

Circular economy and supply chain collaboration: a review on the fashion and textile industry

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Abstract: The fashion and textile industry ranks among the top five most polluting industries in terms of emissions and natural resource usage, including water and land. Recent trends in the industry have led to a surge in overproduction and overconsumption, resulting in millions of tons of textile waste generated each year in Europe, of which only 1% is recycled. Consequently, there is a pressing need to transition from the linear “take-make-waste” system to the circular economy (CE) paradigm, aiming to close the loop and promote the circulation of products and materials. Within the Circular Supply Chain Management (CSCM) research field, literature has explored the drivers, barriers, and enablers of the CE transition in various contexts. However, there is still limited research on successful SC collaboration for the CE transition, particularly in the fashion and textile industry. Therefore, this paper aims to investigate the collaboration features, such as information sharing, goal congruence, decision synchronization, incentive alignment, resources sharing, collaborative communication, and joint knowledge creation, within existing CE implementations in the fashion and textile industry through a systematic literature review. The contributions analyzed were differentiated based on the actors involved in the collaboration for circularity, including traditional players and new actors such as collectors and start-ups, as well as the type of circular strategy implemented (reduce, reuse, recycle). The results suggest a scarcity of reported cases of CE transitions and highlight the importance of trust and a shared vision among SC actors in facilitating the CE transition. Notably, SC collaboration patterns were identified and discussed based on the circular strategy, reflecting a positive influence of sharing risks, costs, and resources, while the significance of sharing information requires further research. Based on these findings, directions for future research are discussed.

Keywords: Circular economy, supply chain, collaboration, fashion and textile, literature review

I. INTRODUCTION

With about 180 billion of clothes produced globally in a year [1], textile and fashion industry are among the most polluting industries. [2] calculated that 654 kg CO₂ equivalent per person are produced in a year within the sector. The sector is also plagued by inefficiencies and the production of waste: around 30% of production it is estimated not to reach the final customer [1]. Moreover, the linear model “take-make-use-dispose” is dominant in the industry, given that out of 5.8 million tonnes of textile discarded every year in EU only 1% is recycled into new clothing [2]–[4].

The adoption of business and supply chain practices oriented towards the circular economy (CE) paradigm can support the reduction of the environmental impact of the industry. CE means “building restorative and regenerative systems aiming at extracting new value from waste” [5]. Public institutions and governments are discussing norms and standards to accelerate the transition in textile and fashion SCs, forcing practitioners to take

action, e.g. the definition of the digital product passport and the application of extended producer responsibility rule also in the sector [6], [7]. While different CE strategies are possible [8], the most commonly used ones are *reduce, reuse, recycle* in the fashion industry.

The transition towards CE requires, among the others, a radical change in how the supply chains (SCs) are designed and managed [9]. In fact, the collection and treatment of waste should be managed by new actors performing new activities [10], while new relationships among the supply chain players have to be established [11]. The research field addressing the shift from linear SCs to circular ones is called Circular SC Management (CSCM) [12].

Literature on CSCM in fashion and textile has developed chiefly around the main drivers and barriers to circular SCs development [13]–[15]. Among the others, collaboration among the SC actors has been identified as a main driver for to the development of circular SCs [16]. Recent studies in

the fashion and textile industry investigate how companies are building collaborative relationships for CE implementation [17]–[19]. However, the knowledge on how to implement successful SC collaboration in textile and fashion industries when different CE strategies are at stake, is still scattered.

Starting from [20] that not only suggest the need of further researches on how to implement and prioritize collaboration practices, but also highlight that the type of CE strategy is contingent upon the type of collaboration practices used, this paper aims at investigating the collaboration features of existing CE implementations in the fashion and textile industry, through a systematic literature review. The main research question (RQ) we want to address is: *How do companies in the textile and fashion supply chains collaborate when implementing different CE strategies?*

II. RESEARCH BACKGROUND

A. CE concept in fashion and textile

Research states that the fashion and textile industry exerts great environmental impact through product lifecycle [13]. CE practices such as recycling and prevention in the manufacturing sector stimulates not only economic activities but also consumer awareness through eco-product development, remanufacturing, and refurbishment [21]–[23]. Indeed, and both businesses and consumers are the key enablers in the circular transition [8] of the sector.

Delightfully, substantial effort has been observed in the fashion and textile industry to drive CE transition. For instance, extant research has proposed mechanism and practices towards CE through conscious product development practices [24], [25] and investigated barriers and indicators for CE [13], [14].

A widely diffused conceptualization of the CE transition relates to the classification of circular strategies into the R-frameworks), e.g. reduce, reuse, recycle, and recover [26]. Among them, Kirchherr and colleagues considered the 4-R framework as the minimum viable coding system of existing CE practices [26], [27]. Relating to the context of fashion and textile, *reduce* stands for the rethinking and redesigning of the product and processes to reduce or prevent the use of resources; *reuse* refers to the action of closing-the-loop by repairing and cycling the end use; *recycle* relates to the discussion of remanufacturing and cycling the waste; while *recover* is linked to the incineration of

materials and waste to recover energy [20], [26], [28].

B. Collaboration for CE in fashion and textile

SC collaboration happens when two or more independent companies in a supply chain establish relationships to jointly plan and execute supply chain operations for a common objective, thus gaining better results than when acting independently [29]. [30] conceptualize SC collaboration in seven dimensions shown in table 1. This framework has been successfully applied to cases of CE in fashion industry [17].

Fashion supply chains have been characterized by collaborative relationships between the brand owning companies and the suppliers, both on product design and operations [31]. The aim of the collaboration was meant for improving operational performance as well as, in response to social and environmental concerns, for increasing transparency [32].

TABLE 1 - SC COLLABORATION FRAMEWORK [30]

SC Collaboration feature	Definition
Information sharing	The extent to which a firm shares a variety of relevant, accurate, complete and confidential ideas, plans, and procedures with its supply chain partners in a timely manner
Goal congruence	The extent to which supply chain partners perceive their own objectives are satisfied by accomplishing the supply chain objectives
Decision synchronization	The process where supply chain partners orchestrate decisions in supply chain planning and operations that optimise supply chain benefits
Incentive alignment	The process of sharing costs, risks, and benefits among supply chain partners
Resources sharing	The process of leveraging capabilities and assets and investing in capabilities and assets with supply chain partners
Collaborative communication	The contact and message transmission process among supply chain partners in terms of frequency, direction, mode, and influence strategy
Joint knowledge creation	The extent to which supply chain partners develop a better understanding of and response to the market and competitive environment by working together

III. RESEARCH METHODOLOGY

A systematic literature review (SLR) is a method for identifying, evaluating, and interpreting every piece of research that is pertinent to a certain research question, topic, or phenomenon of interest, in a rigorous replicable manner [33]. The aim of SLR is to provide collective insights through theoretical

synthesis, gaps identification, frameworks for positioning new research [34]. This study focuses on synthesizing together literature on collaboration for circular economy in the textile and fashion industry, answering the aforementioned research question. In this section, the approach adopted for the article search and selection will be presented, describing steps 2,3 and 4 [35] in detail.

The research studies were searched using Scopus, one of the most recurrent and valid databases for academic papers. From the four research fields at interest of this study – circular economy, supply chain management, fashion and textile, collaboration – keywords were selected and consequently connected with “OR” operator. Different fields were connected with “AND” operator, looking at the intersection of all the fields. The full search string is enclosed in Annex 1. The string was run in Scopus in April 2023. The main steps of the search phase are presented in Figure 1. The initial pool of papers was limited to English, subject area (Engineering, Business, Management and Accounting, Social sciences, Decision sciences) and document type (Article, Review, Conference Paper, Conference Review).

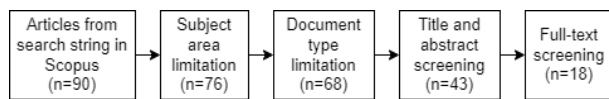


Figure 1 - Screening process with resulting number of articles

The screening phase was performed firstly on titles and abstracts. The exclusion criteria for title and abstracts were mainly three: industry out of scope (e.g. electronics, food, packaging), subjects out of scope (e.g. global platforms, microfiber pollution), and marketing-oriented studies (e.g. pricing, competition, consumer perspective). The resulted 43 contributions from this phase were then screened in full text. The studies selected at the end of the last screening phase satisfy the inclusion criteria of having investigated at least one of the collaboration features proposed by Cao and colleagues [30], while studies merely proposing collaboration without further extension on the subject were excluded (e.g. “collaboration should extend beyond retailers”, “information sharing and dissemination is crucial”).

IV. RESULTS

This section provides the main results of the literature review, explaining the seven SC collaboration features [30] in the fashion and textile industry. Papers were classified by: *i*) the SC actor involved in the collaboration, and *ii*) the R strategies

pursued by the collaborative initiative based on the classification proposed by [26].

Table 2 summarizes the main findings, reporting the references of the SLR. Note that, studies dealing with multiple R strategies are reported in the multiple corresponding columns (e.g. reuse and recycle). *Generic* in both row and column include studies without particular focus on one of the category, or with no specific information available.

Table 2 - SC collaboration for CE

R-Strategy	CE through new operations in traditional SC actors	CE through integrating new SC actors	Generic
<i>Reduce</i>	[18], [19], [36], [37]		[24]
<i>Reuse</i>		[38]–[44]	
<i>Recycle</i>	[18], [19], [37], [45], [46]	[38]–[40]	
<i>Generic</i>	[47]	[17]	[13], [14]
Total	10	11	3

Our analysis identified multiple actors in the circular fashion and textile SC that were already active in the traditional linear SC. Textile and fashion SC encompasses fibre manufacturing, spinning, weaving, dyeing, finishing, printing, cutting, sewing, distribution and retailing. Thus, the traditional SC actors integrating these processes are: yarn supplier, fabric supplier, garment manufacturer and brand owner and retailer [37]. Meanwhile, the introduction of CE may eventually involve new operations to these existing actors, such as collection and sorting of garments and reuse or recycle have to be performed. For instance, recycling can be integrated by suppliers [18], [19], [45], or by new actors [38], [40]. Besides recyclers, there are also new actors to be involved in the circular fashion and textile SC, including “raw material providers, research and development companies, public and private incinerators and remanufacturing companies”, but also NGOs for enhancing information and knowledge on sustainability [46]. For Mishra and colleagues, integrating these new actors, contributes to the creation of eco-industrial parks. Besides, [48] suggests fashion traditional SC actors to collaborate with start-ups to incubate more radical innovations for CE. Our results show a balanced involvement of traditional and new SC actors in collaborations for CE. In particular, among the traditional actors retailers, garment manufacturers and yarn/fabric suppliers were investigated, while new actors

involved were charities, collectors and sorters, municipalities, start-ups and academia (Table 2).

For what concerns the R strategies, *reduce* and *recycle* are dominant strategies for CE through new operations in traditional SC actors, while *reuse* dominates CE through integrating new SC actors. In particular, no contributions were found tackling *reduce* strategy involving new SC actors, and neither tackling *reuse* strategy collaborating with traditional SC actors. In the case of *reduce*, SC collaboration was spotted between suppliers and designers, thus traditional SC actors. The collaboration feature mainly addressed is *resources sharing*, meaning the share of knowledge, capabilities and expertise on new product development [24]. In particular, the co-design for circular products, using new natural-based materials and less resources emerged, involving key suppliers [36], [37] and design institutions [18], [19].

Collaborations for *reuse* encompasses the collection, sorting and redistribution of post-consumption garments, as well as repairing solutions. Studies focusing on this R strategy suggest only collaborations with new actors (e.g. charities, NGOs, private collector and sorters, municipalities), indicating that the SC tend to involve new actors, rather than integrating new operations inside traditional actors. The collaboration feature most investigated in this context is *resources sharing*. The recurrent pattern emerging is to share the resources for performing collection, through physical shops, on-street banks and home collection, to increase volumes, while the sorting activity is performed by the charity [38], [42], [44]. In the case of an online retailer, the collection is performed by a logistics provider, the sorting by a charity and the second-hand garments are sold through the online retailer’s e-commerce [42]. Charities can also collaborate with technology providers, offering platforms for the identification of retailer’s waste, to access also pre-consumption waste [43]. A collaboration among new SC actors was also identified: charity and municipality are sharing their capabilities and resources for the collection and sorting of post-consumer textile waste [42]. Another collaboration feature emerging is *incentive alignment*, an important step to define how to share costs, risks and benefits among partners. Results show two main choices from the literature’s evidence: equity sharing and traditional contracts. An established brand and retailer has

opted to collaborate with CE-oriented new ventures through equity sharing partnerships [38]. This last strategy has proven to be successful in the past for an online marketplace for second-hand sales, which the retailer explored, assessed the impacts and then scaled. Instead, traditional contracts emerged when retailers collect post-consumer waste at their shops and, based on the volumes reached, are paid by a collector/sorter who sustains all the logistics costs and sells the garments in the second-hand market [40]. Within the *reuse* context, collaborations for *joint knowledge creation* and data collection were performed in the form of pilot projects involving charities and municipalities [42].

When *Recycle* strategy is at stake, SC collaboration occurs, almost evenly distributed, between traditional SC actors and involving new SC actors. When traditional SC actors collaborate together to implement recycling activities, three main collaboration features emerged to be relevant in literature: *information sharing*, *resources sharing* and *incentive alignment*. [45] presents the central role of sharing information between a garment manufacturer and a supplier, which integrates the recycling activity. In particular, data related to the recycling process as well as to the materials and product characteristics of the textiles to be recycled, appear to be fundamental to both actors and to the success of the collaboration. From another case, relevant data exchanged is related to production (orders, capacity levels), sustainability and accounting between first tier and second tier suppliers [19]. From this last contribution emerges also the role of digital platforms enabling the data to flow among different suppliers and increase transparency. Regarding *incentive alignment*, among traditional upstream actors in the Prato district, incentive mechanisms are chosen to favor operational integration and strengthen trust and shared vision [18], [19]. Instead, a traditional garment manufacturer and its key supplier created a joint venture for recycling: a new legal entity that shares revenues, costs and investments in an equitable manner [45]. From this last case, from the point of view of *resources sharing*, the supplier shares plants and technical knowledge on recycling, while the manufacturer shares its management and organizational knowledge in the form of patents, licensing. Within the Prato districts, beyond knowledge and capabilities, financial resources are

shared to update suppliers’ equipment [18], [19]. This last case was the only contribution investigating the *decision synchronization*. In particular, yarn and fabric suppliers coordinate with second tier suppliers production planning decisions, fostering a levelled production plan and constant cash flows, with benefits at the SC level [19]. In the case in which recycling practices are tackled with collaborations with new SC actors, *joint knowledge creation* emerged as the most recurrent in literature. Also in this case, projects for developing new technologies are set up between retailers, academia and recyclers and pilots for testing them and acquire knowledge.

In the analyzed literature *recover* strategy was not emerging, while *reduce*, *reuse* and *recycle* were more investigated. This is in line with the Waste Hierarchy that encourages waste management strategies for the most efficient use of resources, reduction of waste generation, and minimization of environmental impacts. According to the framework, the circular strategies of waste prevention (i.e. *reduce*), *reuse*, and *recycling* are preferred over disposal [49].

Overall, our analysis highlights that, *goal congruence* is the most cited SC collaboration feature, in the sense of having a shared value between actors involved in the collaboration. This alignment of vision is important for collaborations in the whole SC, independently of the actors involved, either a traditional or new actor, upstream or downstream, and independently of the R strategy pursued. Moreover, *collaborative communication* was not emphasized in literature. It emerged from [38] that retailer was communicating with partners through continuous audits and reporting requirements in order to better control the performances of collaborations, while [17] reported that frequent visits to plants and offices are relevant for the collaboration success.

V. DISCUSSION AND CONCLUSION

SC collaboration contributes to the critical success factors for CE implementation, i.e. *shared vision* and *trust* [47], in fashion and textile industry. A shared vision among the SC actors is the long-term result of successful collaboration. Our study highlights that *information sharing and communication* is the fundamental component towards a shared vision in the fashion and textile industry CE transition. Moreover, the various forms

of *information sharing*, *incentive alignment* (e.g. equity sharing, JV, incentive mechanisms) and *resource sharing* (e.g. divided operations, joint product development) lead to higher trust among the SC actors during CE implementation [39].

Besides, our results show that effectively combination of SC collaboration patterns facilitates CE implementation in the fashion and textile industry, especially in the context in which traditional SC actors collaborate for recycling. For instance, *decision synchronization*, together with active *information sharing*, provides the basis for SC operations optimization [19]. Meanwhile, in line with existing literature [20], we find the joint result of *incentive alignment*, *resource sharing* and *information sharing* sets the foundation in the negotiation for long-term collaborations and partnership development in CE implementation in the fashion sector. Indeed, in circular fashion SC collaboration, we observe a high level of cooccurrence between *information sharing* and data access, *resource sharing* based on assets and capabilities of the actors, and the *sharing of costs, risks and benefits* [18], [19], [45]. The same cannot be said for collaboration tackling the *reuse* strategy, since cooccurrence is observed between *resource sharing* and *incentive alignment*, while no sufficient observations were found to support the relevance of *information sharing*. Indeed, *reuse* strategy was implemented collaboratively with new SC actors, thus the lack of data sharing between partners is reflecting the barrier of integrating new actors in the textile and fashion SC [13].

This study extends existing contributions [17] by integrating the R strategy to the SC collaboration features, differentiating between traditional and new actors involved. Our paper supports extant studies underlining the critical roles of SC actors in the collaboration scheme for CE implementation [20], in the fashion and textile industry. Results show that the literature on SC collaboration has primarily focused on *reuse* and *recycle*. This emphasis is due to the fact that *reduce*, with its main focus on implementing internal circular practices, typically pertains to a company's perspective. On the other hand, *reuse* and *recycling* predominantly adopt a supply chain perspective, necessitating collaborative efforts among multiple SC actors. As a result, these practices lean heavily on inter-organizational collaboration. As the success of collaboration for CE implementation is determined by the SC position of the innovator [37], it is observed that the most active actors involved in collaborations for circularity are the brand/retailers

and suppliers, either involving each other or new actors, such as charities or municipalities. Meanwhile, we provide evidence demonstrating that the success of CE implementation depends on several contingencies (e.g. SC position, focal R-strategy) [20]. For instance, initiatives emerged from the middle-tier actors (i.e. suppliers of dyeing, spinning, buttons assembly processes) often end without success [37]. Meanwhile, our results also indicate that the involvement of external actors (e.g. charities, municipalities and recyclers) are necessary to promote CE implementation in the industry.

To this end, our discussion gives rise to several promising research directions to be considered by future studies. Firstly, as CE implementation in the fashion and textile industry depends on internal and external contingencies [35], we expect that the easiness to achieve these collaboration pattern and their promised benefit would be significantly different. Hence, future research could address the contingent variables affecting the R strategy to implement, supporting practitioners in the decision-making. Moreover, future studies can take stalk of this paper to better explicate the contingent variables and seek to rank the importance of collaboration patterns in facilitating successful collaboration. Second, while our paper sheds light on the role of SC actors and beyond in CE implementation in fashion, further investigation is needed on how internal (i.e. supply chain actors) and external actors (e.g. consortium, charity, municipality) can effectively act in the diffusion of circular strategy and practices. Third, we remark the necessity to conduct further scrutiny on the components of SC collaboration under the context of advancement in data collection and processing technologies, including, but not limited to big data, blockchain and IoT [50]–[52]. Indeed, some collaboration patterns, e.g. *information sharing*, would be significantly facilitated by the technology advancement [53], that consequently affect the overall scheme of collaboration.

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VII. REFERENCE

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Annex 1 - Search string

(TITLE-ABS-KEY("circular economy" OR circular* OR "closed loop" OR "open loop" OR reus* OR recycl* OR remanufactur*)AND TITLE-ABS-KEY("supply chain" OR "value chain" OR "supply network") AND TITLE-ABS-KEY(fashion OR textile OR apparel OR clothing OR garment) AND TITLE-ABS-KEY(collaborati* OR orchestrat* OR relationship OR partnership))