Section V.

Result-oriented services, in comparison, enabled connection to multiple circular practices via their respective SC configurations. Reduce practices can be implemented effectively because the focal company often retains product ownership and hence *"this means that we make certain to maximize the value of the resources that went into manufacturing those professional laundry appliances"* (Case A, Sustainability report 2018). Here, the closer consumer relationships for delivering the result-oriented service enables

further opportunities for reducing material use during the product use phase. In addition, result-oriented services also enable product reuse as the SC configurations for the service provision and the circular practices align with each other. For lease services, for example, the focal company could access the used product at the end of the service contract for reuse with new consumers. Case company B explained this as follows: *"The idea is to promote the use of resource-efficient refrigerators, washing machines, and dryers by offering attractive leasing terms and conditions, which also include the repair of the appliances. At the end of the lease period, the appliances are returned to [Case company B] for reuse."* (Case B, Sustainability Report 2020). Similarly for remanufacturing, the related SC configurations aligned with each other as the use products returned from consumers could also be remanufactured before redistributing them to new consumers. One notable insight was that the SC configurations for recycling did not directly benefit from those for service provision. The increased access to used products provided by result-oriented services allowed increased numbers of used products to enter these reverse channels but both SC configurations (for service provision and for recycling) were complementary, not co-dependent. Table 6 summarises these connections between service offerings and circular practices via their respective SC configurations.

Table 6: Connecting service offerings to circular practices via supply-chain connections

Service offering	**Supply-chain configurations**	**Circular practice**	**Provided by case companies**
Product-oriented services	The supply chain configurations for the product-oriented services complement the supply chain configurations for product reuse: Spare part provision enable reduction of products on the market through extending product life because of following interactions between the related supply chain configurations: • New suppliers enable integration of new materials (with related properties and enable reduced material use in final products) into new products	Reduce	A, B, C, D, E

	• Involvement of existing supply chain actors in existing relationships creates lock-ins that undermine creation of loops needed for other circular practices.		
Result-oriented services	Respective supply chain configuration for result-oriented services and reduce practices complement each other: Closer consumer relationships (repeated consumer engagements for delivering result-oriented service) offers opportunities and incentives to reduce material use during product use phase, which result in extended product-use phases	Reduce	A, B, C
	The supply chain configurations of result-oriented service provision enable the supply chain configurations for product reuse: • Closer consumer relationships over extended timeframes enable access to used products before economic value is destroyed; • New connections with new supply chain actors (intermediaries, new consumers) facilitate product reuse by satisfying market needs with working products	Reuse	A, B, C
	The supply chain configurations for result-oriented service provision enable the supply chain configurations for remanufacturing: • Close and repeated consumer engagement enables access to used products before economic value is destroyed; • After inspection, returned products may be remanufactured to restore value and update product designs before new connections with new supply chain actors enable distributing these remanufactured products to new consumers.	Remanufacture	A, B, C, D
	Respective supply-chain configurations complement each other: • Close and repeated consumer engagement enables access to used products before economic value is destroyed; • Used products (that cannot be reused or remanufactured), can be recycled by engaging with upstream waste-treatment providers	Recycle	A, B, C, D

V. Discussion

This section discusses our study insights regarding the RQ: How do the SC configurations of service offerings in B2C markets enable manufacturers to implement circular practices?

A Conceptual development

Our case findings indicate three mechanisms connecting SC configurations of service offerings to circular practices as they can complement, enable, or undermine them. Complementary SC configurations do not interfere with each other, i.e. the SC configuration for service provision do not hinder or encourage the SC configurations of circular practices. Together these complementary SC configurations resulted in added benefits to a wider

range of SC actors. Our case evidence showed that the SC configurations of both product-oriented and result-oriented services complemented the configurations for the implementation of reduce practices. While previous research indicated that services could support reduce practices [19], our research shows that it is the complementarity of their respective SC configurations that allows this connection: the SC configurations required to provide services to consumers neither hinder nor enable the SC configurations needed for these circular practices. This connection was also found for result-oriented services and product recycling.

Enabling SC configurations were found in those cases, where the SC configurations for circular practices were dependent on the SC configuration for service provision. Building on prior descriptions of the connection between result-oriented services and circular practices through enabling the creation of closed-loop SCs [22], our findings indicate that it is the enabling role of SC configurations that facilitate this observation. Our findings indicate the closer downstream relationships required to provide result-oriented services. These closer customer relationships enable the manufacturer to access products during their use phase and returning them at the end of their use cycles [46]. Our cases show that it is this access to used products that facilitates product reuse and remanufacturing, which then shape new SC configurations respectively. Our research hence provides detailed nuances to existing descriptions on the role of services for circular practices [13], [19] showing the enabling mechanisms between these connections between specific service offerings and circular practices.

The case evidence further suggests that some service-based SC configurations undermine the implementation of circular practices. Some service offerings create lock-ins in the SC configurations that undermine circular practices to be explored. The case evidence

shows this mechanism especially for product-oriented services. This contradicts insights from prior studies, which indicate that such services extend product life [19], [21]. However, our research indicates a tension between such potential product life effects of product-oriented services and their undermining role in creating circular SCs. Based on our study insights, we suggest two key dynamics that contribute to this undermining mechanism for product-oriented services and circular practices (other than reduce). First, product-oriented services facilitate transactional relationships with consumers [46] and these in turn limit the ability of accessing products during or at the end of their use phase and hence undermine the ability for manufacturers to reintegrate them into reuse. As such, the SC relationships in product-oriented services undermine the ability to access products for circular practices [27]. Second, product-oriented services build on and in turn reinforce configurations of linear SCs as shown in our case findings. Circular practices, such as reuse, remanufacturing and recycling, however, require changes to SC configurations as new SC actors participate (see Table 5). In other words, product-oriented services reinforced linear SC configurations that hindered the implementation of circular SC configurations.

In sum, this research contributes insights into three mechanisms (complement, enable and undermine) connecting service offerings and circular practices via their respective SC configurations. Figure 3 captures these connections and extends our initial conceptual framing (depicted in Figure 1) by detailing these three mechanisms and their effects. For example, the SC configurations of product-oriented services complement the SC configurations of reduce practices, which undermine the SC configurations of reuse, remanufacturing and recycling. In contrast, the SC configuration of results-oriented services complement SC configurations of reduce and recycling practices, which enabling reuse and remanufacturing. These mechanisms form a novel contribution to the academic

understanding of services [1], [33] and circularity [13], [30] in B2C markets. Building on existing works reporting connections between service offerings and circularity [13], [19], the framework gives visibility into how these connections play out and hence expands on existing understanding.

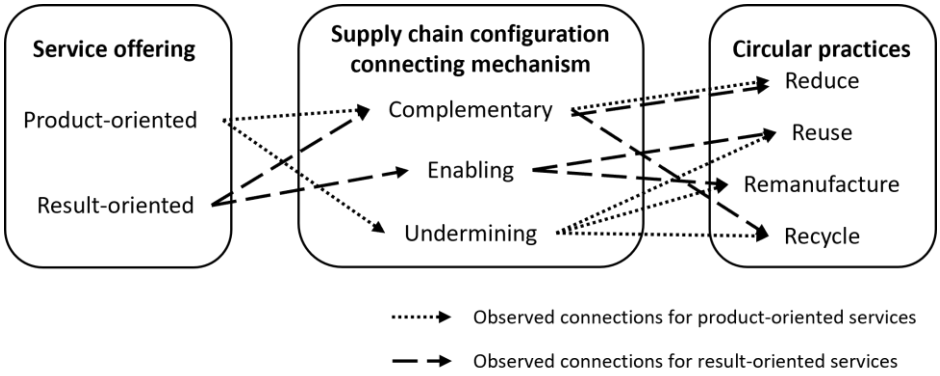


Figure 3: Framework depicting the mechanisms by which the supply chain configurations of service offerings connect to the supply chain configurations of circular practices in B2C markets

B Study limitations

The study has limitations which connect to the nature of case-based research and the approach taken in this regard. We addressed potential limitations arising from observer bias and subjectivity in data analysis [75] through following a clear data analysis process, which we recorded for further rigour [75]. We also addressed this through triangulating insights between various data sources. Limitations also arise from the chosen approach for data collection. While the secondary data gave us rich insights across a range of organisational activities, it creates a bias towards successful initiatives due to selective reporting of company success stories. While this was a suitable basis for the purpose of this research, detailed insights into unsuccessful or failed initiatives are excluded from the presented study. Our study is further limited as we took an “inside out” view of the focal company in terms of their SC interactions and the data collection process. While this gave us a clear

anchoring point for the purpose of this research, it has limited applicability for services or circular initiatives led by external SC actors. Accordingly, future studies might approach data collection from an "outside in" view.

VI. Conclusions

This research set out to answer the RQ: How do the SC configurations of service offerings in B2C markets enable manufacturers to implement circular practices? Based on an initial conceptualisation from the literature, we further defined two objectives to support our academic work: The research aims to (1) identify the SC configurations of service offerings differentiated by their level of service complexity, and (2) identify the SC configurations of circular practices. Following best practices in methodological rigour, we provide in-depth evidence from five cases in the household-appliances industry. We identify the SC configurations of service offerings differentiated by their level of service complexity (objective 1) showing particularly the downstream effects of product-oriented and result-oriented services observed in our empirical cases (Table 4). Furthermore, we identify the SC configurations of circular practices (objective 2) empirically showing their properties (Table 5). In combination, these insights allow us to connect service offerings and circular practices via their respective SC configurations answering our research question. Here, we identify three mechanisms by which the SC configurations of service offerings connect to the SC configurations of circular practices: complement, enable, and undermine. These mechanisms summarised in a framework explain the observations of our empirical cases and descriptions in the literature.

This research contributes to the emerging understanding of the role of servitization in circularity in B2C markets [18], [70]. We connect service offerings to their SC configurations elaborating understanding of B2C servitization [1], [33]. This nuances existing descriptions in

this field highlighting the different configurations to B2B settings [15], [19]. This research shows a range of downstream SC effects of service offerings across complexity levels. This research further contributes to understanding of circularity for consumer products [22], [30]. Our research shows the SC configurations for different circular practices providing detailed insights into the upstream and downstream SC effects. This provides further nuances into understanding of circular SCs [13], [30], detailing particularly the impact of circular practices on SCs. Finally, and in answer to our RQ, our research advances understanding of the connections between service offerings and circularity [13] by identifying three mechanisms that explain how these connections function. This advances current disagreements into the circularity effects of servitization [15], [17], [18], [27] by demonstrating the specific mechanisms by which service offerings complement, enable, and undermine the implementation of circular SCs.

This research has important practical implications for service managers and policy makers. Service managers that also aim to implement circularity are advised to review the SC configurations of their service offerings based on the three identified mechanisms. Managers are advised to avoid service-based SC configurations that undermine the implementation of circular practices. Instead viewing service offerings as discrete choices, implementing individual offerings only, service offerings in B2C markets can be viewed in terms of their dynamic development of related SC capabilities. This may in turn reduce the undermine-mechanism and instead emphasise the complement or enable mechanisms between service-offerings and circular practices. Regulations can provide a further incentive for this dynamic development of circular SC capabilities based on service offerings. New regulations may create unintended consequences where the SC configurations of service offerings (especially product-oriented services) can undermine the implementation of some

circular practices. Instead, new regulations should emphasise service offerings based on their enabling or complement mechanism for circular practices.

This research points towards important areas for future work. First, future research needs to further elaborate on the trade-offs between circular practices in connection to service offerings. An example emerging from our case insights was the trade-off between extended product use life (and hence reduction in resources used in manufacturing) and efficient machines (and hence reduction during product use). Such trade-offs may in turn drive the respective SC configurations as specific circular practices are prioritized over others. Second, future research should study the dynamic, longitudinal developments of implementing circularity from servitization. This study views the connections between service offerings and circular practices via their SC configurations in a somewhat static sense irrespective of their own dynamic developments. A dynamic investigation would enable identification of when and how the implementation of circular practices creates changes within the SCs. Third, further work needs to focus on the network characteristics of circular servitization, including elements such as centrality (of the manufacturer), connectedness and openness. This would extend on this study's exploration of circular SCs.

References

[1] M. E. Kreye and D. P. Van Donk, "Exploring servitization in the Business-to-Consumer context," *International Journal of Operations & Production Management,* vol. 41, no. 5, pp. 494–516, 2021, doi: 10.1108/IJOPM-07-2020-0439.

[2] E. S. Lauritsen, P. J. Cash, and M. Kreye, "Speed Matters: Managing Innovation in the Energy Sector by Building Shared Understanding in the Face of Multiple Clockspeeds," *IEEE Trans Eng Manag*, vol. 71, pp. 1629–1641, 2024, doi: 10.1109/TEM.2023.3336235.

[3] S. Vandermerwe and J. Rada, "Servitization of Business: Adding Value by Adding Services," *European Management Journal*, vol. 6, no. 4, pp. 314–324, 1988.

[4] S. Sarasini, N. Bocken, D. Diener, M. Velter, and K. Whalen, "Reviewing the climatic impacts of product service systems: Implications for research and practice," May 01, 2024, *Elsevier Ltd*. doi: 10.1016/j.jclepro.2024.142119.

[5] M. A. Kanatlı and Ö. Karaer, "Servitization as an alternative business model and its implications on product durability, profitability & environmental impact," *Eur J Oper Res*, vol. 301, no. 2, pp. 546–560, Sep. 2022, doi: 10.1016/j.ejor.2021.10.052.

[6] M. Kumar, R. D. Raut, S. K. Mangla, S. Chowdhury, and V. K. Choubey, “Moderating ESG compliance between industry 4.0 and green practices with green servitization: Examining its impact on green supply chain performance,” *Technovation*, vol. 129, Jan. 2024, doi: 10.1016/j.technovation.2023.102898.

[7] M. Dabić, J. J. Ferreira, J. M. Lopes, and S. Gomes, “Consumer Preferences and Barriers in the Adoption of Drone Delivery Services: A Comprehensive Analysis,” *IEEE Trans Eng Manag*, vol. 72, pp. 47–61, 2025, doi: 10.1109/TEM.2024.3494051.

[8] A. Zhang, V. G. Venkatesh, J. X. Wang, V. Mani, M. Wan, and T. Qu, “Drivers of industry 4.0-enabled smart waste management in supply chain operations: a circular economy perspective in china,” *Production Planning and Control*, vol. 34, no. 10, pp. 870–886, 2023, doi: 10.1080/09537287.2021.1980909.

[9] EC, “Behavioural Study on Consumers’ Engagement in the Circular Economy,” Brussels, Belgium, 2018. doi: 10.2818/956512.

[10] F. Ciulli, A. Kolk, and S. Boe-Lillegraven, “Circularity Brokers: Digital Platform Organizations and Waste Recovery in Food Supply Chains,” *Journal of Business Ethics*, vol. 167, no. 2, pp. 299–331, Nov. 2020, doi: 10.1007/s10551-019-04160-5.

[11] J. S. Srai, N. Tsolakis, M. Kumar, and W. Bam, “Circular supply chains and renewable chemical feedstocks: a network configuration analysis framework,” *Production Planning and Control*, vol. 29, no. 6, pp. 464–482, Apr. 2018, doi: 10.1080/09537287.2018.1449263.

[12] L. Sun, Y. Wang, G. Hua, T. C. E. Cheng, and J. Dong, “Virgin or recycled? Optimal pricing of 3D printing platform and material suppliers in a closed-loop competitive circular supply chain,” *Resour Conserv Recycl*, vol. 162, Nov. 2020, doi: 10.1016/j.resconrec.2020.105035.

[13] M. E. Kreye, “Manufacturer’s service relationships as a gateway to circular supply chains: merging insights from two literature fields,” *Production Planning and Control*, vol. 36, no. 4, pp. 421–441, 2023, doi: 10.1080/09537287.2023.2274920.

[14] D. Simpson, D. Power, K. Riach, and Y. Tsarenko, “Consumer motivation for product disposal and its role in acquiring products for reuse,” *Journal of Operations Management*, vol. 65, no. 7, pp. 612–635, 2019, doi: 10.1002/joom.1049.

[15] G. Bressanelli, N. Saccani, and M. Perona, “Are digital servitization-based Circular Economy business models sustainable? A systemic what-if simulation model,” *J Clean Prod*, vol. 458, Jun. 2024, doi: 10.1016/j.jclepro.2024.142512.

[16] A. Zeeuw van der Laan and M. Aurisicchio, “Archetypical consumer roles in closing the loops of resource flows for Fast-Moving Consumer Goods,” *J Clean Prod*, vol. 236, Nov. 2019, doi: 10.1016/j.jclepro.2019.06.306.

[17] S. K. Johl, K. Ali, K. Shirahada, and O. I. Oyewale, “Green servitization, circular economy, and sustainability a winning combination analysis through hybrid SEM-ANN approach,” *Bus Strategy Environ*, vol. 33, no. 8, pp. 8978–8993, Dec. 2024, doi: 10.1002/bse.3950.

[18] D. Stabler, H. Hakala, T. Huikkola, and A. L. Mention, “Aligning servitization and circularity: The role of institutional confluence in sustainable business models,” *J Clean Prod*, vol. 462, Jul. 2024, doi: 10.1016/j.jclepro.2024.142666.

[19] N. Abdelkafi, M. Pero, A. Masi, and I. Capurso, “Revisiting the servitization-sustainability link: A case study in the professional printing supply chain,” *Cleaner Logistics and Supply Chain*, vol. 4, Jul. 2022, doi: 10.1016/j.clscn.2022.100061.

[20] M. E. Kreye, “Does a more complex service offering increase uncertainty in operations?,” *International Journal of Operations & Production Management*, vol. 39, no. 1, pp. 75–93, 2019, doi: 10.1108/IJOPM-01-2018-0009.

[21] M. Yang and S. Evans, “Product-service system business model archetypes and sustainability,” *J Clean Prod*, vol. 220, pp. 1156–1166, 2019.

[22] V. D. R. Guide and L. N. Van Wassenhove, “The evolution of closed-loop supply chain research,” *Oper Res*, vol. 57, no. 1, pp. 10–18, Jan. 2009, doi: 10.1287/opre.1080.0628.

[23] F.-S. Tseng, K. Tang, H. Moskowitz, and R. Plante, “Maintenance Outsourcing Contracts for New Technology Adoptions,” *IEEE Trans Eng Manag*, vol. 56, no. 2, pp. 203–218, 2009.
[24] A. Behl *et al.*, “Can gamification help green supply chain management firms achieve sustainable results in servitized ecosystem? An empirical investigation,” *Technovation*, vol. 129, Jan. 2024, doi: 10.1016/j.technovation.2023.102915.
[25] V. Tiitola, J. Lyly-Yrjänäinen, M. Apell, M. Rönkkö, and J. Holmström, “Value creation and retention through re-servitization: Product service system for prescription medication dispensing in homecare,” *Technovation*, vol. 140, Feb. 2025, doi: 10.1016/j.technovation.2024.103162.
[26] S. Chowdhury, S. Ren, and R. G. Richey, “Leveraging artificial intelligence to facilitate green servitization: Resource orchestration and Re-institutionalization perspectives,” *Int J Prod Econ*, vol. 281, Mar. 2025, doi: 10.1016/j.ijpe.2025.109519.
[27] M. Kreye, “Circularity in supply chains versus circular supply chains: identifying the need for transformation in manufacturing,” *Supply Chain Management: an International Journal*, vol. 30, no. 3, pp. 339–352, 2025, doi: 10.1108/SCM-05-2024-0295.
[28] M. E. Kreye, “Interactions between perceived uncertainty types in service dyads,” *Industrial Marketing Management*, vol. 75, no. 4, pp. 90–99, Apr. 2018, doi: 10.1016/j.indmarman.2018.04.014.
[29] A. Mackelprang, S. B. Modi, D. D. Dobrzykowski, and P. C. Hong, “Examining sharing economy operations: A process perspective,” Jul. 01, 2023, *John Wiley and Sons Inc*. doi: 10.1002/joom.1269.
[30] A. MahmoumGonbadi, A. Genovese, and A. Sgalambro, “Closed-loop supply chain design for the transition towards a circular economy: A systematic literature review of methods, applications and current gaps,” *J Clean Prod*, vol. 323, no. November 2020, p. 129101, 2021, doi: 10.1016/j.jclepro.2021.129101.
[31] G. Gatenholm, Á. Halldórsson, and J. Bäckstrand, “Enhanced circularity in aftermarkets: logistics tradeoffs,” *International Journal of Physical Distribution and Logistics Management*, vol. 51, no. 9, pp. 999–1021, Oct. 2021, doi: 10.1108/IJPDLM-11-2020-0367.
[32] S. S. Tax, D. McCutcheon, and I. F. Wilkinson, “The Service Delivery Network (SDN): A Customer-Centric Perspective of the Customer Journey,” *J Serv Res*, vol. 16, no. 4, pp. 454–470, Mar. 2013, doi: 10.1177/1094670513481108.
[33] Á. Halldórsson, C. Altuntas Vural, and J. Wehner, “Logistics service triad for household waste: consumers as co-producers of sustainability,” *International Journal of Physical Distribution and Logistics Management*, vol. 49, no. 4, pp. 398–415, 2019, doi: 10.1108/IJPDLM-02-2019-0065.
[34] F. Mahut *et al.*, “Product-Service Systems for servitization of the automotive industry : a literature review,” *Int J Prod Res*, vol. 7543, pp. 1–19, 2017, doi: 10.1080/00207543.2016.1252864.
[35] S. Kortmann, B. A. Bliss, C. Zimmermann, and J. Della Vedova, “Fostering Reverse Innovation With Value Chain Cocreation,” *IEEE Trans Eng Manag*, vol. 72, pp. 768–783, 2025, doi: 10.1109/TEM.2025.3538913.
[36] A. S. Patrucco, P. Bellis, D. Trabucchi, and T. Buganza, “Behavioral Biases and Cognitive Pitfalls: Navigating Resource Orchestration in Supplier-Partnered Innovation Projects,” *IEEE Trans Eng Manag*, vol. 72, pp. 227–239, 2025, doi: 10.1109/TEM.2024.3508593.
[37] R. B. Chase and U. M. Apte, “A history of research in service operations: What’s the big idea?,” *Journal of Operations Management*, vol. 25, no. 2, pp. 375–386, 2007, doi: 10.1016/j.jom.2006.11.002.
[38] J. J. Zhang, B. Lawrence, and C. K. Anderson, “An agency perspective on service triads: Linking operational and financial performance,” *Journal of Operations Management*, vol. 35, no. 0, pp. 56–66, May 2015, doi: http://dx.doi.org/10.1016/j.jom.2014.10.005.

[39] Y. Lin, A. Chen, S. Zhong, V. Giannikas, C. Lomas, and T. Worth, “Service supply chain resilience: a social-ecological perspective on last-mile delivery operations,” *International Journal of Operations and Production Management*, vol. 43, no. 1, pp. 140–165, Jan. 2023, doi: 10.1108/IJOPM-03-2022-0180.

[40] M. E. Kreye, J. K. Roehrich, and M. A. Lewis, “Servitising manufacturers: the impact of service complexity and contractual and relational capabilities,” *Production Planning & Control*, vol. 26, no. 14, pp. 1233–1246, 2015, doi: 10.1080/09537287.2015.1033489.

[41] R. Badinelli, S. Barile, I. Ng, F. Polese, M. Saviano, and P. DiNauta, “Viable service systems and decision making in service management,” *Journal of Service Management*, vol. 23, no. 4, pp. 498–526, 2012.

[42] T. Ramirez Hernandez and M. E. Kreye, “Uncertainty management in engineering-service development: the role of organisational capabilities,” *International Journal of Operations & Production Management*, vol. 42, no. 1, pp. 1–31, 2022, doi: 10.1108/ijopm-08-2020-0559.

[43] F. Vendrell-Herrero, O. F. Bustinza, G. Parry, and N. Georgantzis, “Servitization, digitization and supply chain interdependency,” *Industrial Marketing Management*, vol. 60, pp. 69–81, 2017, doi: 10.1016/j.indmarman.2016.06.013.

[44] T. Baines, H. Lightfoot, P. Smart, and S. Fletcher, “Servitization of manufacture: Exploring the deployment and skills of people critical to the delivery of advanced services,” *Journal of Manufacturing Technology Management*, vol. 24, no. 4, pp. 637–646, 2013.

[45] M. E. Kreye, “Employee motivation in Product-Service-System providers,” *Production Planning & Control*, vol. 27, no. 15, pp. 1249–1259, 2016, doi: 10.1080/09537287.2016.1206219.

[46] M. E. Kreye, “Relational uncertainty in service dyads,” *International Journal of Operations & Production Management*, vol. 37, no. 3, pp. 363–381, 2017, doi: 10.1108/IJOPM-11-2015-0670.

[47] M. E. Kreye, “Can you put too much on your plate? Uncertainty exposure in servitized triads,” *International Journal of Operations & Production Management*, vol. 37, no. 12, pp. 1722–1740, 2017, doi: 10.1108/IJOPM-06-2016-0357.

[48] R. Sousa and G. J. C. da Silveira, “The relationship between servitization and product customization strategies,” *International Journal of Operations & Production Management*, vol. 39, no. 3, pp. 454–474, 2019, doi: 10.1108/IJOPM-03-2018-0177.

[49] F. M. E. Nullmeier, F. Wynstra, and E. M. van Raaij, “Outcome attributability in performance-based contracting: Roles and activities of the buying organization,” *Industrial Marketing Management*, vol. 59, pp. 25–36, 2016, doi: 10.1016/j.indmarman.2016.05.031.

[50] T. Ramirez Hernandez and M. E. Kreye, “Uncertainty profiles in engineering-service development: Exploring supplier co-creation,” *Journal of Service Management*, vol. 32, no. 3, pp. 407–437, 2021, doi: 10.1108/JOSM-08-2019-0270.

[51] L. Batista, M. Bourlakis, P. Smart, and R. Maull, “In search of a circular supply chain archetype–a content-analysis-based literature review,” *Production Planning and Control*, vol. 29, no. 6, pp. 438–451, Apr. 2018, doi: 10.1080/09537287.2017.1343502.

[52] M. Denizel and C. Z. Schumm, “Closed loop supply chains in apparel: Current state and future directions,” *Journal of Operations Management*, vol. 70, no. 2, pp. 190–223, Mar. 2024, doi: 10.1002/joom.1274.

[53] M. Kalverkamp and S. B. Young, “In support of open-loop supply chains: Expanding the scope of environmental sustainability in reverse supply chains,” *J Clean Prod*, vol. 214, pp. 573–582, Mar. 2019, doi: 10.1016/j.jclepro.2019.01.006.

[54] A. Genovese, A. A. Acquaye, A. Figueroa, and S. C. L. Koh, “Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications,” *Omega (United Kingdom)*, vol. 66, pp. 344–357, Jan. 2017, doi: 10.1016/j.omega.2015.05.015.

[55] L. He, R. Han, L. Hou, and X. Yue, “Product Line Design and Channel Configuration in Low-Carbon Supply Chains,” *IEEE Trans Eng Manag*, vol. 72, pp. 78–95, 2025, doi: 10.1109/TEM.2024.3478054.
[56] R. Geyer and T. Jackson, “Supply Loops and Their Constraints: The Industrial Ecology of Recycling and Reuse,” *Calif Manage Rev*, vol. 46, no. 2, pp. 55–73, 2004.
[57] M. R. Galbreth and J. D. Blackburn, “Optimal Acquisition Quantities in Remanufacturing with Condition Uncertainty,” *Prod Oper Manag*, vol. 19, no. 1, pp. 61–69, 2010, doi: 10.1111/j.1937-5956.2009.01067.x.
[58] M. Dora, “Collaboration in a circular economy: learning from the farmers to reduce food waste,” *Journal of Enterprise Information Management*, vol. 33, no. 4, pp. 769–789, Aug. 2020, doi: 10.1108/JEIM-02-2019-0062.
[59] B. Flygansvær, R. Dahlstrom, and A. Nygaard, “Exploring the pursuit of sustainability in reverse supply chains for electronics,” *J Clean Prod*, vol. 189, pp. 472–484, Jul. 2018, doi: 10.1016/j.jclepro.2018.04.014.
[60] X. Schepler, N. Absi, and A. Jeanjean, “Refurbishment and remanufacturing planning model for pre-owned consumer electronics,” *Int J Prod Res*, vol. 62, no. 7, pp. 2499–2521, 2024, doi: 10.1080/00207543.2023.2218942.
[61] A. Ovchinnikov, “Revenue and Cost Management for Remanufactured Products,” *Prod Oper Manag*, vol. 20, no. 6, pp. 824–840, 2011, doi: 10.1111/j.1937-5956.2010.01214.x.
[62] A. Priyono, “Understanding the benefits of product-service systems for parties involved in remanufacturing,” *Journal of Industrial Engineering and Management*, vol. 10, no. 2Special Issue, pp. 323–351, 2017, doi: 10.3926/jiem.2050.
[63] Y. Fernando, M. S. Shaharudin, and A. Z. Abideen, “Circular economy-based reverse logistics: dynamic interplay between sustainable resource commitment and financial performance,” *European Journal of Management and Business Economics*, 2022, doi: 10.1108/EJMBE-08-2020-0254.
[64] A. Alcayaga and E. G. Hansen, “Smart circular economy as a service business model: an activity system framework and research agenda,” *R and D Management*, vol. 55, no. 2, pp. 508–530, Mar. 2025, doi: 10.1111/radm.12707.
[65] M. van der Velden, E. Maitre-Ekern, and D. K. Wanja, “The Role of Independent Repair in a Circular and Regenerative Economy,” *Circular Economy and Sustainability*, Dec. 2023, doi: 10.1007/s43615-023-00304-y.
[66] K. Verleye, A. De Keyser, N. Raassens, A. A. Alblas, F. C. Lit, and J. C. C. M. Huijben, “Pushing Forward the Transition to a Circular Economy by Adopting an Actor Engagement Lens,” *J Serv Res*, vol. 27, no. 1, pp. 69–88, Feb. 2024, doi: 10.1177/10946705231175937.
[67] G. Fisher and H. Aguinis, “Using Theory Elaboration to Make Theoretical Advancements,” *Organ Res Methods*, vol. 20, no. 3, pp. 438–464, 2017, doi: 10.1177/1094428116689707.
[68] M. Ketokivi and T. Choi, “Renaissance of case research as a scientific method,” *Journal of Operations Management*, vol. 32, no. 5, pp. 232–240, 2014, doi: 10.1016/j.jom.2014.03.004.
[69] N. Siggelkow, “Persuasion with case studies,” *Academy of Management Journal*, vol. 50, no. 1, pp. 20–24, 2007, doi: 10.5465/AMJ.2007.24160882.
[70] A. Tukker, “Product services for a resource-efficient and circular economy - A review,” *J Clean Prod*, vol. 97, pp. 76–91, 2015, doi: 10.1016/j.jclepro.2013.11.049.
[71] D. Taylor, “A brief history of (un)sustainable design,” in *Routledge Hand*, J. Chapman, Ed., London, UK: Routledge Taylor & Francis Group, 2018, ch. 1, pp. 11–24.
[72] C. Franzè, D. Pesce, M. Kalverkamp, and A. Pehlken, “‘Scale without mass’: A decision-making tool for scaling remanufacturing practices in the white goods industry,” *J Clean Prod*, vol. 417, Sep. 2023, doi: 10.1016/j.jclepro.2023.138078.
[73] A. Madonna, A. Boffelli, and M. Kalchschmidt, “Panarchy theory: myth or reality? Empirical evidence of the socio-ecological nature of supply chains,” *International Journal of Operations and Production Management*, 2024, doi: 10.1108/IJOPM-05-2023-0337.

[74] M. Gibbert, W. Ruigrok, and B. Wicki, “What passes as a rigorous case study?,” *Strategic Management Journal*, vol. 29, no. 13, pp. 1465–1474, 2008, doi: 10.1002/smj.
[75] R. K. Yin, *Case study research and applications: Design and methods*, 6th ed. Los Angeles, CA, USA: Sage Publications Inc., 2018.
[76] M. B. Miles, A. M. Huberman, and J. Saldaña, *Qualitative data analysis: A methods sourcebook*, 3rd ed. Thousand Oaks, CA, USA: Sage Publications, Inc, 2014.