

# Cascade circular business models in the textile and clothing industry: Understanding facilitators and barriers through a systematic literature review

**Mohammadreza Dehghannejad<sup>1,\*</sup>, Rudrajeet Pal<sup>1,2</sup>, Kanchana Dissanayake<sup>1</sup>**

<sup>1</sup>Swedish School of Textiles, Department of Business Administration and Textile Management, University of Borås, Sweden; <sup>2</sup>Faculty of Engineering and Sustainable Development, University of Gävle, Sweden

\*mohammadreza.dehghannejad@hb.se

## Extended abstract

To achieve the ultimate potential of the circular economy, it is necessary to operationalize a cascaded system where R-imperative circular business models (CBMs) such as repair, reuse, and recycling are implemented/connected sequentially before the materials/products end up in energy recovery (Campbell-Johnston et al., 2020). While renewable materials cascade through biological cycles, technical cycles create added value through specific CBMs (Sehnem et al., 2019). However, the technical part of the cascading system can be enhanced through product and service-oriented activities (Salmi & Kaipia, 2022), while leading different innovations and ecosystem collaboration, thus moving the company-oriented value chain towards mass value creation for more actors (Dagilienė & Varaniūtė, 2023).

Ranked fifth among resource-intensive and polluting industries, textile and clothing (T&C) seeks to create added value (Sandin & Peters, 2018) through implementing circular innovation models such as product-service-system, sharing, repair, resale, and recycling together with digitization in product and design, as well as consumer-user interactions (Koszewska, 2018). In addition to closed-loop cascading, cross-industry value propositions are offered, such as combinations with furniture or insulation industries (Lüdeke-Freund et al., 2018). This means that cascading CBMs in this industry, by slowing down the loops, carry explicit and inherent value considerations (Campbell-Johnston et al., 2020).

Despite frequent discussions of the cascade, however, there is a dearth of literature on its operationalization for greater use of recycled materials/products, as well as its socio-environmental potential to facilitate decision-making (Campbell-Johnston et al., 2020; Sandin & Peters, 2018). Nor does it exist in terms of the responsibility of corresponding individual CBMs, who offers value to whom, how value is delivered and captured, and how material flows are coordinated between companies (Lüdeke-Freund et al., 2018). Even though cascading is practically used in wood and energy conversion, it is tacitly or to a lesser extent referred to in other industries such as using by-products or secondary textile use (Campbell-Johnston et al., 2020). The purpose of this paper is thus ***to understand the facilitators and barriers to cascade CBMs in the T&C industry.***

A systematic literature review was conducted as a structured method to collect literature in this specific field (Snyder, 2019; Wolfswinkel et al., 2017) through database searches in Scopus, Web of Science, and ABI/INFORM Collection. Considering the purpose of the study, main keywords were searched, limited to abstracts of scientific journal articles [e.g., “cascad\*” AND “circula\*” AND (“textile\*” OR “cloth\*” OR “apparel\*”)]. Open-loop and closed-loop were also added within the search strings because of their supplementary coverage of circular economy aspects such as rental, repair, and reuse activities in the inner loop, while remanufacturing and recycling activities in the outer loop, including open-loop activities inter-industrially. Keeping the focus on cascading technical flow, 36 articles remained after the initial screening of the retrieved literature list (N=94) and removing overlaps from databases.

The preliminary results indicate different types of closed- and open-loop cascades in the textile circular economy, involving diverse actors both intra- and inter-industrially. Closed-loop cascading systems operate between the downstream actors (inner loop) of the value chain where brands and service providers are involved. Likewise amidst manufacturers and recyclers engaged in circular activities such as pure separation of nylon fibers from carpets (Mu et al., 2024) or value-adding to fashion through mechanically recycled wool (Norris, 2019). While the latter experiments with various pilot tests to bring remade post-consumer clothing back into fashion under manufacturer-retailer negotiation, a customizable framework of hybrid business models has potentially accelerated the reuse, upcycling, and recycling of worn/secondhand clothing (Jain et al., 2021). Reuse and upcycle services, under a social innovation perspective, are also scaled through a community-based collaboration in a sustainable fashion (Wu et al., 2023). Product-as-service contracts with shifting responsibility and value chain ownership are other cascading flows that have led to material management and product quality improvement (Fischer & Pascucci, 2017). Such joint arrangements even extend the life of the product before it is cascaded to the next stages (e.g., remanufacturing or recycling), creating a systemic socio-environmental impact (ibid.).

In the case of open-loop cascades, this transformation has been reported in textile waste fibers to non-hazardous secondary raw materials for the production of composite materials in construction and geotechnical practices (Rahman et al., 2022). Similarly, processed natural fibers and recycled non-woven textile polypropylene to cavity wall insulation and hybrid sheet materials for building applications, respectively (Echeverria et al., 2020; Wilson, 2015). The use of wood-based fibers, instead of petroleum fibers such as polyester and nylon, or unsustainable plant-based fibers such as cotton (Maximo et al., 2022) has also been highlighted to feed the T&C industry.

Furthermore, several key barriers and facilitators were identified during cascading implementations. In particular, the non-participation of the brand owner in the valuation of used clothes results in the lack of their accessibility thus preventing the scalability of upcycled CBMs, while they remain on the sidelines (Jain et al., 2021). Additionally, the lack of markets and recyclers in the care of textile waste (Schmutz & Som, 2022), effective recycling policies to ensure high quality in recycling (Kazancoglu et al., 2021), along with context-dependency issues in closed-loop implementation, where industry characteristics may not work in other industries (Denizel & Schumm, 2023), can disrupt cascade systems. In contrast, structured provision of information or government financial support (Marlen Gabriele et al., 2023) and some deliberate actions by the economic policymakers, due to slow dematerialization in fashion (Olatubosun et al., 2021), are underlined as cascading facilitators. It has also been emphasized that having a collaborative approach in a closed-loop recycling program can better facilitate reverse logistics than a decentralized approach (Khorshidvand et al., 2023).

To conclude, while the identification of cascading levels and their implementation in the T&C industry introduces new CBMs that can help slowing, narrowing, and closing the loops, it provides the basis for cooperation between actors to grasp uncaptured values in order to better serve circular economy goals. Future research could consider how such cascading systems can be implemented from a strategic point (e.g., in terms of resources and capabilities required, and how a T&C industrial system shift can be enforced).

## Keywords

Cascading, Circular Business Models, Circular Economy, Textile and Clothing Industry

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