Sustainable value creation through new industrial supply chains in apparel and fashion

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Abstract This paper explores the inter-organizational value creation, in apparel supply chain context, through circularity and digitalization for sustainability, by gathering evidences from vivid research experiences. It can be highlighted that inter-organizational value creation in both circular- and digital- apparel supply chains largely builds upon a variety of collaborative initiatives, and among a range of included members. Knowledge co-evolvement and business co-development, end-to-end integration and information transfer, and open networks are crucial to such collaborations – making development of new supply chain structures a meta-capability of apparel firms in the changing industrial landscape.

1. Introduction

Apparel and fashion industries are increasingly striving for a systemic change towards being more sustainable in near future. This is driven by a transition from being cost and labor intensive in a linear economic context towards a digitally-driven one in an emerging circular economy. In light of this transition towards sustainability, various new technologies and business models have already started disrupting the apparel and fashion industries, in order to join the bandwagon of the macro industrial trends of digitalization and circularity [1, 2]. Various technological advances, e.g. from virtualization of customer interfaces to 3D printing for apparel manufacturing have started to digitalize the apparel value chains, and have been complemented by new business models, like open manufacturing, co-creation etc. The trend towards circularity equally has led to advances in new technologies, e.g. for tracing and tracking to recycling, which is increasingly appropriated by companies through advent of new business models aimed at slowing, closing or narrowing the value chains (or loops) in terms of material and energy flows [3]. However, new digitalization- and circularity- enabling technologies and business models even though have captured the attention among both practitioners as well as academics in terms of how they manifest sustainable value creation, the focus has been mostly at the technological process- or intra-organizational- levels. Such value creation requires a wider attention as it is generated along a complex industrial chain (or loop) as in the case of apparel and fashion, and thus spans over multiple processes and organizational boundaries. Thus an inter-organizational focus on value creation is essential, but has not been discussed explicitly so far, despite the obvious importance and rationale behind it. Given this, the goal of the paper is, therefore, to explore inter-organizational value creation, in a supply chain context, through circularity and digitalization for sustainability in apparel and fashion. In the paper, we reason that inter-organizational focus essentially leads to new industrial structures required to create sustainable value for multiple stakeholders. In order to exemplify these ‘new’ industrial structures, an evidence-based analysis is conducted in supply chain context [4]. Evidences gathered from extensive research experiences, are obtained from the apparel and fashion industries and from some successful ongoing initiatives to exemplify the key underpinnings. It is to be noted that in this viewpoint paper, neither the literature review nor the empirical evidences of the cases should be considered to be strictly exhaustive or always best practice. But the empirics merely serve as a lens for putting forward authors’ personal view of the evolution of apparel and fashion supply chains in a changing landscape. This implies by no means a value judgement about the superiority or emergence of one worldview over another. It does, however, allow, for a focused exposition of an opinion, i.e. a forum piece.
2. **On the sustainable value creation concept**

Value creation in the supply chain context generally refers to the economic implications of any process or activity performed to create a product/service that a customer is willing to pay. However, the notion of value has emerged to be much wider than just economic implications, and can include environmental, social and other value types created for diverse stakeholders, such as environment, and society at large [5]. Sustainable value creation, in this context, refers to the approach that creates long-term value for stakeholder(s) by generating all types of values associated with economic, environmental and social developments, without compromising with one at the cost of the other. Keeping in mind the multi-stakeholder perspective of different value types, these multiple benefits can be generated internally in a focal firm, but also externally, i.e. jointly with other engaged actors by bringing in complementary resources, skill sets and knowhow. The benefits of such jointly created value spills over the boundaries of the firms and are generally greater than the individual share for each involved actor. Within the scope of this paper, however, we do not focus on differentiating between the diverse value types (e.g. economic, environmental, image) as prescribed in Schenkel et al. [6], but explore inter-organizationally created value for overall industrial sustainability at an aggregate level.

3. ‘New’ industrial supply chain structures in apparel and fashion

3.1. **Circular supply chain**

In contrast to today’s linear ‘take, make, waste’ industrial economic model, the concept of creating ‘value from waste’ is underpinned by the idea of restoration rather than disposability, by designing and optimizing products and materials flow for multiple cycles of disassembly and reuse [7]. This further corroborates the idea of “slowing the resource loop” through design of long-life products, multiple-life of products and product-life extension [3]. Several examples of circular supply chains and associated product recovery based business models underpin the central notion of circularity; these are: cradle-to-cradle, reuse, recycle, remanufacture, sharing and collaborative consumption, etc. The concept of circular supply chain thus is underpinned by five major underlying models [8]: (i) circular supplies – that provides fully renewable, recyclable or biodegradable resource inputs that underpin circular production and consumption systems, (ii) resource recovery – that enables a company to eliminate material leakage and maximize the economic value of product return flows, (iii) product life extension – that allows companies to extend the lifecycle of products and assets through recovery options, such as repair, upgrade, remanufacture, (iv) sharing platform (peer-to-peer) – that promotes a platform for collaboration among product users, either individuals or organizations, and (v) product as a service – that provides an alternative to the traditional model of “buy and own” through leasing or pay-for-use arrangement. Circular apparel supply chains – being a multi-actor network (consisting of profit-makers, e.g. fashion retailers, commercial recyclers, traders and sorters; public institutions, e.g. municipalities, universities; non-profit organizations, e.g. charities, research institutes) – are however highly fragmented and are fraught with a wide range of challenges related to lack of well-functioning reverse logistics, conflict of stakeholder interest, ownership confusion, and lack of formal legislation and regulation such as extended producer responsibility [9] – that hinders joint value creation.

3.2. **Digital supply chain**

Digitalization and information technology (IT) innovation underpins the biggest opportunity for many industrial supply chains. Coined in Hines (2007) [10], digital supply chains are where goods or services that had previously been supplied in physical form (in analogue supply chains) are digitized as information replaces inventory to remove time, distance and cost in order to improve supply chain performance. Specific to apparel and fashion supply chains, this is increasingly driven by the emergence of customer-focused products and processes, wherein demand is elicited through specifications from customers to initiate the design and production of customized products using systems and tools to support customer involvement [11]. Such customer-driven supply chains are influenced by digitalization of the customer-retailer interface, and is enabled by virtual collaborative
design, purchase decision support, online distribution channels, along with knowledge of customers’ preferences [11]. In relation several virtual reality and/or fitting technologies such as 3D scanning, web-based collaborative design tools and product visualization tools have gained prominence in the recent years [12], while for sales and distribution online sales is quickly replacing traditional formats. Role of digital tools, IT and advanced manufacturing technologies (AMTs) have equally been emphasized in the production side of the digital supply chains for ensuring flexibility, responsiveness and innovativeness [13, 14]. Mechanization of manufacturing processes and supply chains through flexible manufacturing systems based on AMTs such as computer-aided design (CAD), robotics, and computer integrated manufacturing (CIM) etc. supported by complementary business practices can have a significant impact on supply chain performance [13]. However, often the integration and information flow suffers due to increase in product variety (due to high demands on customization, agility, short-series manufacturing, etc.) or lack of integrated knowledge-base and digital technology platforms. This results in inaccuracy in such digital supply chains which in turn increases the production and product costs. Critical in such context, is complete digital integration (end-to-end) through integrated product design structure and production routings [15, 16]. Such end-to-end information transfer largely depends upon the existence of a computerized manufacturing environment and determines the success of a digital supply chains for customized products [16], by enhancing various aspects such as traceability, transparency, trust and security.

4. Evidences on inter-organizational value creation through circular supply chains

Management of used clothes flow in most western economies is recognized as a multi-actor system, however most participating actors tend to play a significant role in handling and treating them single-handedly. However, a clear benefit can be spotted through joint efforts and increased collaboration for achieving higher value-added product recovery, and also leading to new industrial supply chains and business models. Such collaboration has been emerging at various product recovery stages and across options, e.g. for collection and take-back of used clothes, for managing textile wastes, or for subsequent value-added recovery. Many branded fashion retailers, like H&M, Marks & Spencer, have started collaborating with global sorting groups like SOEX and Boer to initiate in-store collection of used clothes, via a system called take-back scheme. Under the scheme, the retailers are predominantly involved in organizing the collection through their stores, which is then handed over to the collaborating for-profit broker/sorter who takes the used clothes through the next reverse logistics and product recovery stages beyond collection, such as sorting, shredding, recycling, even reselling.

Collaborative agreement in such take-back schemes is based upon contract such that the retailers earn revenue from the sales of the used clothes to the broker/sorter, paid per kilo of collected volume, and in turn all collection-related costs are borne by them. These globally operating firms have also ventured out for collaborating with charities and non-profit organizations – a relation based upon improving price point for the charities while access to higher volume for the global operators (e.g. between Human Bridge a Swedish charity run organization and Boer Group, or between Myrorna – a Swedish second-hand retailer and Freitex International – both subsidiary of Salvation Army). In the textile waste management (TWM) system, a common form of collaboration is between academic and research actors with the industry members (retailers, charities, sorting firms, etc.) and governmental institutions (e.g. municipalities). Such collaboration aim at developing new technologies and business innovations, for instance, in areas were commercially viable options are yet not available or are market ready. In fact, to this date there is no commercially viable separation, sorting and recycling technology for materials such as cotton and polyester blends. In order to improve their expertise in this area, and ability to scan and evaluate new research and technologies, H&M has partnered with the Hong Kong Research Institute of Textiles and Apparel (HKRITA) over a four year project. While the new technology and innovation can affect the components of an existing business model and how they interact, it can also create completely new business opportunities in unchallenged market space, as in the above case exploit new recycled materials in the production chain. Such collaboration can also be seen at the sorting stage, for higher value added and demand-driven product recovery options. Few exemplary cases are Recoveortex – an initiative by Ferre Company in Spain and Wargön Innovation – in the region of West Sweden, for establishing sorting facility aimed at recovering used textiles to
recycled materials for many life-cycles. Potential partners in such initiatives are charities, municipalities and other collecting organizations, research institutes for leading necessary research, demonstration and business development through optimized sorting processes, new technologies and feasible business models. Benefits are immense for miscellaneous industry sectors as end users, with the output as garments, textiles, polymers, composites, non-woven, etc. Some interdisciplinary projects, e.g. Mistra Future Fashion, Trash2Cash, Resyntex have exemplified such collaborative pan-European initiatives to strive for overcoming the design, technological and management challenges posed to achieve textile circularity. Trash2Cash, for instance, is a consortium of partners representing universities and research institutes, commercial companies, e.g. design firms, sorters, etc. aimed at regenerating fibers through chemical recycling of textile waste.

What is common to such initiatives is the inter-organizational collaboration (IoC) for creating circular apparel and fashion systems – though consisting of diverse members with different goals. But for developing and managing circular supplies, flows and associated knowledge, for effective and efficient closing, slowing and/or narrowing of the resource loops, these IoCs are essential to secure material sustainability and enhanced industry-wide extended responsibility.

A key driver of such IoCs is trust. It is an important enabler and requirement of partners’ collaboration, which can be built through open communication and knowledge sharing among partners. This is built upon an advanced and comprehensive understanding of each other’s work and core values. For instance, actors like research institutes and charities act under different formats and strive towards different goals, and this might lead to unanticipated challenges when it comes to setting normative orientations in the IoCs, such as for development of a new technology despite their common interest and support for the idea. Similarly in take-back schemes, the retailers and sorters have slightly different focus towards expected value gains and this requires a trusted cost-neutral arrangement for successful functioning.

Governmental legislation (voluntary or mandatory) is another key driver for encouraging collaborative actions among the actors involved in circular supply chains, either within their own organizational structure (e.g. incorporate circular material supplies as a starting point for new production, adopt more servitization schemes to extend their responsibility and stewardship, the charities and retailers utilized the logistics facilities of the private collectors, while the collectors in order to export their collected textiles utilized the charities’ exporting channels, etc.), as well as motivating them to have collaboration beyond their organizational boundaries by taking financial risks.

5. Evidences on inter-organizational value creation through digital supply chains

Digital supply chains permit the realization of direct connections and interactions between diverse actors, such as fashion designers, textile and apparel producers, brands and retailers, IT developing firms, and other concerned professionals – across both business-to-business (B2B) and business-to-consumer (B2C) interfaces. Even though a large number of digital solutions have emerged in the apparel supply chains, they are still not fully connected and lack an integrated knowledge-base. Recent industry level initiatives, such as Apparel made for you (AM4U) and Reshoring Initiative in the United States, for example, have developed various production technologies to create a local textile and apparel production but the digitalization does not include the business-to-consumer (B2C) digital interface. On the other hand, LEAPFROG has developed 3D garment prototyping processes.

For setting the direction towards a more holistic inter-organizational focus in digital supply chains, two recently concluded pan-European projects, Open Garments and fromRoltoBag, lay the foundation.

At the business-to-business (B2B) side, open manufacturing based upon the open innovation concept, lays foundation for such collaborative supply chain structure where the production of customized individual garments is realized by a flexible network of production units ranging in size from micro enterprises to SMEs. While mass customization and rapid manufacturing for fast and flexible fulfillment of small size orders is crucial and is typically achieved through AMTs and virtualization, the most critical factor is the collaboration between enterprises and customers within the individual product-service innovation process. Such new industrial structure through integrated design,
production and sales of consumer designed and configured garments, involve a range of stakeholders, such as designers, manufacturing firms, and manufacturing service providers, where all actors in the value chain contribute and share knowledge. This new industrialization 4.0 structure based on digitalization is not just use of new technologies but more open digital integration among various players involved in the apparel supply chain for seamless information transfer, supporting new manufacturing and design models based upon open networks of flexible, demand-driven mini-factory lines with the know-how of making customized orders of different brands and deliver to the consumer; the brands would log into a cloud-based service portal perhaps run by an e-commerce service provider who organizes such manufacturing networks, operating on service charge basis.

Consumer-drive is another necessity for such customized digitized apparel and fashion supply chains, as diverse digital technologies such as virtual reality and 3D rendering at the customer-retailer interface, and digital pattern and fitting tools at the product design and development stage, are crucial. This is supported by the development and integration of AMTs and digitally-enabled processes based on utilization of existing technologies and/or new technical innovations in an emerging Industry 4.0 context. Examples could be digital printing, cutting, and garment-making techniques (such as bonding techniques). By achieving higher digital integration among various supply chain actors for seamless information transfer, to support the open and distributed manufacturing network of value chain processes are more transparent, integrated, flexible and agile to handle small-series niche volumes thus matching the Industry 4.0 perspective.

Further such integrated digital supply chains and marketplaces act as resource for the regional apparel industries to establish supply chains networks aiming for more seamless integration and fits well with the strategic directions prescribed under Regional Strategies for Smart Specialization (RIS3) – aimed at creating job regionally leading to regional competitiveness and social sustainability.

The above mentioned initiatives suggest that even though digitalization of supply chains has become a core necessity in apparel and fashion industries, critical to its success in a high-cost setting is end-to-end system integration and information transfer based upon an open and distributed network model. This not only renders higher degree of coordination along the digitally integrated supply chain but is required to gain full transparency among all actors. To support this on one side, B2C communication provides scope for agile reorganization and flexible adaptation of the manufacturing processes, through constant exchange of information required to support small batches and high system complexity. On the other, advanced ICT systems and methods of communication and virtualization can render end-to-end digital integration by connecting the front-end to the back-end manufacturing and delivery used by companies for pricing, design and production planning.

6. Concluding remarks

In context to the systemic transition that the European apparel and fashion industries are going through towards a sustainable future, this paper elaborates on two pivotal antecedents to it – circularity and digitalization. As a means to attain sustainable value through the development of new industrial supply chain structures based on these antecedents, the paper argues that beyond technological process- or intra-organizational- focus on value creation, inter-organizational focus is equally crucial.

By drawing inferences from a limited yet vivid set of evidences, this viewpoint paper explores and resonates upon the key drivers/aspects of inter-organizational value creation in circular- and digital-apparel supply chains. In circular apparel supply chains, predominantly where multiples actor types are involved, clear benefits are observed in terms of higher value addition through joint business development efforts through IoCs in the product recovery processes (e.g. in take-back collection schemes, or in technology-based TWM). Key drivers of such IoCs are viewed to be trust and legislative governance. On the other hand, in digital apparel supply chains, IoCs are identified in the form of more open networks structures (e.g. open manufacturing) for knowledge access and co-evolvement, and end-to-end digital integration for seamless information transfer and transparency. Altogether they lead to a new Industry 4.0 setting for inter-organizational value creation.

In particular, it can be highlighted that inter-organizational value creation in both circular- and digital-apparel supply chains seem to a large extent be built upon collaborative initiatives (a dynamic capability in itself), where firms either open up their activities, or couple with diverse actors (from
both primary value chains and secondary actors such as research organizations, etc.), or induce more seamless integration. Therefore, developing new industrial supply chain structures can be perceived to be a meta-capability of firms in the changing industrial landscape. This opens up scope for conducting deeper studies on supply chain structures utilizing multiple theoretical lenses. By understanding these key areas of inter-organizational focus for value creation in circular- and digital- industrial supply chains, the paper prescribes the first step towards devising decision support framework on how and where to devote effort as a means to create higher degrees of sustainable value in apparel and fashion industries. In addition, the paper has discussed circularity and digitalization as two different strands leading to sustainability in the apparel sector; whereas it is worth investigating through further research, how if they reinforce one another.

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