Circular fashion supply chain through textile-to-textile recycling

Ida Marie Sandvik and Wendy Stubbs
Monash University, Melbourne, Australia

Abstract

Purpose – The purpose of this paper is to explore the drivers, inhibitors and enablers of creating a textile-to-textile recycling system in the Scandinavian fashion industry. It investigates the technology, innovation and systemic changes required to enable circular supply chains.

Design/methodology/approach – The research study uses a qualitative, interpretivist approach, drawing on in-depth semi-structured interviews with stakeholders in the Scandinavian fashion industry.

Findings – The main inhibitors to textile-to-textile recycling systems in the Scandinavian fashion industry are: limited technology which creates a challenge for separating materials; high costs of research and development and building the supporting logistics; complexity of supply chains including the multitude of stakeholders involved in product development. The enablers are design and use of new materials, increased garment collection and collaboration. This research suggests that sorting and recycling technology can be enhanced with the use of digital technologies, as this would create transparency, traceability and automatisation.

Research limitations/implications – The research is limited by a small sample size and lack of representation of all key stakeholder groups, which limits the ability to generalise these findings. However, as an exploratory study, the findings provide insights that can be further tested in other contexts.

Originality/value – Understanding of textile-to-textile recycling is emerging both theoretically and practically, however, there is still much that is not understood. This research contributes to furthering understanding of how technology, collaboration and systemic change in the fashion industry can support opportunities for textile-to-textile recycling, thereby aligning with circular economy principles.

Keywords Fashion industry, Circular economy, Textile/clothing supply chains, Circular fashion, Circular supply chain, Textile recycling

Paper type Research paper

1. Introduction

The fashion industry is a significant contributor to environmental degradation and climate change (Allwood *et al.*, 2006). This, in combination with a growing population, has put pressure on natural resources, which are expected to become more scarce (EEA, 2015). Resource scarcity will inevitably affect the fashion industry, as the production of clothes requires materials such as cotton (Müller-Christ and Gandenberger, 2006). The fashion industry is also facing a growing issue of accumulation of textile waste, as fast production and consumption of clothing has led to a perception from consumers that clothes are disposable (Allwood *et al.*, 2006; Andersen, 2017). One approach to addressing these issues is the "circular economy".

The concept of the circular economy dates back to 1976, when Walter Stahel suggested an idea of "economy in loops" (European Commission, 1976). Theoretical contributions have also come from industrial ecology (Frosch and Gallopoulos, 1989), biomimicry (Benyus, 1997), cradle to cradle (McDonough and Braungart, 2002) and performance economy (Stahel, 2010). Ellen MacArthur Foundation (EMF, n.d.), who popularised the term circular economy, defined it as "restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all time". Different methods can be used for companies to apply circular economy, such as reuse, resell, remanufacture and recycle (Kumar and Malegeant, 2006).

Research shows that reuse has greater environmental benefit than recycling (Watson *et al.*, 2015). Yet, reuse on its own is not sufficient to reduce textile waste and does not address the issue of resource scarcity for large fashion companies. Textile-to-textile

recycling is a process of material recovery of pre- and post-consumer textile waste into yarns for new fabrics (Sandin and Peters, 2018). Textile recycling is a way to address both issues of resource scarcity and clothes waste in landfill. However, little is known about how the fashion industry can reuse textiles through recycling. This paper contributes to addressing this gap in knowledge by exploring how the Scandinavian fashion industry can create a system of textile-to-textile recycling. The study utilises an exploratory approach through a qualitative research design, drawing on interviews with fashion industry stakeholders. The main research question is as follows:

RQ1. How can the Scandinavian fashion industry create a system of textile-to-textile recycling?

To address this research question, the study investigates three sub-questions, provided as follows:

RQ1a. What are the drivers, inhibitors and enablers of creating a system of textile-to-textile recycling?

RQ1b. What is the role of technology and innovation to catalyse change in sorting and recycling of textiles?

RQ1c. What types of changes are needed to enable textile-to-textile recycling?

This paper is structured as follows: Section 2 presents an overview of current literature related to textile recycling. Section 3 describes the research methods. Section 4 presents the research findings. At last, Section 5 discusses the research contributions and proposes an agenda for further research.

2. Literature review

2.1 Fast fashion and textiles waste
Fast fashion is characterised by rapidly changing trends and low prices. The advancement of production in combination with increasing consumerism has created a mass market for cheap apparel where products are perceived and treated as disposable (Birtwistle and Moore, 2007; Joy *et al.*, 2012). With the rise of disposable consumer goods, waste is increasingly a global issue. It is estimated that waste from the fashion industry will increase by 60 per cent from 2015 to 2030, leading to 148m tons globally (GFA and BCG, 2017). Textile waste includes industrial waste generated as a side-product to manufacturing, pre-consumer waste which is stock that is damaged or unsuitable for sale, and post-consumer waste which covers textiles discarded by consumers (Leonas, 2017). Clothes degrading in landfills have negative environmental impacts by releasing greenhouse gas emissions and contributing to soil erosion and groundwater pollution (Yacout and Hassouna, 2016).

The global fashion industry is also faced with resource scarcity. Current environmental trends stress the importance of resource-dependent industries, such as the fashion industry, to look for alternative ways to secure supply (Bell *et al.*, 2012). The MEA (2005) shows a decline in ecosystem services which deliver resources for production, while the European Environment Agency (2015) finds that climate change will reduce the availability of virgin materials. In addition, it is expected that cotton fields will be replaced to grow food crops to support the growing population, presenting a challenge to the fashion industry (Müller-Christ and Gandenberger, 2006). GFA and BCG (2017) find that areas in China and India will experience stress on their water supply, which will also impact cotton production. Research suggests that resource-dependent companies need to decouple from natural resources and create alternatives to the linear production model to ensure long-term economic growth (Jackson, 2017; Weetman, 2016).

2.2 Circular economy and the fashion industry

Since 2010, the EMF (n.d.) has been influential through challenging the linear "take, make, dispose" mentality of the business world. Through its work, the concept of circular economy has been increasingly influential in many industries, including the textile and fashion industry. Applying circularity to the clothing and textile industry incorporates the whole value chain in a systemic rethinking of production (Ræbild and Bang, 2017).

In circular economy, waste is considered as a resource (EMF, n.d.). Using textile waste as a resource can be achieved through reversing logistics and thereby redistribute textiles back in the supply chain at different stages (Sas *et al.*, 2015; Bouzon and Govindan, 2015). Kumar and Malegeant (2006) identify five different ways of product recovery: repair, reuse, refurbish, remanufacture and recycle. Stahel (2016) states that companies can implement circular economy concepts in their business models through two different approaches: either extending the product's life or recycle and regenerate the components of the products.

Earley and Goldsworthy (2015) expand Stahel's (2016) approach by adding an element of speed. They argue that it is important to distinguish between short-life fashion and long-life fashion. Reuse, resell, upcycling and remanufacturing methods apply to products based on durability, quality production and long usages. Garments that are produced with low quality through fast production systems often do not have enough value to be repaired or resold, therefore these products should be taken back to recycle (Earley and Goldsworthy, 2015).

Earley and Goldsworthy's (2015) findings align with current practices in the industry, where companies such as Nudie Jeans, Patagonia, VIGGA and Filippa K all have integrated life-extending practices to their business models through either reuse, repair, resell or renting. These companies all produce clothes of high quality and durability, which enable them to maintain the value of the clothes (Pal, 2016). Despite efforts to extend the life of garments, GFA and BCG (2017) find that 82 per cent of clothes are sent to incineration or landfill. This supports the argument that life-extending practices by themselves are not sufficient to address the amount of textiles that are unwanted. Furthermore, all textiles will be out-worn at some point. Enhancing recycling practices is a way of redirecting textile waste away from landfills and utilising it as a resource.

Recycling is done by disassembling, dissolving or shredding materials. Fibres are then regenerated into new materials that can be used in industrial production of new textiles (Leonas, 2017). There are two ways of recycling textiles; mechanically and chemically (Leonas, 2017). Mechanical recycling covers processes of cutting, shredding and mechanically disassembling materials (Palm *et al.*, 2015). Chemical recycling is a process where synthetic materials are broken down for repolymerisation (Leonas, 2017). While recycling of textiles has been explored in academic literature, understanding of the actual practices and the economic feasibility of textile-to-textile recycling is limited and at a development stage. To incentivise stakeholders in the fashion industry to recycle textiles, there needs to be economic reasoning (Sas *et al.*, 2015). With the current technology, textile recycling is not economically beneficial (Bouzon and Govindan, 2015).

2.3 Systemic changes for textile recycling

Textile-to-textile recycling challenges the linear production model that underpins mainstream business models (EMF, n.d.). Changes are necessary throughout the whole value chain and are thereby more than a technical matter; it requires new design practices, collection of used textiles, establishing reverse logistics and supporting legal frameworks (Realff, 2006; Mathews, 2015). With the current financial barriers regulatory pressure and incentives are driving factors for product recovery (Bouzon and Govindan, 2015). Establishing a suitable system for textile recycling requires collaboration between clothing companies and stakeholders such as government, researchers, collectors and recycling companies (GFA and BCG, 2017).

3. Methodology

As little is known about how the fashion industry can reuse textiles through recycling, this research study utilised a qualitative exploratory research design. This is appropriate where little is known about a phenomenon (Blaikie, 2000). This approach was useful as the research was not testing a specific hypothesis, but rather aimed to generate new knowledge about circular fashion (David, 2004). Exploratory studies (developing a rough description or an understanding of some social phenomenon) are useful where little knowledge exists in the literature (Blaikie, 2000). The research study employed an interpretivist mode of inquiry using a qualitative research design. Interpretivism views the social world as the world interpreted and experienced by its members from the "inside". Qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings that "insiders" bring to them (Blaikie, 2000). Thereby knowledge was intersubjective and constructed in a social context. The knowledge generated similarly influenced the reality that it takes part in (Pryke *et al.*, 2003). It also meant that knowledge was a "co-fabrication" between the researcher and participants (Pryke *et al.*, 2003, p. 90).

As the research is exploratory in nature, a qualitative approach is more appropriate to under-studied areas of research (Marshall and Rossman, 1989/1999), in order to generate new theory and knowledge. An interpretivist approach lends itself to engaging actors with qualitative research tools, such as interviews, to draw out the views and meanings actors ascribe to their social realities. Open-ended questions are used as the basis of exploratory research, therefore the research questions are focused on "how" and "what".

3.1 Data selection

Selection of participants for this research was based on an analysis of stakeholders in the Scandinavian fashion industry. This included people involved in; the mainstream fashion industry, sustainability in the fashion industry, the circular economy and sustainable innovation in a general sense. Stakeholders were identified from the literature, participants of the Copenhagen Fashion Summit, organisations collaborating with the European Union on initiatives, policies or technology development, and by using snowballing (David, 2004).

These stakeholders were then analysed for their involvement in textile recycling based on: companies' and organisations' websites; participants in current initiatives about textile recycling; and examples in the literature. The analysis resulted in a participant ranking depending on their readiness and influence to do textile recycling. "Readiness" covered knowledge about recycling, investments in technology and innovation, or participation in initiatives about textile recycling. "Influence" was the power a stakeholder has to determine directions and success of textile recycling (DfID, 2003).

The ranking thereby determined which stakeholders to approach to gain insight about textile recycling. In total, 70 stakeholders were identified through the stakeholder analysis, and 35 related to textile recycling in the fashion industry in Scandinavia. In total, 11 of these stakeholders agreed to participate in the research, representing designers, researchers, sustainability managers, experts in the technical aspects of textile recycling, business consultants, experts in circular economy theory and a project manager of a textile-to-textile programme. See Table I for a summary of participants.

3.2 Data collection

Interviews are a common data collection method in an interpretivist approach. When using interviews as a method, knowledge can be created in the interaction between the social actors involved, in this case the interviewer and the interviewee. The interviewees' statements became data that were interpreted by the interviewer using a high level of reflexivity (Silverman, 2014). Semi-structured interviews provide the opportunity for the researcher to keep the conversation within chosen themes, but leave room for the participants to produce

Stakeholder type	Code	Description
Clothing company, entry-price segment	C1	Sustainability manager
Organisation, design agency	O1	Circular and sustainable design
Organisation, material/fabrics advisory	O2	Circular textiles
Organisation, textile recycling	O3	Circular textiles
Organisation, trade association	O4	Circular economy and sustainability
Organisation, trade association	O5	Sustainable business models in fashion industry
Organisation, freelance	O6	Sustainability in clothing and textiles sector
Organisation, circular fashion	O7	Textiles recycling
Researcher	R1	Sustainable Fashion
Researcher	R2	Circular economy and fashion
Researcher	R3	Sustainable business models in the fashion industry

Table I.
List of participants

their own opinions and ideas (Kvale, 1996). The interview guide addressed the research questions, but had an openness to explore new aspects. This made the interview a form of structured conversation (Kvale, 1996). The interview guide included the following questions:

- Many clothing companies already focus on integrating "sustainability" in their practices – how do you think "circularity" differs from sustainability?
- What does it mean for companies to apply a circular approach?
- What are the main drivers to move towards a circular approach?
- What are the current challenges or barriers?
- (How) can technology and innovation help catalyse change in relation to sorting and recycling textiles?
- What currently inhibits textile recycling?
- What is the potential in the "end-of-life"-phase/textile waste?
- What technologies enable recycling of textiles?
- (How) does digitalisation play a role in sorting and recycling of textiles?
- What opportunities and challenges are related to the use of technology/ innovation/ digitalisation?
- Which initiatives do you find most promising for enabling circularity in the fashion industry?
- How can current initiatives/technologies from the fashion industry be scaled up become mainstream?
- What is the value for a company of collecting clothes when the technology is not yet sufficient to recycle the materials?
- Which stakeholders are involved in creating textile recycling? (How) does collaboration play a role in this?
- What do you think the fashion industry will look like in 10–15 years?

All interviews were recorded, with permission, and transcribed. The interviews were done in person or by phone in the period between June and October in 2017 and were 45–60 min.

3.3 Data analysis
A content analysis of each interview was undertaken using qualitative coding techniques. The transcribed interviews were coded to draw out key themes from the data (Saldaña, 2016).

Coding is a method that "permits data to be divided, grouped, reorganised and linked in order to consolidate meaning and develop explanation" (Saldaña, 2016, p. 9). After initial coding of the interviews, the codes were grouped into categories. The categories were then grouped into the themes: drivers, inhibitors, enablers, technology and systemic change. For example, the initial coding produced codes of: biodegradable materials, recyclable materials and mono-materials. These codes were then grouped under the category of "new materials", under the theme "enablers".

While the small sample size and lack of representation of all key stakeholder groups limit the ability to generalise from the findings, the exploratory research provides insights that can be further tested in other contexts.

4. Findings and discussion
Sections 4.1–4.3 provide insights into *RQ1a* (drivers, inhibitors and enablers). Section 4.4 answers *RQ1b* (role of technology) and Section 4.5 addresses *RQ1c* (changes required).

4.1 Drivers of circular supply chains
Global trends such as growing population and increasing scarcity of resources are driving forces for change in current practices of producing textiles and clothes, as it is increasingly clear that current practices of producing and consuming are not sustainable (O5; C1; EEA, 2015; Weetman, 2016). This means that companies are forced to change current production models if they want to sustain their business:

> [going circular] is not something that should be done of philanthropic reasons, it should be done because if you do not, your company will close. (O5)

The increasing focus on textile-to-textile recycling is therefore a matter of "long-term secur [ing] the materials that we need to create the products" (C1; Müller-Christ and Gandenberger, 2006). In addition to resources becoming scarce, legislation is expected to constrain the availability of natural resources. The necessity of redirecting current textiles waste streams is enhanced by the possibility of extended producer responsibility schemes as a legislative framework (R2; R3; O5; Watson *et al.*, 2015; EU, 2018).

Tapping into current textile waste streams also provides new business opportunities, as the value of utilising textile waste is estimated to contribute with €4bn to the global economy in 2030 (R1; O6; C1; GFA and BCG, 2017). Current developments in Scandinavia show commitment from large fashion corporations to utilise used garments and textiles in business context – making circularity a competitive element in being the market leader (R2; C1). Furthermore, setting up garment collection schemes enhance brand image amongst consumers, who are increasingly aware of companies sustainability profiles and performance in Scandinavia (Choi *et al.*, 2015). Marketing of these kinds of initiatives is therefore a driver to show commitment to sustainability and manage consumer perceptions (O3; O5; Gam *et al.*, 2010). Despite several drivers for textile-to-textile recycling, there are many inhibitors.

4.2 Inhibitors of circular supply chains
As the literature identifies, there is currently no technology to support textile-to-textile recycling on a commercial scale (GFA and BCG, 2017). The technological barrier applies to sorting and recycling (O2; O3; O7; R3). Developing technology is inhibited by challenges with separation of fabrics (O1; O2; O4; O7; R1; R2; R3; Leonas, 2017). The four main technical challenges identified by the participants are as follows:

(1) separation of blends;

(2) separation of additives and trims;

(3) restoring quality; and

(4) all processes need to be sustainable.

4.2.1 Separation of blends. Garments often contain different materials, for example, cotton and polyester – these materials are recycled through different methods, and thereby create a challenge of separation (Leonas, 2017). Yet, completely avoiding blends is not a viable solution because from a design and durability perspective blends can increase the quality of the product (O7; Allwood *et al.*, 2006).

4.2.2 Separation of additives and trims. Besides the blends, additives and trims are also need to be removed from the garments. Additives and trims are elements such as zippers, buttons and chemicals. This further complicates the sorting and recycling process (R3; Elander and Ljungkvist, 2016). It is important to ensure knowledge about chemicals used in garments (O2; O5; O4) and to overcome possible contamination from the use-phase of collected garments (R3). Elander and Ljungkvist (2016) find that there currently is a "[l]ack of information regarding chemicals and hazardous substances in textile products" (p. 32).

4.2.3 Restoring quality. Degradation of fibres begins during consumer use from washing and wearing (O7), but also in the process of disassembling the fibres (O1; O4; O5; O6; O7):

> […] fibres are degraded, and that we somehow need to restore to be able to operate according to circular economy and to compete with virgin high quality materials. So we need to somehow convert this worn material into something with higher value again. (O7)

Trials with recycled textiles result in a quality that can only be used as pillow filling, and thereby only function as downcycling (O4; Elander and Ljungkvist, 2016). The current output of small-scale textile recycling therefore must improve in quality and quantity:

> […] in order to achieve circular economy, it is very important that the fibres that we create, can compete with cotton so that we actually are able to replace cotton. (O7)

Restoring the quality of the fibres is closely related to economic incentives to buy recycled fibres.

4.2.4 Recycling within a sustainable framework. Besides the technical challenges mentioned above, recycling of textiles must fit within a sustainable framework. Wang (2006) suggests that processes of recycling must be considered from both an environmental and economic perspective when comparing alternative methods of material recovery. First, this means that recycled textiles must be able to match current production prices (O7). Second, emissions and resource usages from recycling must not exceed current levels of emissions and resource usage related to production of garments (O5). Textile recycling also contains a range of chemicals, which needs to be considered for full material recovery (R2; R3; O2; O4: O6). At last, social aspects are not directly considered in the circular economy theory (R1; Moreau *et al.*, 2017). Yet, circular economy does not mean compromising on social aspects of production (O1; O2; O4; R1; R2). Moreau *et al.* (2017) propose that principles from solidarity economy can be combined with circular economy theory to establish the social dimension. Solidarity economy is a social movement that builds on foundations of reciprocity and requires responsibility for the other part in an exchange (Moreau *et al.*, 2017).

Another inhibiting factor for textile-to-textile recycling is the related costs of current sorting practices and the costs of developing a recycling system using new technologies (O4; O2; R2; O3). Current sorting practices are "done manually which is a challenge and it is expensive for doing fibre-to-fibre recycling" (O2). Carlsson *et al.* (2015) argue that it is therefore not currently financially viable. Costs related to development of the necessary recycling system are research, technologies, redirecting waste streams and creating infrastructure for used garments (O3; O5; R3). Nayak *et al.* (2015) argue that retail leaders are "concerned about the return on investment and net profit by investing the extra cost into the

existing system" (p. 9) referring to implementation of radio frequency identification (RFID). Costs of new technology must be weighed against the aim of producing cheap garments before large fashion companies will see the benefit of it.

Implementing textile recycling requires involvement of several departments in an organisation and stakeholders in the supply chain. This is inhibited by the size and complexity of the supply chain of large fashion retailers (O3; R1):

> Changing the supply chain is hard, fast fashion supply chain are really big […] A fast fashion company might contract a factory, who contract another factory – so there are subcontractors involved, which makes it challenging. (O3)

Fransson *et al.* (2013) argue that it can be difficult to make all contractors and subcontractors align with a standard proposed by the focal company. In alignment with this:

> […] the supplier industry, or supply chain they are definitely not ready yet. And we are very dependent on the supply chain of fabrics and manufacturing to be able to actually make those nice circular concepts. (O1)

The literature studying the application of sustainability initiatives throughout large supply chains highlights the difficulty of aligning all involved stakeholders (Fransson *et al.*, 2013). Applying a circular approach is no different; all parts of the supply chains need to be aligned to circular principles, and the size and complexity is therefore an inhibiting factor. The physical and mental gap between designers and production creates a barrier for designing for recyclability (O1; O4; O5; O6; R1; R2; Leonas, 2017). Designers do not have responsibility for the products as a whole and are only a small part of the decision process in product development (R1). Findings from Graedel *et al.* (1995) found that 80–90 per cent of a products' environmental and economic cost is determined during design, which reinforces that the lack of designer influence over product development is an inhibiting factor.

The current lack of system for recycling of textiles was also found to be an inhibitor (O1; O2; O3: O4; O5):

> […] if a company is producing products that at end of their first life cycle only can be recycled, there it not much value in those today because […] it is really challenging to use them as a recycling feed-stock today. So these garments are a burden on the system today, because they have limited end-markets for recycling. And the end market for recycling post-consumer textiles that do exist are not very profitable. (O3)

Elander and Ljungkvist (2016), similarly find that there is no sufficient market for recycled textiles. The lack of a recycling market creates an inhibitor to access the needed materials and ensure sufficient supply (O1; O4; C1).

In relation to this, there is a legal barrier to access resources: "current policies [in Denmark] do not allow companies to collect textiles in a scalable amount" (O4). Watson *et al.* (2015) speculate that legal and volunteer extended producer responsibility policies might stimulate companies' collection of textiles. Miljøstyrelsen (2014) advocates for a more cohesive framework concerning waste fees and value added tax rules. In alignment with this, participants highlight that regulations create a foundation for changing current practices in the industry (O6; O7; R2; R3). Yet, recycling of textiles should be incentivised by identified drivers (Section 4.1) and thereby create demand (O1; O4; O5).

4.3 Enablers of circular supply chains

Currently, only 20 per cent of clothes are collected for reuse and recycling practices (GFA and BCG, 2017). Gaining access to the clothes that otherwise end up in landfill or incineration, is an enabling factor to create a recovery stream for textile-to-textile recycling:

> If you look at the total streams of the garments in the world, not only for [company], but for everything, it is absolutely not enough collected today and more needs to be collected. (C1)

Collecting garments is directly related to circularity:

> Reclaiming products at the end of their life is ultimately what circularity is all about, so that is the future of the industry. (O3)

Despite current technological barriers, potential technological solutions can enable the process of textile-to-textile recycling (O5; O1; R1; R2; O7). A trust in technology is apparent: "There is no doubt it will be possible" (O5) – "there are more than enough engineers, technologies and industries that are ready to recycle, or will find solutions" (O1). This is backed up by several current projects, such as EU-project Resyntex (R2). Participant O7 predicts that:

> [...] in 10-15 years we will probably have some kind of fibre recycling plant on a commercial scale for certain controlled streams like cotton or cotton/polyester. (O7)

In addition to technological development, design and the introduction of new materials is an enabling factor for textile recycling (O1; O2; O4; O5; O6; O7; R1; Radhakrishnan, 2017):

> Design is an enormous contributor to circular economy. Adopting a circular design mindset and designing according to circular economy principles is a mandatory skillset for designers. (O2)

Designing to enhance circularity is a matter of designing products that have high durability, longevity or recyclability (Earley and Goldsworthy, 2015). The design phase is crucial to enable recycling (O1; O4; O5; O6; R1; R2). Design to enable recycling should focus on easy disassembling (R3; Radhakrishnan, 2017). Considering the challenge of blended materials, trims and additives, mono-materials are a suggestion to make the disassembling easier (O1). Companies and researchers are experimenting with alternatives such as hemp and waste products, for example, pineapples, grapes, oranges and cow dung (Ananas Anam, n.d.; Global Change Award, 2017b, c; Orange Fiber, n.d.). Yet, the introduction of new materials can be an inhibiting factor, because it creates a challenge with recycling streams (R1; O4). When a new material is introduced, a recovery stream needs to be considered, as well as the recycling process of the material. Participant O4 suggests that companies that choose to introduce new materials must take responsibility for the recycling of them.

As the system of recycling is complex, collaboration is an enabling factor (C1; R1; R2; R3; O1; O3; O4; O5; O6; O7; GFA and BCG, 2017; Pal, 2017). The different kinds of collaborations mentioned throughout the interviews are discussed in Section 4.5. The general finding about collaboration is that it is a necessity to enable textile recycling and creating a stream of recycled materials (C1; O1; O3; O4; O5; R1; R2). For example, collaboration with consumers is crucial to gain access to resources for textile recycling (Carlsson *et al.*, 2015). A final enabler is "conditional design" which differentiates recycling strategies for slow and fast fashion systems. This systemic enabler is discussed in Section 4.5.

4.4 Sorting and recycling technology enhanced by digitalisation
Understanding the drivers, inhibitors and enablers provides a foundation for understanding technological and systemic changes needed to realise textile recycling. The interviews indicate that digital tools are essential in textile-to-textile recycling (O2; O3; O4; O6; O7; R1; R2; R3) (see Table II).

Usage	Suggested technology
Production	3D printing (O5)
	Decentralised production and digital receipt (R1)
Sorting/recycling	Material scanning for easy and commercial sorting (O3; O6; O7)
	Radio frequency identification (RFID) (O2)/tagging (O7)
	Digital passport (ID-code or chip) (R1; R2; O7)
Connecting technology	Connecting demand and supply of "textile waste" (O3; O4; R3)

Table II.
Participants' suggestions of digitalisation to enhance recyclability

In line with other industries, there is a potential for automation and technology to take over current production practices of garments, such as 3D printing (O5) and knitting technology. For example, Dutch designer Iris van Herpen (n.d.) and the Belgian fashion designer Bruno Pieters have experimented with 3D printed garments (Moorhouse and Moorhouse, 2017). Adidas (2017) tested an in-store production technology, where products were fitted to the individual customer and knitted within a few hours. 3D knitting and customisation can reduce clothing waste by producing garments based on real-time demand (O5), and textile recycling presents an opportunity to incorporate design for easy disassembling and recyclability.

Another usage of digitalisation in production is digital receipts that can change the current ways of making clothes, through better documentation and transparency (R1). Through the digital receipts, producers can document used chemicals and materials included in the products, and thereby enhance transparency for recyclers. This is a way of addressing current issues around a lack of knowledge of contents of clothes and textiles. Management consultant McKinsey suggests that digitalisation will create "Supply Chain 4.0"[1] (Alicke *et al.*, 2017). Through digital receipts, information is more accessible (Alicke *et al.*, 2017). Zhu *et al.* (2016) similarly argue that digital information will reshape supply chains, especially concerning information flow. This provides a technological opportunity to enhance recycling.

The current sorting process of textiles and clothes is done manually which is both a costly and labour intensive process (R3; Carlsson *et al.*, 2015), as it can be difficult to identify each fibre type (R2). For textile-to-textile recycling to be an actual business opportunity, the sorting process needs to be automated (O3). To meet demands, a potential sorting technology must therefore be able to identify different kinds of fibres through a method that is fast and cheap (Carlsson *et al.*, 2015). The sorting could be done through surface-scanning (O2; O3; O6; O7):

> […] a sorting-equipment that basically takes finished post-consumer textiles whether that is garments or towels or whatever. It scans the surface and then it can sort those textiles by fibre type. (O3)

A scanning technology for more efficient sorting can also be linked with a chip or an ID-code, through RFID, functioning as digital passports (R1; R2; O7):

> […] every product has either an ID-code or a chip or something that can identify 100% what is the material in this and what chemicals have been used – the story of the garment, so that at the end of life, it can be easily recycled or put into the circular streams. (R2)

This aligns with current developments of an EU-project "Trash-2-Cash" that has used "tagging" as a digital method, and Content Thread (O7). The Content Thread is a digital thread that can connect with RFID technology to inform about content (Global Change Award, 2017a).

The purpose of these technologies is to inform sorters and recyclers about the fibres and chemicals that are included in each garment: "[digitalisation] enables transparency and it enables the possibility of circular supply chains in a consistent and standardised way" (O3). The technologies themselves do not have importance; rather it is the function of them:

> Transparency and standardisation are just as important as the sorting technology and the recycling technology. It is all hooked together. (O3)

The essential functions that must be considered in using technologies in commercial textile-to-textile recycling is traceability (O3: O4), transparency (O1; O3; O4; O7), standardisation (O3), automatisation (O5; O6) and the ability to connect different stakeholders or processes (O3; O4; O6; R3):

> Digital technologies can create value and enhance the sorting and recycling processes through greater accessibility of information and increased transparency. Sorting and recycling technologies must be automatised to be financially feasible. The digital technologies were suggested as a way of addressing the current lack of technology to create auto-sorting.

A digital platform could enhance resource availability for recycling of textiles, by connecting supply and demand of "textile waste" (O1; O3; O4; O6; R3):

> Basically [a digital platform] will allow people that have textile waste to find places to get it recycled or reused in some sort of way. And it will allow people that are reusing or recycling to find material suppliers – so essentially it is a circular supply chain builder. (O3)

The use of connecting digital platforms is predicted to have increasing influence on industries, both in supply chains but also to connect with consumers in a new way (Schwab, 2017).

4.5 Systemic change and industry-wide collaboration

Besides technological developments, there is a need for systemic change to create a recovery stream of recycled textiles and adopt circular economy in the fashion industry (Weetman, 2016).

Even though there is a need for the whole system to change simultaneously, the identified enablers (Section 4.3) can be used as catalysts for change. An important enabler of textile-to-textile recycling is creating a material stream of used textiles and garments. Despite the lack of sufficient technology to support the recycling of clothes, companies such as H&M and Bestseller are collecting clothes. Creating a take-back system is a way of training the consumers for when the technology is available (R1). Furthermore it is a way of collecting sufficient amounts to have a business case for when the technology is available (O5; C1):

> […] that is a question of scale; in order to get the technology, you also need to develop a business case. (C1)

Elander and Ljungkvist (2016) find that there is currently no business case for textile-to-textile recycling and that there is a "[l]ack of textiles available for recycling due to insufficient collection" (p. 18). A certain volume of collected textiles is needed to create the business case and to push the recycling industry (C1; O1; O3; O4; O5; R1; R2). This highlights the importance of engaging with consumers to recover enough textiles and clothes to support a stream of recycled materials.

As mentioned in Section 4.3, collaboration is crucial for change towards circularity (Pal, 2016; Poldner, 2013; C1; R1; R2; R3; O1; O3; O4; O5; O6; O7) (see Table III).

In order to ensure a large flow of materials the relationship with consumers needs to be redefined (O3; R2). This could be done by letting consumers be part of the sorting process if companies are allowed to collect through campaigns – this would require a change of the current legal framework (O4). Mathews (2015, p. 56) argues that "recyclable does not mean that it will be recycled". Goworek *et al.* (2013) find that consumers do not have enough knowledge about the environmental impacts of their clothes, and that educating consumers is an important element in gaining access to the clothing "waste". Therefore, it is important to ensure that consumers understand the value of their used clothes:

> […] the brands actually have to take the educator role as well, in informing and actively engaging. (R2)

Purpose of collaboration	Type of collaboration to support textile-to-textile recycling
Collect	Collaboration with consumers (C1; O1; O3; O4; O5; R1; R2)
	Collaboration with charity (R1)
Recycle	Collaboration with collectors/recycling industry (R1; R2)
	Collaboration with researchers (R1; R2; C1)
Change	Collaboration between designers and recyclers (O1; O5; R1; O7)
	Collaboration between small and large companies (O1; O3; O4; O5)
	Collaboration between large companies (R1; R3; O1; O5; O6)

Table III.
Types of collaboration to support textile-to-textile recycling, identified through primary data

Radhakrishnan (2017) suggests that retailers should promote the return of clothes. As shown, changing consumers' behaviour, even before the technology is in place, is essential to enable a stream of textiles (O5; R1; Mathews, 2015).

Large clothing companies are currently collaborating with collector I:CO (Stål and Corvellec, 2017). This collaboration is important in terms of managing the textile waste stream (R1; R2):

> I:CO provides them the reverse logistics solution and takes care of the sorting and reselling, reuse, recycling. (R2)

I:CO's collaboration with large companies creates a stream of used textiles and garments, which is highlighted in the literature and by the participants as crucial to enable textile-to-textile recycling (O1; O5; O4; O3; R1; R2; Allwood *et al.*, 2006).

To manage the waste streams and create a new supply of recycled textiles, large and small companies must work together. The collaboration is needed to create logistics (O1; O3; O4), systematisation of access to materials on an industry-wide basis (O5), and to reach scale to create enough demand for recycling technologies (O1; O3; O4; O5; C1; R3). Poldner (2013) argued that "strategic alliances" can create benefit for everyone involved. Poldner uses the Sustainable Apparel Coalition as an example of how companies can work together to create system-wide knowledge for the larger benefit. However, "[i]t is hard to collaborate with the competitor to make a massive industry shift" (O3).

The interviews indicate that change has to start from large companies due to resource availability and possibility to influence producers and regulation (O1; O5; O6; R1; R3). This perspective aligns with Larsson *et al.* (2013, p. 273) who argue that "[a] large corporation will have more resources to become a role model, which may inspire other corporations to follow". Participant O3 adds:

> I think fast fashion, because of the volume they produce, could be a really important accelerator for the volume of recycled textiles in the market. (O3)

Large corporations therefore have an important role in creating change, yet the systemic change will not occur until SMEs and the luxury brands participate (O2; O4; C1). Participant O4 explained it with a metaphor:

> [...] there is only a sustainable transition when the grass is green: that is, when all the blades of grass have become green. It might be, that there are a few green spots that represent the large companies, but that won't make the whole field green. (O4)

O3 further explained:

> This is a really big system in general, so it is an industry-wide shift, not an individual company shift. A lot of brands have to do this at the same. (O3)

The participants acknowledged that Scandinavian organisations cannot achieve full circularity alone due to the global nature of the supply chain and manufacturing processes, reinforcing the importance of industry-wide collaboration "since we are all dependent on each other" (O7):

> [...] circular economy is not just about the manufacturer next door, it is a global supply chain – so there are many things that have to work – so it has to be this "systemic" approach. (R1)

Despite the emphasis on "pushing in the same direction" and collaboration, the interviews and literature suggest that a division between slow and fast systems might influence strategies applying circular practices (O1; O3; O5; Earley and Goldsworthy, 2015). Stahel (2016) suggested two ways of prolonging product life: reuse or recycling. These practices are seen to apply differently; where small niche companies can increase their focus on services that prolong the life of garments such as repairing or reselling, the larger mainstream companies cannot follow this strategy due to the lower quality (O1; O3; O5).

Earley and Goldsworthy (2015) believed that the fashion system could have two different kinds of materials: the ones for the "fast" fashion and one for "slow" and quality fashion. One participant reinforces this perspective by suggesting two different textile systems – one focused on long life and one focused on short life with easy recyclability (O3). The design of the t-shirt, for example, is therefore not just about the materials that are used and technologies available, it is about understanding the current and potential material flow and strategically integrating it as part of the business model. Goldsworthy (2017) surmised that it is possible to "build the notion on speed into the whole cycle to ease the flow, including super-efficient materials recovery" (p. S1968).

Participant R3 calls this conditional design, where the context that the clothes will be used in is considered. It is about understanding what value the consumer attributes to the product, for example, when purchasing a t-shirt. If the perception of the cheap t-shirt is that it is disposable after it has gone out of trend, then the strategic conditional design for this kind of product is about creating a fast take-back to recycle the materials (R2; Goldsworthy, 2017). Furthermore, participant O4 argued that the real challenge is not to change the product itself, but to use the product as a means to change the system.

5. Conclusion and implications

The aim of this research study was to explore how the Scandinavian fashion industry can create a system of textile-to-textile recycling. This was done by investigating the drivers, inhibitors and enablers of textile-to-textile recycling (*RQ1a*); the role of technology and innovation (*RQ1b*); and, the types of changes required (*RQ1c*). While the research provides further support for drivers identified in the literature, it contributes new findings in three areas: circularity can create new business opportunities, contribute to reaching sustainability goals, increase competition and be a way to engage with consumers; additional inhibitors and enablers were identified; and the nature of systemic and technological change were further elaborated.

This research contributes to the existing literature, by identifying additional inhibitors, such as the number of decision makers involved in product development in large fashion companies, the lack of legal support to create a textile waste stream through companies and that there is not a sufficient market for recycled materials, meaning that it is difficult to reach scale for a new business opportunity within recycling.

In addition to the enablers identified in the literature such as technology, design and new materials, garment collection and collaboration, this research identified new findings by suggesting that digitalisation provides an opportunity to create a textile recycling system.

The current literature states that systemic change and technological development are needed for textile recycling. This research extends knowledge on the types of systemic and technological changes required to enable textile-to-textile recycling: recycling technology can be enhanced with the use of digitalisation, as this would create transparency, traceability and automatisation; collaboration on many levels to replace the linear production model; and, different strategies for slow and fast fashion systems, by focusing on "conditional design".

This research was limited to only looking at the materials, and thereby excludes energy and chemicals that also need to be considered to create a fully circular system. The research was also limited by the small sample, which does not represent the full range of stakeholders. Future research could expand the sample of stakeholders and consider other country contexts.

Note

1. Referring to the Fourth Industrial Revolution – Industry 4.0. The fourth industrial revolution is based on interconnected technologies – physical, digital and biological. Technologies such as artificial intelligence, nanotechnology and big data are predicted to revolutionise business practices (Schwab, 2017).

References

Adidas (2017), "Adidas knit for you", available at: http://adidasknitforyou.com (accessed 28 September 2017).

Alicke, K., Rexhausen, D. and Seyfert, A. (2017), "Supply Chain 4.0 in consumer goods", available at: www.mckinsey.com/industries/consumer-packaged-goods/our-insights/supply-chain-4-0-in-consumer-goods (accessed 28 September 2017).

Allwood, J.M., Laursen, S.E., Rodriguez, C.M. and Bocken, N.M.P. (2006), *Well Dressed?: The Present and Future Sustainability of Clothing and Textiles in the United Kingdom*, Cambridge University, Cambridge.

Ananas Anam (n.d.), "Ananas Anam presents Piñatex™", available at: www.ananas-anam.com/ (accessed 25 September 2017).

Andersen, K.R. (2017), "Stabilizing sustainability: in the textile and fashion industry", Copenhagen Business School, PhD Series, No. 05.2017, Copenhagen.

Bell, J.E., Autry, C.W., Mollenkopf, D.A. and Thornton, L.M. (2012), "A natural resource scarcity typology: theoretical foundations and strategic implications for supply chain management", *Journal of Business Logistics*, Vol. 33 No. 2, pp. 158-166.

Benyus, J.M. (1997), *Biomimicry: Innovation Inspired by Nature*, Perennial, New York, NY.

Birtwistle, G. and Moore, C.M. (2007), "Fashion clothing – where does it all end up?", *International Journal of Retail & Distribution Management*, Vol. 35 No. 3, pp. 210-216.

Blaikie, N.W.H. (2000), *Designing Social Research: The Logic of Anticipation*, Polity Press, Malden, MA.

Bouzon, M. and Govindan, K. (2015), "Reverse logistics as a sustainable supply chain practice for the fashion industry: an analysis of drivers and the Brazilian case", in Choi, T.M. and Cheng, T.C.E. (Eds), *Sustainable Fashion Supply Chain Management*, Springer International Publishing, pp. 85-104.

Carlsson, J., Torstensson, H., Pal, R. and Paras, M.K. (2015), "Re:textile – planning a swedish collection and sorting plant for used textiles, feasibility study", Högskolan i Borås, Västra Götaland.

Choi, T.M., Guo, S., Ho, S.S.Y. and Li, W.Y. (2015), "Effects of used garment collection programs in fast-fashion brands", in Choi, T.M. and Cheng, T.C.E. (Eds), *Sustainable Fashion Supply Chain Management*, Springer International Publishing, pp. 183-199.

David, M. (2004), *Social Research*, SAGE, London.

DfID (2003), "Tools for Development", Department for International Development, London, available at: http://webarchive.nationalarchives.gov.uk/ or www.dfid.gov.uk/Documents/publications/toolsfordevelopment.pdf (accessed 25 September 2017).

Earley, R. and Goldsworthy, K. (2015), "Designing for fast and slow circular fashion systems: exploring strategies for multiple and extended product cycles", paper presented to Product Lifetime And The Environment Conference, Nottingham Trent University, Nottingham, 17/19 June, pp. 1-7.

EEA (2015), *The European Environment – State and Outlook 2015*, European Environment Agency, Copenhagen.

Elander, M. and Ljungkvist, H. (2016), "Critical aspects in deign for fiber-to-fiber recycling of textiles", Mistra Future Fashion, Stockholm.

EMF (n.d.), "Circular economy overview", available at: www.ellenmacarthurfoundation.org/circular-economy/overview/concept (accessed 20 October 2017).

EU (2018), "EU ambassadors approved new rules on waste management and recycling", available at: www.consilium.europa.eu/en/press/press-releases/2018/02/23/eu-ambassadors-approve-new-rules-on-waste-management-and-recycling/ (accessed 29 April 2018).

European Commission (1976), *The Potential for Substituting Manpower for Energy*, European Commission, Brussels.

Fransson, K., Brunklaus, B., Sverker, M. and Zhang, Y. (2013), "Managing chemical risk information: the case of Swedish retailers and Chinese suppliers in textiles supply chain", in Gardetti, M.A. and Torres, A.L. (Eds), *Sustainability in Fashion and Textiles: Values, Design, Production and Consumption*, Greenleaf Publisher, Sheffield, pp. 82-97.

Frosch, R.A. and Gallopoulos, N.E. (1989), "Strategies for manufacturing", *Scientific American*, Vol. 261 No. 3, pp. 144-153.

Gam, H.J., Hauntian, C., Farr, C. and Kang, M. (2010), "Quest for the eco-apparel market: a study of mother's willingness to purchase organic cotton clothing for their children", *International Journal of Consumer Studies*, Vol. 34 No. 6, pp. 648-656.

GFA and BCG (2017), "Pulse of the fashion industry", Global Fashion Agenda and Boston Consulting Group, Copenhagen.

Global Change Award (2017a), "Content Thread", H&M Foundation, available at: http://globalchangeaward.com/winners/content-thread/ (accessed 10 October 2017).

Global Change Award (2017b), "Grape leather", H&M Foundation, available at: https://globalchangeaward.com/winners/grape-leather/ (accessed 10 October 2017).

Global Change Award (2017c), "Manure couture", H&M Foundation, available at: https://globalchangeaward.com/winners/manure-couture/ (accessed 10 October 2017).

Goldsworthy, K. (2017), "The speedcycle: a design-led framework for fast and slow circular fashion lifecycles", *The Design Journal*, Vol. 20 No. 1, pp. 1960-1970.

Goworek, H., Hiller, A., Fisher, T., Cooper, T. and Woodward, S. (2013), *Consumers' Attitudes towards Sustainable Fashion: Clothing Usage and Disposal*, Greenleaf Publisher, Sheffield.

Graedel, T.E., Comrie, P.R. and Sekutowski, J.C. (1995), "Green product design", *AT&T Technical Journal*, Vol. 74 No. 6, pp. 17-25.

Jackson, T. (2017), *Prosperity without Growth: Foundations for the Economy of Tomorrow*, Routledge, New York, NY.

Joy, A., Sherry, J.F., Venkatesh, A., Wang, J. and Chan, R. (2012), "Fast fashion, sustainability, and the ethical appeal of luxury brands", *Fashion Theory*, Vol. 16 No. 3, pp. 273-296.

Kumar, S. and Malegeant, P. (2006), "Strategic alliance in a closed-loop supply chain, a case of manufacturer and eco-non-profit organization", *Technovation*, Vol. 26 No. 10, pp. 1127-1135.

Kvale, S. (1996), *InterViews: An Introduction to Qualitative Research Interviewing*, Sage, London.

Larsson, A., Buhr, K. and Mark-Herbert, C. (2013), "Corporate responsibility in the garment industry – towards shared value", in Gardetti, M.A. and Torres, A.L. (Eds), *Sustainability in Fashion and Textiles*, Greenleaf Publisher, Sheffield, pp. 262-277.

Leonas, K.K. (2017), *The Use of Recycled Fibers in Fashion and Home Products*, Springer, Singapore.

McDonough, W. and Braungart, M. (2002), *Cradle to Cradle*, North Point Press, New York, NY.

Marshall, C. and Rossman, G.B. (1989/1999), *Designing Qualitative Research*, Sage Publications, Thousand Oaks, CA.

Mathews, B. (2015), "Closing the loop", available at: www.circle-economy.com/wp-content/uploads/2016/05/CTL-Samples-Circle-Economy-1.pdf (accessed 10 October 2017).

MEA (2005), *Ecosystems and Human Well-Being*, Millennium Ecosystem Assessment, World Resources Institute, Washington, DC.

Miljøstyrelsen (2014), *Mindre affald og mere genanvendelse i tekstilbranchen*, Miljøstyrelsen, Copenhagen.

Moorhouse, D. and Moorhouse, D. (2017), "Sustainable design: circular economy in fashion and textiles", *The Design Journal*, Vol. 20 No. 1, pp. 1948-1959.

Moreau, V., Sahakian, M., Griethuysen, P. and Vuille, F. (2017), "Coming full circle: why social and institutional dimensions matter for the circular economy", *Journal of Industrial Ecology*, Vol. 21 No. 3, pp. 497-506.

Müller-Christ, G. and Gandenberger, C. (2006), "Sustainable resource management – illustrated at the problems of German textile industry", IFSAM VIIIth World Congress, Berlin.

Nayak, R., Singh, A., Padhye, R. and Wang, L. (2015), *RFID in Textile and Clothing Manufacturing: Technology and Challenges*, Springer Science+Business Media, Heidelberg.

Orange Fiber (n.d.), "Orange Fiber", available at: http://orangefiber.it/ (accessed 24 September 2017).

Pal, R. (2016), "Extended responsibility through servitization in PSS", *Journal of Fashion Marketing and Management*, Vol. 20 No. 4, pp. 453-470.

Pal, R. (2017), "Sustainable design and business models in textile and fashion industry", in Muthu, S.S. (Ed.), *Sustainability in the Textile Industry*, Spring, Hong Kong, pp. 109-139.

Palm, D., Elander, M., Watson, D., Kiørboe, N., Salmenperä, H., Dahlbo, H., Rubach, S., Hanssen, O-J., Gislason, S., Ingulfsvann, A-S. and Nystad, Ø. (2015), "A Nordic textile strategy: Part II: a proposal for increased collection, sorting, reuse and recycling of textiles", Vol. 513, TemaNord, Nordisk Ministerråd, Copenhagen.

Poldner, K. (2013), "Zigzag or interlock? The case of the sustainable apparel coalition", in Gardetti, M.A. and Torres, A.L. (Eds), *Sustainability in Fashion and Textiles*, Greenleaf Publisher, Sheffield, pp. 277-294.

Pryke, M., Rose, G., Whatmore, S., Sage, P. and Open, U. (2003), "Using social theory thinking through research", SAGE, London.

Radhakrishnan, S. (2017), "Denim recycling", in Muthu, S.S. (Ed.), *Textiles and Clothing Sustainability: Recycled and Upcycled Textiles and Fashion*, Springer, Singapore, pp. 79-125.

Ræbild, U. and Bang, A.L. (2017), "Rethinking the fashion collection as a design strategic tool in a circular economy", *The Design Journal*, Vol. 20 No. 1, pp. 589-599.

Realff, M. (2006), "Systems planning for carpet recycling", in Wang, Y. (Ed.), *Recycling in Textiles*, Woodhead Publishing Limited, Cambridge, pp. 46-57.

Saldaña, J. (2016), *The Coding Manual for Qualitative Researchers*, Sage, London.

Sandin, G. and Peters, G.M. (2018), "Environmental impact of textile reuse and recycling – a review", *Journal of Cleaner Production*, Vol. 184, pp. 353-365, available at: www.sciencedirect.com/science/article/pii/S0959652618305985

Sas, I., Thoney, K.A., Joines, J.A., King, R.E. and Woolard, R. (2015), "Reverse logistics of US carpet recycling", in Choi, T.M. and Cheng, T.C.E. (Eds), *Sustainable Fashion Supply Chain Management*, Springer International Publishing, Switzerland, pp. 3-30.

Schwab, K. (2017), *The Fourth Industrial Revolution*, Crown Publishing Group, New York, NY.

Silverman, D. (2014), *Interpreting Qualitative Data*, Sage, London.

Stahel, W.R. (2010), "The performance economy", 2nd ed., Palgrave Macmillan, Basingstoke and New York, NY.

Stahel, W.R. (2016), "The circular economy", *Nature*, Vol. 531 No. 75952, pp. 435-438.

Stål, H.I. and Corvellec, A. (2017), "A decouple perspective on circular business model implementation: illustrations from Swedish apparel", *Journal of Cleaner Production*, Vol. 171, Supplement C, pp. 630-643.

van Herpen, I. (n.d.), "About", available at: www.irisvanherpen.com/about (accessed 15 October 2017).

Wang, Y. (2006), *Recycling in Textiles*, Woodhead Publishing Limited, Cambridge.

Watson, D., Kiørboe, N., Palm, D., Tekie, H., Ekvall, T., Lindhqvist, T., Tojo, N., Salmenperä, H., Hanssen, O.J., Rubach, S., Lyng, K.-A. and Gislason, S. (2015), *EPR-Systems and New Business Models: Part II: Policy Packages to Increase Reuse and Recycling of Textiles in the Nordic Region*, TemaNord and Nordisk Ministerråd, Copenhagen.

Weetman, C. (2016), *A Circular Economy Handbook for Business and Supply Chains: Repair, Remake, Redesign, Rethink*, Kogan Page, London.

Yacout, D. and Hassouna, M. (2016), "Identifying potential environmental impacts of waste handling strategies in textile industry", *Environmental Monitoring and Assessment*, Vol. 188 No. 8, pp. 1-13.

Zhu, X., Song, B., Ni, Y., Ren, Y. and Li, R. (2016), *Business Trends in the Digital Era: Evolution of Theories and Applications*, Springer, Singapore.

Corresponding author
Ida Marie Sandvik can be contacted at: ida_m_sand@hotmail.com