Circular Economy and Sustainability (2026) 6:202
https://doi.org/10.1007/s43615-026-00936-w

ORIGINAL PAPER

Unravelling Challenges to Cascading Circularity in the Textile and Clothing Industry: A Combined Paradox-Cascade Chain Perspective

Mohammadreza Dehghannejad[1] · Rudrajeet Pal[1,2] · Kanchana Dissanayake[1]

Received: 10 December 2025 / Accepted: 29 March 2026

Abstract

Cascading plays a critical role in preserving the value of products and materials in circular economy (CE) practices, yet its operationalization remains complex and poorly understood. In practice, the sequential operationalization of circular business models (CBMs) creates interdependent and often conflicting demands across processes, structures, and stakeholder priorities. These conditions give rise to paradoxical tensions (PTs) that can constrain effective cascading. However, existing research offers limited insight into how such tensions emerge and, more importantly, how they influence cascading operations across interconnected CE loops. To address this gap, this paper investigates how PTs influence cascading in the textile and clothing (T&C) industry. The study, guided by a combined perspective of paradox and cascade chain theories, is based on semi-structured interviews with 26 actors in the T&C sector. The findings identify four PT categories: loop prioritization tensions, organizational and structural coordination tensions, socio-ethical tensions, and spatial frictions in circular resource cascades. Building on this analysis, the study further examines the underlying challenges that give rise to these tensions and links them to four key cascading principles. Finally, the study maps how these challenges disrupt the cascade chain across inner and outer CE loops. The findings highlight the need for firms to strengthen internal capabilities and develop strategic partnerships to effectively navigate PTs, while policymakers can play a critical role in enabling cascading by aligning regulations, harmonizing fiscal instruments, and expanding infrastructure to support effective cascading in the T&C sector.

Keywords Cascading · Paradoxical tensions · Circular business model · Textile and clothing

Extended author information available on the last page of the article

Published online: 16 April 2026

Introduction

In response to the dominant linear "take-make-dispose" model, the Circular Economy (CE) has emerged as a regenerative and restorative paradigm aimed at reducing resource extraction and environmental degradation by keeping products and materials in circulation [1–3]. Central to CE implementation are circular business models (CBMs), including repair, reuse, remanufacturing, and recycling, which translate circular principles into practice [4]. These CBMs operate through two interconnected loops: inner loops (e.g., repair, reuse) that preserve product integrity and retain higher embedded value, and outer loops (e.g., remanufacturing, recycling) where integrity is partially or fully broken and materials are reprocessed into new production cycles [5, 6]. Through their interaction, product lifetimes are extended and material flows are recirculated according to a value hierarchy, with products moving from inner to outer loops as quality declines [7]. This hierarchy reflects the principle of cascading, defined by Sirkin and ten Houten [8] as the "sequential re-use of the remaining resource quality from previously used commodities and substances" (p. 215) across multiple stages. Cascading thus unfolds through an ordered configuration of CBMs (e.g., reuse → remanufacturing → recycling) that structures how value is retained over time as products and materials transition through successive uses in response to declining quality [3, 9].

The textile and clothing (T&C) industry holds significant potential for operationalizing cascading, as it has already introduced diverse CBMs, including rental, repair, resale, remaking/upcycling, and recycling [10, 11]. In principle, this portfolio supports cascading by enabling products to circulate sequentially along inner and outer loops, following the CE waste hierarchy. Some degree of cascading is already visible in the T&C industry. For example, Houdini Sportswear integrates several sequential CBMs, where products are first designed for repair and subsequently offered through rental and resale, and finally recycled when they can no longer be used [12]. Similarly, Patagonia extends product lifetimes through its repair and resale program before garments ultimately enter recycling streams [13]. However, not all companies that operate CBMs demonstrate clear cascading; many instead implement multiple CBMs in parallel. For instance, H&M simultaneously runs resale and recycling initiatives rather than in a strict sequence, while Filippa K offers repair and resale concurrently [14]. These examples suggest that, while cascading exists in some cases, other firms offer multiple CBMs in parallel.

Operationalizing cascading effectively through sequential CBMs is largely constrained by various challenges and paradoxical tensions (PTs). While challenges for cascading refer to structural or operational problems, including high costs, limited knowledge, and technological and organizational limitations [15], PTs arise from contradictions between interdependent yet opposing elements that emerge as organizations respond to these challenges [16]. These PTs may evolve and intensify over time due to conflicting stakeholder objectives, competitive dynamics, and structural misalignments [16–18]. As such, they are critical because they are persistent and must be managed rather than eliminated [16, 19]. First, they manifest as contradictory forces, such as standardization versus innovation in products or centralized versus decentralized operations [16, 20], influencing organizational decision-making and impacting CBM implementation and scaling [18, 21, 22]. Second, the underlying challenges driving PTs, such as infrastructural gaps, economic constraints, policy misalignment, and organizational rigidities, can mutually reinforce one another and impede the formation of sequential loops and the coordinated progression of products and materials across reverse supply chains [11, 23, 24]. Within the T&C sector, for example, outsourcing garment repair could generate tensions between maintaining control and fostering collaboration [25, 26]. While collaboration may support repair-reuse cascading, reduced control can compromise quality and brand legitimacy, prompting firms to skip repair and redirect high-quality garments toward lower-value recovery options. Similarly, integrating recycled fibers poses safety and hygiene challenges, creating tensions between social and environmental objectives pursued through closed-loop operations [21]. This can fragment closed-loop cascading, diverting costly recycled materials toward downcycling or open-loop recycling and causing resource leakage from the T&C value chain [27]. Although these examples offer some insights into how PTs may influence cascading operations within the circular T&C sector, this issue has not been fully explored in the literature. Therefore, it is essential to understand how PTs can lead certain CBMs within cascading operations to be sidelined, implemented in parallel, or hindered in achieving maximum value recovery, thereby reducing cascading to downcycling or recycling [3]. Against this backdrop, this paper examines *how PTs influence the operationalization of cascading in the T&C industry* and uncovers the mechanisms through which these tensions constrain value retention across sequential loops.

To address the study's purpose, we synthesize cascade chain theory [8] and paradox theory [16] to explain how root challenges trigger PTs that reshape CBM sequencing and disrupt cascading. While cascade chain theory emphasizes sequential value retention across CBMs, it assumes coordinated progression and overlooks organizational tensions. Paradox theory explains persistent contradictory pressures but has rarely been applied to sequential resource flows in reverse supply chains. Integrating these perspectives, we show how PTs arising from underlying challenges shape organizational responses that influence CBM sequencing and disrupt value flows across loops. This synthesis advances CE scholarship by linking structural value hierarchies with organizational dynamics and offering a processual explanation of how cascading trajectories fragment or regress toward lower-value loops.

The paper is structured as follows: Sect. 2 reviews the literature; Sect. 3 presents a theoretical framework combining cascade chain and paradox perspectives; Sect. 4 outlines the methodology; Sects. 5 and 6 present findings and discussion; and Sect. 7 concludes with key implications for research and practice.

Literature Review on PTs Influencing Cascading in the T&C Industry

This section synthesizes existing literature to show how PTs may arise and hinder cascading in the T&C industry. Cascading refers to the sequential circulation of products and materials according to their remaining quality through inner and outer loops to maximize value retention [8]. Inner loops include low-intervention strategies like repair and garment transfer for reuse, while outer loops involve resource-intensive processes like remaking or fiber recovery for new production [6]. Although these loops are theoretically designed to form a coherent cascade, empirical studies reveal persistent contradictions that disrupt this logic. Since research rarely examines these contradictions through a paradox lens or in relation to cascading, and given the absence of established frameworks, this section adopts an exploratory approach. It therefore integrates insights from existing studies to situate PTs within the operational context of cascading.

Operational challenges within inner loops reveal how PTs emerge and compromise circularity. Research on rental, repair, and resale CBMs highlights tensions between meeting hygiene or safety requirements versus extending product lifespan. While the latter is vital for enabling garment circulation in inner loops, hygiene and performance concerns (e.g., in footwear or workwear) often lead to early removal from rental and reuse, generating a PT between ensuring safety for social sustainability and durability for environmental goals [28, 29]. Similarly, quality concerns arising from outsourcing repairs to third parties can erode customer trust due to a loss of accountability, even as such practices may enhance repair-reuse cascades [25, 26]. Beyond these operational challenges, market-mediated dynamics further complicate inner-loop circularity. Resale platforms, while designed to extend product lifespans through reuse, may unintentionally disrupt cascading by promoting premature recirculation. Increased convenience and strong sustainability framing can accelerate turnover and shorten ownership duration [30]. This creates a PT in which efforts to retain value through frequent circulation simultaneously dilute value extraction per use phase. As a result, garments may circulate more rapidly without fully exhausting their embedded utility, weakening the sequential logic of cascading.

At the systemic level, policy and regulatory frameworks further shape these tensions. Economic incentives often reinforce linear consumption patterns: access to inexpensive new garments discourages repair, while higher taxes on repair services compared to raw material use undermine service-life-extending efforts [23, 25]. In parallel, charities scaling resale models face trade-offs between maintaining autonomy, critical for preserving their social mission, and engaging in horizontal and vertical collaboration under Extended Producer Responsibility (EPR) schemes. While such collaboration can improve operational efficiency, it may also increase costs, add complexity, and dilute social objectives [31]. Trade policies further complicate inner-loop dynamics, as high tariffs on second-hand clothing imports, intended to protect local industries, contrast with zero-tariff policies on new clothing entering the same markets, thereby constraining reuse flows [32]. Collectively, these policy-related tensions hinder the interactions necessary for effective cascading within inner loops.

Research on outer-loop CBMs such as remaking and recycling reveals additional challenges that generate PTs in the T&C context. At the operational and design level, remaking can extend textile lifespans but faces constraints, including limited technical expertise, material incompatibility, and unstable consumer demand [33]. This creates a PT in which firms must balance craft-based, customized innovation with the need for scalable and efficient production, often confining remaking to niche applications. Similarly, in recycling, design-related challenges generate a PT between the use of blended fibers to enhance garment durability across multiple use cycles [10] and the reduced recyclability of such blends due to technological limitations in fiber separation [22]. In combination with high logistics and processing costs, these dynamics can paradoxically render recycling less economically viable than incineration, resulting in resource leakage [34]. Beyond these PTs, value chain configurations introduce additional tensions in cascading operations. For instance, centralized recycling operations can improve profitability and economies of scale but tend to increase environmental impacts, whereas decentralized systems enhance sustainability outcomes while reducing economic efficiency [35]. Likewise, global sourcing strategies may stabilize material supply and improve process efficiency; however, they also intensify coordination complexity, transportation requirements, and associated greenhouse gas emissions [23, 36].

At the systemic level, policy and regulatory frameworks further reinforce these tensions. EPR schemes, designed to promote the collection of non-wearable textiles for fiber-to-fiber recycling, often conflict with existing practices in the EU, where collection systems prioritize reusable items with higher resale value [37]. As a result, collectors tend to avoid textiles suitable only for recycling, creating a PT between policy intent and market incentives. Additional policy misalignments, such as stricter hygiene regulations on recycled materials in Italy compared to broader EU standards, can further reinforce negative perceptions of recycled fibers, generating a PT between public safety concerns and the uptake of secondary materials [21]. Collectively, these operational, structural, and policy-related challenges hinder effective material cascading across outer loops.

Theoretical Framework

Cascade Chain Theory

Cascade chain theory, likened to a river flowing across plateaus, illustrates the staged recovery of residual value from used products and materials [8]. According to this definition, cascading occurs when products or materials re-enter the reverse supply chain after their initial use (whether through changes in ownership, usership, or function at end-of-use or end-of-life), enabling further recovery through inner- and outer-loop CBMs [8, 38]. To achieve this, effective operationalization of cascade chains requires a diverse set of actors, including commercial and non-profit organizations, as well as short- and long-loop operators that shape B2B, B2C, and C2C exchanges [4]. This multi-actor, multi-loop integration is what facilitates cascading within the broader CE framework by continuously preserving value and ensuring efficient resource use [3].

Cascading consists of two interrelated components: four dimensions and guiding principles. The dimensions, resource quality, utilization time, salvageability, and consumption rate [8], reflect principles that explain how products or materials flow within and across value chains over time. These principles include: Appropriate Fit, which aligns resource quality with usage demands, reserving high-quality materials for complex tasks and lower-quality materials for simpler needs; Augmentation, which increases resource utility over time by improving quality and durability through repair, maintenance, reuse, or protective coatings; Consecutive Relinking, which promotes reintegration of materials into new processes after each use to enable continuous reuse; and Balancing Resource Metabolism, which regulates consumption speed to prevent depletion and ensure long-term sustainability [3, 8]. According to Sirkin and ten Houten [8], while the first three principles support the formation of cascade chains, balancing resource metabolism is essential for sustainable resource management.

Paradox Theory

Paradox theory, as defined by Smith and Lewis [16], describes “contradictory yet interrelated elements that exist simultaneously and persist over time” (p. 382). These elements often manifest as tensions, conflicting demands or goals, that organizations must navigate concurrently; elements that, while individually rational, often become incompatible when considered together [16]. A common example is the tension between efficiency and innovation: while organizations need experimentation and risk-taking to achieve market advantage, they also strive to streamline operations for efficiency [16]. This challenge "persists over time" and is not easily resolved because it endures across contexts and periods, continually reappearing and shaping organizational processes, structures, and behaviors [39]. Therefore, rather than attempting to eliminate these PTs, organizations are encouraged to embrace and manage them in a balanced way [16].

To understand how to effectively manage paradoxes, Smith and Lewis [16] categorize organizational tensions into four classes: organizing, performing, belonging, and learning. Organizing tensions arise from competing organizational structures and processes, such as control versus flexibility or centralization versus decentralization [16, 18]. Performing tensions reflect conflicting stakeholder interests that lead to opposing goals and strategies, like conflicts between environmental and economic sustainability [16, 20]. Belonging tensions involve identity struggles, including tensions between individual and collective identities or personal and organizational values [40]. Finally, learning tensions highlight the simultaneous challenge of balancing exploration, focused on innovation and new knowledge, with exploitation, which emphasizes efficiency and optimization [16, 41]. These tensions may also intersect, creating inter-class paradoxes. For example, organizing-learning tensions arise when companies simultaneously strive for efficiency and agility [16]. This requires leaders to continuously adapt and integrate competing demands.

A Combined Paradox-cascade Chain Perspective

Although literature combining cascade chain theory and paradox theory remains limited, integrating these perspectives is theoretically justified and analytically valuable. Cascade chain theory explains sequential value recovery through inner and outer loops, guided by cascading dimensions and principles [8]. In the T&C industry, this arrangement is illustrated by Dehghannejad, Pal, and Dissanayake [11] through aggregated cascade chains, where garments may be rented multiple times, repaired to enhance quality and fit for reuse, and eventually relinked for remaking and closed-loop recycling. Such cascading promotes sustainable consumption by slowing and closing resource loops [7]. While this perspective focuses on the physical movement of products and materials, cascade chains rarely operate within a single organization. Instead, effective cascading depends on organizational and social embeddedness, including coordinated stakeholder value propositions, aligned delivery and capture mechanisms, and governance of material and energy flows across firms [2, 3, 42]. Coordinating these flows requires multiple actors, often specializing in collection, sorting, resale, or recycling, to operationalize sequential valorization of products or materials across inner- and outer-loop CBMs [11]. Paradox theory complements this perspective by highlighting contradictory yet interrelated forces that arise when aligning actors' values, processes, and value chain structures [16], potentially disrupting CBM sequencing and leading to stalled cascades or parallel implementation. From this combined lens, cascading becomes a socio-technical, dynamic, and tension-laden process in which each CBM reflects both resource characteristics and ongoing organizational contradictions. Accordingly, sustainable resource management requires adaptive governance, continuous learning, and leadership capable of navigating paradoxes while sustaining value across sequential loops [16, 19].

Methodology

This study adopts a qualitative research method to examine how PTs influence the operationalization of cascading in the T&C industry. To address this purpose, the unit of analysis is the organizational decision level, focusing on how PTs hinder T&C actors in making decisions about cascading CBMs, their implementation, and sequencing. Given this focus, the global T&C value chain involves diverse actors, such as brands, charities, and recyclers, whose interactions, spanning both inner and outer loops of cascading, are characterized by interconnected and sometimes contradictory logics. Understanding these complex dynamics therefore requires rich, contextual, and interpretive insights rather than predefined variables or quantitative tools [43]. This qualitative orientation also necessitates an inductive approach to develop theoretical understanding from empirical evidence and to "give voice to the informants in the early stages of data gathering and analysis and to represent their voices prominently in the reporting of the research" [44, p. 17]. Moreover, PTs are inherently fluid and evolving [16]; they emerge across CBMs, may collide with one another, and influence cascading operations. Therefore, inductive, process-oriented methods are essential to identify their emergence within and across loops [45]. Guided by these premises, semi-structured interviews were conducted with actors operating within the T&C reverse supply chain (Sect. 4.1), and the data were analyzed using the Gioia methodology [44] to identify and develop patterns (Sect. 4.2).

Sample Selection and Data Collection

This study employed purposive sampling to generate rich insights into PTs in the T&C circular value chain and to enable meaningful comparisons while avoiding redundancy [46]. In line with qualitative research principles, sample size was guided by information power and data saturation rather than statistical criteria [47, 48]. Sampling and analysis therefore proceeded iteratively until theoretical saturation was reached. Consistent with the study's operational definition of cascading, sampling prioritized actors involved in successive stages of the T&C reverse supply chain (e.g., collection, sorting, resale, remaking, and recycling) to capture how sequential cascade transitions are coordinated across organizational boundaries.

The study initially focused on Sweden due to its advanced CE policies, EPR schemes, and strong institutional support for textile circularity [e.g., 49, 50]. Swedish actors were identified via organizational websites, circular initiatives, and documented collaboration in cascading operations. Early interviews, however, showed that these operations were not nationally bounded but relied on international partnerships to address infrastructural gaps, especially in sorting and mechanical recycling. Because the research aimed to identify PTs that influence the operationalization of cascade chains, the sampling frame was expanded to include non-Swedish actors who currently maintain supply chain links with Swedish actors. These actors, based in the Netherlands, Germany, Finland, Norway, Poland, and Switzerland, provided capabilities lacking in Sweden and enabled the study to capture tensions arising from infrastructural asymmetries and differing spatial contexts (see Table S1 in the Supplementary Material).

Within this expanded frame, the final sample included 26 actors representing the main categories in T&C reverse supply chains: collectors, brands, charities, sorters, and recyclers. Collectors drive the initial stage of cascading by gathering and pre-sorting post-consumer textiles for reuse and recycling. Brands operationalize rental, repair, reuse, and remaking CBMs, collaborating with recyclers to integrate recycled materials into new production. Charities expand reuse through donation networks and coordinate with sorters and recyclers to handle unsold or low-quality items. Sorters, using manual or semi-automated processes, direct textiles toward reuse or recycling and engage in both closed- and open-loop operations. Recyclers convert textile waste into raw materials through chemical and mechanical processes, enabling closed-loop cascading.

Data collection was carried out through semi-structured interviews with nominated circularity experts. Interviews drew on tensions identified in the literature (Sect. 2) and explored how PTs emerge in cascading operations, particularly those stemming from conflicting logics within loops or leading to CBM disposition or substitution. Discussions also covered competitive operational strategies, supply chain frictions (e.g., global versus local sourcing), trade challenges, policy misalignments, and stakeholder conflicts. Because 'paradox' and 'cascading' are relatively unfamiliar terms, participants were asked to describe enduring tensions or conflicts in operationalizing their CBMs that affect loop formation. Early interviews generated preliminary PT categories, which were refined and challenged through subsequent interviews with actors in diverse organizational and national contexts. To deepen insights, some interviews included multiple interviewers or participants, and although scheduled for one hour, a few extended into deeper discussions of reverse supply chain complexities. Theoretical saturation was reached when additional interviews reinforced existing categories without introducing new dimensions. The cross-national design strengthened analytical robustness by revealing that core PTs recurred across institutional contexts. All interviews were conducted online in English, recorded with verbal consent, anonymized, and reviewed to assess the need for follow-up clarification.

Data Analysis

To address the research purpose, the data were analyzed and coded inductively, following the method outlined by Gioia, Corley, and Hamilton [44]. This analysis proceeded through two concurrent steps.

In the first step, the first author re-read the interview transcripts and identified PTs by examining contradictory yet interrelated elements, following Smith and Lewis [16]. The coding process was conducted by one primary coder (the first author). These PTs were extracted and mapped in an Excel sheet to determine whether they influenced cascading operations. At the outset, PTs unrelated to CE practices, as well as those affecting CE more broadly, such as tensions experienced by brands in their linear operations or those emerging during the transition to circularity, were excluded. However, a few PT examples, while initially appearing irrelevant – as cascading materials were operationalized globally – represented rebound effects due to high transport costs and environmental impacts. These PTs were included in the dataset as they influenced sustainable resource management during cascading operations [8]. This filtering process also involved evaluating tensions against the broader definition of cascading, whereby products, components, or materials re-enter the reverse supply chain [8]. The literature indicates that service-oriented CBMs, such as repair or rental, may sometimes extend product life only in a linear manner, without enabling cascading [11]. Applying this lens, a repair-related tension from Brand #6, extending jacket lifespan via repair within a single ownership cycle without garments entering the reverse supply chain, was excluded. This process resulted in 35 cascading-related PTs, which formed the first-order concepts (see Fig. 1). These PTs were then grouped based on their similarities in influencing cascading, resulting in the formation of 13 second-order themes (e.g., design for longevity versus recyclability, reuse versus recycling optimization). These 13 themes were finally aggregated into four overarching PT categories representing higher-level dimensions.

The second step focused on extracting the underlying challenges driving the four identified PTs (aggregated dimensions) from the first step. These challenges were extracted from the 35 first-order concepts (as indicated by the blue dashed arrow at the top of Fig. 1). They were grouped by similarity (as shown in Fig. 1, under 'Challenges to cascading,' with numbers in brackets under each challenge group corresponding to the relevant first-order concepts) and linked to the four PTs through colored arrows. For example, challenges related to material and design complexity, market and economic barriers, and infrastructure and technical capacity limitations, all indicated by green arrows, contribute to 'Loop-prioritization tensions in cascading operations.' This step enabled a deeper understanding of the eight structural and operational challenges driving PTs in cascading operations.

The analysis then proceeded in Table 1 by mapping the eight identified challenges and related PTs onto the four cascading principles: appropriate fit, augmentation, consecutive relinking, and balancing resource metabolism. A coding rule was applied to guide this mapping: each root challenge causing PTs was examined and assigned to the principle(s) it affected, following Sirkin and ten Houten [8]. For example, refusing to repair a product by including a material with a different composition than the original constrained product life

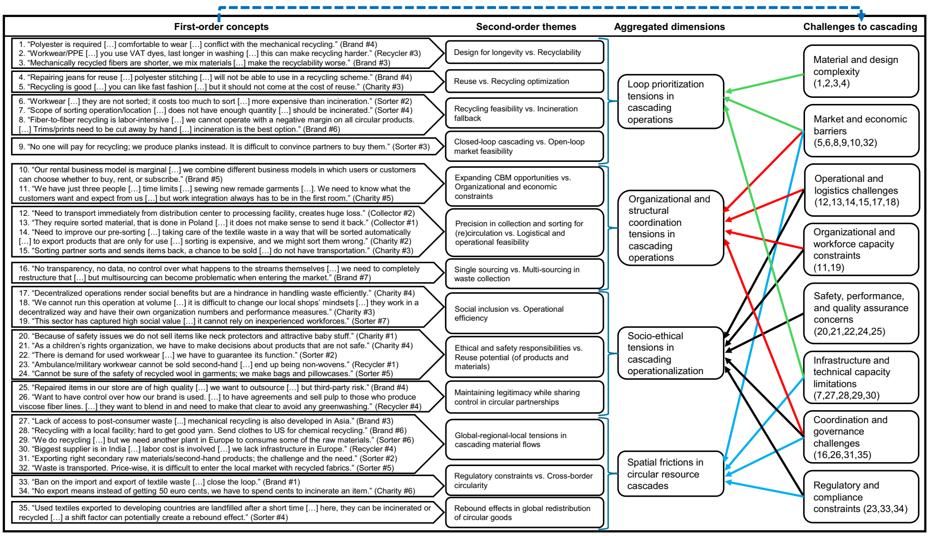

Fig. 1 Data structure

Table 1 Analytical mapping of underlying challenges driving PTs onto the cascading principles

Challenges to cascading	Appropriate fit	Augmentation	Consecutive relinking	Balancing resource metabolism	Affected loops (evidence)
Material and design complexity			🟩 Blended materials incorporated at the design stage, from dyes to strengthening fibers obtained from mechanical recycling, impede later recycling and material relinking (1, 2, 3).		Outer loop (Brand #3; #4; Recycler #3)
		🟩 Avoiding repairs to minimize the introduction of non-original materials and safeguard the homogeneity necessary for recycling ultimately weakens product augmentation (4).	🟩 Failure to perform repairs interrupts the continuity of relinking within integrated repair-reuse cascades (4).		Inner loop (Brand #4)
Market and economic barriers		🟩 Fast fashion models requiring prioritization of recycling over reuse risk undermining efforts to extend product lifespans and fully realize the benefits of second-hand markets (5).		🟩 Fast fashion models institutionalize accelerated material throughput, thereby disrupting resource metabolism (5).	Inner loop (Charity #3)
			🟦🟩 Labor-intensive, costly sorting processes leading to negative margins, along with transportation costs, make recycling economically unviable, hindering material relinking (6, 8).	🟦 Cost pressures within the recycling system steer waste management toward incineration, disrupting resource metabolism (6, 8).	Outer loop (Brand #6; Sorter #2)
	🟩 Radical innovations, even those introducing high-quality materials, result in market misfit and limited user acceptance (9).		🟦🟪 Open-loop cascading diverts materials from closed-loop relinking operations, while committing to relinking materials through open-loop innovation remains constrained by insufficient support from local governments and the EU (9).	🟦🟩 Energy-intensive sorting, treatment, and transport within open-loop cascading, together with the diversion of materials from closed-loop systems, generate significant environmental impacts and contribute to resource leakage (9).	Across value chain (Sorter #3)
	🟦🟩 The lack of economies of scale in rental models, which results in blended CBM portfolios (rental, subscription, and reuse), undermines the appropriate fitting of products to task demands (10).		🟦🟩 Blending CBM portfolios (rental, subscription, and reuse), intended to enhance customer flexibility and economic viability, can undermine the sequential progression of garments across these models (10).	🟦 The lack of effective management of sequential CBMs disrupts the CE waste hierarchy and weakens overall resource metabolism (10).	Inner loop (Brand #5)
	🟩 Recycled materials that involve high sorting and processing costs are less appropriate for European markets, as they increase prices and reduce demand (32).			🟩 Offshored recycling operations and European brands' preference for using cheaper virgin materials increase transport burdens and promote linearity, disrupting resource metabolism (32).	Outer loop (Sorter #5)
Operational and logistics challenges	🟦 Low-volume collection and dispersed material flows prevent garments from being consistently routed to CBMs that match their quality, compromising appropriate fit (12).		🟦🟩 Logistical strain and financial losses associated with transporting low-value garments in low-volume markets undermine the consecutive relinking of collected items into higher-value, reuse- and open-loop recycling-based CBMs (12).		Inner loop; Across value chain (Collector #2)
			🟦 Constraints in sorting, including an insufficient workforce and inadequate structure, undermine efforts to relink materials to recycling (13).		Outer loop (Collector #1)
	🟩🟧 Insufficient understanding of destination-market dynamics (including limited automated sorting) when processing reusable garments leads to market misfits, increases costs, and reduces acceptance (14).			🟩 Exporting unsorted garments for resource cascading leads to the disposal of non-reusable portions and disrupts resource balance (14).	Inner loop (Charity #2)
	🟦 Lack of standardized logistical systems hinders re-sorting opportunities for matching garments within reuse-based CBMs (15).	🟦 Lack of standardized logistical systems hinders the recirculation of reusable garments (store-to-store), weakening augmentation efforts (15).			Inner loop (Charity #3)
	🟦 Decentralized operations introduce sorting inconsistencies, reducing the ability to appropriately sort products and materials for specialized reuse and recycling pathways (17, 18).		🟩🟪 Decentralized operations, driven by local stores' pursuit of autonomy and individual performance priorities, hinder logistical alignment and collaboration with waste-management actors, thereby undermining efficiency in relinking across reuse- and recycling-based CBMs (17, 18).		Inner-to-outer loops (Charity #3; #4)
Organizational and workforce capacity constraints	🟧 Insufficient understanding of target-group preferences results in poor fit within remaking strategies (11).	🟦🟧 Resource constraints (encompassing staff, time, and market knowledge) block life-extending repair and remaking CBMs (11).	🟦 Concerns over organizational integrity, arising from the perceived cannibalization of mainstream reuse by repair and remaking, impede the consecutive relinking of garments across repair-resale-remaking (11).		Inner-to-outer loops (Charity #5)
	🟩 Engaging an inexperienced workforce to support social programs undermines sorting accuracy, reducing the efficiency of fitting garments into reuse- and recycling-based CBMs (19).				Inner loop; Outer loop (Sorter #7)

Table 1 (continued)

Challenges to cascading	Appropriate fit	Augmentation	Consecutive relinking	Balancing resource metabolism	Affected loops (evidence)
Safety, performance, and quality assurance concerns	🟩 Safety and performance concerns render used clothing unfit for reuse (20, 21, 22).	🟩 Safety and performance concerns result in garment recirculation through reuse being overlooked, limiting augmentation efforts (20, 21, 22).	🟩 Overlooking reuse, due to safety and performance concerns, disrupts the smooth consecutive relinking in cascading operations (20, 21, 22).		Inner loop (Charity #1; #4; Sorter #2)
	🟩 Safety requirements render recycled wool unfit for closed-loop recycling in garment production (24).	🟩 Safety constraints hinder efforts to extend the life of recycled wool through closed-loop garment production (24).	🟦🟩 Safety uncertainties and high batch-testing costs discourage the relinking of recycled wool into garments, diverting materials to lower-risk applications (24).	🟩 Redirecting materials from closed-loop garment systems to lower-standard products (e.g., pillowcases, bags) undermines resource retention (24).	Outer loop (Sorter #5)
	🟦 Outsourcing repair to third parties risks losing operational control and producing lower-quality outputs, leading to mismatches for reuse (25).	🟦 Outsourcing repair to third parties with inconsistent quality undermines brand credibility in life-extension strategies, weakening efforts to augment product value (25).	🟦 Inconsistent repair quality in outsourced operations disrupts consecutive relinking within repair-reuse cascades (25).		Inner loop (Brand #4)
Infrastructure and technical capacity limitations			🟦 Limited sorting scale and infrastructure access result in insufficient material volumes for viable recycling, undermining material relinking (7).	🟦 Infrastructure and system-level constraints skew waste management toward incineration, disrupting resource metabolism (7).	Outer loop (Sorter #4)
				🟦 Limited post-consumer waste feedstock forces local chemical recyclers to rely on overseas pre-consumer inputs, while mechanical recycling of fiber-to-fiber polyester yields low-quality yarn, and chemical recycling requires long-distance transport and high energy use – together increasing environmental costs and disrupting resource metabolism despite global material relinking (27, 28).	Outer loop (Brand #3; #6)
			🟦 Limited local chemical recycling infrastructure to process waste generated by other recyclers undermines material relinking (29).		Outer loop (Sorter #6)
				🟦🟩 Local and regional shortages of precision sorting for recycling, combined with labor-cost advantages of global sourcing, drive long-distance transport and increase pollution, destabilizing system equilibrium (30).	Outer loop (Recycler #4)
Coordination and governance challenges	🟦 Fragmented collection systems and opaque material flows prevent different fractions from being matched to CBMs according to their quality (16).	🟦 Lack of transparency and control over intake limits repair, reuse, remake, and rental activities, thereby reducing the ability to maintain or enhance product utility (16).	🟦 Insufficient coordination across partners disrupts the consecutive relinking of garments between rental, reuse, remaking, and recycling (16).		Inner loop; Outer loop (Brand #7)
	🟦 Inconsistent material blending decisions within co-branding agreements weaken value chain governance and compromise material compatibility and quality fit in garment production (26).			🟦 Greenwashing risks arising from changing material compositions and reduced material purity undermine transparency and downstream control, leading to resource imbalance (26).	Outer loop (Recycler #4)
	🟩 Global trade can exacerbate the misallocation of used resources through insufficient coordination for reuse and recycling abroad and resulting market mismatches, thereby hindering the delivery of materials of the right quality to the markets that need them (31).			🟦🟩 A lack of value chain governance results in mismatched and mis-valorized reuse and recycling fractions in importing markets, leading to disposal and landfilling and thereby weakening overall resource metabolism (31).	Inner loop; Outer loop (Sorter #2)
		🟩🟧 Exporting reusable garments intended for recirculation in overseas markets (where data on their duration of use is lacking) risks undermining augmentation efforts if the garments are landfilled after export (35).		🟩 Rebound effects stemming from garments being landfilled after exportation rather than reused, along with the associated transportation and environmental costs, destabilize resource metabolism (35).	Inner loop (Sorter #4)
Regulatory and compliance constraints	🟩 Liability and security requirements render quality workwear (ambulance, military, police) unfit for reuse (23).	🟩 Liability and security requirements hinder reusing workwear (ambulance, military, police), limiting augmentation efforts (23).	🟩 Overlooking reuse due to liability and security requirements disrupts the consecutive relinking of workwear within cascades (23).		Inner loop (Recycler #1)
			🟦🟩 Cross-border regulatory fragmentation, by limiting the return of post-use garments needed to regenerate capital products and close the loop, impedes recycling and the relinking of materials (33).		Outer loop (Brand #1)
		🟦 Export bans restrict opportunities for life-extension strategies through reuse (34).	🟦🟩 Export bans, combined with insufficient local recycling capacity and unregulated tax regimes, hinder the relinking of waste to reuse and recycling CBMs (34).	🟦🟩 Export bans imposed without adequate local recycling capacity or compensatory measures result in incineration, textiles ending up in incineration, destabilizing system balance (34).	Inner loop; Outer loop (Charity #6)

Table guide – paradox classes: 🟦 Organizing, 🟩 Performing, 🟧 Learning, 🟪 Belonging

extension and was therefore linked to augmentation, which emphasizes increasing resource utility over time through repair, maintenance, or reuse [8]. Likewise, prioritizing incineration over recycling, driven by insufficient local recycling infrastructure, was assigned to balancing resource metabolism, reflecting unsustainable resource management and resulting in resource leakage from the T&C value chain. Some root challenges were mapped to multiple principles if their paradoxical effects spanned cascading dimensions. For instance, safety and performance concerns may render used garments unsuitable for reuse, preventing them from meeting the appropriate fit for inner-loop applications. Once diverted from inner loops, this also limits augmentation and disrupts consecutive relinking, illustrating multi-principle assignment based on impact.

This mapping also integrated paradox classes and inter-class tensions into the framework by identifying and assigning them to the affected cascading principle(s) based on their underlying sources of tension, as visualized through color coding in Table 1. This identification was guided by the definitions of Smith and Lewis [16]. For example, PTs stemming from competing organizational processes and structures, such as when enhancing cascading through the addition of repair or remaking initiatives cannibalizes standardized reuse operations, were classified as organizing tensions. Similarly, PTs arising from conflicting stakeholder values in cascading operations, such as when efforts to enhance sorting accuracy result in socio-environmental and efficiency conflicts, were classified as performing tensions. Several tensions exhibited inter-class paradoxes due to their multifaceted nature; for instance, at times when PTs derived from both structural coordination challenges and identity-related disagreements, or from interactions between operational processes and stakeholder value conflicts. As an example, organizing-belonging PTs arose as charities struggled to balance centralized and decentralized value chains, with individual stores' autonomy in defining their own values and performance measures often taking precedence over alignment with broader ecosystem values. In this case, organizing cues relate to coordination and governance structures (centralization versus decentralization), while belonging cues emerge from narratives emphasizing local identity, autonomy, and value alignment.

To conclude this step, cross-reference numbers corresponding to the relevant first-order concepts in Fig. 1 (also listed under 'Challenges to cascading') were assigned within this framework, and the affected CE loops (e.g., inner loops, inner-to-outer loops) were identified in the last column based on the CBMs that actors reported as being influenced in cascading operations. All steps of the analysis were subsequently reviewed, discussed, and validated by the co-authors to enhance the robustness of the coding and interpretation.

Research Quality

Research quality was ensured through several measures. A diverse set of actors representing different CBMs and potential cascading collaborations within reverse supply chains was included, primarily from Northern Europe, where relatively similar organizational and operational contexts facilitated the identification of PTs affecting cascading operations. This diversity provided rich empirical insights, thereby enhancing the credibility, analytical depth, and transferability of the findings. Methodological rigor was maintained through a systematic data analysis process, in which co-authors were actively involved in reviewing coding and interpretations to minimize bias and resolve discrepancies through discussion, ensuring that the findings remained grounded in the empirical data and consistent with established practices for intercoder reliability [51]. To ensure the study's dependability and transparency, the interview protocol was designed carefully with reference to gaps identified in the literature, and all conversations were recorded and transcribed verbatim to maintain accuracy and minimize researchers' influence. Including a variety of organizational roles, such as collectors, brands, charities, sorters, and recyclers, further strengthened the analysis by capturing diverse perspectives, enhancing the confirmability of the findings.

Results

This section offers an exploratory analysis of how PTs influence cascading operations within the T&C industry, as illustrated in Fig. 1; Table 1.

Loop Prioritization Tensions in Cascading Operations

Loop prioritization tensions, as indicated by green arrows in Fig. 1, arise from three main challenges: material and design complexity, market and economic barriers, and infrastructure and technical capacity limitations.

The first challenge relates to material and design complexity, encompassing fiber blends, chemical additives, and structural designs. As highlighted by several actors (e.g., Brands #3 and #4, and Recycler #3), design choices aimed at extending product lifespan include blending polyester, polyamide, or elastane with natural fibers, reinforcing recovered fibers, and applying vat dyes in workwear to ensure wash durability. However, these durability measures pose challenges in mechanical and chemical recycling and obstruct material relinking, creating a longevity-recyclability PT. A circular system requires both extended durability and efficient end-of-life processing, yet these objectives are inherently contradictory. Current technological limitations prevent resolving both objectives simultaneously: chemical recycling cannot easily process mixed materials or efficiently separate certain dyes, while mechanically recycled fibers are short and low in quality.

> *"If we use mechanically recycled fibers, they are shorter [...] then the material becomes weaker and potentially has a shorter life length [...] sometimes we mix materials [...] with polyester or polyamide or other things that would make the fabric last longer, but it would make the recyclability worse."* (Brand #3).

Brand #4 further illustrates this challenge in denim repair. Repairing jeans often involves attaching cotton denim patches using polyester stitching, thereby introducing fiber heterogeneity. Although the base fabric is predominantly cotton, the presence of synthetic thread is important for durability but complicates mechanical recycling. As a result, repaired garments may be diverted from recycling streams at the end of their life if the proportion of non-recyclable fibers exceeds certain thresholds. Measures intended to strengthen the early stages of cascading can therefore inadvertently restrict downstream loops. This creates a persistent tension for actors, who must weigh the benefits of product augmentation through repair, supporting robust repair-reuse cascade chains, against preserving material purity to maintain recyclability for future consecutive relinking. Collectively, these examples reflect a performing-class tension, in which pursuing one desirable outcome (durability, aesthetic appeal, or repairability) inevitably conflicts with another, such as maintaining material purity to ensure recyclability.

The second challenge involves market and economic barriers, which create PTs by forcing actors to prioritize loops based on financial feasibility rather than circular objectives. For example, Brand #6 notes that recycling often becomes economically less viable compared to incineration. In their words:

> *"Our fiber-to-fiber recycling project is labor-intensive, and we cannot operate with a negative margin on all circular products. We cannot make our products using only recycled materials; we need to use what is available, as it has to be done on a scale. So, when you see how many trims and prints are on a garment that need to be cut away by hand, you can see that incineration is the best option in many cases."* (Brand #6).

On the one hand, environmental ambitions for consecutive material relinking in closed-loop cascading operations are necessary to enable sustainable circular practices. On the other hand, economic constraints are crucial for maintaining financial viability, yet they limit the brand's ability to fully pursue these circular objectives. This tension persists over time, as cost pressures repeatedly push waste management toward incineration, disrupt resource metabolism, and interrupt closed-loop cascade chains. It exemplifies an inter-class organizing-performing PT, in which the brand's inability to restructure circular operations intersects with conflicting environmental and economic demands.

In some cases (e.g., Sorter #3), the lack of economic justification for closed-loop cascades diverts textile waste toward open-loop applications, such as composite boards. While this creates opportunities for alternative uses and fosters circular innovation, it also sidelines closed-loop cascading operations, leading to resource leakage from the T&C sector. This generates a tension between closed-loop ideals and open-loop innovation. Without sufficient institutional support from actors such as local governments or the EU, however, the scalability of these innovations, and the potential to relink materials within open loops, remains limited. Market misfit and low consumer acceptance further constrain adoption, particularly as the company is *"the sole company in the world that has such material."* Consequently, actions intended to enhance circularity can paradoxically weaken resource metabolism: materials exit the intended textile cascade and circulate in parallel industrial systems, fragmenting the sequential loops envisioned by cascade chain theory. This tension introduces a belonging dimension to the existing organizing-performing PT, as the company strives to anchor its identity in innovation despite limited external validation within policy contexts that favor standardized closed-loop models over open-loop alternatives.

The final challenge stems from infrastructural and technical capacity constraints, which create a PT in outer-loop cascading operations, such as recycling. As Sorter #4 notes, small-scale sorting facilities often lack the operational scope, geographic reach, and material throughput needed to reliably supply recyclers, especially when handling mixed materials. When volumes fall below the thresholds required for economically viable recycling, incineration or landfilling becomes the only practical option. This creates a paradox: recycling systems depend on large, consistent material flows to function efficiently, yet fragmented collection and sorting infrastructure prevent these flows from forming. These competing value recovery options, which often lead to prioritizing incineration over recycling, represent an organizing tension that disrupts the cascade chain, prematurely halting resource circulation. The PT endures as long as infrastructure gaps remain unaddressed throughout the recycling value chain, leading to failed relinking and reduced resource metabolism.

Organizational and Structural Coordination Tensions in Cascading Operations

Organizational and structural coordination tensions, as indicated by red arrows in Fig. 1, stem from four key challenges: market and economic barriers, operational and logistical constraints, limited organizational and workforce capacity, and shortcomings in coordination and governance.

First, economic barriers often arise as cost inefficiencies within inner-loop CBMs. For instance, Brand #5's rental model delivers environmental benefits but struggles with scale and profitability. To sustain operations and increase customer flexibility, the brand has integrated rental with resale and subscription offerings, achieving economies of scale. While this blended CBM portfolio enhances financial sustainability, it creates functional misalignment: premium, high-durability items intended for rental or subscription are diverted to resale channels for revenue, while lower-quality garments circulate in rental pools that depend on robust items to endure multiple uses. This mismatch weakens product-function fit and undermines the ability to consecutively relink items across these models. As a result, strategies that improve economic viability can paradoxically compromise environmental objectives, which are necessary to maintain balanced resource metabolism. This reflects an organizing-performing tension as firms navigate trade-offs among profitability, functionality, and material relinking.

Second, operational and logistical challenges generate PTs across collection, consolidation, and processing activities. A clear example comes from Collector #2, whose service agreement with a global retail partner requires the collection of all garments deposited in stores and their immediate transport to processing facilities. Because many of the collected garments have extremely low or even negative market value, prolonged storage is economically unjustifiable, making rapid transport the only viable option. While this fast turnaround supports the brand's front-end collection goals, downstream sorting and fractionation, needed to enable the consecutive relinking of materials into reuse channels (e.g., vintage or export-grade second-hand) and open-loop recycling pathways (e.g., insulation, wiping cloths, or incineration), remain the responsibility of the collector. Complicating this, the agreement obliges coverage across more than 70 markets, some of which generate negligible returns, within which the collector cannot consolidate sufficient material flows to perform the fractionation required for relinking garments into subsequent CBMs. Consequently, items that could theoretically circulate through multiple loops cannot be effectively redirected into appropriate inner loops or downstream pathways.

> *"The value of the garments is only a few cents. So, it does not make sense to store it too long [...] we need to transport immediately. [...] in those countries where we are collecting close to zero, we [still] need to offer a solution. [Across] our 70 markets we have a whole lot of markets where we are creating a huge loss."* (Collector #2).

This creates an inter-class organizing-performing PT, arising from the simultaneous need to maintain broad market coverage to fulfill contractual and brand obligations while ensuring efficient, volume-based collection to make sorting and processing economically viable. Because neither objective can be reduced without economic or reputational consequences, this tension persists over time.

A similar dynamic occurs in Charity #3, which partners with Sorter #7 to re-sort unsold items by functional characteristics and redirect them through appropriate reuse channels (e.g., store-to-store). This initiative aims to extend product lifespan and strengthen inner-loop cascades, directly supporting circularity. However, operationalizing it relies on a fragile logistics system, with volunteers transporting items in their own cars. This creates an organizing PT: initiatives in precise sorting are necessary to maintain product-function fit and maximize reuse potential, while scalable, standardized solutions are required to handle larger volumes and broaden impact. Although both are essential, they are inherently contradictory, since involving volunteers in handing over garments can, in this context, compromise the operational integrity of the social organization.

Third, limited organizational capacity and workforce constrain actors' ability to operationalize and coordinate inner-to-outer loop cascades. Charity #5, with only three staff members covering all operations, faces this challenge. Despite initial successes, like leather repair, the team must constantly choose between repairing existing items, sewing and remaking new garments, or focusing on resale, all while maintaining organizational integrity as a core mission. As they state:

> *"We have just three people responsible for design, production management, selling, the web shop, marketing [...] and the same in collecting and sorting. Planning for new business models is not really there [...] we have time limits; should we sew the garment or repair the leather goods? [... but] we also have to create more events. We need to do classic target group work, know what the customers want and expect from us. But work integration always has to be in the first room. So, when we scale up, we have to keep that part with us. We cannot just open a factory and hire a lot of people; we need to move step by step."* (Charity #5).

This situation reflects an organizing tension that evolves into an inter-class paradox: the ambition to expand CBM operations and strengthen cascading is necessary to enhance circular impact, yet it is constrained by limited capacity and workforce, which are equally critical for maintaining operational feasibility and organizational integrity. Prioritizing one CBM (e.g., repair) reduces attention to others (e.g., remaking or resale), disrupting augmentation efforts and weakening consecutive relinking across the inner-to-outer loop cascade chains (i.e., repair-reuse-remaking). At the same time, limited understanding of customer preferences, which requires additional market analysis and target group exploration when implementing remaking, creates a learning gap that further undermines reuse fit. These dynamics persist over time, as the organization must continually balance operational scale, workforce constraints, and learning requirements, producing a combined organizing-learning paradox.

Ultimately, shortcomings in coordination and governance challenge circular operations by fragmenting collection networks and reducing transparency. This becomes particularly visible in Brand #7's reassessment of its long-standing relationship with Collector #2. While relying on a single global partner enables operational simplicity and centralized coordination, Brand #7 highlights that this model simultaneously undermines transparency, limits control over material flows, and restricts the ability to channel garments into CBMs:

> *"The back side is that it gives no transparency, no data, you have no control on what happened with the streams itself; you lose the potential revenue that you could get*

from it. And you cannot connect it to other streams within your ecosystem, which is exactly what you want to do. So, we need to completely restructure that. [...] In some places we decided to find a local solution, but they [Collector #2] are a major partner and have more than 100 different local sorters. So, they are more like a coordinator than one global partner." (Brand #7).

This lack of visibility prevents the brand from identifying appropriate routes for used garments, despite implementing multiple CBMs such as rental, repair, resale, and remaking, all of which depend on quality-controlled, transparently sorted intake. It also constrains augmentation by limiting circulation within inner-loop CBMs, leading to these models being implemented in parallel, disrupting consecutive relinking in cascade chains, while simultaneously restricting outer-loop recycling due to an insufficient supply of consistent, traceable fiber fractions required by partners such as Recycler #4. To address these gaps, the brand is seeking to adopt a multi-sourcing strategy by engaging local partners in markets where Collector #2 cannot provide sufficient transparency or service quality. However, this shift introduces coordination challenges, including heterogeneous infrastructures, shifting regulations, variable partner capabilities, and the loss of a single global coordinator. This creates an organizing paradox: single-sourcing simplifies coordination but undermines transparency and integration, whereas multi-sourcing enhances visibility and governance but increases coordination complexity. Because neither approach can be abandoned without operational consequences, this tension persists over time.

Socio-Ethical Tensions in Cascading Operationalization

Socio-ethical tensions in cascading operations, as indicated by black arrows in Fig. 1, are driven by five core challenges: operations and logistics, organizational and workforce capacity, safety and quality assurance, coordination and governance, and regulatory compliance.

Operationally, the tension between decentralized and centralized processes creates a paradox in the recovery and valorization of material flows across inner- and outer-loop CBMs. In social organizations, such as charities, this tension is particularly pronounced, as these actors prioritize social integrity, volunteer engagement, and organizational autonomy alongside material efficiency. Charity #3 reflects this challenge:

"Our sorting partner [Sorter #7] can help us identify item compositions, which is crucial for long-term cooperation with Recycler #4, but we cannot scale this operation as it is difficult to change our local shops' mindsets [...] they work decentralized, have their own organization numbers, and measure themselves." (Charity #3).

Charity #4 elaborates on the trade-offs:

"Decentralized way of operation brings significant value to volunteers [...] provides greater social benefits, particularly in terms of work opportunities, work integration, and well-being. [... But] local decision-making hampers value extraction [...], what to donate, when to contact the logistics operator [...], and hinders developing new partnerships with the waste management company for better waste handling and gaining better data on sorting and recycling." (Charity #4).

These accounts reveal a PT: centralized operations are necessary for precision sorting, allocating materials to appropriate inner- and outer-loop CBMs, and forming reuse-recycling cascade chains by consecutively relinking non-wearables to specialized pathways, such as chemical recycling, whereas decentralized operations are essential to maintain social value, volunteer engagement, and local autonomy – core to the charities' mission. These competing operations, with their inherent tension between efficiency and social value creation, initially constitute an organizing-performing paradox, but over time evolve into an organizing-belonging paradox, as the circular system increasingly depends on centralization to enable inner-to-outer loop cascades while local actors remain committed to identity-driven values. The contradiction persists, and may even intensify, because both system-level integration and local social objectives are simultaneously necessary and inseparably linked.

Organizational and workforce capacity constraints further intensify socio-ethical tensions in cascading operations. This is evident in the operations of Sorter #7, which prioritizes reinforcing social values such as job creation, including relying on inexperienced labor that often compromises the accuracy required for advanced textile sorting:

> *"Traditionally, this sector has had very high social value capturing. But to be an efficient textile sorting plant, and as we are becoming more innovative, you cannot rely on very inexperienced workforces. You cannot trust that you can get inexpensive stuff in and out."* (Sorter #7).

Here, decision-making at the sorter level, whose main task is to classify items and bridge upstream collection systems with downstream reuse and recycling actors, directly affects whether materials are appropriately fitted to their intended pathways. Employment-oriented practices may reduce sorting precision and throughput, yet they also reinforce workforce participation and organizational legitimacy. These two elements are simultaneously interdependent and in tension, creating a performing paradox.

The third challenge relates to safety and quality assurance. Actors like Charities #1 and #4 highlight that items such as vintage textiles with unknown chemical specifications, children's clothing, and safety-related products such as helmets or neck protectors cannot be sold second-hand due to hygiene risks and the need to protect users. Similar concerns were raised by sorters (e.g., Sorter #2), who are unable to sell used workwear without guaranteed protective functions. These safety concerns render certain items unfit for reuse and disrupt consecutive relinking in the cascade chain by removing them from the inner loops, thereby limiting augmentation efforts. Such situations exemplify a performing PT, where environmental goals achieved through extending product lifespans persistently collide with socio-ethical imperatives, as safeguarding users requires excluding certain items from reuse even when doing so constrains circularity.

Coordination and governance in circular value chains create a fourth challenge that shapes socio-ethical tensions. Recycler #4, the producer of Circulose, a dissolving pulp made from textile waste, illustrates how ethical concerns around transparency jeopardize brand legitimacy when collaborations lead to a loss of control over the uniqueness of their materials:

> *"Our core business is to make pulp from raw materials, and we run our own process in-house. We are very restricted in allowing others into our IP. [...] Collaboration*

> *with brands and with fiber producers who buy the pulp and make fibers is important for us, [but] we need agreements that [regulate] how our brand is used [...] about how much they want to blend in. [...] Whether the material is made of Circulose or made with Circulose, we require at least 50% of that. If they use less, they must state that clearly to avoid any greenwashing."* (Recycler #4).

Collaboration is essential to sustain cascading material flows, yet it is constrained by competing imperatives: protecting IP, preserving brand integrity, and ensuring transparency. Even minor alterations in material composition or reductions in purity can render materials unfit for closed-loop recycling, introduce greenwashing risks, reduce downstream control, and hinder the effective return of materials to the system, thereby disrupting circular resource metabolism. From a critical perspective, circularity cannot be separated from responsibility: materials carry embedded expectations of accountability, and their movement through loops depends as much on governance, trust, and ethical stewardship as on technical or logistical capabilities. This tension reveals an organizing paradox at the core of circular value chains, where the very collaborations that enable circularity simultaneously threaten both its ethical and operational foundations.

Finally, compliance requirements continuously restrict reuse pathways for high-quality textiles, generating PTs. Recycler #1 explains that, despite heavy-duty workwear's durability and suitability for reuse, legal constraints require it to be recycled rather than resold:

> *"Working with a supplier that supplies ambulance, military, and police workwear, these clothes cannot be sold second-hand because you cannot have them out there [...] these fabrics are really good quality, but they end up being non-woven fabrics."* (Recycler #1).

Here, liability and security requirements not only render high-quality, specialized workwear unfit for reuse but also remove these fractions from inner loops, hindering augmentation and consecutive relinking by breaking the cascade chain through which items would normally circulate and contribute to ongoing resource flows. These restrictions create a performing paradox between environmental goals, maximizing resource utilization, and critical social imperatives such as safety and confidentiality. Both are necessary for circularity, yet they conflict.

Spatial Frictions in Circular Resource Cascades

Spatial frictions, as indicated by blue arrows in Fig. 1, fragment cascading operations across local and global scales and are driven by four key challenges: market and economic barriers, infrastructural and technical capacity limitations, coordination and governance issues, and regulatory compliance requirements.

First, cost disparities and market dynamics across regions shape decisions regarding sorting and recycling locations. As Sorter #5 explains, textile waste is transported to Morocco for final sorting and recycling because labor costs are considerably lower than in Europe:

> *"Textile wastes are transported to Morocco for final sorting and recycling [as] labor is too expensive in the Netherlands [...] sorting and removing buttons and zippers*

> *makes this step quite expensive. It means that our end product will always be a bit more expensive than virgin textiles. [Also,] customers are used to buying cheaper items, and brands are accustomed to working with virgin materials."* (Sorter #5).

Exporting materials to lower-cost regions is necessary to maintain economic viability and sustain recycling at scale; yet, it simultaneously undermines local value retention and neutralizes efforts to relink materials, given the impacts of transportation and associated environmental pollution. Simultaneously, high labor costs in Europe make recycled materials more expensive, creating a market misfit, as customers and brands continue to favor cheaper, virgin alternatives. These interrelated dynamics reinforce one another over time, leading to an imbalance in resource metabolism, in which circular flows depend on externalization while struggling to be reintegrated locally. This ongoing tension between economic viability and environmental goals constitutes a performing paradox.

Second, efforts to localize circular operations often face gaps in infrastructural and technical capacity. Brand #6 reports that, due to local limitations where they cannot *"get [a] good yarn from mechanical recycling,"* garments are sent to the United States for chemical recycling. While this helps relink materials within closed-loop cascading operations, it also results in high greenhouse gas emissions and transportation delays. Similarly, Brand #3 emphasizes the difficulty of sourcing sufficient post-consumer waste, which forces their local partner to rely on imported pre-consumer waste. According to them:

> *"If we talk about reducing overproduction, the first step would be to develop nearshoring. However, working locally comes with the challenge of limited access to sufficient post-consumer waste. [...] We are working with Recycler 3, but they do not have access to enough post-consumer waste. They are starting to import pre-consumer waste from production markets. [...] Mechanical recycling is also developed in Asia. Therefore, if this is to be done at scale, it has to be global, which is not always ideal due to transportation issues."* (Brand #3).

These challenges give rise to organizing PTs, where system design is not aligned with circular functionality. Local solutions provide flexibility and reduced environmental impact, but they are constrained by technical capacity and scale limitations. Global infrastructures, in contrast, offer the efficiency and technological capability necessary for scaling circular operations, yet they increase carbon intensity and fragment cascading flows, disrupting resource metabolism. The tension between these interdependent strategies illustrates how circularity necessitates navigating trade-offs that are simultaneously conflicting and mutually reinforcing.

Third, export strategies aimed at strengthening cascading may, under weak coordination and governance, give rise to PTs. Sorter #2 advocates shipping second-hand garments and high-quality secondary raw materials to markets like China upon request, arguing that global exchange reduces virgin resource extraction and supports cascading operations within inner and outer loops. However, the misallocation of garments to inappropriate CBMs hinders the delivery of the 'right quality' to the 'right market.' As this actor notes, this becomes both *"the challenge and the need,"* as mis-valorized fractions ultimately end up in disposal and landfilling. Sorter #4 interprets this as a rebound effect, noting that reusable textiles exported to Sub-Saharan African countries, despite their high environmental production costs, are often landfilled shortly after arrival. As they explain, even small changes in product displacement rates (e.g., replacing one T-shirt with only 0.7 new products instead of 0.8 in the reuse-to-production ratio) can tip the balance and raise questions about whether the environmental gains of reuse are realized in practice. This situation exposes a performing-learning PT, in which export strategies aimed at augmenting product lifespans may lead to contradictory outcomes. The lack of reliable data and tracing systems on garment life after export also prevents organizations from determining whether overseas reuse truly extends product life or instead accelerates rebound effects, thereby disrupting resource metabolism.

Finally, regulatory mechanisms challenge cascade chains on a global scale. Brand #1 notes that bans on the import and export of textile waste hinder efforts to close material loops, while Charity #6 warns that stricter export restrictions after 2025 under EPR could force actors to incur higher incineration costs rather than operationalize cascading through inner- and outer-loop CBMs:

> *"After 2025, if we are forced to have fewer or no exports, it means that instead of getting 50 euro cents, you will have to either spend 12 to 13 euro cents to incinerate an item, or else find clients like Sorter #6 who can pay an amount comparable to 50 euro cents. Also, if the tax is not reduced on sales to local actors [...], you will have to sell at a loss."* (Charity #6).

Export bans are intended to support local looping and reduce transportation impacts, making local cascading both necessary and desirable. Yet these same measures can hinder the relinking of reusable products and materials to overseas markets. Combined with limited local demand for reusable fractions, constrained recycling capacity, and tax disincentives, materials may be forced toward incineration, limiting augmentation and consecutive relinking within local cascade chains, while also disrupting resource balance. These interdependent dynamics illustrate an organizing-performing paradox: regulatory compliance designed to structure and enable local cascading inherently generates economic-environmental conflicts, simultaneously supporting and constraining the circulation of materials.

Discussion

This study examined how PTs affect cascading operations in the T&C industry by linking their root causes to the four cascading principles: appropriate fit, augmentation, consecutive relinking, and balancing resource metabolism [8]. Our findings show that, while firms often implement multiple CBMs, PTs frequently prevent these models from forming sequential cascade chains. As a result, product flows are diverted into parallel or truncated loops that terminate in lower-value recovery pathways rather than progressing through the intended cascade. This occurs because the challenges that create PTs are interdependent, affect multiple principles simultaneously, and reinforce one another, systematically obstructing the cascading of CBMs. Below, we discuss these dynamics across the four cascading principles, as detailed in Table 1.

Appropriate Fit

Although the principle of appropriate fit aligns resource quality with task requirements, its practical implementation is constrained by performing and organizing PTs rooted mainly in safety, organizational, market, and coordination challenges (see Table 1). In practice, safety and performance standards often override circularity goals, sidelining garments not due to actual quality loss but because of heightened hygiene and functional concerns, thereby classifying otherwise reusable items as unfit for reuse. As a result, performing paradoxes in rental and resale contexts persist [28, 29], making it difficult for actors to balance safety compliance with circularity without undermining legitimacy or reuse viability. Simultaneously, organizational constraints, particularly in semi-autonomous charities operating between collection and redistribution, generate organizing paradoxes that complicate allocation decisions. Tensions between centralized and decentralized operations create inconsistent sorting practices, while limited skills, manual processes, and weak market insights prevent garments from reaching appropriate loops. Nevertheless, decentralized approaches endure because charity shops prioritize social and community values, even when this disrupts coordinated cascading [16, 40]. Meanwhile, market pressures, including resistance to new materials and the need for economies of scale, especially among inner-loop, service-based CBMs, force trade-offs between economic and environmental goals [23, 25], often resulting in suboptimal choices such as favoring resale over rental due to high operational costs, as illustrated by Brand #5. Because these pressures are embedded in entrenched market structures, they continually reproduce tensions between profitability and circularity. Finally, coordination failures across collection, sorting, and global trade channels fragment material flows, preventing garments from reaching CBMs that match their specifications [11]. Taken together, these dynamics demonstrate that misalignments in the principle of appropriate fit arise not merely from quality issues but from PTs shaped by material realities, operational norms, and market incentives, with coordination constraints further limiting opportunities for augmentation and consecutive relinking.

Augmentation

Augmentation depends on actors' capacity to restore garments for continued circulation, yet its practice is constrained by multiple PTs that arise at technical, organizational, and systemic levels. The performing paradox occurs because textiles that appear unfit for reuse do not always reflect structural degradation; nevertheless, garments are frequently excluded from repair or remaking due to liability, hygiene, or functional concerns, making technically restorable items practically unaugmentable. Efforts to preserve recyclability can heighten this tension, as clothing repair often requires heterogeneous materials, such as synthetic threads, which may compromise fiber purity and hinder mechanical recycling, leaving actors caught between restoration and recycling loops. These challenges interact with the organizing paradox, which emerges when repair activities are scaled or outsourced: quality assurance difficulties and unclear accountability can undermine customer trust and brand legitimacy [25, 26]. Charities face additional constraints that intensify this paradox, including a limited workforce, scarce operational resources, and non-standardized logistics, all of which restrict garment repair, re-sorting, and inner-loop recirculation. These operational limitations are reinforced by power asymmetries in the T&C value chain, where dominant actors control product decisions, sustainability priorities, and resource allocation [52], thereby reducing the influence of weaker partners over circular practices. Consequently, charities are often required to manage large volumes of mixed-quality donations without sufficient infrastructure or incentives, and skill gaps further reduce sorting accuracy [53]. These constraints limit their ability to prioritize life-extension practices such as repair and remaking; activities that, as highlighted by Charity #5, require time, experimentation, capacity, and knowledge of fashion trends. System-level constraints, including liability laws, unregulated tax regimes, and trade regulations, further restrict the cascading of reusable textiles within inner loops and shape decision-making regarding garment circulation [23, 32]. Together, these layered challenges and paradoxes make augmentation episodic rather than routine, frequently redirecting clothing toward outer-loop pathways such as recycling or downcycling while sustaining persistent PTs across cascading loops.

Consecutive Relinking

The principle of consecutive relinking assumes that used garments transition smoothly across CBMs, from reuse to remaking and ultimately recycling; however, in practice, this sequential valorization often fractures as interdependent challenges accumulate along the cascade. Upstream design choices – fiber blends, chemical additives, and dyes – exacerbate the paradox between durability and recyclability. This tension is amplified by scarce advanced automated sorting technologies, such as near-infrared (NIR) spectroscopy, and by underdeveloped mechanical and chemical recycling processes, which together limit effective fiber-to-fiber relinking [22, 54]. These design-related constraints then extend downstream: garments excluded from repair or reuse due to safety concerns or chemical inputs often become similarly non-negotiable for recycling, compounding exclusions and disrupting inner-to-outer loop cascades. Operational fragmentation, including decentralized processes, uneven capacities, and weak logistics, intensifies organizing tensions, frequently leading to mis-valorization or the discard of post-consumer clothing that could otherwise be consecutively relinked. While decentralization can enhance resilience, responsibility management, and individual profitability [35], effective cascading requires centralized, coordinated multi-actor operations spanning collection, sorting, reuse, and recycling [34, 55, 56]. Differences in incentives, capabilities, and decision criteria perpetuate coordination gaps, reproducing tensions in cascading operations. Weak coordination further drives downstream inefficiencies, including labor-intensive sorting, limited infrastructure, and high transport costs, which undermine the financial rationale for relinking and divert materials toward incineration. These dynamics produce a performing tension within organizing gaps, reflecting economic-environmental trade-offs, and sustain organizing-performing PTs in consecutive relinking. Policy frameworks aimed at local resilience and reducing waste dumping [37] further constrain cross-border flows, limiting brands' ability to reclaim capital products for relinking. Overall, unlike appropriate fit and augmentation, consecutive relinking fractures primarily through organizing and inter-class organizing-performing tensions, with performing tensions contributing less, revealing it as a fragile socio-technical accomplishment dependent on synchronized design, risk interpretation, operational capacity, incentives, and regulation.

Balancing Resource Metabolism

The principle of balancing resource metabolism envisions a circular system where material consumption and recovery evolve in equilibrium. Yet our findings show this balance is consistently disrupted by multiple challenges, resulting in organizing, performing, and inter-class organizing-performing PTs (see Table 1). These disruptions are reinforced by the persistent appeal of fast-fashion models, whose rapid production cycles, combined with labor-intensive and costly sorting, intensify performing PTs by favoring recycling over reuse and sometimes making incineration economically preferable, thereby accelerating resource leakage [34]. Structural limitations further exacerbate these imbalances: Europe's constrained mechanical and chemical recycling infrastructure, together with inadequate precision sorting technologies – discouraged by low profit margins and weak investment returns [32] – limits domestic relinking capacity, while insufficient EPR incentives further restrict circular operations [11, 32]. These gaps often push brands to rely on overseas facilities, as seen with Brands #3 and #6, which, while supporting closed-loop relinking, increase transportation burdens, reduce environmental benefits, and reflect organizing PTs highlighted in global sourcing literature [e.g., 36]. This reliance, compounded by systemic challenges such as limited market understanding, inconsistent data and tracking systems, transparency gaps, and greenwashing, further complicates decision-making and intensifies organizing-performing tensions in cascading operations. Because these issues span multiple actors and institutional domains, no single actor can fully manage them, allowing tensions to persist across the system and diverting materials into suboptimal or unknown routes. Consequently, circular operations fail to fully slow or close the resource loop, reinforcing cycles of overproduction and overconsumption [30]. From a degrowth perspective, these misalignments also challenge the environmental rationale of circular strategies, as rebound effects can offset efficiency gains [57]. Overall, these intertwined dynamics suggest that balancing resource metabolism requires more than increasing recycling or reducing consumption; it demands harmonizing material flows across actors, loops, geographic scales, and regulatory frameworks while addressing structural inefficiencies and systemic misalignments to prevent persistent resource imbalances.

Inter-Principle Interactions

Building on the principle-specific challenges that drive PTs, the analysis demonstrates that disruptions in cascade chains rarely originate from a single principle; rather, they emerge from the interdependencies among principles. Breakdowns in appropriate fit, for example due to strict safety compliance or quality assessments, reduce the pool of garments eligible for inner-loop reuse and constrain opportunities for augmentation through repair or remaking. As this pool contracts, the capacity to extend product lifetimes diminishes, making consecutive relinking of garments increasingly difficult across reuse, remaking, and recycling CBMs. The cumulative effect is to confine cascading to downcycling or incineration [3], which ultimately undermines the principle of balancing resource metabolism and weakens broader circularity outcomes. Economic and operational pressures further compound these dynamics, as cost-driven streamlining reduces sorting accuracy and product-task alignment, simultaneously affecting multiple cascading principles. At the same time, decentralized and fragmented operations create coordination gaps and localized bottlenecks, while policy misalignments introduce restrictions that reverberate throughout cascading chains. As a result, PTs do not remain limited to individual principles but migrate fluidly across cascading operations, evolving and compounding over time. These dynamics highlight the need for adaptive, system-level strategies capable of addressing the tension-laden nature of cascading operations to sustain circularity in the T&C industry [16, 19].

Conclusion

This study showed that cascading operations in the T&C industry are influenced by PTs, which complicate the sequential valorization of products and materials across both inner and outer CE loops. Mapping PTs against cascading principles revealed root challenges that disrupt cascade chains, arising not only from structural gaps but also from behavioral decisions when balancing economic, social, and environmental objectives. As PTs intensify, garments are increasingly diverted to outer loops, often resulting in downcycling or incineration. This explains why multiple CBMs frequently remain isolated or operate in parallel rather than forming coherent cascades. The findings highlight that cascading is neither linear nor frictionless; it unfolds within complex organizational structures, competing processes, evolving knowledge, and conflicting stakeholder values, reframing CE-cascading as not merely a technical problem but as one deeply intertwined with organizational decision-making. Advancing effective cascading, therefore, requires paradox-aware, adaptive managerial and policy strategies to translate CE ambitions into practice.

This study makes several important theoretical contributions. First, it integrates paradox theory with cascade chain theory, offering a novel lens to understand how PTs influence the cascading of CBMs. Rather than viewing cascading as purely technical, it demonstrates that it is shaped by persistent tensions affecting how product and material value are recaptured. Second, it deepens understanding of the organizational and operational dynamics that generate and sustain PTs across cascade stages, and how these dynamics constrain cascading practices. The findings show that PTs can lead to breaks, discontinuities, or simplifications, whereby actors intentionally bypass certain loops. Together, these insights contribute to both paradox and cascade chain theory by illustrating how persistent tensions actively reshape cascading decisions, often resulting in shortened or selectively implemented cascades.

From a managerial perspective, cascading challenges primarily arise from competing demands in daily decision-making, where internal priorities such as cost, speed, quality, and infrastructure constrain which CBMs and cascading pathways are feasible. Improving cascading outcomes therefore requires making these underlying tensions explicit and systematically accounting for them in strategic and operational processes, rather than treating constraints as isolated technical failures. Managers should recognize that cascading systems are inherently constrained by persistent tensions that cannot be fully eliminated, and instead assess where these tensions may accumulate and restrict sequence and scalability. For example, differing decisions in manual sorting, combined with high costs and limited market awareness, complicate matching garments to appropriate CBMs, sustaining PTs from inner to outer loops. Addressing this may involve investing in sorting technologies such as NIR and hiring experienced staff to circulate quality garments within inner loops while directing reliable fractions toward specialized recycling, making the process economically viable and reducing incineration. Similarly, hygiene and safety protocols and certifications can ensure that liability-sensitive items follow inner loops. By making these pressure points visible, managers can prioritize cascading loops more effectively, supporting realistic planning, clearer expectations, and targeted allocation of resources.

Complementing managerial strategies, policymakers can strengthen cascading in the T&C sector by aligning incentives with products' cascading potential and operational realities. First, EPR fees should reward designs suited for reuse, repair, and recycling, while charging more for products with low cascade potential. Second, transitional periods for EPR implementation and trade restrictions are necessary to avoid mis-valorizing reuse and recycling fractions or overwhelming domestic capacity. During these phases, pre-sorting incentives – particularly in high-labor-cost regions – ensure that fractions are exported only when they match foreign market needs and appropriate loops. Third, time-bound support for local infrastructure, precision sorting, and recycling can prevent premature incineration and preserve material value. Fourth, targeted fiscal measures can bridge economic gaps and reduce rebound effects; for example, reduced or zero VAT on repair services, tax credits for recycled content, and subsidies for multi-loop reuse or recycling can encourage brands to prioritize cascading over linear disposal. Finally, standardizing digitalization tools, such as digital product passports, helps track fiber composition, repair history, and prior reuse, reducing information asymmetry and enhancing loop selection and transparency. This enables actors to route materials efficiently, minimize misallocation, and safeguard environmental outcomes.

Despite these contributions, the study has limitations that suggest directions for future research. First, it did not differentiate PTs by national or institutional context. Although the sample included actors from multiple Northern European countries, most were Swedish, reflecting mature circular ecosystems, so caution is needed when generalizing to regions with different institutional, regulatory, or labor conditions. Future research could examine how PTs vary across countries with differing institutional frameworks and levels of CE development. Second, while PTs that challenge cascading were identified, strategies for managing them were not explored; future studies should investigate organizational approaches, including collaborative governance, adaptive capability development, and innovation networks. Finally, digital solutions such as product passports and blockchain-enabled traceability systems merit deeper study to assess their potential in mitigating PTs and improving data-driven coordination across circular value chains.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s43615-026-00936-w.

Acknowledgements This research was funded by FORMAS, the Swedish Government Research Council for Sustainable Development [grant number 2021−00529].

Author Contributions Conceptualization: Mohammadreza Dehghannejad, Rudrajeet Pal; Methodology: Mohammadreza Dehghannejad; Formal analysis: Mohammadreza Dehghannejad; Data curation: Mohammadreza Dehghannejad, Rudrajeet Pal and Kanchana Dissanayake; Writing – original draft: Mohammadreza Dehghannejad; Writing – review & editing: Mohammadreza Dehghannejad, Rudrajeet Pal and Kanchana Dissanayake; Validation: Rudrajeet Pal, Kanchana Dissanayake; Supervision: Rudrajeet Pal, Kanchana Dissanayake; Project administration: Rudrajeet Pal; Funding acquisition: Rudrajeet Pal.

Funding Open access funding provided by University of Boras. This research was funded by FORMAS, the Swedish Government Research Council for Sustainable Development [grant number 2021−00529].

Declarations

Ethics approval is not applicable to this research. Verbal informed consent was obtained from the respondents prior to the interviews.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

1. Ellen MacArthur Foundation (n.d.) Circular economy introduction: Overview. https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview. Accessed 17 November 2025
2. Lüdeke-Freund F, Gold S, Bocken NMP (2018) A review and typology of circular economy business model patterns. J Ind Ecol 23(1):36–61. https://doi.org/10.1111/jiec.12763
3. Campbell-Johnston K, Vermeulen WJV, Reike D, Brullot S (2020) The circular economy and cascading: towards a framework. Resources, Conservation and Recycling X 7:100038. https://doi.org/10.1016/j.rcrx.2020.100038
4. Reike D, Vermeulen WJV, Witjes S (2018) The circular economy: new or refurbished as CE 3.0? — exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. Resour Conserv Recycl 135:246–264. https://doi.org/10.1016/j.resconrec.2017.08.027
5. Ellen MacArthur Foundation (2022) The technical cycle of the butterfly diagram. https://www.ellenmacarthurfoundation.org/articles/the-technical-cycle-of-the-butterfly-diagram/. Accessed 17 November 2025
6. Bakker C, Balkenende R, Poppelaars F (2019) Design for product integrity in a circular economy. In: Charter M (ed) Designing for the Circular Economy. Routledge, London, pp 148–156
7. Bocken NMP, de Pauw I, Bakker C, van der Grinten B (2016) Product design and business model strategies for a circular economy. J Ind Prod Eng 33(5):308–320. https://doi.org/10.1080/21681015.2016.1172124
8. Sirkin T, ten Hou M (1994) The cascade chain: a theory and tool for achieving resource sustainability with applications for product design. Resour Conserv Recycl 10:213–277. https://doi.org/10.1016/0921-3449(94)90016-7
9. Hopkinson P, Zils M, Hawkins P, Roper S (2018) Managing a complex global circular economy business model: opportunities and challenges. Calif Manag Rev 60(3):71–94. https://doi.org/10.1177/0008125618764692
10. Pal R, Gander J (2018) Modelling environmental value: an examination of sustainable business models within the fashion industry. J Clean Prod 184:251–263. https://doi.org/10.1016/j.jclepro.2018.02.001
11. Dehghannejad M, Pal R, Dissanayake K (2025) Cascading of circular business models in the textile and clothing industry: insights for operationalization through a systematic review. Resour Conserv Recycl Adv 28:200293. https://doi.org/10.1016/j.rcradv.2025.200293
12. Holtström J, Bjellerup C, Eriksson J (2019) Business model development for sustainable apparel consumption: the case of Houdini Sportswear. J Strategy Manage 12(4):481–504. https://doi.org/10.1108/JSMA-01-2019-0015
13. Shourkaei MM, Taylor KM, Dyck B (2023) Examining sustainable supply chain management via a social-symbolic work lens: lessons from Patagonia. Bus Strategy Environ 33(2):1477–1496. https://doi.org/10.1002/bse.3552

14. Stål HI, Corvellec H (2018) A decoupling perspective on circular business model implementation: illustrations from Swedish apparel. J Clean Prod 171:630–643. https://doi.org/10.1016/j.jclepro.2017.09.249
15. Pedersen ERG, Earley R, Andersen KR (2019) From singular to plural: exploring organisational complexities and circular business model design. J Fashion Mark Management Int J 23(3):308–326. https://doi.org/10.1108/JFMM-04-2018-0062
16. Smith WK, Lewis MW (2011) Toward a theory of paradox: a dynamic equilibrium model of organizing. Acad Manage Rev 36(2):381–403. https://doi.org/10.5465/amr.2011.59330958
17. van Bommel K (2018) Managing tensions in sustainable business models: exploring instrumental and integrative strategies. J Clean Prod 196:829–841. https://doi.org/10.1016/j.jclepro.2018.06.063
18. De Angelis R (2021) Circular economy and paradox theory: a business model perspective. J Clean Prod. https://doi.org/10.1016/j.jclepro.2020.124823
19. Hofmann F, Jaeger-Erben M (2020) Organizational transition management of circular business model innovations. Bus Strateg Environ 29(6):2770–2788. https://doi.org/10.1002/bse.2542
20. Schad J, Lewis MW, Raisch S, Smith WK (2016) Paradox research in management science: looking back to move forward. Acad Manage Ann 10(1):5–64. https://doi.org/10.1080/19416520.2016.1162422
21. Daddi T, Ceglia D, Bianchi G, de Barcellos MD (2019) Paradoxical tensions and corporate sustainability: a focus on circular economy business cases. Corp Soc Responsib Environ Manage 26(4):770–780. https://doi.org/10.1002/csr.1719
22. Sandvik IM, Stubbs W (2019) Circular fashion supply chain through textile-to-textile recycling. J Fashion Mark Management: Int J 23(3):366–381. https://doi.org/10.1108/jfmm-04-2018-0058
23. Brändström J, Jazairy A, Lindgreen ER (2024) Barriers to adopting circular business models: a cross sectoral analysis. Bus Strateg Environ 33(5):4331–4350. https://doi.org/10.1002/bse.3653
24. Dehghannejad M, Rudrajeet P, Dissanayake K, Sandberg E (2025) Exploring paradoxical tensions in scaling circular business models within the textile and clothing industry. Sustain Prod Consum 56:579–592. https://doi.org/10.1016/j.spc.2025.04.022
25. Kemi AP, Zilahy G (2025) Sustainable post-purchase behaviour of consumers of fashion textile products. Discover Sustain. https://doi.org/10.1007/s43621-025-00888-5
26. Salmi A, Kaipia R (2022) Implementing circular business models in the textile and clothing industry. J Clean Prod. https://doi.org/10.1016/j.jclepro.2022.134492
27. Siderius T, Poldner K (2021) Reconsidering the circular economy rebound effect: propositions from a case study of the Dutch circular textile valley. J Clean Prod. https://doi.org/10.1016/j.jclepro.2021.125996
28. Mittal S, Khan MA, Yadav V, Sharma MK (2024) Footwear as product-service systems: toward sustainable alternative consumption scenarios. Bus Strateg Environ 33(2):726–741. https://doi.org/10.1002/bse.3519
29. Nilsson L, Björklund A, Waller JH, Bäckström M (2024) Is it worth buying a second-hand shell jacket? An evaluation of shell jackets' functionality and price over time. Sustainability. https://doi.org/10.3390/su16083451
30. Dekhili S, Achabou MA, Nguyen TP (2025) When the pro-ecological intentions of second-hand platforms backfire: an application in the case of Vinted. J Clean Prod. https://doi.org/10.1016/j.jclepro.2024.144399
31. Zanjirani Farahani R, Asgari N, Van Wassenhove LN (2022) Fast fashion, charities, and the circular economy: challenges for operations management. Prod Oper Manag 31(3):1089–1114. https://doi.org/10.1111/poms.13596
32. Charnley F, Cherrington R, Mueller F, Jain A, Nelson C, Wendland S, Ventosa S (2024) Retaining product value in post-consumer textiles: how to scale a closed-loop system. Resour Conserv Recycl. https://doi.org/10.1016/j.resconrec.2024.107542
33. Paras MK, Curteza A, Varshneya G (2019) Identification of best reverse value chain alternatives: a study of Romanian used clothing industry. J Fashion Mark Management: Int J 23(3):396–412. https://doi.org/10.1108/JFMM-04-2018-0060
34. Schmutz M, Som C (2022) Identifying the potential for circularity of industrial textile waste generated within Swiss companies. Resour Conserv Recycl. https://doi.org/10.1016/j.resconrec.2021.106132
35. Khorshidvand B, Guitouni A, Govindan K, Soleimani H (2023) Pricing strategies in a dual-channel green closed-loop supply chain considering incentivized recycling and circular economy. J Clean Prod. https://doi.org/10.1016/j.jclepro.2023.138738
36. Sandberg E (2017) Introducing the paradox theory in logistics and SCM research – examples from a global sourcing context. Int J Logist Res Appl 20(5):459–474. https://doi.org/10.1080/13675567.2017.1280007
37. Boschmeier E, Ipsmiller W, Bartl A (2024) Market assessment to improve fibre recycling within the EU textile sector. Waste Manag Res 42(2):135–145. https://doi.org/10.1177/0734242X231178222

38. Kalverkamp M, Pehlken A, Wuest T (2017) Cascade use and the management of product lifecycles. Sustainability. https://doi.org/10.3390/su9091540
39. Clegg S, Cunha MPE, Harvey C, Maclean M, Silva ÁFD (2025) Organising through time: paradox and history. Bus Hist 67(2):413–429. https://doi.org/10.1080/00076791.2025.2461064
40. Cuganesan S (2016) Identity paradoxes: how senior managers and employees negotiate similarity and distinctiveness tensions over time. Organ Stud 38(3–4):489–511. https://doi.org/10.1177/0170840616655482
41. Jarzabkowski P, Lê JK, Van de Ven AH (2013) Responding to competing strategic demands: how organizing, belonging, and performing paradoxes coevolve. Strateg Organ 11(3):245–280. https://doi.org/10.1177/1476127013481016
42. Vermeulen WJV, Witjes S (2016) On addressing the dual and embedded nature of business and the route towards corporate sustainability. J Clean Prod 112:2822–2832. https://doi.org/10.1016/j.jclepro.2015.09.132
43. Eisenhardt KM, Graebner ME, Sonenshein S (2016) Grand challenges and inductive methods: rigor without rigor mortis. Acad Manag J 59(4):1113–1123. https://doi.org/10.5465/amj.2016.4004
44. Gioia DA, Corley KG, Hamilton AL (2013) Seeking qualitative rigor in inductive research: notes on the Gioia methodology. Organ Res Methods 16(1):15–31. https://doi.org/10.1177/1094428112452151
45. Langley A (1999) Strategies for theorizing from process data. Acad Manage Rev 24(4):691–710. https://doi.org/10.5465/amr.1999.2553248
46. Nyimbili F, Nyimbili L (2024) Types of purposive sampling techniques with their examples and application in qualitative research studies. Br J Multidiscip Adv Stud 5(1):90–99. https://doi.org/10.37745/bjmas.2022.0419
47. Malterud K, Siersma VD, Guassora AD (2016) Sample size in qualitative interview studies: guided by information power. Qual Health Res 26(13):1753–1760. https://doi.org/10.1177/1049732315617444
48. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, Burroughs H, Jinks C (2018) Saturation in qualitative research: exploring its conceptualization and operationalization. Qual Quant 52(4):1893–1907. https://doi.org/10.1007/s11135-017-0574-8
49. Statens offentliga utredningar (2020) Producentansvar för textil – en del av den cirkulära ekonomin. Regeringskansliet, Stockholm. https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2020/12/sou-202072/. Accessed 22 March 2026
50. Vinnova (2024) Framework for circular textiles – Classification of recycled textiles and criteria for circularity. https://www.vinnova.se/en/p/framework-for-circular-textiles---classification-of-recycled-textiles-and-criteria-for-circularity/. Accessed 1 March 2026
51. Campbell JL, Quincy C, Osserman J, Pedersen OK (2013) Coding in-depth semistructured interviews. Sociol Methods Res 42(3):294–320. https://doi.org/10.1177/0049124113500475
52. Talay C, Oxborrow L, Goworek H (2022) The impact of asymmetric supply chain relationships on sustainable product development in the fashion and textiles industry. J Bus Res 152:326–335. https://doi.org/10.1016/j.jbusres.2022.07.034
53. Dissanayake K, Pal R (2025) Toward a just circular economy: exploring societal implications of used clothing supply chains. Societal Impacts. https://doi.org/10.1016/j.socimp.2024.100101
54. Silva AC, Barreiros MP, Azevedo T, Brás D, Teixeira MA, Fangueiro R, Ferreira DP (2026) Fibre-to-fibre recycling in textiles: strategies, limitations and industrial perspectives. Textiles. https://doi.org/10.3390/textiles6010030
55. Sandberg E, Pal R (2024) Exploring supply chain capabilities in textile-to-textile recycling – a European interview study. Cleaner Logistics and Supply Chain. https://doi.org/10.1016/j.clscn.2024.100152
56. Reike D, Hekkert MP, Negro SO (2023) Understanding circular economy transitions: the case of circular textiles. Bus Strategy Environ 32(3):1032–1058. https://doi.org/10.1002/bse.3114
57. Schröder P, Bengtsson M, Cohen M, Dewick P, Hofstetter J, Sarkis J (2019) Degrowth within – aligning circular economy and strong sustainability narratives. Resour Conserv Recycl 146:190–191. https://doi.org/10.1016/j.resconrec.2019.03.038

Authors and Affiliations

Mohammadreza Dehghannejad[1] · **Rudrajeet Pal**[1,2] · **Kanchana Dissanayake**[1]

✉ Mohammadreza Dehghannejad
mohammadreza.dehghannejad@hb.se

Rudrajeet Pal
rudrajeet.pal@hb.se

Kanchana Dissanayake
kanchana.dissanayake@hb.se

[1] Department of Business Administration and Textile Management, Swedish School of Textiles, University of Borås, Allégatan 1, Borås 503 32, Sweden

[2] Faculty of Engineering and Sustainable Development, University of Gävle, Gävle, Sweden