

# Dressed in data: the role of digital technologies in the transition to circular fashion

Opportunities, challenges, and trade-offs of data-driven business model innovation for circular fashion

**Saskia Manshoven<sup>1,\*</sup>, Anse Smeets<sup>1</sup>**

<sup>1</sup> VITO (Vlaamse Instelling voor Technologisch Onderzoek),  
Boeretang 200, B- 2400 Mol, Belgium

\*[saskia.manshoven@vito.be](mailto:saskia.manshoven@vito.be)

## Extended abstract

Digital technologies are widely acknowledged as important enablers of circular business models (Antikainen et al., 2018; Bressanelli et al., 2018; Kristoffersen et al., 2020). These technologies can take different forms, such as Internet of Things (IoT), Big Data, artificial intelligence (AI), computer-aided design (CAD), 3D printing, blockchain, augmented (AR) and virtual reality (VR) environments, and metaverse (Rantala et al., 2023; Wiegand and Wynn, 2023). Digital technologies deliver a kaleidoscope of data on customer behaviour, product use, system performance, and material flows, presenting a powerful source of knowledge and insights to improve the design, production, and management of products and services throughout their lifecycle, as well as the development of data-driven circular business models, such as use- and result-based product service systems, sharing models and digital market places (Luoma et al., 2021). The functionalities offered by digital technologies and data analytics deliver the necessary information to inform decision-making and optimisation processes to increase resource efficiency, extend product lifetimes through maintenance and repair, and to close product and material loops (Antikainen et al., 2018; Bressanelli et al., 2018). This provides major opportunities to create and capture more economic, environmental, and social value through circular business models.

In this study, we aim to explore the role of digital technologies in the transition to a circular and sustainable fashion system. Recently, the fashion sector has received a lot of public attention due to its heavy environmental and social impacts. Moreover, the industry is struggling with enormous overproduction. It is estimated that 130 billion clothing items are produced each year, of which only about 80 billion are sold, half of which at a discount (Peleg Mizrahi and Tal, 2022; SITRA and Circle Economy, 2015). While in 2000, an average brand released two clothing collections per year, today, some brands launch up to twenty-four and average garment lifespan has halved (Centobelli et al., 2022; Remy et al., 2016). Per year, the fashion industry produces about 92 million tons of waste (Niinimäki et al., 2020). Only 25% of textile waste is collected for reuse and recycling, while less than 1% is recycled into new textile fibres (Ellen MacArthur Foundation, 2017). A circular fashion system, built on sustainable resource use, longer product life and high-quality recycling is put forward as a key solution to turn the tide (Ellen MacArthur Foundation, 2020, 2017). In academia, the transition to a circular fashion system has received increasing attention (Abdelmeguid et al., 2022; de Aguiar Hugo et al., 2021; Dissanayake and Weerasinghe, 2022; Jia et al., 2020) and in policy, textiles has become one of the priority sectors for circular economy action (European Commission, 2020).

In 2022, the European Commission proposed a comprehensive EU Strategy for Textiles, highlighting the potential of digitalization and announcing a mandatory development of digital product passports (European Commission, 2022). Digital technologies can play an important role in circular fashion design, resource-efficient production processes, the adoption of new business models, and information sharing and transparency across the value chain, enabling better collaboration and more sustainable and ethical consumption (Wynn and Jones, 2022). For example, computer-aided design can help designers to consider the whole lifecycle of products in the design stage (Hwang and Zhang, 2020), while on-demand manufacturing reduces overproduction (Friedman, 2019). IoT and blockchain can help to monitor performance in service models (Husband, 2021). RFID tags can give access to a digital twin of items, which enables product composition and repair information to be stored in a digital product passport (Van Herzele, 2023). AI and image recognition can support consumers in maintenance and repair (Rantala et al., 2023). Virtual dressing rooms enable buyers to have a fitting experience similar to a physical shop, potentially reducing the amount of textile returns in e-commerce (Owusu, 2022). After discarding, intelligent identification of waste textiles via NIR (Near Infra-Red) technologies and AI allows for improved sorting of textiles towards reuse or recycling (Du et al., 2022).

Still, digitalization in fashion also has some drawbacks. Many companies seem reluctant to embark on -what is called- the Fourth Industrial Revolution or Industry 4.0 (Jin and Shin, 2021; McKinsey & Company, 2022), for example, because of a lack of digital expertise, technology availability, or economic viability (Wynn and Jones, 2022). Also consumers may experience trust barriers concerning circular or data-driven business models (Charnley et al., 2022). And finally, also the sustainability claims related to digital technologies need to

be assessed to assure they really reduce environmental and social impacts related to fashion production and consumption.

The purpose of this study is to explore the emerging and future role of digital technologies in the transition to a circular and sustainable fashion system.

The research questions we aim to investigate are:

- RQ1: What digital technologies are currently used by European fashion companies in support of their transition to circularity?
- RQ2: What is the role of digital technologies in enabling circular business models for fashion and the transition to a circular and sustainable fashion system?
- RQ3: What opportunities and barriers do European fashion companies encounter when aiming to adopt digital technologies?

We focus on the opportunities and challenges that digital technologies can bring in the textile value chain, in relation to extending the life of clothing (*slowing loops*), improving resource efficiency and reducing waste in fashion production and use (*narrowing loops*), and facilitating reverse flows and high quality textiles recycling (*closing loops*) (Bocken et al., 2016). More specifically, we explore what role digital technologies play in the creation, delivery, and capture of circular value within circular business models for textiles (Coscieme et al., 2022). Barriers, trade-offs, or potentially perverse effects are also discussed.

The research starts from a systematic literature and practice review of scientific and grey literature on existing and emerging digital technologies for circular fashion. Since digitalization for circular economy is still in its infancy within the fashion industry, most articles stay at a conceptual level and relatively few have studied case studies (Akhtar et al., 2022; Colombi and D'Itria, 2023; Wiegand and Wynn, 2023). Therefore, findings from literature are enriched by semi-structured interviews with frontrunner European fashion companies and SMEs, as well as sector organisations and expertise centers on sustainable fashion.

This work will be used to formulate recommendations to European policy makers on the role of digital technologies in achieving the EU vision on circular textiles. It will also be inspiring for fashion designers, entrepreneurs and businesses looking into the potential of digital technologies and circular business models.

## Keywords

Circular fashion, digital technologies, circular business models, sustainable production and consumption, data technology

## References

- Abdelmeguid, A., Afy-Shararah, M., Salonitis, K. (2022). Investigating the challenges of applying the principles of the circular economy in the fashion industry: A systematic review. *Sustainable Production and Consumption*. 32, 505–518.
- Akhtar, W.H., Watanabe, C., Tou, Y., Neittaanmäki, P. (2022). A New Perspective on the Textile and Apparel Industry in the Digital Transformation Era. *Textiles*. 2, 633–656.
- Antikainen, M., Uusitalo, T., Kivikytö-Reponen, P. (2018). Digitalisation as an Enabler of Circular Economy. *Procedia CIRP, 10th CIRP Conference on Industrial Product-Service Systems, IPS2 2018, 29-31 May 2018, Linköping, Sweden*. 73, 45–49.
- Bocken, N.M.P., Pauw, I. de, Bakker, C., Grinten, B. van der (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*. 33, 308–320.
- Bressanelli, G., Adrodegari, F., Perona, M., Sacconi, N. (2018). Exploring How Usage-Focused Business Models Enable Circular Economy through Digital Technologies. *Sustainability*. 10, 639.
- Centobelli, P., Abbate, S., Nadeem, S.P., Garza-Reyes, J.A. (2022). Slowing the fast fashion industry: an all-round perspective. *Current Opinion in Green and Sustainable Chemistry*. 100684.
- Charnley, F., Knecht, F., Muenkel, H., Pletosu, D., Rickard, V., Sambonet, C., Schneider, M., Zhang, C. (2022). Can Digital Technologies Increase Consumer Acceptance of Circular Business Models? The Case of Second Hand Fashion. *Sustainability*. 14, 4589.
- Colombi, C., D'Itria, E. (2023). Fashion Digital Transformation: Innovating Business Models toward Circular Economy and Sustainability. *Sustainability*. 15, 4942.
- Coscieme, L., Manshoven, S., Gillabel, J., Grossi, F., Mortensen, L.F. (2022). A framework of circular business models for fashion and textiles: the role of business-model, technical, and social innovation. *Sustainability: Science, Practice and Policy*. 18, 451–462.
- de Aguiar Hugo, A., de Nadae, J., da Silva Lima, R. (2021). Can Fashion Be Circular? A Literature Review on Circular Economy Barriers, Drivers, and Practices in the Fashion Industry's Productive Chain. *Sustainability*. 13, 12246.
- Dissanayake, K., Weerasinghe, D. (2022). Towards Circular Economy in Fashion: Review of Strategies, Barriers and Enablers. *Circular Economy and Sustainability*. 2, 25-45.
- Du, W., Zheng, J., Li, W., Liu, Z., Wang, H., Han, X. (2022). Efficient Recognition and Automatic Sorting Technology of Waste Textiles Based on Online Near infrared

Spectroscopy and Convolutional Neural Network. Resources, *Conservation and Recycling*. 180, 106157.

Ellen MacArthur Foundation (2020). Vision of a circular economy for fashion. Available from: <https://emf.thirdlight.com/link/nbfff6ugh01m-y15u3p/@/preview/1?o> [Accessed: 31<sup>st</sup> January 2024]

Ellen MacArthur Foundation (2017). A New Textiles Economy. Available from: <https://emf.thirdlight.com/link/2axvc7eob8zx-za4ule/@/preview/1?o> [Accessed: 31<sup>st</sup> January 2024]

European Commission (2022). EU strategy for sustainable and circular textiles. COM(2022) 141 final.

European Commission (2020). A new circular economy action plan for a cleaner and more competitive Europe. COM(2020) 98 final.

Friedman, A. (2019). This Manufacturer's On-Demand 3D Knitting Launch Tackles Fashion 'Wastage.' *Sourcing Journal*. Available from: <https://sourcingjournal.com/topics/raw-materials/22-factor-shima-seiki-on-demand-3d-knitting-upcycled-yarn-178086/> [Accessed: 30<sup>th</sup> January 2024].

Husband, L. (2021). H&M launches first blockchain-based IoT clothes rental service. *Just Style*. Available from: <https://www.just-style.com/news/hm-launches-first-blockchain-based-iot-clothes-rental-service/> [Accessed: 30<sup>th</sup> January 2024]

Hwang, C., Zhang, L. (2020). Innovative Sustainable Apparel Design: Application of CAD and Redesign Process, in: Muthu S.S. (Ed.) *Sustainable Textiles: Production, Processing, Manufacturing & Chemistry*. Springer International Publishing, Switzerland, pp. 87–107.

Jia, F., Yin, S., Chen, L., Chen, X. (2020). The circular economy in the textile and apparel industry: A systematic literature review. *Journal of Cleaner Production*. 259, 120728.

Jin, B.E., Shin, D.C. (2021). The power of 4th industrial revolution in the fashion industry: what, why, and how has the industry changed? *Fashion and Textiles*. 8, 31.

Kristoffersen, E., Blomsma, F., Mikalef, P., Li, J. (2020). The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies. *Journal of Business Research*. 120, 241–261.

Luoma, P., Toppinen, A., Penttinen, E. (2021). The Role and Value of Data in Realising Circular Business Models – a Systematic Literature Review. *Journal of Business Models*. 9 (2), 44-71. Available from: <https://journals.aau.dk/index.php/JOBM/article/view/3448/5860> [Accessed: 30<sup>th</sup> January 2024]

McKinsey & Company (2022). What is industry 4.0 and the Fourth Industrial Revolution? | Available from: <https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-are-industry-4-0-the-fourth-industrial-revolution-and-4ir#/> [Accessed 30<sup>th</sup> January 2024].

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., Gwilt, A. (2020). The environmental price of fast fashion. *Nat Rev Earth Environ.* 1, 189–200.

Owusu, A. (2022). Let's Talk Fashion: How Digital Technology Can Support the Circular Economy. Digital@DAI. Available from: <https://dai-global-digital.com/lets-talk-fashion-how-digital-technology-can-support-the-circular-economy.html> [Accessed: 30<sup>th</sup> January 2024]

Peleg Mizrachi, M., Tal, A. (2022). Regulation for Promoting Sustainable, Fair and Circular Fashion. *Sustainability.* 14, 502.

Rantala, T., Saari, L., Jurmu, M., Behm, K., Heikkilä, J., Jokinen, A., Palmgren, R., Paronen, E., Rainio, K., Valtanen, K., Vierimaa, M., Ylikerälä, M. (2023). Digital technologies for circular manufacturing (VTT White Paper Vol. 2023). VTT Technical Research Centre of Finland. Available from: [cris.vtt.fi/ws/portalfiles/portal/76497949/Digital\\_technologies\\_for\\_circular\\_manufacturing\\_white\\_paper.pdf](https://cris.vtt.fi/ws/portalfiles/portal/76497949/Digital_technologies_for_circular_manufacturing_white_paper.pdf) [Accessed 30th January 2024]

Remy, N., Speelman, E., Swartz, S. (2016). Style that's sustainable: A new fast-fashion formula. Available from: <https://www.mckinsey.com/business-functions/sustainability/our-insights/style-thats-sustainable-a-new-fast-fashion-formula> [Accessed 29<sup>th</sup> January 2024].

SITRA, Circle Economy (2015). Service-based business models & circular strategies for textiles. Available from: <https://s3-eu-west-1.amazonaws.com/stjm/20160330092502/Service-based-business-models-and-circular-strategies-for-textiles-2015-SITRA-STJM.pdf> [Accessed: 30<sup>th</sup> January 2024]

Van Herzele, C. (2023). Designing a Product Service System for Digital Product Passport in the Fashion Industry in Compliance with the European Commission's Ecodesign for Sustainable Products Regulation. Available from: <https://biblio.ugent.be/publication/01H8KZ4M1X93ZK63Y1R3Y06M96> [Accessed 31st January 2024]

Wiegand, T., Wynn, M. (2023). Sustainability, the Circular Economy and Digitalisation in the German Textile and Clothing Industry. *Sustainability.* 15, 9111.

Wynn, M., Jones, P. (2022). Digital Technology Deployment and the Circular Economy. *Sustainability.* 14, 9077.