Entrepreneurial Practices in Eco-Innovation: Circular Challenges Related to the Tomato Textile Project in the Netherlands

Iris Lommerse and Ellen Loots

Abstract Values such as circularity, local production, and the use of more environmental-friendly materials have started to reshape various domestic industries. Because of the social and environmental challenges that the Textile & Clothing industry faces, solutions proper to slow fashion practices are gaining importance. The present chapter presents a case study of a local production network that roots in the maker movement and experiments with various aspects of circular practices, to develop new material: the Tomato Textile project. Based on ethnography and action research methods, the challenges of entrepreneurial practices in eco-innovation are identified and discussed.

Keywords Eco-innovation · New materials · Circular practices · Slow fashion · Maker movement · Local production

Introduction

The impact of global warming on our planet is pressing. Policy reports by the Intergovernmental Panel on Climate Change and the United Nations acknowledge technology as a way to reduce, tackle, or even prevent the threats caused by climate changes (Harvey, 2018; IPCC, 2018). Equally, a variety of influential works call for more holistic, circular approaches to our economy, necessary to keep society from reaching its limits (Ellen MacArthur Foundation, 2017; McKinsey & BOF, 2018; Murray et al., 2015; Raworth, 2017). The publication of the United Nations' Sustainable Development Goals (SDG) has fed the public debate on the need for a systemic change (United Nations, 2015), and the Circular Economy (CE) has entered the arena as a new paradigm. For example, honoring the SDG's, the European Commission (2018) considers the CE as an opportunity to develop a continent that respects the world's boundaries to resources, which can equally create employment and a competitive advantage for various industries in its member states. Its

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Circular Economy Action Plan articulates a focus "on the design and production for a circular economy, with the aim to ensure that the resources used are kept in the EU economy for as long as possible" (European Commission, 2020). Efforts to simplify and harmonize the Extended Producer Responsibility systems (EPR) in Europe are at the top of the agenda, likely to lead to a dedicated forum "where stakeholders could take stock of best practices" (Ecommerce Europe, 2022).

An industry that faces severe challenges in the transformation into a new economy, is the Textile and Clothing (T&C) industry (Ellen MacArthur Foundation, 2017, 2021; McKinsey & BOF, 2018). While 'growth' epitomizes the old economic paradigm, it has become a core value of the T&C industry: between 2000 and 2015, global clothing production almost doubled to approximately 100 billion units produced in 2015 (Ellen MacArthur Foundation, 2017), accounting for a growth rate of 4 to 5% per year (Global Fashion Agenda, 2019). Particularly the 'fast fashion' phenomenon has been responsible for such growth rates and detrimental impacts on society and the planet. Characterized by mass-production, offshoring to developing countries, and other bad habits such as 'take-make-dispose' and the 'race to the bottom',[1] the fast fashion industry has been accountable for severe environmental catastrophes (e.g., the exhaustion of the Aral Sea Basin in Kazakhstan by cotton production [Hoskins, 2014]) and humanitarian dramas (e.g., the collapse of the Rana Plaza factory in Bangladesh).

Alternative practices have started seeing the light, one being the 'slow fashion' movement in which values such as sustainability, social responsibility, and transparency take center stage (Clark, 2008) and traditional production and innovative design techniques are used to develop products with a long lifecycle (Bakker et al., 2014; Fletcher, 2010). Exemplary of the movement are eco-innovations such as the production of new materials based on CE principles. With its manifestation mainly in niche markets and local production networks, eco-innovations in a slow fashion can be considered part of the umbrella term of the 'maker movement' that refers to individuals who collaborate to produce tangible products outside of the traditional manufacturing firm (Doussard et al., 2018). The usage of technology (Anderson, 2012), open innovation, and knowledge-sharing are core characteristics of the maker movement (Browder et al., 2019). The notion captures the innovations and entrepreneurship by various makers—including entrepreneurs, designers, hobbyists, artists, researchers, students, and educators—which are commonly part of a 'making and sharing economy' (Browder et al., 2019). The maker movement has sparked the interest of policymakers because of its potential to catalyze an entrepreneurial environment and act as a precursor of the next industrial revolution (Browder et al., 2019).

Eco-innovations are confronted with challenges related to learning processes and entrepreneurship, in particular when it comes to technology and the creation of

[1] Take-make refers to a profit-model based on the production of low quality products that end up in landfill sites. In the 'race to the bottom', firms seek to produce as much and fast as possible at the lowest price. Both principles are exemplary for linear ways of production and business.

a market (Brown et al., 2019; Dougherty & Dunne, 2011). While presently eco-innovation practices are championed in several sectors of society, at the same time, the quest for new business models (BM) that help firms analyze, plan, and communicate within the increasing complexity of the new economy is at full pace (Bocken et al., 2019; Boons & Lüdeke-Freund, 2013; EMF, 2015; Geissdoerfer et al., 2018; Hultberg & Pal, 2021). BM for the CE underwrite the circular values and seek to integrate the radical changes in production and consumption, as well as the collaborative aspects of innovation. Several authors have argued that experimentation and innovation in BM are needed (Antikainen & Valkokari, 2016; Bocken et al., 2016; Boons & Lüdeke-Freund, 2013) because circular goals stand in contrast with the bias toward growth common to business (Tunn et al., 2019). However, clear and theoretically grounded ways to determine which BM best suits CE (closed-loop) practices are (still) in development (Lüdeke-Freund et al., 2018). A transition to a CE requires that experimental innovations turn into more embedded (decision-making, resourcing, networking, selling,…) practices organized around a shared understanding of how things should go (Thompson et al., 2020).

The present chapter seeks to unravel the challenges of eco-innovations, using a case study of the production process of new material for a circular T&C industry. Located in Rotterdam, a city that claims to be "the European centre of the bio-based and circular economy" (City of Rotterdam, 2015), the Tomato Textile (TT) project involves pioneers who are collaborating in a process for producing a yarn made out of tomato stems, a residual product of one of the largest export products of the Netherlands. The TT-project is an ongoing journey from cradle to cradle in which waste is considered to be a valuable resource. Stakeholders from various parts of the supply chain (from horticulture to fashion designers and scientists, to marketers and business leaders) are involved in the development of technology and a market, two of the greater challenges in the maker movement (Brown et al., 2019).

Our empirical study entails ethnography and an action component with the aims to, first, reveal emerging entrepreneurial practices related to eco-innovations, second, fuel the recent developments in circular practices and business model innovation with the perspective of makers in the slow fashion movement (cf. Antikainen & Bocken, 2019; Bocken et al., 2016; Boons & Lüdeke-Freund, 2013; Hultberg & Pal, 2021), and third, establish a link between eco-innovation and the maker movement (cf. Browder et al., 2019; Brown et al., 2019). After a compact literature overview of the T&C industry, Circular Economy business models, and eco-innovation, several key challenges of circular eco-innovation practices in the maker movement are derived from the case study.

The Textile and Clothing Industry

The Textile and Clothing industry is an integral part of everyday life and an important sector of the global economy (Ellen MacArthur Foundation, 2017). The industry consists of the production of fibers (such as cotton, wool, silk, nylon, and polyester),

knitting and weaving of garments, and finishing activities (such as dying, bleaching, and printing). On a global scale, societal and environmental issues have become increasingly intertwined with the T&C industry. In a report of 2018 on the state of fashion, McKinsey and BOF predict major changes:

> For fashion players, 2019 will be a year of awakening. The ones who will succeed will have to come to terms with the fact that in the new paradigm that is taking shape around them, some of the old rules simply don't work. (p. 10)

More recently, the Ellen MacArthur Foundation (2021) reported the following vision:

> Material innovation and recycling are important elements of the solution, but they alone cannot create a thriving fashion industry. In a circular economy for fashion, clothes are used more, made to be made again, and made from safe and recycled or renewable inputs. (p. 4)

The environmental and social challenges that typify the T&C industry arise at all stages of its complex supply chain (Franco, 2017). Already at the initial stage of production, the materials for garment production are often extracted from non-renewable resources such as polyester (98 million tonnes annually) and water-consuming resources such as cotton (using around 93 billion cubic meters annually) (Ellen MacArthur Foundation, 2017). Production processes heavily pollute the environment and account for severe social costs, such as damages to crops and workers by the chemical pesticides of the cotton industry, and social problems like low wages, child labor, and unhealthy labor conditions associated with garment production in lower-income countries (Lueg et al., 2013).

Designed to be short-lived (Fletcher, 2010), fast fashion has affected people's consumption patterns, currently characterized by disposability (Global Fashion Agenda, 2019) and under-utilization of items. There is a lack of innovative and economically viable solutions for up-cycling and recycling: the donation of garments for good causes to developing countries leads to a transportation burden and the abolishment of domestic clothing industries (Brooks, 2015); not to speak about the impact of the destruction (burning) of non-sold items (Celie, 2017).

While the demand for garments is still unremittingly accumulating (Ellen MacArthur Foundation, 2017, 2021; McKinsey & BOF, 2018), consumers do gain an increasing awareness of the (un)ethical side of the fashion industry, caused by sweatshop scandals associated with brand names such as Nike and Levi-Strauss (Brito et al., 2008), and the disastrous collapse of the Rana Plaza factory in Bangladesh. Today, in search of more transparency and sincere brand narratives, consumers are increasingly susceptible to smaller brands that put purpose and values at the heart of their strategies. Such an "explosion of the small" (McKinsey & BOF, 2018, p. 74), converges with the rise of platforms and niche markets that broaden purchasing opportunities (Ellen MacArthur Foundation, 2017).

Established fashion brands have started to feel pressure to meet new standards (Brydges, 2018), and turn to corporate social responsibility strategies such as integrating sustainable innovation solutions into their collections and awarding sustainable initiatives. Still, even if the financial gains of tackling societal and environmental

problems have been estimated at €160 billion per year (Global Fashion Agenda, 2019), 40% of the companies have in 2019 not seriously considered sustainability practices, and of those who have, 60% are SMEs or start-ups.

The disposability and short-life cycles of garments in today's fast fashion industry stand in contrast with the slow fashion movement and its paradigm of sustainable fashion solutions that include alternative strategies for design, production, and consumption (Fletcher, 2010). A key characteristic of the slow fashion movement is the valuation of local resources (Clark, 2008). However, upscaling and mass-production in the T&C industry urge businesses in the slow fashion movement to reinvent production networks closer to home. A variety of local resources are used to compete locally and abroad by local production networks that are organized as "collaborative linkages between local firms and local factors of production" (Simmie & Hart, 1999, p. 445). These networks could benefit from agglomeration economies that increase the ability to adapt to radical changes, cluster and network effects, and from innovation (Feld, 2012; Simmie & Hart, 1999). However, the mere nature and effectiveness of the practices of such networks are underexposed.

The Circular Economy and its Business Models

The Circular Economy arose as an alternative to a linear system in which waste had become the natural result of the usage of products (Pearce & Turner, 1990). While a linear economy is one of "converting natural resources into waste, via production" (Murray et al., 2015, p. 371), in a circular approach, products remain in the 'loop' or 'cycle' and eventually return to the system by either repairing, manufacturing or recycling. In the CE, furthermore, waste is being reduced through efficient production methods and extended product life cycles in which producers remain involved, and thus responsible (Bocken et al., 2016; Erler & Rieger, 2016).

Several approaches to the CE co-exist. The 'cradle to cradle principle', for example, states that products should either be treated as long-life goods or reused as resources because they will always remain on earth (McDonough & Braungart, 2002). Similarly, in the perspective of 'a looped and performance economy', the loop of reusing, repairing, and remanufacturing goods up to their molecular components takes centre stage (Stahel, 2010). The Blue Economy framework articulates that small, local, and clean technologies are needed to increase resource efficiency in the production of goods and solutions for a more sustainable economy (Pauli, 2010). Common to those schools of thought are the central roles of designers, entrepreneurs, and pioneers to instil change and innovation.

Business models for the CE are considered operational tools that have the potential to support businesses with the implementation of practices to address circular and sustainability goals (Ellen MacArthur Foundation, 2021; Hultberg & Pal, 2021; Kirchherr et al., 2017; Linder & Williander, 2017; Murray et al., 2015). A BM is a simplified version of how a firm arranges its business in which commonly a value proposition (what the firm delivers, its target consumers, and competitive advantage),

value creation and delivery, and value capture (the revenue model) are distinguished (Barney, 2002; Richardson, 2008). The nine 'building blocks' of the 'Business Model Canvas' are an extension of such a value framework that give business developers the flexibility needed in today's increasingly complex economy where innovation and experimentation are key (Osterwalder & Pigneur, 2010). Ries (2012) and the lean start-up movement take the experimentation further, relying on principles such as hypothesis-testing and the agile development of a minimum viable product that is adapted according to immediate consumer feedback (Blank, 2013).

Circular business models challenge the traditional BM mainly by its distinct objectives in terms of value creation that resides in social and environmental concerns rather than in the gains that result from strategically marketing a product and creating competitive advantage (Geissdoerfer et al., 2018). Furthermore, circular BM need to address the peculiar challenges of narrowing, closing, and/or slowing the loop (Antikainen & Bocken, 2019; Nußholz, 2017; Stahel, 1994). Circular businesses could either choose to innovate and update existing business models or create new business models to implement their circular economy practices (Bocken et al., 2019). While some scholars advocate a radical change in BM (e.g., Raworth, 2017), others suggest that existing models could integrate practices crucial to the CE: the focus on sustainable value and stakeholder and supply chain management (Geissdoerfer et al., 2018), sustainable innovations (Boons & Lüdeke-Freund, 2013), and various strategies for closing the loops (Bocken et al., 2016; Linder & Williander, 2017; Nußholz, 2017).

Eco-Innovation and the Maker Movement

During transitions such as the techno-economic paradigm shift that society has been experiencing for some years, there could be a leading role for entrepreneurship in developing innovative industrial and systemic solutions (Perez, 2002), as well as for local production networks that engage with niche and pioneering experiments (Brydges, 2018; Grin et al., 2010; Perez, 2002; Simmie & Hart, 1999). Within such complex processes of opportunity search and development, especially at the front-end of innovation, research through design (Maher et al., 2018) is a common practice: through iterations, reflections and experimentation, innovations can be developed while potential risks are kept at a minimum (Bocken et al., 2014a, 2014b). The inclusion of circular concerns at those early stages of innovation allows for the development of really new value propositions and production systems (Bocken et al., 2016; Nußholz, 2018). 'Eco-innovation' as an umbrella term for any "form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development" (European Commission, n.d.) is particularly discrete in those front-end processes, because of the heterogeneous, yet very specialized knowledge that is needed at the early stage. Oftentimes start-ups and their inter-disciplinary teams engage with eco-innovation (Perez, 2002), motivated not just by economic benefits, but more so by the search for new knowledge or enhanced skills, or ego-centric

motives as career progression or the status that follows from becoming a CE thought leader (Brown et al., 2019). Eco-innovation can be sustainably oriented (Brown et al., 2019), and aim at "competitively priced products and technologies with better environmental performance than relevant alternatives" (Bocken et al., 2014a, 2014b, p. 43). Eco-innovation can also be circularly oriented, and take the process one step further by aiming at the integration of "CE goals, principles, and recovery strategies into technical and market-based innovations, such that the circular products and services that are brought to market purposively maintain product integrity and value capture potential across the full life-cycle" (Brown et al., 2019, p. 3).

According to Brown et al. (2019), the success of eco-innovation is dependent on two aspects: technical advancement, and the creation of a market. Still, to succeed, eco-innovation must overcome challenges, particularly related to its collaborative learning aspect: the installation and maintenance of an "innovation-oriented learning culture" (as well as 'unlearning') that can help partners to adapt their visions and critically reflect on the process (Brown et al., 2019, p. 6), coordination between interdependent partners whose goals may not be aligned, and entrepreneurial processes more in general (Dougherty & Dunne, 2011). When they take place outside the firm, those collaborative learning processes aimed at innovative manufacturing practices are prototypical of the maker movement (Browder et al., 2019; Doussard et al., 2018).

Policymakers in the European Union have recognized the potential of eco-innovation in the start-up landscape, in that "SMEs and especially start-ups can be ideal incubators for eco-innovation and can bring to market new, less environmentally damaging products, services, and processes" (European Commission, 2012). Policies of several EU countries have led to several 'start-up hubs' that concentrate on the design of innovative products and technologies aimed at addressing the many social and environmental challenges of today (Smale, 2018).

The Case Study

Using an empirical study, we identify the challenges that pioneering entrepreneurs in eco-innovation face. Because little is known still about circular practices, strategic processes, new forms of organizing, and the dynamics within the stakeholder networks (van Dijk et al., 2014), an exploratory case study has been conducted (cf. Ghisellini et al., 2016). Such an inductive approach has been effectuated using ethnographic research in combination with an action component. More specifically, between February and May 2019, a *micro-ethnography* (Wolcott, 1991) of the crucial front-end processes of the eco-innovation (Bocken et al., 2014a, 2014b) within the Tomato Textile project in Rotterdam (the Netherlands) was conducted by the first author who took up the insider's role of a *complete participant* (Gold, 1958).

The case was purposely selected because it exemplifies an eco-innovation situated in the maker movement, which involves multiple stakeholders with a shared interest in innovative circular economy practices. It is experimental, because it is a small-scale activity with access to limited resources only, with the aim of collective learning,

that takes place before larger scale piloting and eventually scaling up. Yet, because it did not have a clear BM for hands to address value creation, capture, and delivery, it allowed the first author to experience the entrepreneurial process during which these value-related processes were experienced and negotiated (cf. Antikainen & Bocken, 2019; Bocken et al., 2018). The first author was granted access to all documents and meetings, including expert meetings and events organized by Blue City Lab—the hub that hosts the TT-project as well as other start-ups in the new material maker movement—and could rely on the coordinator of the project as a key informant. To learn from frontrunners, the first author conducted interviews with four Dutch entrepreneurs who are equally developing textile products in the T&C Industry from residual waste. Field notes, pictures and videos, and the interview transcripts were subject to a thematic analysis based on a hybrid coding procedure (Strauss & Corbin, 1990).

The Challenges of Circular Practices and Eco-Innovation

Transforming tomato waste into a competitively priced textile product with better environmental performance than its alternatives (cf. Bocken et al., 2014a, 2014b), entails numerous big and small challenges (cf. Brown et al., 2019). The TT-project is initiated by the Dutch horticulture organization Greenport West-Holland (2022) (a triple helix organization consisting of entrepreneurs, governments, and knowledge institutions) with the aims to become the first horticulture region independent of fossil fuel, switch the horticulture's energy to sustainable sources, and reduce the combined CO2 emissions. To showcase a bio-based economy, Greenport decided to invest in the waste flows that are created by tomato production, and more specifically the tomato stems that are left behind after grubbing the plants. After previous projects in which the fibers in the tomato stems have been transferred into paper and packaging material already used by some local tomato producers, Greenport wanted to pivot a business case (a T-shirt) and develop the technology and market until a stage where an entrepreneurial start-up could take over and scale-up.

Blue City, "an incubator for circular entrepreneurs in and around Rotterdam" (Blue City, 2019) created on the Blue Economy principles (Pauli, 2010), hosts the TT-project. As a hub for makers, Blue City houses a wide range of entrepreneurs, start-ups, and small initiatives that work on sustainable solutions in which values such as cooperation, waste elimination, and local production are central. The organization makes her *wet* and *dry labs* available to numerous makers to create and develop new materials and products.

The TT-project team represents various stakeholders that share the CE vision and values such as the promotion of the maker industry, innovation in the T&C industry, and the advancement of local production and consumption. At an early stage of the process, a roadmap of three consecutive stages had been conceptualized:

- Stage 1: The tomato plant is shredded and made into a 'pulp soup', which is transformed into cellulose that can be used to make fibers;
- Stage 2: The tomato fibers are turned into yarn;
- Stage 3: The yarn is used to knit a textile product such as a T-shirt.

At the time of the study, the project is at the front-end innovation process (step 1), in which the possibilities for extracting the cellulose out of the pulp are being researched and tested. Up until that point, besides the technological and market challenges that eco-innovations typically face, we identified four other challenges.

* 1: The Technological Challenge

In determining the direction of the project, already during the creation of the cellulose, competing possibilities with distinct financial, societal, and environmental implications had to be assessed, with the trade-off between time and place found most urgent. Eventually, it was decided to save on time and search costs, and to involve a lab in Bavaria (Germany) that would test the pulp of the plant, next to two local entrepreneurs.[2] Thus, the decision to develop the product locally was compromised by the choice for including an international partner that would be able to add to the speed of the creation of a minimum viable product of a decent quality. As was testified by the project coordinator:

> We have decided to continue to work in the direction of a product, meaning that for now, we do not focus on researching the most responsible [sustainable] way of producing but to focus on craftsmanship production.

During the first stage (from cellulose to fibers), more restrictions related to the timing and place of future production processes had been identified. Time would become an issue because harvesting tomatoes only occurs for three months a year, and drying pulp is time-consuming. While currently pulp is being created by hand, scaling up will lead to location decisions because of the absence of pulp-producing plants in the Netherlands. Lüdeke-Freund et al. (2018) have suggested that circular BM can imply "complex trade-offs", including those between a company's private benefits or losses on the one hand, and social benefits and costs on the other hand. Considering that eco-innovation entails environmental and societal values, such decisions cannot rely on straightforward calculations of costs and benefits but intricately relate to the fundamental mission of the project and the shared values of the team members. In line with the "affordable loss" principle common to the effectuation approach to strategy (Sarasvathy, 2001), the team decided that the loss in terms of locality was acceptable because it would contribute to the technical advancements of the TT-project (material development).

[2] A start-up that collects and recycles second-hand textiles (post-consumer waste) and a pulp specialist.

During the second stage of the TT-project (from fibers to yarn), the team will investigate if the fiber is suitable for the production of textile yarns. The lab in Germany is expected to develop a 'recipe' for cellulose that will lead to a yarn suitable for textile production. The main goal is not to be a frontrunner in the market but rather the advancement of knowledge and innovation in the T&C industry using horizontal cooperation (Feld, 2012). Therefore, it was decided that the recipe would be shared under a Creative Commons license that could enable future users and producers to develop the initial work further. This decision epitomizes the values of the maker movement and stands in contrast with how manufacturing firms that would rely on their legal departments normally proceed with technological innovations (Browder et al., 2019).

*2: The Market Challenge

Several business models attribute a prominent role to the consumer, and to value propositions that aim to increase consumer satisfaction (e.g., Blank, 2013). Hence, a key issue in BM that seek to meet the objectives of the CE, relates to the value propositions of producers who face new relations with their consumers as well as with their products. For example, Erler and Rieger (2016) acknowledge how a shift to circular business practices expands the responsibility of the producer for the entire lifecycle of her products. Such an extension of the product-value relationship implies practices such as re-manufacturing, preparing, and recycling, and forms of ownership that are not restricted to a consumer solely but entail product-related services such as renting and leasing (Bocken et al., 2014a, 2014b). Thus, recently, BM in the CE started to shift from being product-oriented to service-oriented (Antikainen & Bocken, 2019; Heiskanen & Jalas, 2003), and design thinking and lean thinking methods have been used to engage consumers more in the development of viable value propositions (Blank, 2013).

However, the centrality of customers is less salient in eco-innovation because of its strong orientation toward inputs and technology rather than toward products or services that address consumer needs. Especially when alternatives are for hands, consumers may not care too much about eco-innovations that seek to develop new products or materials. While makers in eco-innovation look for a circular BM that could epitomize how their environmental and societal responsibilities can be translated into value creation, consumers still need to become incentivized to participate in narrowing, slowing down, or closing the loop (Antikainen & Bocken, 2019). Therefore, eco-innovation in slow fashion may face severe market challenges, but also great opportunities, not in the least because of how the fast fashion industry has evolved and cast bad aspersions on itself. While the highly subjective nature of taste preferences in fashion and the concomitant structural uncertainty for many suppliers has incentivized the industry to produce large numbers of 'push products' that are pushed into the market to increase the likelihood of success (Jin & Cedrola, 2018; McKinsey & BOF, 2018), the drawbacks of fast fashion have longer been recognized

(Fletcher, 2010). Equally, the T&C industry is characterized by asymmetric information that has reduced the transparency for consumers of its production processes and supply chain, to which objections have started to emerge (McKinsey & BOF, 2018). Here could lay room for the introduction of innovative, transparent, and local material production methods that underwrite a novel approach to fashion, appealing to consumers. Yet, producers and developers have to take into account consumer behavior, which has been found to diverge greatly among consumer groups and product types when it comes to circularity (Edbring et al., 2016; Tunn et al., 2019).

For slow fashion products to be able to succeed, the added value and aesthetics of the items are vital to create an appealing brand for consumers. Circular brands should find ways to distinguish themselves from the incumbents in the fast fashion industry because they generally appeal to a consumer segment only that possesses relatively higher levels of willingness to pay. This was recognized for the TT-textile as well, and emphasized during a discussion of the TT-business case: "It [Tomato Textile] will never be fast fashion, we are in a different price category" (Participant, Blue business club 21/03/2019). Therefore, a fair balance needs to be sought when the product is put on the market and scaled up, as linear practices are currently still the status quo and more conducive to economies of scale.

*3: The Circular Challenge

In the TT-project, a valuable waste stream is created, in line with the BM strategy of *industrial symbiosis* (Bocken et al., 2014a, 2014b): the waste of one industry (Dutch horticulture industry), is used as a resource for another industry. Industrial symbiosis aims at creating an interconnected network of partners that eliminates waste and eventually creates surplus-value. As such, next to the consumer, also the supplier of the raw materials should be considered in the further development of the TT-project, particularly in addressing the question of how to close the loop, where responsibilities lie and "efforts" need to be made (Tunn et al., 2019). Because the team's focus has mainly been on technology rather than on market development up until the stage when the study took place, the B2B (network) aspect needs to be addressed more to determine how to evolve from a sustainable to a circular BM that implies a closed-loop (Brown et al., 2019). Closing the loop of the TT-project still required three solutions, regarding:

1. the residual waste in the production process (extraction of the cellulose);
2. the emissions by the transportation of the products, considered to be a bottleneck in CE; and
3. the end-use phase (after usage by the consumer).

At the moment of the study, the team had an awareness of those issues but had not developed a strategy, partly because decisions about final products and the involvement of extra partners were in the pipeline.

* 4: The Collaborative Challenge

Key in eco-innovation is collaborative learning. Even if shared motivation acts as the glue that holds a team together, coordination problems and leadership issues may emerge (Brown et al., 2019). Overcoming the differences in knowledge and professional values are vital in eco-innovation practices; in the TT-project, those emerged strongest between scientific and industrial partners, and between fashion and product designers. While design processes regularly depart from the available (raw) materials and/or the ideas of the designers, the end product (a T-shirt) had been determined; what needed to be established was the roadmap to the product. At the early stage of production, the quality of the polymers and cellulose was uncertain, and this rose questions about the ideal end product (a T-shirt or a fabric?), particularly by the material experts and designers. As formulated during a discussion, "the freedom for designers is important; if you attach yourself to a product, you will limit this freedom" (Participant, Blue business club 21/03/2019). Still, the collaborative nature of the project seemed to be able to create strong bonds toward a joint purpose. However, the heterogeneous 'role-related values' and interests of stakeholders could form a challenge in future stages, because the commissioner and the designers may target other goals.

Managing collaborative learning such as eco-innovations implies good HR-practices. While eco-innovators would ideally dispose of the upfront knowledge of specific CE design processes and resource and recovery strategies (such as reuse and repair), the intended value cycle of the innovation is more frequently unpredictable than known (cf. Brown et al., 2019). To be able to forecast the impact of eco-innovations at the system level and across multiple life cycles, designers, as well as other team members, need skills and knowledge that they normally do not rely on (Brown et al., 2019). Additionally, members of eco-innovation teams could benefit from some soft skills that benefit a smooth collaboration between various professional roles. Motivation, vision, and enthusiasm are important (Brown et al., 2019), but do not guarantee the absence of thorough disagreements and coordination problems. In the TT-project, the inclusion of a team member with a specialization in circular textile innovation had been very fruitful for aligning the team members and creating a form of interdisciplinary empathy and engagement.

Future steps will continue to challenge the collaboration, particularly when extra partners become involved in B2B relationships. At the stage of the research, four directions are considered:

1. the development of an iconic tomato T-shirt for the horticulture industry, with mostly a symbolic value;
2. the development of a product for the B2C market;
3. a collaboration with an incumbent in the T&C industry, for example in outdoor clothing production (B2B);
4. collaborations with small local brands and stores (B2B).

Each direction would challenge the collaborative process and the goal to keep the fabric in the loop because of the additional stakes, and thus call for a distinct BM, acknowledged by the project leader: "the eventual product is an important component in the development of the textile and the business plan."

*5: The Institutional Challenge

Circular business models challenge the wider institutional context, and, inversely, they are challenged by the context as well (Antikainen & Bocken, 2019; Schaltegger et al., 2016). Hence, besides the customer proposition, companies in the CE need to formulate environmental and societal propositions (Antikainen & Bocken, 2019; Manninen et al., 2018). A major challenge here is to complement the typical idea of the "value-added" that refers to the economic value accumulated by firms along linear or "forward" supply chains, with the "value retained" of a used product and its composite elements, also at the societal level (EMF, 2015; Lüdeke-Freund et al., 2018).

While underwriting the blue economy values (Pauli, 2010) and the premise of local production and consumption, the TT-project was confronted with the consequences of the de-industrialization in the region. The lack of pulping facilities led the team to Germany, which affects its circularity goals. So, the institutional context, including the stage of transition that an industry is in at the local level, creates both drivers and barriers to eco-innovation (Brown et al., 2019). According to our interviewees, the T&C industry is not in transition yet: even if the TT-team sought to deliver value to society using a local production process, the context urged them to alleviate their aspirations.

A critical mass in terms of producers, stakeholders, and start-up communities in a place (cf. Feld, 2012; Lorenzen & Fredrikson, 2008) may be necessary to leverage place-based eco-innovations that seek solutions for local waste. For eco-innovations to thrive, a concentration of resources (in terms of specific knowledge, suppliers, and equipment), economies of scale (sharing fixed costs), and concomitant network effects could be necessary. Such clustering processes may be especially palpable for interdisciplinary projects such as the production of new materials, which, because of their newness, could be expected to only slowly integrate into the political, economic, and socio-economic spheres. Being a frontrunner in an eco-innovation, the TT-project cannot benefit (yet) from the spillover effects onto the local economy in terms of employment or reputational benefits; even if consumers and producers of the waste stream might at some point start responding to the new offering, at the moment of study, the TT-project needed financial support because otherwise, it would not survive. Benevolence and trust present within the institutional environment are crucial for the survival of entrepreneurs and start-ups with innovative high-risk projects that prioritize environmental and societal value over clear profit, particularly when they have yet to overcome the (R&D) phase between starting-up

and early-stage, referred to as 'the valley of death' (Circle Economy, 2016; Fischer & Achterberg, 2016).

In terms of institutional support, the TT-project could benefit from the policies on T&C at the national level of governance. Based on a report about circular consumer behavior commissioned by the Dutch Ministry of Infrastructure and Environment (Drijver & Broer, 2014), already in 2016 a covenant about 'sustainable clothing' was developed by a consortium of branch organizations, unions, NGOs, and the government, with the aims of reducing environmental and social damages, increasing the transparency of the supply chain, and developing tools (SER, 2016). In a subsequent 'implementation program circular economy 2019–2023', the national government articulates the importance of new materials development within the T&C industry, with the inclusion of grants for the 'circular make and craftsmanship industry'. A landmark project ('Dutch circular textile valley') should set the standards for circular textile development and inspire suppliers to focus on new materials, recycling, and craftsmanship, while research and legislation are being adjusted accordingly. Taken together, those measures favorably affect the institutional context of the TT-project; still, the policy is not likely to wait when collaborative learning processes falter.

**6: The Existential Challenge*

The starting point of the TT-project is 15.000 tonnes of waste that are yearly produced by the Dutch tomato sector. As an eco-innovation at the front end of a possible innovation, the TT-project relies on a local production network that needs experimentation and iterations to learn whether a minimally viable product can be developed (Brydges, 2018; Grin et al., 2010; Maher et al., 2018; Perez, 2002; Simmie & Hart, 1999). Hence, during the first stage of the project (from cellulose to fibers), a key question that would determine the direction of the project needed to be addressed: is it relevant and achievable to create this new material and technology? It soon became clear that the question converged with another one, more impactful: is it relevant and achievable to create a new industry? Even if the raw materials and prototyping equipment come cheaply at the first stage of technological production, and the capital formation challenges necessary for accessing a market may be overcome, the TT-project will face scale-up challenges from the moment larger batches of the input material will be produced. At that crucial point, the absence of the benefits of a larger firm's infrastructure and the network advantages of being part of an industrial cluster, common to the maker movement (Doussard et al., 2018), will be suffered. While motivators as a shared purpose, collaborative learning, and the fun of discovering drive the making process, pioneering teams may turn into lone wolves when prosperous eco-innovations call for the furthering of an industry.

Conclusion

The Textile and Clothing industry is increasingly characterized by sustainable entrepreneurship and local production networks that seek innovations in order to disrupt the conventional production processes and address the environmental and societal challenges that the industry faces (Schaltegger et al., 2016). Novel and innovative design ideas for reshaping the T&C industry and its practices have been popping up as part of "our generational design challenge" (Raworth, 2017, p. 246), in which designers and other pioneers are ever more warranted the roles of problem-solvers (Hussain, 2018). Especially small, experimental practices that would scale up if successful, could make a difference (Beinhocker, 2012). The global maker movement encompasses many of those "potentially emergent manufacturers" (Doussard et al., 2018, p. 652) who, loose from a firm, cooperate and use technology (including craft methods and simple machinery) to learn and create the knowledge that could turn into an entrepreneurial solution (Browder et al., 2019). Those pioneers operating in niche markets are inventing practices and searching for new business models to introduce their innovative products to the market and eventually scale up (Schaltegger et al., 2016). When they adhere to the values of the circular economy, the search for an adequate business model becomes particularly challenging, because a transition to a radically new economic system that slows, narrows or closes resource loops, requires novel ways of value creation and distribution between the different stakeholders involved (Bocken et al., 2016; Ellen MacArthur Foundation, 2021; Ghisellini et al., 2016; Linder & Williander, 2017; Nußholz, 2017).

As an eco-innovation that seeks to integrate CE goals and values into a technological innovation with market potential, the Tomato Textile project is a learning process by an interdisciplinary team that faces several, intertwined challenges. First is the technological challenge that entails overcoming a knowledge gap and numerous decisions on trade-offs, affordable losses (Sarasvathy, 2001) and the open access to intermediate innovations. While the technology absorbs much of the attention and resources in the upfront processes of eco-innovation, the market is considered as well, with particular questions about how to achieve sustainable consumption (Tunn et al., 2019) and a circular product-service system. Even if cost leadership in a broad market is by far the aim of the TT-project, typical marketing questions about value propositions and value capturing (Manninen et al., 2018) came up, as to how the final product would be able to engage consumers who have many alternatives, and which brand/consumer segment combination would be able to succeed at the local level (in line with the Blue Economy principles). Additionally, major circular and collaborative challenges relate to how consumers will be involved in closing the loop, and to new partnerships, particularly when the eco-innovation urges B2B solutions. Fifth, the TT-project is confronted with a complex two-tier institutional environment, with on the one hand a global T&C industry that is unprepared yet to embrace radical changes, and on the other hand, a local policy climate that is supportive of a circular maker movement. Regardless of the current favourability in the environment, eco-innovation that includes making is about the "action of coordinating resources for

commercial projects under uncertainty" (cf. Browder et al., 2019, p. 2). It always runs the risk of lagging, because the velocity of the technology development is unpredictable. Governments may be willing to support eco-innovations because of their potential to catalyze a system-wide change ranging from optimal land usage to the reduction of plastic. This, however, makes the case at stake vulnerable, because as long as there is no market demand for tomato textile, it is replaceable. The last challenge is very existential and questions the purpose of the eco-innovation, which converges with the installation of a new industry. Even if the team is ambitious and strongly committed to the project, the realization that an eventual shift from a prototype to a process will propel a new industry is intimidating.

In conclusion, entrepreneurial circular eco-innovation practices imply making fast and slow decisions under uncertainty, propelled by the volatility that industries experience in terms of consumer demand, but also by environmental trends such as changes in policy and technology. Therefore, it has been suggested that innovations need experimentation, also in terms of business modeling (Antikainen & Bocken, 2019; Bocken et al., 2019; Linder & Williander, 2017), in line with the premises of the lean start-up movement (Ries, 2012). It can be expected that circular business models will emerge in convergence with the trial and error methods that characterize so many of the circular product-making practices of today. Only a critical mass of eco-innovation experiments like the TT-project will provide deeper insight into how those experiments can, at a micro-level, be eventually transferred from pilots in scale-ups (cf. Antikainen & Bocken, 2019). At the macro-level, replication is needed to scale up solutions to lead to sustainable transitions. The more the aforementioned challenges in eco-innovation will become addressed, the more it is expected that they turn into practices based on a shared understanding of how things should go (cf. Thompson et al., 2020) to move toward a Circular Economy.

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