Article No. 5

CO-CREATING A 'BUSINESS BEHAVIOR DISRUPTION' FOR INSTITUTING CLOSED LOOP PROCESSING AS MAINSTREAM MANUFACTURING TECHNIQUE IN TEXTILE AND CLOTHING BUSINESS

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Abstract: Introduction
Textile and clothing industry has emerged as one of the most polluting industries owing to increased production and extensive use of chemicals. Fast consumption and irresponsible post-consumption disposal are intensifying the environmental impact of this business, with global consumption of fibre materials reaching to 11.4 kg per capita in 2016 (Quantis, 2018). At the current level of post-production solid waste generation and end-of-use, fashion industry's waste is expected to be 148 million tons (60% increase from 2015 to 2030) (Boston Consulting Group, 2017).

Purpose
Closed-loop processing, assessed as a significant impact reduction strategy of the circular economy, is being used to bring innovative solutions for transforming waste into useful resources for the manufacture of new products (Ellen MacArthur Foundation, 2013). However, a gainful manifestation of closed-loop processes in this industry requires disruption in the well-established linear model, through (i) disruption in design thinking, (ii) Technological disruptions and (iii) Business model disruptions.
Fashion and lifestyle brands started making big claims about their sustainable, eco-friendly lines and pro-environment business practices for many years. However, the business behaviour of major actors is predominantly governed by linear and obstinate models. At the retail-front, consumers are being lured with 'chemical-free', 'low impact', 'responsible', 'earth-friendly' buzzwords. However, an inside view of the back-end functioning reveals complex behavioural disorientations of supply-chain actors and operational inconsistencies, complicating the business functioning of mechanically recycled textiles.

Research gap
Sustainability objectives have been conceptualised by industry actors across the world. However, the implementation of such initiatives faces enormous challenges. There is a dearth of research, in general regarding challenges in institutionalising sustainability initiatives in business, and specifically in the business of mechanically recycled textiles. Since textile and clothing constitutes a prominent consumer product category, and 'recycling' has the potential to emerge as a remedy for reducing the environmental impact of fashion, there is a dire need to address issues that hinder the implementation of this initiative.

Objectives

The paper highlights the urgency of closing-the-loop in the industry and unveils certain inevitable limitations of mechanically recycled textile and clothing products (legacy substances in feed-stock and recycling processing) that emerge as buyer acceptance concerns. The paper discusses initiatives of prominent sustainability torch-bearers and the disruptions required in business behaviour of supply-chain actors and operational routines for operationalising the circular economy framework in the business of mechanically recycled textiles and clothing.
The paper provides directions of possible remedial measures for building collaborative interfaces, re-orienting business actors' behaviour and developing operational systems to institutionalise mechanical recycling of textiles as mainstream processing technique.

Research Methodology
An extensive review of the literature including Greenpeace and EU reports, research papers and articles was done. Interviews with representatives from mechanical recycling textile units and textile and clothing brands were conducted to gain insights into limitations related to feed-stock and processes and concerns among the supply-chain actors.

The implication of the study
Findings of the study could be used to sensitise supply-chain actors of limitations in the processing of mechanically recycled textiles and induce supply-chain broad collaboration for addressing the concerns, and to formalise operational routines through orienting actor behaviour for pro-environment business.

Keywords: Textile & Clothing, Disruption, Business behaviour, Sustainability, Mechanical recycling

Introduction

Textile and clothing industry has emerged as one of the most polluting industries owing to increased production and extensive use of chemicals. Fast consumption and irresponsible post-consumption disposal are intensifying the environmental impact of Textile and Clothing business, with global consumption of fibre materials reaching to 11.4 kg per capita in 2016 (Quantis, 2018). At the current level of post-production solid waste generation and end-of-use, fashion industry's waste is expected to be 148 million tons (60% increase from 2015 to 2030, which amounts to 17.5 kg per capita annually across the planet) (Boston Consulting Group, 2017). The Textile and Clothing industry's production impacts on climate change increased by 35% between 2005 and 2016 and are projected to steadily rise in 2020 and 2030 if the usual scenario of a dominant linear model prevails (Quantis, 2018).

The Fashion industry functions on cyclical trends of planned obsolescence. The currently prevalent 'Fast Fashion' model has increased the frequency of the fashion cycle (from two seasons to monthly to weekly) due to the reduced intervals between production and consumption (Moon et al., 2015; Ozdamar Ertekin & Atik, 2015). The modern-day fast-paced fashion industry is characterised by "artificial newness … disposable trends and aesthetic fads…" (Ozdamar Ertekin & Atik, 2015). The massive growth of the fashion industry, in the past few decades, has increased its importance largely, but has also made it a significant polluter and exploiter of both environmental and human resources through chemical toxicity, water pollution, harmful emissions, excessive waste generation, poor working conditions, child labour, low wages etc.

With increased consumption, post-consumer fashion disposal has become a significant concern. Despite innovative pro-earth initiatives such as vintage stores, clothing libraries, rented fashion, and online e-commerce platforms, textile and clothing waste is still ending up in landfills in alarming quantities (the EPA in the US estimates that as of 2014, 64.5% of textiles generated ended up in landfill as opposed to reused or recycled). New styles and fashion affordability encourages a culture of disposal, with an estimated 350,000 tonnes of clothing sent to landfill

each year in the UK alone. Increasing criticality of the landfill problem has made closed-loop manufacturing need of the hour.

Research gap

Sustainability objectives have been conceptualised by industry actors across the world. However, the implementation of such initiatives faces enormous challenges. There is a dearth of research, in general regarding challenges in institutionalising sustainability initiatives in business, and specifically in the business of mechanically recycled textiles. Since textile and clothing constitutes a prominent consumer product category and 'recycling' has the potential to emerge as a remedy for reducing the environmental impact of fashion, there is a dire need to address issues that hinder the implementation of this initiative. Although the textile and apparel industry has stepped forward in directions of the circular economy, yet there are certain bottlenecks related to 'feed-stock' and 'technology' utilised in the mechanical recycling processes that need to be addressed through disrupting the currently prevailing business orientation, business behaviour and business processes.

Objectives

The paper highlights the urgency of closing-the-loop in the industry and unveils certain inevitable limitations of mechanically recycled textile and clothing products (legacy substances in feed-stock and recycling processing) that emerge as buyer acceptance concerns. The paper discusses initiatives being taken in the realm of the circular economy. It discusses in detail the EU proposal in this direction and the nature of disruption expected to be triggered in the present-day linear business models, to facilitate the incorporation of sustainability road-map according to EU proposal. It also proposes a mechanism for a smooth transition towards more conducive business behaviour of supply-chain actors and devising operational routines for institutionalising circular economy framework in the business of mechanically recycled textiles and clothing.

Research Methodology

An extensive review of the literature including Greenpeace and EU reports, research papers and articles was done. Information about the mechanical recycling of textiles was obtained through visits to textile recycling plants in Gujarat region in India. Interviews with representatives from mechanical recycling textile units and textile and clothing brands were conducted to gain insights into limitations related to feed-stock and processes, concerns among the supply-chain actors and their behavioural disorientations, operational challenges due to inconsistencies in acceptance criteria during testing and lack of quality parameters for recycled material.

Closed-loop manufacturing as a Sustainability strategy

Closed-loop processing, assessed as a significant impact reduction strategy of the circular economy, is being used to bring innovative solutions for transforming waste into useful resources for the manufacture of new products. The closed-loop model is an industrial system that is restorative by design and in which materials are kept to circulate infinitely and in high quality (Ellen MacArthur Foundation, 2013). Many authors have come forward or translated this definition into a more specific definition for the circular textiles industry. "A circular textiles industry is based on a system where textiles products, fabrics and fibres are infinitely and effectively cycled through connected loops within and across industries transparently and economically, where producers apply business practices that enable circular use of textile

resources and promote social justice, and consumers have a healthy relationship with textiles, based on sustainable consumer practices" (Mathews, 2015).

'Circular' is the new approach that has created momentum across the whole textile and clothing value chain and is bringing changes in the way products are designed, produced, shipped, bought, used and recycled. Circular business models include products and business processes designed to enable the retention of material quality and value at the end of use to ensure 'endless' cycling of resources through a circular system. In order to ensure fully circular loops, the business model needs to address the inherent recyclability of materials, design of the product, the infrastructure for product take-back and collection and process infrastructure for recovery of materials and product manufacturing. The reuse of clothing has been found to require 10 to 20 times less energy than producing a new one, and decrease environmental impacts overall (Sandin G. et al., 2018). The development of closed-loop business models is growing in the fashion industry is faced with many challenges. Some fashion brands have developed vertically integrated product take-back programs that also include their resale platform. However, there is an urgent need to bridge the gap between closed-loop processes and the traditional mainstream manufacturing systems. Stemming from the fact that textile recycling is perceived to be less feasible, less economical and disordered for apparel and fashion retailers, issues pertaining to reuse, remanufacturing, and end-of-life solutions have received far less attention from big companies until recently, and thus there is a lack of ample examples of classic reverse logistics and closed-loop supply chains in this sector.
A gainful manifestation of closed-loop processes in this industry requires disruption in the well-established linear model, through (i) Disruption in design thinking, (ii) Technological disruptions and (iii) Business model disruptions. Fashion and lifestyle brands started making big claims about their sustainable, eco-friendly lines and pro-environment business practices for many years. However, the business behaviour of major actors is predominantly governed by linear and obstinate models which may pose various systemic inefficiencies that create various feed-stock and processing limitations and concerns down the supply chain. At the retail-front, consumers are being lured with 'chemical-free', 'low impact', 'responsible', 'earth-friendly' buzzwords. Various progressive, pro-earth fashion businesses have initiated significant moves in reducing the environmental impact of their processes. An inside view of the back-end functioning reveals complex behavioural disorientations of supply-chain actors and operational inconsistencies, complicating the business functioning of mechanically recycled textiles.

Mechanical recycling of textiles: The process and the limitations

Mechanical recycling processes start with the procurement of post-consumer textile and clothing articles that are not fit to be sold in second-hand clothing markets, from various sources. These are sorted manually on a conveyor belt either by segregating products according to contents mentioned on the label or simply touching and feeling different fabrics by experienced workers. The process separates woollen, cotton, acrylic and other textiles. A secondary sorting is done on the colour composition of the textiles.

After sorting, the textiles undergo cleaning process for removal of all buttons, zippers, trims and labels. In the next step, fibre is mechanically pulled or recovered from the 'clean' textile pieces through Rag Tearing machines. Depending on the specification and use of the final product, the fibres may be strengthened through blending with post-consumer regenerated polyester. The

fibres are then spun into yarns suitable for knitting or weaving. This yarn is used by textile and clothing manufacturers to make a wide variety of clothing items such as socks, scarves, pullovers, gloves, and also woollen fabrics, bags, canvas, throws blankets, bed covers, curtains etc.

As a sustainability measure, the entire process is kept chemical- and dye-free. Today, mechanical recycling methods are already playing a crucial role in paving the road to circular, offering 'textile to textile' solutions that proximate virgin quality and that are ready for further scaling, however, there are certain constraints and concerns which are inhibiting these closed loop efforts. Many authors argued that the real revolution for making future textiles from existing textiles, thus reducing the need for virgin resource used in production, will be the material recovery technologies which are currently development, but 'technological bottleneck' is not the only reason which is limiting the ability to truly 'go circular', the other bottleneck is 'legacy substances'(Mathews, 2015). In lack of 'legislative framework' and collaboration throughout the supply chain, technological innovation will face another bottleneck: a circular technology in a linear system.

It is important to note that the mechanical recycling of textiles does not come without its inherent, inevitable limitations, majorly related to feed-stock and the processing techniques. Feedstock for recycled textile products comes from different sources and thus cannot be certified for its fibre and chemical composition. At present the mechanical processing of textiles lacks the availability of sophisticated solutions that could aid more accurate sorting; even if some solutions are devised, the systemic inflexibilities might make their assimilation in the current manufacturing routines very challenging. Also, extensive sorting and testing routines make the processing time and cost considerably higher, making the recycling business less attractive and practical. As composition testing is currently not possible for all the lots of feedstock, there are cases of presence of AEPO/NPO and other restricted substances, formaldehyde etc.

Post-consumer clothing, from disparate sources, constituted the feed-stock for mechanically recycled textiles, inducing the likelihood of entry of 'Residual Chemicals', also known as Legacy Substances in the process flow. Many products contain chemicals of concern that were legal when first manufactured but are now either restricted or banned. Such substances of concern in recovered material are known as 'legacy substances' (European Commission, 2017). The batch-to-batch composition of the mechanically recycled textile lots differs due to varying quantities of APEO / NPEO and other chemicals such as Formaldehyde and heavy metals, in the feed-stock. The current technological limitations do not support batch-to-batch screening of the feedstock for residual chemicals.

Supply-chain actor concerns in the business of mechanical recycling of textiles

Limitations related to feedstock and processing result in specific concerns downwards in the supply chain of mechanically recycled textile products. Buyers have their specification for accepting the recycled lots, and meeting these specifications was not possible for every recycled lot due to inconsistencies in the composition of feed-stock which kept differing for different lots. In the absence of standard guidelines, there is a possibility of acceptance of a lot having '*higher*' level of restricted substances and rejection of a lot at much *'lower'* levels at different times. There were cases with different acceptance levels for APEO/NPEO content in recycled material (250 ppm and 100 ppm) in testing reports of the same year. In specific test reports, acceptance

limits of formaldehyde and other restricted chemicals were much higher than in those made from post-consumer mechanically recycled textiles, indicating a highly unrealistic proposition. Lack of consistent testing routines induced hesitation and apprehension in recycled textiles acceptance decisions. The acceptable testing standards also lacked consistency leading to further anomalies in the treatment and acceptance of mechanically recycled textiles.

REACH amended AEPO/NPO acceptance in 2016 (Commission Regulation (EU), 2016), but the present level of awareness of this amendment, along with many other policy directives, is so insubstantial that either many are entirely unaware whereas other lack the right interpretation of the regulations. In situations where policy framework is understood, the implementation efforts are debilitated by the obstinate, inflexible, customary practices in the linear business model. Lack of a standard regulatory framework and clear policy directives make the supply-chain actors behave inconsistently in a different situation, in ways advantageous to them. Disoriented behaviour is challenging the sustenance of the mechanical recycling business. The Chemical Restriction 2017: Restricted Substance list guidelines compiled by a significant buyer provided a chapter on 'Mechanically Recycled Natural & Synthetic Materials and Remade Materials' containing essential guidelines related to acceptance. However, this chapter was not available in the January 2018 guidelines (H &M 2017; H&M, 2018). The unavailability of such essential guidelines restricts the supply-chain-wide understanding and consequent acceptance. Lack of policy guidelines and system barriers are debilitating the sustainability initiatives of the industry and posing an impediment in the objectives of the recycling business. The business vision is myopic, reckoning process limitations as system barriers, and fostering operational challenges.

Although the role of mechanical recycling methods in paving the road for the circular economy cannot be doubted, constraints and concerns are inhibiting the mechanical recycling efforts. Both researchers and practitioners agree that making future textiles from existing textiles through the use of material recovery technologies will significantly reduce the need for virgin resources. The major bottleneck limiting the circular system to achieve its full potential is the 'technological insufficiency', but at the same time, it is important to acknowledge that the 'unpremeditated ingress of legacy substance' is another factor inhibiting the wider acceptance of mechanically recycled products. In lack of 'legislative framework' and collaboration throughout the supply chain, what will be achieved will not be an 'end-to-end closed-loop circular economy', but 'circular economy in a linear system'.

The EU action plan for circularity

To boost the efforts of the circular economy, European Union launched its ambitious Circular Economy Package in December 2015, outlining wide-ranging measures that, if realised, would help consumers choose products and services that are better for the environment and, at the same time, provide monetary savings and increased quality of life. The EU action plan for Circular Economy aims to undertake an 'options analysis' to "address the interface between chemicals, products and waste legislation, including how to reduce the presence and improve the tracking of chemicals of concern in products" and in turn developing a framework to address the problem of legacy substances. Four main issues, essential to facilitate the transition of present-day linear models to circular models, have been identified in discussions and consultations by EC with all stakeholders (European Commission, 2018a). The issues are:

1. Insufficient information about substances of concern in products and waste

2. Addressing the presence of substances of concern in recycled materials
3. Uncertainties about how materials can cease to be waste
4. Difficulties in the application of EU waste classification methodologies and impacts on the recyclability of materials (secondary raw materials)

The outcome of options analysis was the suggested action plan, and the implementation of the same requires an apparent disruption in the processes, business behaviour. The first two issues that specifically address the limitations and concerns due to the presence of 'Legacy substances" or 'Substances of concern', which also is the focal area of the current research have been further discussed in Table 1.

Table 1. Summary of options analysis for the first two issues highlighted in EU road-map for circularity through mechanical recycling

Issue	Challenges to be addressed for the transition to Circular Economy	Option Analysis
Inadequate information about substances of concern in products and waste	Defining substances of concern and further tracking of the same.	Specific and unambiguous identification and documentation of substances of concern is essential. For tracking substances of concerns, improved supply chain collaborations, extended producer responsibility schemes are the key, keeping in view the stipulated production technologies required for manufacturing of the product
Addressing the presence of substances of concern in recycled materials	In the current state, where the technical and economic feasibility of removing substances of concern (legacy substances) is case dependent, ensuring the quality parameters for recycled material	To sustain the credibility and acceptance for recycled materials, it is essential that it should be at par with their comparable grade of primary materials in terms of performance and chemical composition, however in the absence of quality parameters for secondary materials, an allowance can be considered for recovered materials, bearing in mind the risk, socioeconomic factors and environmental outcome based on lifecycle thinking.

(European Commission, 2018b)

Remedial measures for institutionalising circular economy textiles and clothing recycling business

Incorporation of the proposals of the EU action plan for circularity is expected to trigger a disruption in the present-day linear business models of the textiles and clothing industry. A smooth transition towards circularity can be achieved through promoting conducive and collaborative business behaviour of supply-chain actors and devising operational routines for institutionalising circular economy framework in the business of mechanically recycled textiles and clothing.

Disruption or, more specifically, 'disruptive orientation', both in business processes and in the behaviour of supply chain actors is expected to bring the required shift in the business of mechanical recycling of textiles. Disruption refers to disturbances that interrupt an event, activity

or process. The Foundation of Urgent Spanish BBVA describes it as "a process or a way of doing things (…) which ousts and displaces those that were used before." The 'primary forces of disruption' as identified by EY, include innovation, technology, globalisation and demographics (EY, 2018)

The current business scenario of mechanically recycled textiles is witnessing operational difficulties due to process limitations, disorientation in business behaviour of supply-chain actors and lack of policy framework that could facilitate supply-chain actor collaboration and consequently result in resolving the operational difficulties of the business. The proposed disruption in the business orientation, business behaviour and business processes is expected to pave the path for mechanical recycling to become a mainstream manufacturing technique.

Constraints and concerns in the business of mechanically recycled are majorly the derivations of disorientation in business behaviour and process (including resource and technological limitations). A Standardized policy framework, well designed to facilitate closed-loop processes and well communicated to all business actors for correct interpretation and compliance, is needed. A three-faceted operational framework for closed-loop orientation of mechanical recycling of textiles is proposed for initiating systemic efforts in the direction of institutionalising closed-loop processes in the industry and to facilitate the establishment as a mainstream manufacturing technique. The three proposed facets, based on core business activities, are-

(i) Facet- 1: Re-orienting business actors' behaviour,
(ii) Facet- 2: Building collaborative interfaces and
(iii) Facet- 3: Aligning the operational systems towards circularity

The framework for disruption required in the business of mechanically recycled textiles endorses three operational, action-oriented facets that may be employed to give a direction to the business for addressing the present-day business anomalies. The proposed facets and the specific action-plans are detailed below:

Facet-1: Re-orienting business actors' behaviour – It is important to orient the business ideology, understanding and behaviour in the direction of the current state of environmental exigencies and to prioritise environmental gains along with business' financial objectives. Awareness has to be created and buyer acceptance decisions to be supported with standardised operational guidelines based on the EU's regulatory framework.

Facet-2: Building collaborative interfaces – Collaborative interfaces need to be developed for consensual agreements, sharing and discussions of mechanical recycling limitation areas and creating operational charters for addressing concerns of all supply-chain actors in the business of mechanical recycling of textiles. Supply-chain extensive collaboration must be extended to all stakeholders in the business to educate them about the uniqueness of mechanically recycled products and the environmental importance of these lower-impact articles. A bottom-up approach to involve all actors, especially buyers, and identifying the right product-groups could reduce incidences of non-acceptance, which are significant threats to the business of mechanical recycling of textiles.

Facet-3: Aligning the operational systems towards circularity – Accentuated efforts for precise identification of substances of concern and Extended Producer Responsibility should

create a platform to provide certainty to recyclers and to keep the tracking of substances manageable. A clear directive concerning the quality parameters of recycled materials resonating among various stakeholders will create a conducive environment for the acceptability of secondary raw materials. Availability of validated information about the chemicals of concern in consumer products can co-creates a stipulated environment of the sustainable supply chain. Designing of fluid product lifecycle management system, which fosters for circularity, is another thing for which business should respond.

Conclusion

The Textile and Clothing industry is a prominent sector, catering to the quintessential lifestyle needs of consumers at one end, and providing employment to millions of people around the world. Textiles products have become essential constituents of almost all sectors of life and are used extensively by different industries. Thus, textiles are making a significant impact on human lives and also to the environment. At the same time, the drawbacks of textile production and consumption should not be ignored. Textiles system operates in an almost entirely linear manner; vast quantities of non-renewable resources are used for textile and clothing production, which are used for a short period in the fast-fashion era, and are sent to landfills much before the end-of-life stage. Recycling is an answer to the increasing landfill problem and, mechanical recycling is the more promising solution due to the avoidance of any kind of chemicals during the entire processing. However, certain inevitable limitations of the mechanical recycling process and the absence of a fully-supportive business system are obstructing the progression of mechanical recycling from a short-term, fancy buzzword to become a mainstream solution.

The numerous material identification and recovery technologies under development can catalyse the vertical linking of contemporary business models towards an adaptable and acceptable circular economy. It is imperative to rationalise the business actor's behaviour and streamline operational bottlenecks. The paper highlighted the presence of legacy substances as one of the significant operational barriers in the uptake of mechanically recycled products. The paper provides a retrospect in the organised steps taken by European Commission for developing a well- functioning business environment for secondary raw materials and highlights the need of disruption in business actors' behaviour for the incorporation of those steps. A three-faceted framework has been proposed for managing the disruptions required to make mechanical recycling a mainstream closed-loop solution in the textile and clothing industry.

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