

## Article

# Fashion Digital Transformation: Innovating Business Models toward Circular Economy and Sustainability

Chiara Colombi and Erminia D'Itria \* 

Design Department, Politecnico di Milano, 20158 Milano, Italy

\* Correspondence: erminia.ditria@polimi.it

**Abstract:** The fashion industry is at a stage of profound transformation of its operating paradigm. Because of their stakeholders' pressure, companies have begun to pursue strategic solutions that include sustainability as a guiding principle. Such strategies push for effective organizational solutions and production models that take into consideration the conservation of the planet's resources, respect for people, and the sustainability of their profits. In this context, the fashion industry is now recognizing the circular economy (CE) as the primary BM to address sustainability-related industry issues. The authors have adopted a specific technological-driven perspective that attempts to analyze today's context and map digitally driven practices in European fashion companies. These practices are emerging to support fashion organizations so that they can focus their sustainability agendas and better implement circular BMs. This perspective is consistent with the current fashion context, where digital transformation is recognized as an asset that could transform the industry into a more sustainable business. This proposed objective is realized through an iterative process of modeling data. The BMs identified here are grouped according to Bocken's eight archetypes: maximize material and energy efficiency; create value from 'waste'; substitute with renewables and natural processes; deliver functionality rather than ownership; adopt a stewardship role; encourage sufficiency; re-purpose the business for society/the environment and develop scale-up solutions. They guide the authors in modeling mechanisms and solutions that help build business innovations that work to ensure circularity. Analyzing the current best practices, this article introduces a taxonomy that highlights current approaches that lead to incremental changes toward CE through digital solutions.

**Keywords:** fashion design; circularity; sustainability; digital transformation



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## 1. Introduction

In recent years, such phenomena as the climate change crisis, exponential global population growth, and land and water shortages have been escalating. Accordingly, production processes' adverse effects on sustainability have become more relevant, particularly in the fashion industry [1]. The sector's sustainability issues make the transformation to a more sustainable economic system increasingly desirable, and the shift to a model based upon the circular economy (CE) is recognized as the leading entrepreneurial model to address sustainability-related industrial issues. To achieve this transition, companies are critical stakeholders because they can rely on more resources and capabilities [1]. In this context, innovation at the business model (BM) level is needed to align incentives and market logic to take advantage of circular solutions that can increase technological advances support to achieve sustainability [2]. In recent decades, we have witnessed various digital technologies' introduction into design, manufacturing, and sales processes, e.g., big data analytics and artificial intelligence [3]. As Bertola and Teunissen [4] discussed, the digital-driven adoption of these technologies allows for faster innovation, research into new processes, the production of new products, and subsequent business growth. What characterizes this path today is the speed at which technology is advancing, as we are witnessing a faster evolution than in the previous decade [5]. This rapid growth has led to a decrease in

these technologies' cost and availability. Consequently, iterations in different sectors and throughout the supply chain have changed [1].

These circumstances encourage a faster transformation of economic models from linear to circular through broad business innovations which elicit social changes that can meet current market needs, from producers to consumers, while ensuring that future needs can be met by reducing the consumption of resources, particularly those that are nonrenewable [6]. To achieve these goals, it is necessary to develop more environmentally friendly products and process innovations [7] that can arise from adopting new BMs [8–12]; these are facilitated by technology that generates transparent and, thus, sustainable supply chains. The development of such an ecosystem is consistent with our modern society that faces the challenges of climate change, pollution, and a lack of adequate infrastructure, and where the use of digital technologies must be extended beyond simply improving economic efficiency and competitive advantages that have a positive influence on sustainability [13,14]. While process and product innovations have often improved the adverse effects of manufacturing and service processes often, for the most part, they have failed to reach a critical mass [15]. This is changing today because of increasing interest in circularity on the part of different stakeholders, including customers, shareholders, local communities, and the government [12]. However, circularity necessitates transforming the industrial system, specifically the way companies generate value, understand, and do business. This transition requires rethinking existing business models (BM) to allow value creation and resource consumption to be decoupled [16]. Therefore, BM innovation (BMI) toward circularity is a crucial capability for companies.

In the context outlined above, the fashion industry is notorious for its high resource use and adverse environmental effects. The principal disadvantage of the existing fashion industry is that it operates according to the linear system, and even when it engages in sustainable practices, these are focused solely on the environmental dimension [17]. Certainly, improvements in the eco-efficient approach enabled by the digital medium have helped reduce energy and resource use, emissions, and waste in manufacturing processes. For example, Nayak et al. [18] described the way that using radio frequency identification (RFID) technology can reduce the amount of fashion waste products that end in landfills, which reduces carbon emissions and greenhouse gas (GHG) generation. However, these actions alone cannot offset the resource use and environmental effects associated with exponential population growth and needs.

In this scenario, sustainable BMs for the fashion industry can serve as a vehicle to coordinate technological innovations with circularity to reach sustainability. The authors adopted the definition of a sustainable BM, which, as proposed by Lüdeke-Freund, ([19], p. 15), is “... a business model that creates competitive advantage through superior customer value and contributes to the sustainable development of the company and society”. Such BMs preserve the environment and continue to improve the quality of human life as well from a perspective that examines both systems and enterprise levels. The primary challenge is precisely the design of these BMs, which must allow the company to earn a profit while they deliver a system of social and environmental benefits simultaneously [20]. While improvements in efficiency and quality may translate into profits easily, it is not simple for companies to understand the way that providing social and environmental value can translate into profit and competitive advantage. This is changing today thanks to the advent of CE models that are working to establish a system that is characterized by stricter regulation, resource supply contracts, climate change effects, and changing social pressures that are pressuring companies increasingly to identify opportunities that can gain this competitive advantage. These solutions are intended to create multiple types of value and achieve a more resource-efficient and effective economic system [21].

In this context, the authors investigated the way digital innovations can enable CE and design innovative BMs [22]. Such processes offer increased resource efficiency and effectiveness and slow and change the way that resources are exploited [23], which allows new market segments (e.g., extended life and closed-loop strategies) to be created that generate jobs and provide access to products that improve the quality of life [24–27], as well as traceability and transparency throughout the product cycle [28,29]. Circularity-oriented BMI incorporates CE principles as guidelines for designing BMs.

This paper presents a model of “digital-driven business innovation approaches” in a future circular fashion system in which innovative organizational and productive processes could nurture the industry’s transition to a circular paradigm. Section 2 provides a review of the literature considering the way digitalization supports a sustainable BM to improve the transition to a CE. The literature explores those BMs that have major positive effects on the environment and society through changes in the way the organization and its value network create, capture, and deliver value. These are suitable models related to the paper’s findings that support the development and discussion of the propositions of the research model presented. Section 3 describes the methods and materials and the technique of mapping European fashion companies’ circularity-related BMs. This part of the research was carried out through an iterative process to model the data that informed the development of the research model. The authors are aware that, in recent years, the fashion industry has introduced many digital technologies into its design, production, and sales processes [30]. Nevertheless, according to the scope of this study, the decision to focus on the European region specifically is related to different factors: (1) The fashion industry’s role in the European economy. This is an important asset for the European manufacturing industry, which employs 1.7 million people and generates a profit of 166 billion euros. The industry has undergone a radical change, which is attributable to the current economic and climate crisis, to maintain its competitiveness by shifting to alternative BMs. In addition, the European fashion industry is a leader in world markets. The European Union (EU) exports more than 30 percent of the world market, while the EU market alone is also one of the most important with respect to size, quality, and design ([https://single-market-economy.ec.europa.eu/sectors/fashion/textiles-and-clothing-industries\\_en](https://single-market-economy.ec.europa.eu/sectors/fashion/textiles-and-clothing-industries_en), accessed on 2 December 2022); (2) the European Commission’s new directives under the Green Deal program. This is a package of policy initiatives that are intended to set the EU on the path to a green transition by promoting initiatives that use digital transformation as a catalyst for a sustainable economy. They focus on the development of a digitally driven transition in infrastructure which is needed to decarbonize European economies [31]; (3) the pool of knowledge and experience of the research group in which the authors are members is based upon academic studies, teaching, networks, projects, and other research and practices that team members in the field of fashion design and circularity have carried out. Section 4 reports the results and discusses the analysis of the current industry BM that embeds circularity through the digital medium. The model describes the way companies transform their conceptual framework by investing in technologies that allow faster innovation and search for new products, processes, methods of communication, and business growth. Here, the sustainable BM archetypes [16] were adopted and adapted to group the mechanisms and solutions that have been identified to help build the circular BM. Sections 4.1–4.8 discuss the eight archetypes in detail to provide a unified framework that combines the themes identified in the circularity under the umbrella topic of BMI. These archetypes represent the underlying mechanisms through which circularity is delivered in the BM. Section 5 concludes the paper by explaining the way the presented model creates opportunities for research to understand the way organizations can design new legitimation strategies to adopt circular technology solutions and the business changes they bring effectively. It also reports the limitations and prospects of the research.

## 2. Literature Review

An initial review of the literature was conducted to build the study's theoretical framework. The objective was to define the concepts of BMs and digital innovation in the CE to understand the framework in which an organization creates, captures, and delivers value in a circular economic system through product or business process innovations that rely on digital components for their development or implementation. This made it possible to define a model that was suitable for the results of this study and, subsequently, to form the propositions of the research model designed.

In this phase, information was collected from Scopus, Science Direct, and Google Scholar. These databases functioned to guarantee extensive coverage of the topic. The authors included scientific articles, papers, conference proceedings, and book chapters. A preliminary exploration illustrated the way digital and circular BMI were the two critical determinants of a CE [32]. The objective was to examine the present state-of-the-art; the study covers a time horizon of 10 years, 2012–2022. Identifying keywords proved challenging because the topics studied involved interdisciplinary fields in which business, management, and engineering predominated. As a result of this initial phase, six keywords were identified and researched: Fashion industry, Sustainability, Circular economy, Digital innovation, and Business model innovation. From those six keyword equations, 1681 documents were identified. The research was applied to titles, abstracts, and keywords for Scopus and Science Direct and to “any type” for Google Scholar. The filtering process required several steps to code the reference literature, which was found to be extensive and mixed across disciplines. The titles and abstracts were checked first. This allowed publications unrelated to the study of creating circular BMs in the fashion industry through digital innovations to be excluded. Then, duplicates were checked and removed, after which 20 publications remained. Next, a complete reading was carried out, which allowed for the identification of such inclusion and exclusion criteria as (1) the date of publication—only articles published in the last ten years; (2) the language of publication—only articles in English; (3) the study design: qualitative and quantitative studies, and (4) outcomes—articles that included frameworks and guidelines that could support the investigation of current digital-driven approaches to incremental changes towards CE. The first reading showed that nearly all articles were related to business and management. The authors decided to include only those articles that presented general discussions but were highly relevant to the purpose of the study and began to code the models that were illustrated to draft their framework. The second round of reading was performed by selecting only those publications that further supported certain models identified previously. This final selection reduced the sample to 11 publications.

The process of reviewing the literature presented here is reported in Table 1.

The initial systematic review supported the raw structure of the study model. It informed knowledge on the way adopting the archetype model that Bocken et al. [16] developed could meet the modern BM design criteria to shift the fashion industry to digital circular fashion. It refers to the dual role of digital innovations as critical enablers and triggers for circular BMs. As Ranta et al. [33] discussed, this translates into adapting digital technologies to circular BMs and, simultaneously, changing BMs according to the most suitable technological functions. This reference, which emerged from the scientific literature, showed the way the development of strategic planning models—such as the one proposed in this article—synthesizes the way digital technologies catalyze innovation in the BMs designed for circularity by creating value, beginning with the identification of technology types, and allowing the further analysis of their usefulness when businesses implemented them to allow circular systems that created value with the goal of sustainability.

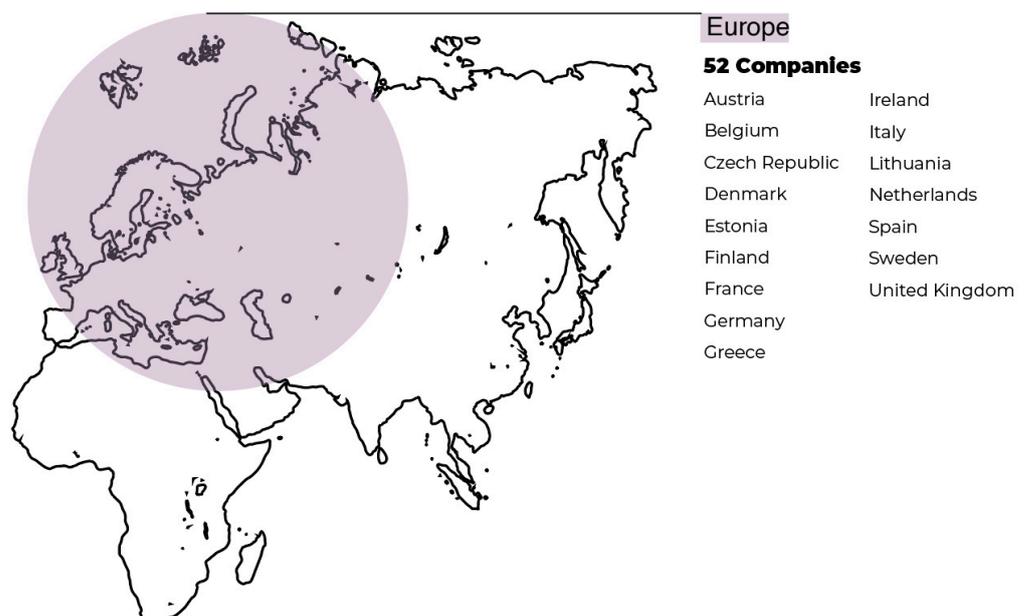
Table 1. Full texts final selection.

Document Included (Typology)				Scientific Articles, Papers, Conference Proceedings, Book Chapters		
Time Horizon				2012–2022		
Keywords				Fashion Industry, Sustainability, Circular Economy, Digital Innovation, Business Model Innovation		
Search Applied to Titles, Abstract, and Keywords				Scopus → 2 references Science Direct → 679 references Google Scholar → 1000 references		
Screening of Titles and Abstract				20 references, excluding publications unrelated to the study		
Full Text Analysis and Final Selection				11 references, selecting only publications that supports some of the identified practices further		
Title	Type	Source	Year	Business Model Innovation	Circular Economy	Digital Innovation
Business model innovation for circular economy and sustainability: A review of approaches	Scientific article	Science Direct	2019	✓	✓	
Enabling circular business models in the fashion industry: The role of digital innovation. <i>International Journal of Productivity and Performance Management</i> .	Scientific article	Google Scholar	2021	✓	✓	✓
Sustainability benefits of RFID technology in Vietnamese fashion supply chain.	Scientific article	Science Direct	2022			✓
Enablers, levers and benefits of circular economy in the electrical and electronic equipment supply chain: A literature review.	Scientific article	Science Direct	2021		✓	✓
Business model transformation toward sustainability: The impact of legitimation	Scientific article	Google Scholar	2020	✓		
Sustainable business model innovation: A review	Scientific article	Science Direct	2018	✓		
A literature and practice review to develop sustainable BM archetypes	Scientific article	Science Direct	2013	✓		
How digitalization supports a sustainable business model: A literature review	Scientific article	Science Direct	2022	✓		✓
Sustainable design and business models in textile and fashion industry	Book Chapter	Google Scholar	2017	✓		
Fashion 4.0. Innovating fashion industry through digital transformation	Scientific article	Google Scholar	2018			✓
Digital technologies catalyzing business model innovation for circular economy—Multiple case study	Scientific article	Google Scholar	2021	✓	✓	✓

### 3. Materials and Methods

The data were collected from the knowledge reservoir produced by the Fashion in Process Research Lab. of the Politecnico di Milano. Specifically, the data were collected during the authors' participation in four international field studies that involved a consortium of academic and European research institutions and private companies [34–37] and from the results of one of the authors' doctoral research projects [38]. Methodologically, the research approach consisted of three primary stages to build knowledge: the first step consisted of desk research on the current digital-driven BMs in the fashion field to map the present circular practices among European companies and ways in which to identify the best practices; the second consisted of an in-depth qualitative analysis of the best practices identified, and the last combined all of the data and filtered them through the lens of Bocken's et al. [16] archetype model which outlines directions to implement sustainability through digitalization.

The first phase of the research focused on mapping European fashion companies' digital-related practices that permit circularity. The initial phase of desk research and the literature review investigated academic and practice-based databases that covered the period from 2011 to 2023. The specific time frame was chosen because the German government developed a plan to renew the country's manufacturing system in 2011 to support its competitiveness by harnessing digital technologies' potential. Then, that was followed by many other initiatives in Europe and around the world that pursued the goal of strengthening the beneficial effects of the digital component [5]. The mapping led to the identification of 52 companies located in 16 nations on the European continent that distinguished themselves by having reached a mature level of adoption of digital technologies in the circular BMI to narrow, slow, and close resource flows (Figure 1). This indicates that they are acting in the management and technological aspects. Further, the findings that emerged from the research demonstrated the commitment these companies exhibit in meeting their stakeholders' new sustainability demands proactively, the way they pursue the strategic implementation of circular practices within their system by adopting a digital-driven approach that generates ideas that are humanly desirable, technologically feasible, and financially viable, makes it possible to implement their organizational solutions at scale. The size composition was heterogeneous and consistent with the continent's industrial development trends, and most of these companies were micro or small and medium-sized enterprises (SMEs) [39].



**Figure 1.** Companies map.

Of the 52 companies mapped (Table 2), 14 European initiatives were selected as case studies for further investigation (Table 3). The decision to focus on the European region was based upon geographic proximity and past collaborative experiences with local companies. The cases that were presented distinguished themselves through the way they adopted innovative BM approaches that were consistent with CE principles through digital solutions. These companies met the criteria used to select and categorize the different cases to reconstruct the model of the eight digital-driven circular BM archetypes that the authors proposed. The definition of the cases was based on a methodological framework that highlighted the similarities and differences and the constant comparison of these exemplary types, together with the comparison between low-level codes (company-specific innovations and initiatives) and higher-level codes (for details, see Bocken et al. 2014 [16]). Such a framework is consistent with the qualitative case study approach that was adopted [40]. Such an approach allowed the transformation of BMs through digital media in the context of the fashion system to be investigated and relied on a variety of sources and data. The variety of sources (company reports, scientific papers, specialized press, and government publications) allowed the object of our study to be explored with a holistic perspective on the eight archetypes, which was able to highlight the different characteristics of the models analyzed and understand them so that they could be coded. Specifically, this involved multiple case studies that were examined to understand the similarities and differences between them to predict similar results [41]. Such an approach made it possible to break down the fashion system's complex context and its transition to circularity into simple steps and to analyze the way companies addressed these challenges in their own internal system, as well as in the wider context of their industry. For this article, the case study method offered an excellent opportunity to collect data from a variety of sources, code them, and gain case-specific insights.

**Table 2.** List of the companies mapped.

Country	Sector	Name	Description	Large	Medium	Small	Micro
Austria	Materials/Fibers Innovation	<b>Vienna Textile Lab</b>	<i>Producing textile dyes using naturally occurring bacteria.</i>				✓
Austria	Materials/Fibers Innovation	<b>Lenzing</b>	<i>Major production of all three man-made cellulose fiber generations, from viscose to lyocell and modal. Developed in a closed loop. Resortecs leads the circular transition in fashion with heat-dissolvable stitching threads and thermal disassembly systems.</i>	✓			
Belgium	Process Innovation	<b>Resortecs</b>	<i>Through targeted innovations in the way clothes are assembled and disassembled, their solutions allow fashion and workwear brands to rise to meet today's environmental challenges.</i>				✓
Belgium	Business model transformation	<b>Ebuu</b>	<i>Childrenswear rental and e-shop with natural cosmetics.</i>				✓
Belgium	Materials/Fibers Innovation	<b>Centexbel</b>	<i>Technology Center for research and innovation in textiles and plastics focused on profitable and sustainable solutions—biobased, solvent-free</i>		✓		
Czech Republic	Textile/Clothing	<b>Bohempia</b>	<i>Sneakers, clothing, and accessories are made of hemp. Environmental and social sustainability at the core of business philosophy</i>				✓

Table 2. Cont.

Country	Sector	Name	Description	Large	Medium	Small	Micro
Czech Republic	Process Innovation	<b>Ofform3D</b>	OFFORM3D is the first PhyGital Fashion Hub in Prague that identified the intersection of technology and fashion according to the idea that designers no longer need fabric, pins, scissors, and paper to design a garment.				✓
Denmark	Fashion Practices	<b>Manufacture Copenhagen</b>	<i>Manufacture Copenhagen is a lab that began with the design concept to create a Nordic community that was focused on sustainable design practices.</i>				✓
Denmark	Organizational and BMI	<b>Son of a tailor</b>	Son of a Tailor is a Copenhagen-based fashion-tech company that offers custom fit essentials for men, with a proprietary algorithm that requires just height, weight, age, and shoe size to achieve a perfect fit.		✓		
Denmark	Business model transformation	<b>GANNI</b>	Ganni is a contemporary ready-to-wear fashion brand for women.	v			
Denmark	Organizational innovation	<b>Chare</b>	<i>Grassroots clothing sharing scheme.</i>				✓
Estonia	Organizational innovation	<b>UPMADE®</b>	UPMADE® software (UPMADE®, Tallin, Estonia) gives brands and manufacturers a holistic and transparent view of their material flow so that they can make the most of what they have already. It allows brands to create upcycled products easily and quickly.			✓	
Estonia	Business model transformation	<b>Reverse Resources</b>	<i>Reverse Resources (RR) offers a sustainable solution to the textile waste management problem by developing an online marketplace.</i>			✓	
Finland	Materials/Fibers Innovation	<b>The Infinited Fiber Company</b>	<i>This turns textile, cardboard, and agricultural waste into a new natural fiber, thereby reducing the use of virgin materials.</i>			✓	
Finland	Materials/Fibers Innovation	<b>Spinnova</b>	<i>This represents a disruptive ecological innovation that turns cellulose and waste streams into textile fiber simply without dissolving any harmful chemicals.</i> <i>Spinnova developed the most sustainable fiber in the world.</i>			✓	
Finland	Organizational innovation	<b>Emmy</b>	<i>An online platform that allows customers to sell their high-end clothing to other customers.</i> <i>The C2C business collects clothes, takes photos, and places them online.</i>				✓
Finland	Materials/Fibers Innovation	<b>Pure Waste</b>	<i>A company that uses textile waste and other valueless materials (such as a focus on cotton) and recycles them into new products. Offers other companies the co-branding of the Pure Waste logo as a certificate of ecology and quality.</i>			✓	

Table 2. Cont.

Country	Sector	Name	Description	Large	Medium	Small	Micro
Finland	Organizational innovation	<b>Pumpa Upcycle</b>	Rather than being thrown away and burnt, Pumpa Design Oy receives useless textiles and upcycles them into new products: dog/cat beds, grocery bags, bags, and pouches in different sizes.			✓	
France	Organizational innovation	<b>Kering</b>	Kering S.A. is an international luxury goods group. As a responsible luxury group, Kering has made sustainability an ethical necessity as well as a determinant of its business strategy.	✓			
France	Organizational innovation	<b>Vestiaire Collective</b>	<i>Vestiaire Collective is the leading global online marketplace for desirable pre-loved fashion. They are major players in collecting, sorting, and recycling used textiles throughout Europe.</i>	✓			
Germany	Materials/Fibers Innovation	<b>Texaid</b>	<i>EU-wide—Austria, Bulgaria, Germany, Hungary (branches); Switzerland (headquarters).</i>	✓			
Germany	Materials/Fibers Innovation	<b>Adidas</b>	Adidas is a German multinational company based in Herzogenaurach. Adidas produces footwear, clothing, and other sporting goods for professional, amateur, and leisure activities.	✓			
Germany	Organizational innovation	<b>The Textile Prototyping Lab</b>	<i>An advanced prototyping lab for textiles supported by the German Ministry for Science and Education/futuretex.</i>				✓
Germany	Materials/Fibers Innovation	<b>Algaelife</b>	<i>Algaelife formulates eco-positive, scalable solutions to manufacture fibers and dye fabrics.</i>				✓
Germany	Organizational innovation	<b>I:CO</b>	<i>Solutions and innovation in the collection, reuse, and recycling of clothing and shoes. The Making Lab in Athens focuses on textiles processing (primarily wet processing, i.e., dyeing and finishing), with the goal of providing functional properties to textile substrates and/or increasing the sustainability of production.</i>	✓			
Greece	Materials/Fibers Innovation	<b>Athens Making Lab</b>	<i>A community and online clothes-sharing platform.</i>		✓		
Ireland	Business model transformation	<b>Nu Wardrobe</b>	<i>A digital collective specializing in photo-real 3D fashion design and animation. Their software allows the first digital twin of a product to be created.</i>				✓
Italy	Process Innovation	<b>TWIN:ONE</b>	<i>With TwinOne, brands can create the content they need to display a product virtually and benefit from its photorealistic quality, unprecedented speed, and zero environmental impact.</i>				✓
Italy	Organizational innovation	<b>WRAD</b>	<i>A sustainable fashion brand that is challenging the status quo through sustainable innovation and social change.</i>				✓

Table 2. Cont.

Country	Sector	Name	Description	Large	Medium	Small	Micro
Italy	Materials/Fibers and Process Innovation	ACBC	ACBC is a BCORP leader in applied sustainability within the fashion industry and serves more than 40+ global footwear and accessories premium brands already.			✓	
Italy	Clothing	Stella Jean	Stella Jean is an Italian designer of Haitian origin. Her work focuses on a standard of sustainability and multiculturalism that can be applied to the fashion industry.				✓
Italy	Process Innovation	Rayonvert	Rayon Vert's goal is to produce clothes and technical accessories defined by an aesthetic, gorpcore-urban, following a different, liquid, and light model in the form of Open Manufacture.				✓
Italy	Organizational innovation	Aura	In April 2021, international leaders of the luxury industry jointly created the Aura Blockchain Consortium, which promotes the use of a single global blockchain solution that is open to all luxury brands worldwide to provide consumers with additional transparency and traceability.	✓			
Italy	Textile/Clothing	Calzedonia	Calzedonia is an Italian company that owns seven brands linked to the clothing sector, which are marketed in single-brand shops in fifty-five countries.	✓			
Italy	Business model transformation	Dress you Can	An innovative SME that focuses on renting fashion products to increase sustainable purchasing choices.				✓
Italy	Business model transformation	YNAP	Yoox Net-A-Porter Group S.p.A. is an Italian company active in the online sales of fashion, luxury, and design goods.	✓			
Lithuania	Business model transformation	Vinted	Vinted is an online sales site based in Lithuania on which new or second-hand items, largely clothing, and accessories, can be bought, sold, and exchanged.	✓			
Luxembourg	Textile/Clothing	Benu Couture	Collects old clothes, changes (upcycles) them, and thus creates modern clothes again in series, which are produced and sold locally (Founded by Georges Kieffer)				✓
The Netherland	Business model transformation and Process Innovation	Dutch aweaness	<i>A 'circular chain manager' for the textile industry uses their track and trace system to locate garments and ensure that those that are no longer worn are returned and recycled in a CE.</i>				✓
The Netherland	Business model transformation	MUD jeans	<i>Lease or buy options to recycle and resell one's own products.</i>			✓	
The Netherland	Process Innovation	The Fabricant	<i>Digital fashion house—a league of designers who specialize in photo-real 3D fashion design and animation.</i>				✓
The Netherland	Business model transformation	LENA	<i>They develop fashion editorials, digital clothing, and occasional collections, available as a service for fashion brands and designers.</i>				✓
The Netherland	Business model transformation	LENA	<i>A clothing library that allows users to borrow vintage items with a monthly subscription.</i>				✓

Table 2. Cont.

Country	Sector	Name	Description	Large	Medium	Small	Micro
The Netherlands	Process Innovation	<b>Textiel Recycling (VHT)</b>	<i>A network for textile sorters and charitable and commercial collectors that represents more than 90% of businesses in the Dutch textile recycling industry.</i>				✓
The Netherlands	Process Innovation	<b>Boer Group Recycling Solutions</b>	<i>Founded by the Boer Group in 2015 to support promising research projects on innovative textile recycling methods.</i> Ecoalf is a sustainable and ethical fashion brand that intends to reduce the fashion industry's adverse effects and the use of the planet's natural resources. By integrating breakthrough technology, ECOALF creates clothing and accessories made entirely from recycled materials.	✓			
Spain	Textile/Clothing	<b>Ecoalf</b>	<i>The Clothing library allows users to borrow high-end brands and emerging designer items from their online selection.</i>		✓		
Sweden	Business model transformation	<b>Curatorz</b>	<i>Clothing library—users can rent designer dresses for special occasions and rent out dresses they no longer wear.</i>			✓	
Sweden	Business model transformation	<b>The Wow Closet</b>	<i>Blockchain-powered transparency and traceability technology for the fashion industry. NB: owned by Houdini's CEO.</i>			✓	✓
Sweden	Materials/Fibers Innovation	<b>Renewcell</b>	<i>Renewcell is an award-winning textile-to-textile recycling company based in Sweden.</i>		✓		
UK	Materials/Fibers Innovation	<b>Worn Again Technologies</b>	<i>PET into textiles—pioneering polymer recycling technology.</i>				✓
UK	Organizational Innovation	<b>Unmade</b>	<i>A fashion technology business with specialized software for mass customization of knitwear and prints.</i>			✓	
UK	Business model innovation	<b>DePop</b>	<i>Depop is a peer-to-peer (P2P) social e-commerce company based in London.</i>	✓			

This paper's contribution is precisely in re-coding the higher-level codes from the original perspective of the study: innovations at the level of raw materials, sustainable processes, and alternative forms of consumption. These three macro areas have been defined according to the CE framework, which discusses the way innovation occurs by maintaining materials in the loop at their highest value, designing and making products that can be reused, as well as considering the way people use products by shifting the focus from ownership to performance [39].

The next section illustrates these cases and their key features for each archetype by using them as examples that support the circular practices of each archetype in the model proposed. The authors acknowledge that these cases should not be considered exhaustive but only representative of the main types of each archetype's circular BM (CBM) and their design elements. Therefore, the use of these real-world examples was studied, and their function was extrapolated to represent the archetypes and CBMs.

Table 3. List of the case studies.

Country	Sector	Name	Description	Large	Medium	Small	Micro
Denmark	Organizational and BMI	<b>Son of a tailor</b>	Son of a Tailor is a Copenhagen-based fashion-tech company that offer custom fit essentials for men, with a proprietary algorithm that requires just height, weight, age, and shoe size to create a perfect fit.		✓		
Denmark	Business model transformation	<b>GANNI</b>	Ganni is a contemporary ready-to-wear fashion brand for women.	✓			
Estonia	Business model transformation	<b>Reverse Resources</b>	<i>Reverse Resources (RR) offers a sustainable solution to the textile waste management problem through the development of an online marketplace.</i>			✓	
France	Organizational innovation	<b>Kering</b>	Kering S.A. is an international luxury goods group. As a responsible luxury group, Kering has made sustainability an ethical necessity as well as a determinant of its business strategy.	✓			
France	Organizational innovation	<b>Vestiaire Collective</b>	<i>Vestiaire Collective is the leading global online marketplace for desirable pre-loved fashion.</i>	✓			
Germany	Materials/Fibers Innovation	<b>Adidas</b>	Adidas is a German multinational company based in Herzogenaurach. Adidas produces footwear, clothing, and other sporting goods for professional, amateur, and leisure activities.	✓			
Germany	Materials/Fibers Innovation	<b>Algaelife</b>	<i>Algaelife formulates eco-positive, scalable solutions for manufacturing fibers and dyeing fabrics.</i>				✓
Italy	Process Innovation	<b>TWIN:ONE</b>	A digital collective specialized in photo-real 3D fashion design and animation. Their software allowed the first digital twin of a product to be created. With TwinOne, brands can create the content they need to display a product virtually and benefit from photorealistic quality, unprecedented speed, and zero environmental impact.				✓
Italy	Clothing	<b>Stella Jean</b>	Stella Jean is an Italian designer of Haitian origin. Her work focuses on a standard of sustainability and multiculturalism applied to the fashion industry.				✓
Italy	Organizational innovation	<b>Aura</b>	In April 2021, international leaders of the luxury industry jointly created the Aura Blockchain Consortium, which promotes the use of a single global blockchain solution that is open to all luxury brands worldwide to provide consumers with additional transparency and traceability.	✓			
Italy	Textile/Clothing	<b>Calzedonia</b>	Calzedonia is an Italian company that owns seven brands linked to the clothing sector and is marketed in single-brand shops in fifty-five countries.	✓			
Italy	Business model transformation	<b>Dress you Can</b>	Innovative SMEs focus on renting fashion products to increase sustainable purchasing choices.				✓
Lithuania	Business model transformation	<b>Vinted</b>	Vinted is an online sales site based in Lithuania for the buying, selling, and exchanging of new or second-hand items, largely clothing, and accessories.	✓			
UK	Business model innovation	<b>DePop</b>	Depop is a P2P social e-commerce company based in London.	✓			

#### 4. Modelling Digital-Driven Circular Business Innovation Approaches

This section illustrates the archetypes of digital-driven CBMs identified in this paper (Table 4).

**Table 4.** Sustainable BM archetypes (adapted from Bocken et al., 2014, pp. 48–54 [16]).

4.0 Components	Dominant Area of Innovation	BM Archetype	Value Proposition	Value Creation and Delivery	Value Capture
Smart products	Raw materials	Creating value from waste	Eliminating waste by turning waste into input for other production	Recycling waste, closing resource loops, and making use of under-used capacities	Cost reductions from reusing materials, and reducing waste and the use of virgin material
		Maximizing material and energy efficiency	Products and services that use fewer resources to reduce waste, emissions, and pollution	More efficient production processes that use fewer resources and reduce waste	Cost reduction from optimal use of resources, and reduction in waste and adverse environmental impacts
Smart factories	Sustainable processes	Substitution with renewable resources and natural processes	Products based upon renewable resources and natural processes	Innovative production processes based upon renewable resources, energy, and natural systems	Revenues from new products and the reduction in environmental impacts attributable to the use of non-renewable resources
		Re-purposing the business for society/the environment	Prioritizing social and environmental benefits over economic profit	The development of products and services with the local community as the stakeholders promoting participation and integration	Environmental and social benefits from locally embedded enterprises
		Development of scale-up solutions	The large scale delivery of sustainable solutions	Development of channels and partnerships for scale-up solutions	Revenues for upscaling (e.g., franchising, licensing fees) and benefits from partnerships
		Delivery of functionality, rather than ownership	Shift from selling physical products to consumers and providing services for them	The redesign and delivery of product/service offerings based upon reuse, reparability, and upgradability	Revenue to provide services and increased access for consumers
Smart networks	Alternatives to consumption	Adoption of stewardship role	Products and services that ensure stakeholders' long term well-being	Production and supply systems that deliver environmental and social benefits	Revenues from stewardship and benefits of the stakeholders' well-being
		Encouragement of sufficiency	Products and services intended to reduce consumption and production	Promotion of less consumption and less waste and more durable products	Revenues from durable products and environmental and social benefits from reused and reduced consumption

The authors began by reading the model that Bertola and Taunissen proposed of the 4.0 components (smart networks, smart products, and smart factories) and principles (decentralization, modularity, interoperability, real-time capabilities, virtualization, and

service orientation) within fashion business units [5]. The three areas of paradigmatic change that are proposed here represent the model's upper level and identify the frame of the authors' analysis and work. Thus, beginning with the model's framework, the authors continued to categorize the main areas of innovation determined by paradigmatic changes in which the most interesting and incisive phenomena of the sector's transformation were taking place in order to reinterpret and define the sustainable BM archetypes that digital transformation allows. To achieve this, the authors used the same coding method that Bocken et al. [16] proposed and based this upon Corbin and Strauss's work [42,43]. This method uses constant comparisons between the three different dimensions of the model to allow the themes and categorizations to be analyzed and generated through the emergence of similarities and differences that are precise and consistent:

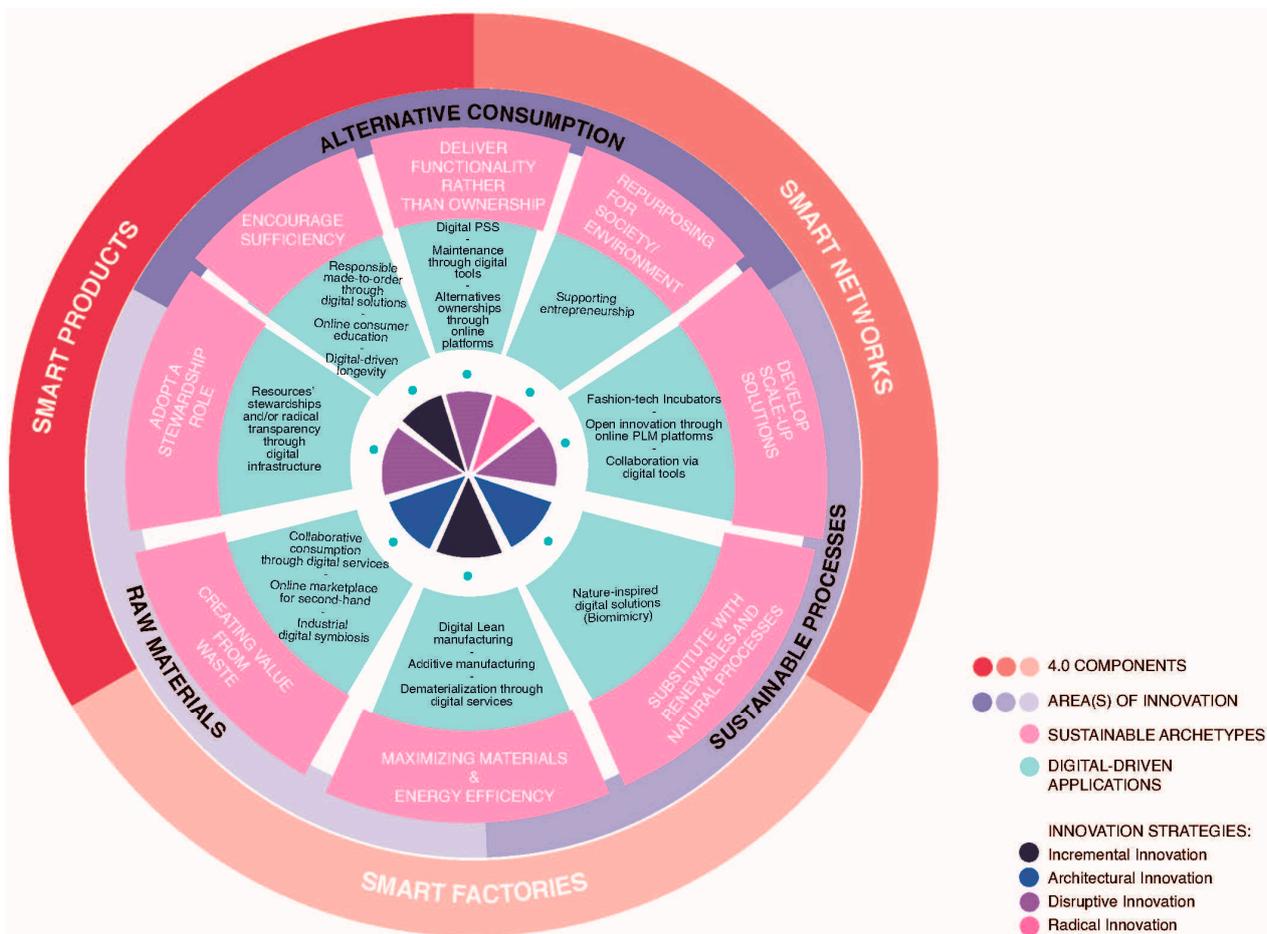
- The higher-level categorization defined the macro areas that emerged from Bertola and Taunissen's model, which introduced the main paradigmatic changes that have led the fashion system to adopt the concept of Industry 4.0, which is understood as the combination of smart factories where the physical and digital environments converge; smart networks that allow interaction, co-working, and knowledge exchange, which are permitted by digital manufacturing, and smart products that connect the physical and digital dimensions in a cyber-physical system and allow the industrial ecosystem represented by the company, users, and social environment to be reconsidered completely
- The medium-level categorization groups the different areas that emerged from the literature, where the groundwork is being laid for the fashion system's potential transition to a new circular age through BMI: raw materials; sustainable processes, and alternative forms of consumption. The materials grouping includes archetypes with a dominant component of material-driven innovations (e.g., redesign of sourcing and the concept of "new" materials), the grouping of processes includes archetypes with a dominant component of process innovation (e.g., redesign of production practices and products), while the archetypes in the alternative consumption grouping have a dominant component of organizational innovation (e.g., products that offer consumers with innovative solutions that support a change in their consumption behavior/habits.)
- The lower-level categorization reports the archetypes that are identified and present examples on which they can rely on the specific practices that companies carry out according to both the literature and industry.

As part of this process, the authors conducted a joint discussion to understand the reasoning behind these categorizations. This allowed an iterative process that resulted in the final categorization of circular BMs' design-driven archetypes. Table 4 shows the results of the coding exercise that was carried out to develop the archetypes.

However, compared to Bocken et al.'s model [16], the one proposed herein shows an overlap between the higher-level, 4.0 components and the lower level of the archetypes. In fact, from the development of the iterative process presented here, the way the three archetypes serve strategically as the bridging element between the different 4.0 paradigms emerged (Figure 2):

- Delivering functionality rather than ownership is the bridge between smart products and smart networks. This archetype is shifting in the concept of the product's performance. It involves imagining services that meet the users' needs by offering alternatives to possess an object. Companies that fall into this category operate between these two components of Industry 4.0 by adopting digital solutions to engage end-users with new BMs that feature new forms of ownership.
- The substitution with renewable and natural processes connects smart networks and smart factories. This archetype addresses growth limits that are associated with non-renewable resources that feed current production systems. Companies in this area are working to replace the current models with circular sourcing and create intelligent networks that use the digital component to build sustainable supply chains that offer new synergies and industrial ecosystems which are able to reshape the very concept of a factory.

- Creating value from waste links smart factories and smart products. This archetype acts on the management of waste streams to maximize their value. Companies that work in this category shift their focus from developing their products to creating new infrastructure systems for digitally enabled intelligent production; this can minimize waste and works on the concept of secondary raw material.



**Figure 2.** Sustainable BM archetypes (adapted from Bertola and Teunissen, 2018, p. 357; Bocken et al., 2014, pp. 48–54 [16]).

Moreover, as this work explores the concept of design-driven innovation, which each of these archetypes produces, the last level of the model lists the related types of innovations in the framework that Reed Kennedy [44] proposed and considers market and technological interdependence:

- Incremental innovation is the continuous improvement of existing products or services to provide more value to an existing market.
- Architectural innovation modifies existing solutions for an entirely new market.
- Disruptive innovation is the creation of new technologies and products that serve an existing market.
- Radical innovation is a technological breakthrough that transforms industries and often creates new markets.

Each of the eight archetypes is discussed in detail in the following sections. A total of 15 case studies are presented for the categories proposed. These cases are emblematic of the themes that represent approaching BMI from a digital-driven perspective. These companies promote innovative models that support the development and adoption of circular practices to achieve the fashion system's sustainability.

#### 4.1. *Creating Value from Waste*

“The concept of ‘waste’ is eliminated by turning waste streams into a useful and valuable input to other products and making better use of underused capacity” ([16], p. 9).

Companies in this category shift from developing individual technologies to creating new systems [44]. They operate according to different models that use the following digital-driven applications: collaborative consumption through digital services, online marketplaces for second-hand products, and industrial digital symbiosis. Companies such as Vestiaire Collective, DePop, and Vinted are working to improve collaborative consumption by allowing sharing practices [45]. Further, they are working to develop an online marketplace model to capitalize on bringing second-hand clothing back into the market to create a circular system. They are now pursuing actions to reduce fashion waste significantly by reconsidering the very concept of “new” and allowing customers to buy and sell secondhand fashion items instead. They are exploiting the power of digital technologies to recontextualize the concept of new when applied to unused clothing. Providing these products to new customers increases the number of uses and gives existing products a second, third, or even fourth life. On the other hand, Reverse Resources focus on exploiting the circular possibilities offered by adopting industrial symbiosis practices for a win-win BM of remanufacturing—integrating pre-consumer waste into the same production. This specific case highlights the way the digital medium can support a circular transformation in the fashion sector. Focusing on providing reliable data from factories, their goal is to facilitate the virtual traceability of resources and digital interconnections throughout supply chains. Reverse Resources is a tracking and trading platform for textile waste that works to implement transparency in the global waste flows. They intend to overcome the problem of blocked access to waste, incomplete waste data, and inflated prices attributable to current waste handling and trading practices. To do so, the company established a large global network of critical stakeholders. This network allows them to match supply and demand, break down market barriers, shorten supply chains, and thereby increase value along the way. They can reduce the cost of textile-to-textile recycling and support the scale-up of the CE by describing an alternative pricing scheme that could offer excellent economic incentives for suppliers to open up their data digitally. Adopting such a BM could be crucial in building an effective CE and supporting the many digital solutions offered by the industry 4.0 globally, for example, enabling blockchain-based transparency.

#### 4.2. *Maximizing Material and Energy Efficiency*

“Do more with fewer resources, generating less waste, emissions, and pollution” ([16], p. 8).

These companies work to innovate their BMs by embedding different digital-driven solutions to change the way they conduct business and extend beyond processes and products [46]. They nurture innovations that reduce adverse environmental effects significantly by changing the way the organization and its value network operate with resources. The digital-driven applications that emerged in this category included digital lean manufacturing, additive manufacturing, and de-materialization through digital services. The Italian company Calzedonia, which operates in the hosiery and swimwear sector, innovated their model by adopting a digital solution to lean their manufacturing. By adopting the lean manufacturing software that Lectra Italy, a world leader in the production of technology solutions, designed and distributed, they performed a constant improvement within the production chain to increase safety, work quality, and consequently, workers’ behavior and productivity. At the same time, costs were reduced and optimized, and waste was virtually eliminated. Maximizing material and energy efficiency is coherent with the key principles of lean manufacturing applied in the fashion sector [47]. Inefficiency can be avoided much more easily with technological devices. Thanks to digitization, it is possible to monitor an incredible amount of data constantly, which, if interpreted in the best possible way, can serve not only to identify any waste and faulty production processes in real time but also to engage immediately in the actions intended to solve problems. Companies such as Adidas rely on additive manufacturing solutions to shift their business-as-usual model toward

circularity. The digital medium allows these companies—particularly those in the footwear business—to change the way their products are made radically. For example, Adidas has been developing its Futurecraft project, a new, fully automated digital shoe construction process. At the same time, the brand is collaborating with Carbon, an American 3D printing technology company, to develop a novel 4D latex midsole technology. Combining the knowledge of these two projects resulted in the 4DFWD shoe being produced. The innovative characteristic of this product’s manufacturing process is that data collected on athletes are processed through Carbon’s digital light synthesis technology to produce high-precision 3D-printed midsoles. The 4DFWD shoe is the first in the world to offer the ability to fine-tune midsoles to specific movement patterns so that athletes can benefit from the most accurate performance with every step. This innovation could pave the road for disruptive models that allow different concepts, such as a one-size-fits-all, build-for-inventory, and planned obsolescence, to be altered radically. Such a scenario could also support the development of an alternative way to conduct business that minimizes resource exploitation by performing a dynamic upgrade of fashion products, such as clothing repair, reconfiguration, and design personalization. These could become feasible and accessible to everyone through additive manufacturing. Another example of maximizing material and energy efficiency is through dematerialization. TwinOne is an Italian-based company that developed an adaptable and user-friendly real-time rendering software for product design and marketing. Their software can provide realistic images and videos quickly, and it easily produces high-quality visual content on a large scale as well. This is a powerful strategy that many manufacturers are now pursuing to improve their triple-bottom line and reduce their reliance on physical resources (Planet-People-Profit) [48].

#### 4.3. *Substituting with Renewables and Natural Processes*

“Reduce environmental impacts and increase business resilience by addressing resource constraints ‘limits to growth’ associated with non-renewable resources and current production systems” ([16], p. 10).

The third archetype refers to companies that seize opportunities that the ever-changing economy presents as a transition to sustainability [49]. They work to substitute current models with circular, renewable, and natural processes sourcing to achieve sustainable supply chains by taking advantage of the digital components available. Companies, particularly textiles, reconsider their model by applying biomimicry through nature-inspired digital solutions. They emulate natural models, systems, and elements to solve complex business problems [50]. Investing in applying biological technologies to fashion is a way to differentiate themselves in the market and disrupt their BM by adopting innovative and hyper-sustainable practices [51]. Biomimicry can innovate the business system and, at the same time, safeguard the environment and consumer health. An example of this is the German-Israeli company, Algalife. This start-up has used zero-waste technology to create textiles and colors from algae. Only water and sunlight are needed to create these fabrics and reduce energy use and pollution significantly. As these algae are invasive, the harvesting action that is carried out also balances the ecosystem where they grow. Further, the algae fabric has been developed to preserve the plant’s inherent characteristics, nourish the skin while consumers wear it, and eliminate all chemicals and allergens from the colors completely. According to this archetype, companies that innovate their BMs promote better energy use by offering less energy-intensive products and services by developing technologies—electronic tools and devices—that promote source reduction compared to conventional products [52].

#### 4.4. *Developing Scale-Up Solutions*

“Delivering sustainable solutions at a large scale to maximize benefits for society and the environment” ([16], p. 13).

These companies embed digital technologies to promote sustainable open innovation and create shared value. They operate according to the modern European paradigm of

green transition [31] that recognizes sustainable and digital transition as interdependent. Such companies adopt approaches that can foster innovation and collaboration within the fashion and technology sectors. They use the following digital-driven applications: fashion-tech incubators, open innovation through online PLM platforms, and collaboration via digital tools. This category describes a growing network of fashion-tech startups, SMEs, incubators, accelerators, and investors. These actors collaborate to disseminate knowledge and increase the best practices for other fashion-tech communities. Open-source platforms are a tangible expression of this thriving ecosystem [53,54]. Working with these platforms allows fashion companies to create customized versions of apps and software. Such an approach may also foster collaboration and make it easier for companies to pool resources to address issues such as sustainability. The Kering Group One provides one of the first examples in the fashion landscape. In 2016, the group began to develop an app called My EP&L—Environmental Profit & Loss account. This app estimates for its users the environmental impact of certain fashion products along the supply chain [55]. This is a form of open innovation because Kering allows other companies to use its EP&L tool. They also provide a WeChat version to allow the Chinese fashion industry to access it. Through this open-source approach, Kering can reach all of the actors along the supply chain with a tool that monitors sustainability in the design process [56]. Companies that innovate their model through this archetype are attempting to change the consumption model by influencing the production model radically and providing shared solutions that have an important and significant influence on the industry's environmental impacts. These interaction innovators support both upstream and downstream businesses and are responsible for building the infrastructure to connect other stakeholders, third parties, and consumers via the digital medium of the online platform/app.

#### *4.5. Re-Purposing the Business for the Society/Environment*

“Prioritizing delivery of social and environmental benefits rather than economic profit (i.e., shareholder value) maximization, through close integration between the firm and local communities and other stakeholder groups. The traditional business model where the customer is the primary beneficiary may shift” ([16], p. 13).

Fashion companies in this category develop hybrid BMs and typically incorporate sustainable and ethical practices into them. Their goal is to support a positive sectorial social change [57]. In this context, the digital medium allows traditional product sales to be mixed with the addition of hardware, software, cloud offerings, and other services. Further, they apply design-driven solutions to support entrepreneurship. For example, the Italian brand Stella Jean promotes a platform approach that connects previously unconnected actors indirectly [19]. In particular, the company offers an online marketplace for sustainable and fair-trade products. This marketplace provides a space for companies to offer products to a wide range of customers. In her Workshop of Nations, Stella Jean organized a cooperative that recognizes and disseminates the culture it meets and contributes to the empowerment of the communities involved through the development of a sustainable BM. The designer works on projects that focus on international cooperation and field missions in such developing countries as Peru, Pakistan, Benin, Haiti, and Mali. Thus, each collection is the result of a cultural bridge created between Italian design and the artisanal expertise of the women in these local communities. The primary objective is to preserve the heritage of craft techniques that are otherwise at risk of extinction. This has a twofold effect: it offers economic autonomy to the workers while, at the same time, preserving traditions by giving them a place in the global market. Supported by digital components, these kinds of organizations could permit a sustainable transition that generates profit while improving the communities composed of those workers whose labor is key to the organization's success overall [58].

#### 4.6. Delivering Functionality Rather than Ownership

“Provide services that satisfy users’ needs without having to own physical products” ([16], p. 10).

Companies in this category adopt digital solutions to engage their final users with new BMs that present new forms of ownership. They use digital-driven applications such as digital PSS, maintenance through digital tools, and alternative ownership through online platforms. Further, they develop models based on renting. These models typically rent high-quality, high-priced clothes or accessories. Because it is a rental, the company that makes the garment available is responsible for the product’s maintenance, control, and sanitization upon its return and retains possession of it. These companies were established either with this model, such as the Italian Dress You Can, or are consolidated companies that integrate these solutions into their current model, including the Danish brand GANNI. Dress You Can offer a tailor-made service and manages logistics (A/R shipments) and washing at the rental’s end. The wide range of products allows the customer to indulge in several whims without straining the wallet and damaging the environment. A product can be rented comfortably from home via the platform or in the Milan showroom. Choosing a rental product is a consumer choice which, in addition to preventing many tons of new clothes from being sent to landfills, can slow the overproduction of clothes in the long term. On the other hand, Ganni has developed an alternative pattern of consumption to optimize its sustainable action. Its rental platform provides a new kind of wardrobe upgrade that shifts the idea of consumption towards use. Users can rent a garment from one to three weeks or book their clothes to rent in the future, select the rental’s start and end date, and extend the rental period if necessary. All rentals are delivered in reusable packaging, and all items that are returned are checked carefully and treated according to strict cleaning methods. Once returned, items are washed professionally before they are sent to the next customer. Renters can unlock the history of each piece and find out who rented it previously. By shifting the focus from possession to use, the product’s useful life can be extended significantly, which eliminates the environmental effects associated with the creation of a new garment. Further, this solution represents a useful tool with which fashion companies can strengthen their competitive advantage in the market. The implementation of the clothing rental service allows companies to stand out from their competitors and retain their customers more easily.

#### 4.7. Encouraging Sufficiency

“Solutions that actively seek to reduce consumption and production” ([16], p. 12).

This archetype refers to companies that work upstream in the fashion supply chain. They work on their sourcing to achieve sustainable supply chains by taking advantage of their position at the beginning of the flow of goods and services. Companies are rethinking the system by redesigning the processes of a stakeholder’s access to materials, production, logistics, transportation, and distribution. Their goal is to adopt digital solutions to promote responsible production that considers a product’s longevity in relation to the limited availability of the planet’s resources, including responsible made-to-order clothing through digital solutions, online consumer education, and digital-driven longevity.

As Casciani et al. [59] discussed, on-demand production and personalized/customized clothing could lead to the production of fewer physical garments that are used for longer. Companies such as Son of a Tailor are examples of such approaches that are emerging. Son of a Tailor is a Danish fashion and technology company that has developed a BM based upon developing and implementing a proprietary algorithm that requires only height, weight, age, and shoe size to create a perfect fit. The model is innovated through the digital medium that allows a Toyota-inspired lean supply chain [60]. The on-demand production of made-to-measure garments leads to zero inventory waste, halves carbon emissions, connects those who produce the garments with those who wear them, and traces production end-to-end. Companies in this category are now leading the market through a fundamental change in their sector economic model to move from a system based upon a

market economy, the throw-away paradigm, and planned obsolescence to a new circular system in which digital components could enhance product durability and longevity.

#### 4.8. Adopting a Stewardship Role

“Proactively engaging with all stakeholders to ensure their long-term health and well-being” ([16], p. 11).

These companies bring innovation to their model by implementing radical transparency. They use digital-driven applications for resource stewardship and/or provide radical transparency through digital infrastructure. In this context, the digital medium is a valuable ally that permits employees’ and managers’ internal business processes, which can be traced to the external processes of the network of suppliers, intermediaries, and retailers. This mapping is crucial to allow companies to adopt a stewardship role to implement an ethical management strategy for common goods (resource stewardship) and products (eco-efficiency). In this context, a key aspect of fashion supply chain management is the lack of transparency attributable to the presence of multiple intermediate steps between the production of raw materials and the purchase of a finished product [61]. The adoption of blockchain technology is the leading solution to identify and track sources of unsustainability to allow companies to act on these issues [62]. The blockchain can register different data forms without relying on an intermediary or having to interact with other users. The data can be of any kind: products, materials, or suppliers. Accordingly, the blockchain can help track any item throughout its life cycle. The case of the AURA blockchain is exemplary in the field of fashion. In 2021, leading labels such as Prada, Louis Vuitton, and Cartier launched a blockchain consortium referred to as Aura. This project promoted the use of a single global blockchain solution that was open to all luxury brands worldwide to guarantee consumers greater transparency and traceability. It allowed consumers to access luxury goods’ history and proof of authenticity—from sourcing to sales, all the way to second-hand markets. In 2022, the consortium joined the Sustainable Markets Initiative Fashion Task Force, a private-sector coalition, to accelerate the transition to a more sustainable future in the global fashion, textile, and apparel sectors. These companies’ objective is to realize an innovative joint action that can use the digital medium to work together to build new models for a sustainable and prosperous economy that, through transparency and traceability, can generate long-term value through the balanced integration of natural, social, human, and financial capital.

## 5. Conclusions

This paper discussed the framework of European fashion companies’ digitally driven practices that are emerging today to support the implementation of circular BMs. New digital technologies are spreading and are recognized at different levels as essential to redefining business processes and practices that can achieve sustainability [63]. Thus, many companies are innovating their BMs by integrating the sustainability dimension to increase their competitive advantage. In doing so, digitization and sustainability can enable the implementation of new BMs, as different scholars have discussed [33,64,65]. Here, the authors contributed to this discussion by reporting on innovators in the eight categories selected that are representative cases and that have introduced a change at the core of their BMs to maximize social and environmental benefits by extending beyond mere economic profit through digital technologies. Specifically, the cases offer certain insights into digital technologies’ potential to support an industrial transition to circularity on the part of the fashion sector. Whether we are moving upstream through customized on-demand design, downstream, as in the service-based model, or along the supply chain, as in the case of the adoption of blockchain mapping technology, such solutions can contribute substantially to a circular and sustainable fashion industry.

## 6. Study Limitations and Future Research Directions

This study has certain limitations that the authors wish to address. Acknowledging the limited scope of the data, this paper does not attempt to propose new theories. Still, it provides integrative insights that demarcate a specific perspective [16] with which to understand sustainable and digital-driven BMI. This study was conducted in the context of the fashion industry in the developed European economy that has specific social and economic characteristics. The choice to focus only on the European region seemed logical, as some of the studies that were included in this work have their foundations on this continent. The mapping of the cases revealed the way the different realities have or are developing strongly a high level of awareness on sustainability issues and a willingness to improve efforts and actions. In light of this, the results should be interpreted according to this framework.

In the study of the proposed model, it emerged how a systemic application of technologies enables the current gap in the digital capabilities of the system to be closed by allowing access to and the subsequent development of relevant resources and skills within organizations [66].

Through the diversity in their organizational differences, the companies included in this study demonstrated the characteristics necessary to acquire the resources, skills, and competencies could move toward digital-driven circularity:

1. The internal integration of competencies that are linked to a company ethos of a digital native and has the components necessary to propose a disruptive BM designed to achieve circularity.
2. The necessary external acquisition through collaborations and the mix of its traditional practices and systems with the addition of hardware, software, and other services.

Thus, future research should investigate the factors that influence aspects of the organizational design and could lead to potential different research directions to explore:

1. The development, adaptation, and modification of digital technologies for circular fashion BMs and converse.
2. Obstacles to adopting the circular BM for digital fashion.
3. The effect of digital fashion BMs on a systemic level, for example, in networking.

To conclude, digital innovation and circular BMI are two key contributors to the CE. This study provides the first indications of the way circular BMI could be implemented based on intrinsic business capabilities, technological skills, and organizational strategies. Emerging trends in new fashion markets (e.g., rental, production to order) and consumers' awareness of sustainability should be taken into account as well. Further, in addition to adopting specific independent strategies, fashion industry players should consider collaborating with other technology providers and startup companies to develop more radical innovations.

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