

1. Circular fashion supply chain management: exploring impediments and prescribing future research agenda

1.1 *Contextualizing the need for circularity in fashion supply chains*

This Editorial emerges at the time when the notion of “circularity” or circular supply chains and business models has gained considerable momentum in the fashion industry worldwide. Through several disruptive innovations related to products and materials, such as use of recycled fibres, process technologies related to sorting and recycling, and several newly observed practices, such as collaborative consumption, take-back schemes, etc., the industry as a whole has strived towards being more restorative and regenerative in the flow of not only products, but also by-products and wastes by narrowing, slowing and closing the resource and energy flows (Pal and Gander, 2018; Bocken, 2016). However, currently the dominant operating logics of fashion businesses of mass production, fast fashion consumption and linear take-make-disposal model (Pulse of the Fashion Industry, 2017) still remain intact, where only around 20 per cent of clothing is recycled or reused (Global Footprint Network, 2017). As a consequence, the fashion industry is highly wasteful and resource draining in nature – ranking fourth in terms of environmental impact with a strikingly high environmental cost (EEA, 2014), stemming from extent of natural resource usage, generation of effluents during apparel production and the scale of landfill produced during disposal (Pulse of the Fashion Industry, 2017). The intensity of the problem is increasing with the proliferation of demand for clothing, as global production surmounted 1bn items in 2014 and consumption is over 62m tons and is expected to increase by 63 per cent to 102m by 2030 (McKinsey & Company, 2016; Pulse of the Fashion Industry, 2017).

With increasing expectation and demands from the government and the public that enterprises should manage their wastes and products’ end-of-life there is requirement for comprehensive attention towards underlying circular supply chains and associated business models (Bocken *et al.*, 2014, 2016). Over the last decade, the concept of circularity has gone beyond just recycling and encompasses a holistic view along five major underlying principles of circular supplies, resource recovery, product life extension, sharing or collaborative economies, and product-as-service. The inner circular loops following the principles of sharing/collaboration and product-as-service provide the possibility to retain higher value of the original product predominantly centred on service or product-service design. These loops can be operationalized through long-lasting design, maintenance and repair (Geissdoerfer *et al.*, 2017), and demands continuous exchange of resources and information facilitated by reverse logistics and supply chain. The transition to a circular model thus demands a new logistics system which considers the entire lifecycle of the product and its circulation within the society for as long as possible, with the maximum product longevity coupled with the maximum efficient utilization of resources, minimum waste production and least environmental damage and pollution (Ferguson, 2009). Such exchanges in supply chains go beyond organizational boundaries to include inter-organizational collaboration and networks (Bourlakis *et al.*, 2014) where organizations from diverse sectors (profit, governmental and social) play a more interactive and relational role (Pal, 2017).

However, despite this necessity and several strong emerging cases of circularity in fashion, the status quo in this industry is referred as at the beginning of a journey, with only around 20 per cent of garments globally collected for reuse or recycling through a variety of systems, and approximately 80 per cent of the materials used for clothing are sent to landfill



or incinerated (Pulse of the Fashion Industry, 2017). Several barriers such as technological limitations, institutional inertia and dynamic customer preferences restrict scalability of the circular business models (CBMs) (Pal and Gander, 2018). From the research front, sustainability issues in fashion supply chains and business models have been focused on a much wider perspective (Shen *et al.*, 2014; Shen, 2014), and have not been targeted to systemically cover circularity and its management. In light of this, the objective of this Editorial is to create comprehensive and focused understanding of the impact and implications of circular supply chain and business model operations, practices and strategies of extended fashion enterprises, through synthesis of the accompanying special issue (SI) papers. Guided by the cascading notion of circular economy which underpins the normative structure of circular supply chain (De Angelis *et al.*, 2018), the SI papers present a wide range of topics that are of central importance for establishing, implementing and mainstreaming circularity in fashion supply chains.

2. Guide to the special issue papers

This Editorial begins by briefly presenting the diverse topics discussed in the included papers and their positioning in largely under-explored circular fashion supply chain management research stream. Pedersen *et al.* (2019) present CBMs based on principles of sharing, leasing and recycling as plural, i.e. combination of business models throughout the product lifecycle, instead of most common depiction of CBMs in isolation. Henninger *et al.* (2019) present such a cascaded supply chain of clothes swap-shop phenomenon constituted by multiple consumption cycles. Such cascading production and consumption cycles have more power in creating and capturing value from the material flow across different supply chain loops when the value retention is much more of a product's embedded materials (EMF and McKinsey & Company, 2012). Three SI papers illustrate single circular business systems in detail: Kant Hvass and Pedersen (2019) present the in-store take-back system of a fashion brand, Sandvik and Stubbs (2019) present the textile-to-textile recycling system and Machado *et al.* (2019) explore the second-hand market for reuse of fashion clothes. These papers gather empirical data over many countries, thus demonstrating differences in the status quo of circular fashion practices. For instance, both Kant Hvass and Pedersen (2019) and Sandvik and Stubbs (2019) capture the practices in Scandinavia, which is at the forefront when it comes to circular economy in fashion (Watson *et al.*, 2019). On the other hand, Paras and Curteza (2019) present the Eastern European context through the study of the used clothing industry in Romania, which is one of the largest importers of used clothes from the western and northern European countries. These imported used clothes fall under different categories: reusable, recoverable textiles, reprocessed and unusable which further determine the choice of subsequent disposition route. Machado *et al.* (2019) present the consumers' role in buying from street fairs and thrift stores in Brazil. Henninger *et al.* (2019) provide evidence of collaborative consumption phenomenon through swap-shops in three countries: the UK, Finland and Germany, and argue that such multi-country settings are not studied in the extant literature. More specifically, each paper is briefly summarized below to highlight their "lines of enquiry".

Pedersen *et al.* (2019) engage in examining the organizational complexities of designing for CBMs in fashion to explain the status quo of their relatively slow adoption in the industry. Through an action research to develop a Service Shirt concept – a physical prototype for exhibition – the paper demonstrates, how multiple business models come into play during the entire, deliberately extended product lifecycle, and further discuss the implications of designing for the circular economy within fashion. Here, the role of the designer is central to solving the complexities that arise in combining circular economy thinking with conventional business model logic. As opposed to the convention of designing products of single use, circularity demands designers to develop products for plural

function and use, thus requiring forecasting in terms of the product's fashion, style, materials and longevity.

Transition of the product along plural or multiple CBMs also results in transfer of its ownership along different consumption cycles underpinned by either monetary (e.g. selling) or non-monetary (e.g. swapping) transactions. Henninger *et al.* (2019) investigate the implications of consumers acting as suppliers in swapping supply chain, unlike other types of collaborative consumption models, e.g. renting, where the transfer of ownership occurs peer-to-peer. As a peer, the consumer has a fluid role in the supply chain either as a supplier or a buyer. The paper investigates swap-shops, where individuals participate in events and provide garments that can be swapped, to specifically explore the opportunities as well as challenges associated with managing this "new" supply chain from both organizational and consumers' perspectives. The paper further discusses how such inner loop swapping supply chains are organized in terms of the product movement through the channel members to recapture value. This has the possibility to generate higher sense of responsibility and ownership among the fashion consumers thereby creating a community that is inclusive in nature. Machado *et al.* (2019) reinstate similar argument, highlighting that the consumer plays a very active role in slowing down fashion consumption to induce extended fashion product life in circular economy through higher reuse. The paper shows that the three dimensions of consumer motivations (economic, critical – ecological and ethical, and hedonic/recreational) to buy second-hand fashion are inter-related and in fact overlap in a virtuous circle of motivation. This is initially driven by nostalgia of childhood memories of family exchanges of clothes, followed by in the adulthood this is further sparked by financial reasons and the realization that buying used clothes is a way to get quality products that last longer. This further instigates the consumers to "reject" the traditional perspective on fashion consumption that is driven by fast fashion attitude, and instead buy less but more durable fashion clothes. Consequently, social relationships start forming, i.e. with owners of thrift store, other second-hand customers and this rejuvenates the childhood nostalgia.

In the reverse value chain, another crucial aspect is determining the best disposition alternative that the end-of-life or end-of-use product should undergo in order to regain its value and find utilization again in the consumption cycle (Skinner *et al.*, 2008). In used clothing industry context, five disposition alternatives, namely, direct reuse, upcycling, down-cycling, incineration and landfill, are identified by Paras and Curteza (2019), which is further used to evaluate, using analytic hierarchy process tool, what and how different criteria related to material, economy and technology influence decision making. Results show that material-related aspects have the highest importance and technology was found to be of least importance, while upcycling and direct reuse are the two most suitable disposition alternatives when material is of good quality. However, for upcycling or reusing the clothes quality and cleanliness are very crucial, while in the absence of right technical skills the product is reused instead of being upcycled. One of the most crucial stages for the used clothing reverse logistics is collection, and a number of challenges related to insufficient volume, lack of timeliness, etc., hinder its competitive performance (Pal, 2017). New players, mainly fashion retailers and brands are trying to find innovative business models and solutions to tap the potential, of which take-back schemes or systems (Stål and Corvellec, 2018) are rapidly developing. However, there remains limited evidence in the extant literature, beyond identifying a number of generic CBM challenges, on how such take-back systems are actually implemented, i.e. developed and tested in practice, by overcoming the "roadblocks" to a successful transition. Kant Hvass and Pedersen (2019) present a single case study of a fashion brand's development and testing of an in-store take-back system in an existing business model to explore the implementation process and highlight the challenges in practice related to transforming into a circular value proposition, rethinking customer's role and engagement, and in building new partnerships with

external stakeholders. Along the outer circularity loop, e.g. recycling, Sandvik and Stubbs (2019) present the textile-to-textile recycling in the fashion industry, and inherent challenges due to a lack of systemic knowledge and technical inhibitors. It is also identified that the key enablers include access to adequate used textiles, availability of technological solutions for textile-to-textile recycling and new/mono materials and product design that can make disassembly easier.

3. Impediments in circular fashion supply chains

Several key challenges and barriers that hinder uptake of circularity in supply chains and business models are identified already in the extant literature. Major ones, those relevant for the fashion industry, are related to the product process, e.g. in terms of uncertainties in the volume and timeliness of return, material quality, lack of organizational resources and change to implement circularity, and external factors, such as lack of customer demand, unsupportive regulation. As the starting point for the SI papers, these challenges and barriers impeding the development of circular fashion supply chains and business models are revisited for presenting the status quo, and to identify prescribed solutions. These solutions are mainly devised through corporate actions, systemic changes by individual organization and in the value network that hold both practical and scientific relevance. Table I classifies these challenges and barriers as “impediments” of five main categories, and enlists several impediment types and potential solutions to overcome these, as empirically evidenced in the SI papers.

4. Emerging themes for setting future research agenda

4.1 *Dual perspectives in exploring circularity*

Two distinct units of analysis are used in the SI papers for understanding circular flow in fashion supply chains. A product lifetime perspective captures the products' lifecycle along the different cascading loops, and in connection presents the central role of product attributes, such as its design and material content, quality, functionality and longevity in constituting the use and exchange values as the product transits from one consumption cycle to the next. On the other hand, the supply chain perspective presents the distribution and reverse logistics processes of the product in these cascading loops, and how different stakeholders engage to exchange the product.

4.1.1 Product lifetime perspective. Pedersen *et al.* (2019) depict the Service Shirt's 50-year use and exchange cycle where the original product (after personal use) is redesigned using digital printing techniques so that the life of the shirt can be extended, and it can first be exchanged within the friend circle and then put on rental. Following this, i.e. beyond 17 years of lifetime, the shirt is proposed to be used as lining material inside a polyester jacket, which goes through the same lifecycle stages of first private use, followed by sharing in family circles and finally ending up under the rental scheme. Beyond 33 years, the jacket is transformed into one-off jewellery products after being cut into strips, hand-rolled, folded and stitched. In fact, such transition of the product after certain value addition or repurposing along multiple consumption cycles (n_1, n_2, n_r) is also presented in context to swapping supply chains by Henninger *et al.* (2019); however, the probability of the high-end disposition options decreases due to quality deterioration as the product enters new cycle.

In addition to quality, fashionability and trend of fashion products also play vital roles in determining the disposition option (Henninger *et al.*, 2019). Along the same line, Paras and Curteza (2019) highlight the highest importance of material-related criteria, such as brand, fabric colour, quality, size, type and smell in determining the best disposition option for used clothes. When the material quality is good, direct reuse or upcycling are more viable alternatives, and this means that the original use value of the product is retained and the

Table I.
Impediments and solutions to establishing, implementing and mainstreaming circular fashion

Impediment classification	Impediment type	Prescribed solutions	Empirically evidenced in
Reverse supply chain ineffectiveness	High uncertainty, e.g. in stock, availability, quality and sizes of used clothes	Generate higher sense of responsibility and ownership among consumers	Henninger <i>et al.</i> (2019), Pedersen <i>et al.</i> (2019), Paras and Curteza (2019)
	Traditional infrastructure	Enter into partnership	Kant Hvass and Pedersen (2019)
Customer and market unacceptance	Lack of understanding of customer motivation to purchasing used clothes	Institutionalize consumers' active roles as customers, sellers, partners and suppliers Encourage consumer involvement with slow fashion	Machado <i>et al.</i> (2019), Kant Hvass and Pedersen (2019)
	Lack of sufficient market	Product lifecycle-centred sales and marketing instruments	Kant Hvass and Pedersen (2019), Sandvik and Stubbs (2019)
Organizational inertia	Combining circular economy thinking with conventional business model logic	Integrate role of designers to design multi-function products for plural CBMs Define circular value proposition	Kant Hvass and Pedersen (2019), Pedersen <i>et al.</i> (2019)
	Myopic firm-centric view	Collaborate across professions, departments and organizations in the loops Cross-organizational commitment	Kant Hvass and Pedersen (2019), Pedersen <i>et al.</i> (2019)
Technological un-readiness	Lack of technology, e.g. for separation of blends or recycling	Circular product design strategies, e.g. design for disassembly, mono-materiality Innovative recycling technologies	Sandvik and Stubbs (2019)
Strategic misalignment	Difference in practices, goals and strategies, e.g. related to material quality, design perspectives, pace of product introduction	Consumers' rejection of the fast fashion attitude Lifecycle focused customer engagement strategy	Kant Hvass and Pedersen (2019), Machado <i>et al.</i> (2019), Sandvik and Stubbs (2019)
	Fast fashion quality	Build to last	Paras and Curteza (2019), Pedersen <i>et al.</i> (2019)

exchange value, i.e. the price obtained by the seller could be considerably high. However, within the fashion industry an interesting systemic difference is presented by Sandvik and Stubbs (2019), the paper emphasizes that the product lifecycle for textile-to-textile recycling differs on the basis of different kinds of material that feeds into the cycles: for the “fast” fashion system where the inherent product quality is low, recycling is the major option. Such a system relies on several technical parameters at different stages of the value chain, for example at the design stage use of mono materials or design-for-easy disassembly plays holds strategic importance to ensure higher material circulation, while in the post-consumer stage, recyclability is ensured by easy separation techniques for blended fibres, additives and trims or methods to restore degradation of material quality.

On the other hand, “slow” fashion system where the inherent product quality is higher and increased focus is on prolonging the life of garments through repairing or reselling.

Machado *et al.* (2019) provide evidence of this growing slow fashion movement in emerging nation's context, as they found shopping second-hand clothes in thrift stores is often considered by consumers as a way to reject fast fashion and end consumerism. In their study, it was evident that several participants associated ethical consumption to use second-hand products, as they considered "buying used clothing is one way to get quality products that last longer". With this central role of the consumers and their engagement in determining the longevity of the product in circulation, Kant Hvass and Pedersen (2019) further enunciate the role of businesses in communicating the circular value proposition to customers and engage them in practice by highlighting "a life-cycle focused customer engagement strategy is required that informs customers about the reuse and recycling value of the products they have purchased. This can be achieved through product life-cycle centred sales and marketing messages".

4.1.2 Supply chain perspective. Three aspects underpin the circular supply chain perspective. These are: reverse logistics collaboration, reverse logistics costs and consumers' role. Kant Hvass and Pedersen (2019) highlight that the reverse logistics infrastructure requires identifying key partners, and in the used clothing take-back system this is either through collaboration with charities or professional garment collectors. Traditional infrastructure, internal capabilities and partnerships of a fashion company are not sufficient for setting up a product take-back system with reverse logistics. Such supply chain level inter-organizational collaboration was also highly valued as an enabler of systemic change in the textile-to-textile recycling system by Sandvik and Stubbs (2019). Industry-side collaboration requires participation from SMEs and brands beyond larger corporations. Equally important is collaboration with global supply chain providers, as exemplified by the collaboration with ICO for managing the textile waste stream and providing reverse logistics solution related to sorting, reuse and recycling. Such collaboration is "needed to create logistics, systematisation of access to materials on an industry-wide basis, and to reach scale to create enough demand for recycling technologies", as argued by Poldner (2013) that strategic alliances such as that of Sustainable Apparel Coalition can work as a platform for companies to create system-wide knowledge for the larger benefit. However, a major drawback to achieve such industry level collaboration is the difference in practices between different actors, when it comes to goals and strategies related material quality in products, design perspectives, pace of product introduction (Sandvik and Stubbs, 2019). Pedersen *et al.* (2019) conceptualize overcoming such challenges can create an integrated circular supply chain of a multi-life "Service Shirt" as it gets exchanged between fablabs, remanufacturing artisans and recyclers for value addition over a 50-year cycle.

Financial aspects in the reverse supply chain are also crucial to consider for making the circular supply chain economically viable, as was highlighted for systems for take-back (Kant Hvass and Pedersen, 2019) or textile-to-textile recycling (Sandvik and Stubbs, 2019). Though storing, sorting and disposal costs can be minimized by entering into partnership with professional collectors, in general the costs of current sorting practices and that for developing new recycling technologies to meet present limitations are considerably high in textile and fashion industry. This has a considerable influence in determining the choice of the disposition alternative of used clothes, in particular Paras and Curteza (2019) found that the cost factors such as distribution and processing costs associated with reverse logistics have moderate influence, though not as much as the material-related aspects, like quality, etc.

The consumers' role is also crucial in the circular supply chain, particularly in the swapping supply chains presented by Henninger *et al.* (2019), where they act as suppliers thus blurring the difference between supply and demand sides. Such fluidity in the consumers' role as customers, sellers, partners and suppliers is also highlighted by Machado

et al. (2019), as the enabler of higher social relationships in the supply chain, e.g. with other customers, business owners, etc. As the product circulates through different consumption cycles, different transactions, monetary to non-monetary are constituted.

4.2 Multiplicity of circular business models and their underlying “integrators” in establishing cascaded loops

Another emerging theme regards to the presentation of circular supply chains as cascading loops of repair, reuse, refurbish and recycle, for circulating materials not only within the same supply chain, but also to unravel the possibility to create and capture value across different supply chains (De Angelis *et al.*, 2018; EMF and McKinsey & Company, 2012). In such cascaded loops, while it is important to concretely implement the processes that aim transition towards circular economy and bring along business model innovation and the related organizational change, the real potential may lie in the combination of business models throughout the product lifecycle.

Each loop – within the larger cascade – requires a well-functioning singular CBM; Kant Hvass and Pedersen (2019) conclude using the take-back case that such a singular CBM requires: a transformational value proposition, rethinking customer’s role and engagement, and building new partnerships with external stakeholders. Pedersen *et al.* (2019) on the other hand raise the issue on how different CBMs need to interact with each other in order to enable a truly integrated cascade of circular supply chains. Each loop in the cascade forms a system of product flow across different actors/stakeholders, associated technologies and processes. These loops are further constituted by one or many consumption cycles, with its own characteristics in terms of product quality, supply-demand uncertainty, user interaction, ownership and transaction, constitute a “systemic” loop within the larger circular use phase. But how to operationalize such a cascade of circular supply chains in reality? By exploring the SI papers we identify three such “integrators” that operate across single supply chains and business models.

4.2.1 Product design, designers and process technology. Resonating the “power of product design” in ensuring high durability, longevity or recyclability (Earley and Goldsworthy, 2015), we found designing to enhance circularity is an important integrator, and is enabled by use of mono materials, easy disassembling techniques, etc. (Sandvik and Stubbs, 2019). This necessitates the need to think about the product’s “fashion”, style, materials and more so that the fashion product is “build to last” as long as the material it was made from (Pedersen *et al.*, 2019). However, the paradox lies in the fact that the introduction of new materials can be an inhibitor too, because it may not be suited to the current recycling processes. In such scenario, different digital tools and technologies both, at the process level such as sorting and recycling technologies, and at the supply chain level such as RFID, digital passports, Content Thread (used in EU project “Trash-2-Cash”) are needed for facilitating the cascaded flow of materials in the system.

Using the “Service Shirt” example, Pedersen *et al.* (2019) emphasize that designers have a central role to play when designing products for multiple, complementary business models, such as reuse, remanufacturing, renting, recycling and uses as opposed to a singular function and use. However, designers do not have responsibility for the products as a whole and are only a small part of the decision process in product development, thus the physical and mental gap between designers and production creates a barrier for designing for recyclability (Sandvik and Stubbs, 2019). Working at the local or regional scale, as exemplified by the case of Fashion Alpha ReFashioned in Pedersen *et al.* (2019) opens up the possibility to create more design-production integration with a circular mind-set, and more importantly explore new cross-functional roles of designers by fusing creativity with production process knowhow.

4.2.2 Inter-organizational collaboration. In line with the existing literature, the need for alignment of CBMs and collaboration throughout the lifecycle across multiple cascading loops is emphasized in the SI papers. Pedersen *et al.* (2019) urgently call for collaboration across professions, departments and organizations, thus ultimately requiring a shift in the predominant, firm-centric view and the myopic focus on short-term economic value to holistic, long-term value creation, delivery and capture that is aligned, agreed and coordinated throughout the entire product lifecycle (e.g. 50-, 100-, 200-year lifespan) between all (internal and external) stakeholders in the loops, e.g. fablabs, artisans and recyclers. This highlights the ability to co-create CBMs through the combination of different business models.

The other studies take a delimited view towards exploring collaboration along single circular supply chain; for instance, Sandvik and Stubbs (2019) concentrate on the larger loop of the circular system, i.e. textile-to-textile recycling to highlight the importance of industry-wide collaboration. Such collaborations have been noticed at different stages of the textile-to-textile recycling supply chain with the purpose of improving collection amount (with consumers and charities) or for developing recycling technology (with recyclers and researchers) or for leading a systemic change (between designers and recyclers, between large companies and SMEs, and among large companies). Kant Hvass and Pedersen (2019) explore the in-store take-back initiative to reason that one of the main hindrances to cross-organizational commitment and successful implementation of a circular initiative is difference in understanding and evaluation of circular value proposition by different engaged internal and external stakeholders. In order to ensure cascading flow of material in multiple loops of product lifecycle, solving organizational complexities through higher levels of collaboration in each loop is crucial.

4.2.3 Consumers in multiple roles. In various cascading loops of circular supply chain, particularly in those led by collaborative consumption practices (Belk, 2014), the consumers often play active roles as customers, sellers, partners and suppliers of used clothes, thus acting as a crucial integrator. Henninger *et al.* (2019) depict such integrating role, in the cascading loops of multiple use lives of the clothes in swapping supply chains, where the consumers take a fluid market role as they act as buyers when making a purchase, and consequently switch role when being involved in depositing the used clothes. The fluid role of the consumer in swapping supply chains highlights the peer-to-peer relationship. Such fluid consumers' role also initiates the multiple consumption cycles through which the product goes through, thus constituting several peer-to-peer cascading loops of swapping. The study indicates that the quality and type of clothes brought to these swap-shops depends on the individual swappers and their attitudes towards these swaps, which can be influenced by the way facilitators, i.e. swap-shop organizers, communicate about swappable items and the areas that these swaps are held.

Machado *et al.* (2019) similarly demonstrate such integrating role of the consumer beyond collaborative consumption that spans over peer-to-peer exchange of used clothes between family members and friends followed by buying of used clothes. This constitutes a virtuous circle of motivations involving the consumer in an active role, first driven by nostalgia of childhood memories of family exchanges of clothes. In the adulthood, this is further sparked by financial reasons, and the realization that buying used clothes is a way to get quality products that last longer. In this virtuous circle, the consumers engage as active buyers of slow fashion, and develop social relationship with other actors, such as owners of thrift stores, and other customers. Such social relationships extend into the friend and family circle, when the consumer shows the items they purchased at these stores, and even exchange other clothes they no longer need, thus promoting collaborative consumption and second-hand purchases.

5. Conclusion

The SI results evidenced in circular fashion supply chain context calls for generating a system-wide solution. As also noted by De Angelis *et al.* (2018), the real potential of circular supply chains is realized through the integration of multiple cascading loops for circulating materials across different supply chains. First, it is important to create understanding of the main impediments that currently hinder the establishment, implementation and mainstreaming of CBMs, and what solutions to seek. Typically, these solutions are centred on building robust products in terms of content, design and quality that are suited to multiple consumption cycles and across different cascaded use, and/or organizing a well-functioning supply chain enabled by multiple, complementary stakeholders that collaborate and exchange mutually to scale-up possibilities and improve economic viability. Multiplicity is a key requirement in order to enable cascaded loops of repair, reuse, refurbish and recycle for circulating materials, and create and capture value across different supply chains. Three key “integrators” that encourage the operationalization of such cascade of circular supply chains into an ecosystem are design and technology, collaboration and consumers.

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