European Commission

Monitoring the twin transition of industrial ecosystems

TEXTILES

Analytical report

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Executive summary

Measuring performance and monitoring change within an industrial ecosystem are vital components that enable policymakers and industry stakeholders to track progress over time and obtain valuable feedback on whether the system is moving in the desired direction. This report is a contribution to the 'European Monitor of Industrial Ecosystems' (EMI) project, initiated by the European Commission's Directorate General for Internal Market, Industry, Entrepreneurship, and SMEs, in partnership with the European Innovation Council and SMEs Executive Agency (EISMEA). Its primary objective is to present the current state and the advancements achieved over time in terms of the green and digital transition of the European textiles industrial ecosystem.

In this project, the green and digital transition of industrial ecosystems have been analysed based on a harmonised monitoring framework and dataset. The own data collection included a business survey, text mining of company websites, startup data, patent applications, trade and production, investment data, online job advertisements and job profiles and environmental impact data from Exiobase. The methodology of the data calculations is included in report about the conceptual and methodological framework.

Key findings about the green transition

The textiles industrial ecosystem has a significant impact on the environment with mixed trends over time as the analysis of Exiobase data suggest. Textile production requires natural resources and generates pollution throughout the entire industrial value chain. The main environmental concerns are **water pollution, greenhouse gas emissions, and waste production**. The excessive production of textiles is particularly concerning, as it leads to large volumes of unsold products due to inaccurate forecasting and long lead times. The assessment of the EU27 textile industry's environmental impact conducted in this study reveals an **overall decline in greenhouse gas emissions and material extraction from 2010 to 2021**. However, recent trends suggest that there is now a renewed increase. **Land and water use have increased during the same period**, as well as **particulate matter emissions** from 2017 to 2021. A significant concern is the extensive use and consumption of blue water, specifically surface water or groundwater, during industry processes. The textile industry has been causing **damage to the ecosystem and biodiversity**, with increasing impacts over time. Additionally, the industry has a **high energy demand** at every stage of its value chain.

The negative impacts have been recognised and extensively discussed in recent years, and various measures have been taken to encourage new behaviours. The textile industry has begun to change, with new companies offering environmental services and traditional textile companies adopting eco-friendly solutions. Furthermore, new infrastructure and networks are supporting the transition to sustainability, reshaping the industry. These changes have been studied using a combination of different data sources such as startup data, business surveyor patent applications.

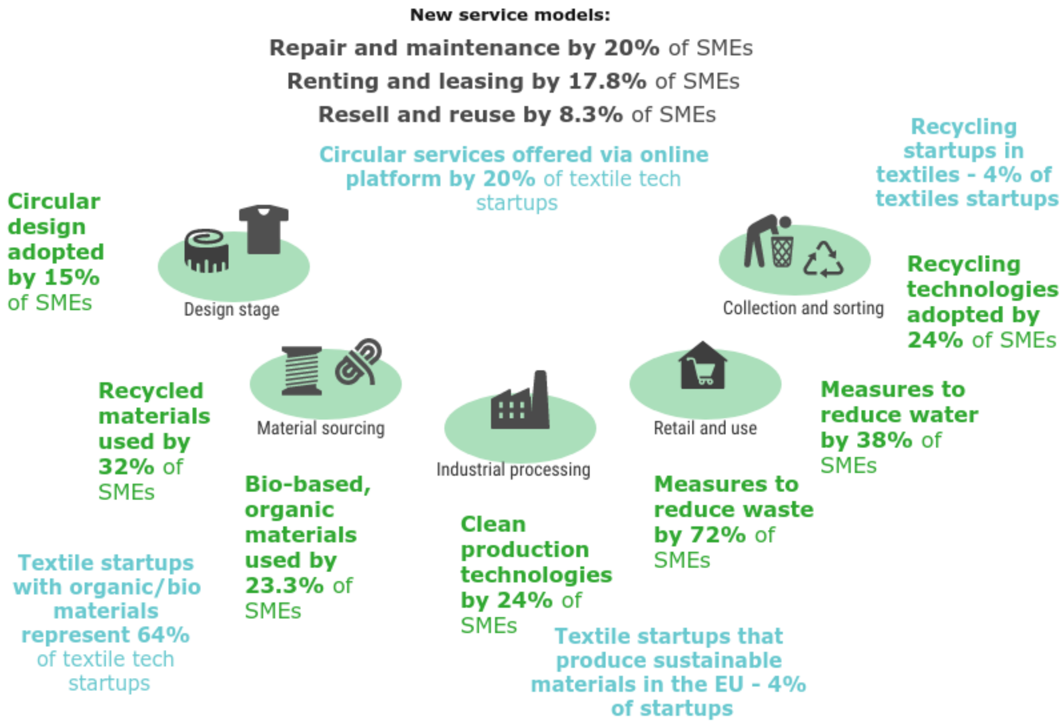
The results of the telephone interview-based survey conducted with 326 textiles SMEs in this project show that close to **42% of the respondents adopted at least one type of green technology or a related environmental measure**, which is a promising result. Despite these positive developments, we also find that real commitments to environmental conscious business practices are still limited and the share of green activities within the overall business operation is still low.

The detailed survey results demonstrate that SMEs in the ecosystem have been most active in the use of recycled materials and to a lesser extent adopting recycling technologies within their own operation. Clean production technologies are a further important technology cluster in terms of adoption. The least cited green technologies include carbon capture and hydrogen. It has been a positive trend that the number of environmental certificates issued to textiles companies in the EU27 grew significantly, although still low relative to the size of the industry.

Both the patent data and text mining of textile company websites show that **close to half of the innovations in green technologies are in sustainable materials** such as in recycled or bio-based materials. Sustainable, alternative fibres have become an important trend, aiming to reduce the environmental and climate impacts of textiles.

There has been a sharp increase in the number of textiles startups in particular with green technologies and green business models over the period from 2010 to 2021, which indicates a growing popularity among entrepreneurs venturing in this field and focusing on sustainable textile fibres and materials. Some of the innovative textile companies have scaled up, more specifically **30 green textiles scaleups have been identified.**

Figure 1: Adoption of green technologies and business models by SMEs in the textiles industrial ecosystem following the EMI survey results and analysis of startups



Source: Technopolis Group and KAPA Research, 2023

According to the EMI survey results, **32% of the textile SMEs indicated the use of recycled materials** (at least to some extent), **but a lower share notably 23.3% the use of bio-based sustainable materials**. Recycled materials have also ranked at the top of green transition technologies that had been mentioned the most often on textiles company websites (11% of companies referring to recycled materials). Interestingly, among textiles startups a reversed trend can be observed with bio-based materials a more common topic for new business. Despite these positive steps, In nearly half of the cases, the share of recycled materials used in the products or production of textile companies surveyed is below 5%. This suggests that the **adoption of recycled materials is still in an early stage**. It is an issue that there is relatively lower interest in producing and marketing **textile products that are more durable**. The company websites, which are advertised as having a core business value, have hardly emphasised durability and longevity.

SMEs were surveyed about the adoption of circular business models and other circular practices such as circular design, repair, renting, leasing or design for durability. The results indicate that the largest share notably **20% of the respondents adopted repair and maintenance service models** including for example cleaning services and laundry.

A further clear issue is that circular services still do not seem to be profitable. In essence, **75.9% of the textile companies surveyed said that the use of circular service models is not yet cost-effective for their business**.

The green transition requires substantial investments to make a real change. The analysis in this report found that **both private and public investments are still below the necessary level needed to address the environmental challenges** in the textiles ecosystem. Nonetheless, positive trends can be also observed. The survey shows that 51% of the respondents had increased their investments dedicated to the green transition and environmental sustainability during the past five years. However, close to half of these respondents **invested below 5% of their revenue**. This indicates that there is still a moderate actual action despite the interest to increase spending on clean technologies and sustainability.

The **estimated private equity and venture capital investment in green textile innovation amounted to €1.6 bn over the period from 2010 to 2022**. Investments into green textile startups witnessed a sharp increase. Most VC went into online marketplaces that are environmentally oriented. Green textile technology entrepreneurs are still kick-starting within the ecosystem. Nevertheless, 2021 saw a peak in late funding and exits that is an indication that some of the European green textile startups managed to scale up and prove their business models (in recycling and bio-based materials).

The EU27 was a net foreign direct investor in the rest of the world in the field of textiles over the period from 2010 to 2022. It invested €10.3 bn in non-EU countries and was the destination of a total of €4.4 bn FDI capital investment from third countries in textiles. Intra-EU FDI amounted to a value of €6.7 bn. **It is estimated that 12% of the EU related investment projects had an element relevant for the green transition** and include examples of new factories powered by renewable energy and investment into recycling factories and production of bio-based materials.

Results show that **public procurement of textiles is concentrated on traditional procurement notices on supplies and services while green public procurement is limited, although it could have a significant impact for the transition.** The analysis of EU research and innovation funding data found that the development of clean technologies in textiles has been supported only partially with an amount of €18m dedicated to this topic.

The number of professionals with environmental and green profiles and the demand for such employees as expressed via job advertisements can shed further light on the importance of green and digital technologies and services for companies. Within the registered professionals on LinkedIn employed in the textile industrial ecosystem, only **1.61% claimed having skills related to the green transformation, but the number of professionals with green skills grew by 20%** over the period from 2021 to 2022. Among the more specific green skills, recycling related skills tops the list in the EU27 following the share of professionals with general environmental skills. Recycling is followed by energy efficiency. On the demand side, based on the analysis of online job advertisements, 0.68% of online job advertisements required any form of green transition related skills.

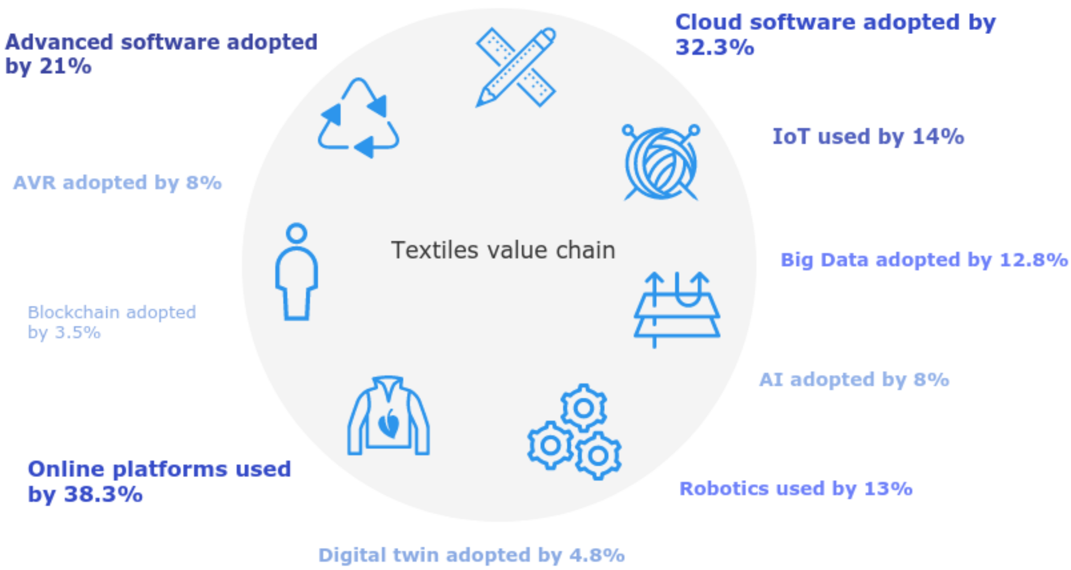
Key findings about the digital transition

Digital technological models that have been increasingly common in textiles since the 2000s and now are established include e-commerce and digital printing. The emergence of online platforms is still decisive and is shaping the transformation of the industry’s supply chain.

A growing number of digital textile tech startups provide new services, opportunities for differentiation and new sources of revenue powered by artificial intelligence, augmented and virtual reality, and blockchain. Startups often combine various digital technologies to create new value propositions for the textiles industry.

SMEs in the textiles industrial ecosystem have been less engaged in digital technologies than in the green transition. The text mining of company websites shows that around **65% of textile companies in the sample have a website** and approximately 54% of the companies with a website had a website with more than 10 pages.

Figure 2: Adoption of digital technologies by SMEs in the textiles industrial ecosystem following the EMI survey results



Source: Technopolis Group, 2023

The use of online platforms by 38.3% of the SMEs in the ecosystem reflects the importance of the platform economy and e-commerce in the industry. In particular since the Covid-19 pandemic, textiles sales moved extensively online as already discussed in the previous chapter. Internet of Things technologies have been indicated by 14% of the survey respondents and are on the top of the list among the advanced digital technologies in use. Textiles companies connect most often their products and materials to the internet with the objective to track their inventory. They are also using IoT for predictive maintenance. Some respondents indicated to integrate IoT into the production process and monitor machines. Remote monitoring thus allows the optimisation of production and reduction of errors. Robotics technologies are important for textiles SMEs. Within the ecosystem, 13% of the respondents expressed the use of this technology. Unsurprisingly, the most important use case of robotics is in product assembly. Robots can print and draw designs on fabrics, can inspect products and enhance textiles machines. Automated sewing robots have been pointed out that help creating custom design.

Big data and related data analytics have been adopted by 12.8% of the SMEs in the ecosystem as found by the EMI survey. Artificial Intelligence has an uptake of 8% among SMEs in the textiles ecosystem. Additional questions of the survey revealed that AI is being used extensively across the full value chain with various use cases, but most importantly has been applied within the production process notably for optimisation and automation. Secondly, AI has been used in the design phase of the value chain notably for material selection and design. Augmented and virtual reality has been mentioned by 8% of the respondents. AVR is used most in virtual product development and virtual product sourcing.

Digital twins create a virtual replica of a physical product, process or system and allow for real time analysis. The survey concluded that 4.8% of the respondents adopted this technology within the textiles ecosystem that is still a low result. By creating virtual replicas of new textiles designs, users can review and suggest changes during the design process almost real time.

Both the digital transition and green transition of the ecosystem will be enhanced by the implementation of digital labelling and digital product passports that will allow automatic sorting; however, this shift is highly dependent on the technical developments, data infrastructure, regulation and the implementation throughout the whole ecosystem.

The survey results show that **47% of the textiles SMEs indicated to having increased their investments dedicated to digital technologies during the past five years**. However, digital investments meant less than 5% of companies' revenue in most cases.

The estimated private equity and venture capital investment in digital textiles tech startups amounted to €3.8 bn over the period from 2010 to 2022 and have been growing steadily based on calculations of Crunchbase data. Most VC investment went into e-commerce and online applications. The link between **digital and green technologies are demonstrated by the fact that green textile startups using digital technologies such as artificial intelligence or blockchain have attracted €172 m venture capital investment in 24 funding rounds over 2010-2022.**

Following the analysis of FDI data, it is estimated that **21% of FDI investment destined to EU countries (in 2015-2022) has a digital component either as digitally enabled factory, digital showrooms, digital ID system or online commerce.** Some of the investment projects aim at the rehabilitation of craft skills combined and upgraded with digital technologies. In some of the investment projects extra-EU investors such as from China bring in automation and digital knowledge.

Within the registered professionals on **LinkedIn employed in the textile industrial ecosystem, 1.42% had digital skills in 2022**. There have been 29% more professionals in the textiles industrial ecosystem claiming to have an advanced digital skill from 2021 to 2022. On the demand side based on the analysis of online job advertisements, the share of online job advertisements that required any form of moderate digital skills (excluding basic IT office skills) was 18.25% over the period from 2019-2022, while this percentage was 9.09% for advanced digital skills. The absolute number and share of job ads with digital skills requirement increased over time. Although the two data sources cannot be compared directly, the results still suggest a mismatch between the available digital skills and the actual demand within the textiles industrial ecosystem.

1. Introduction

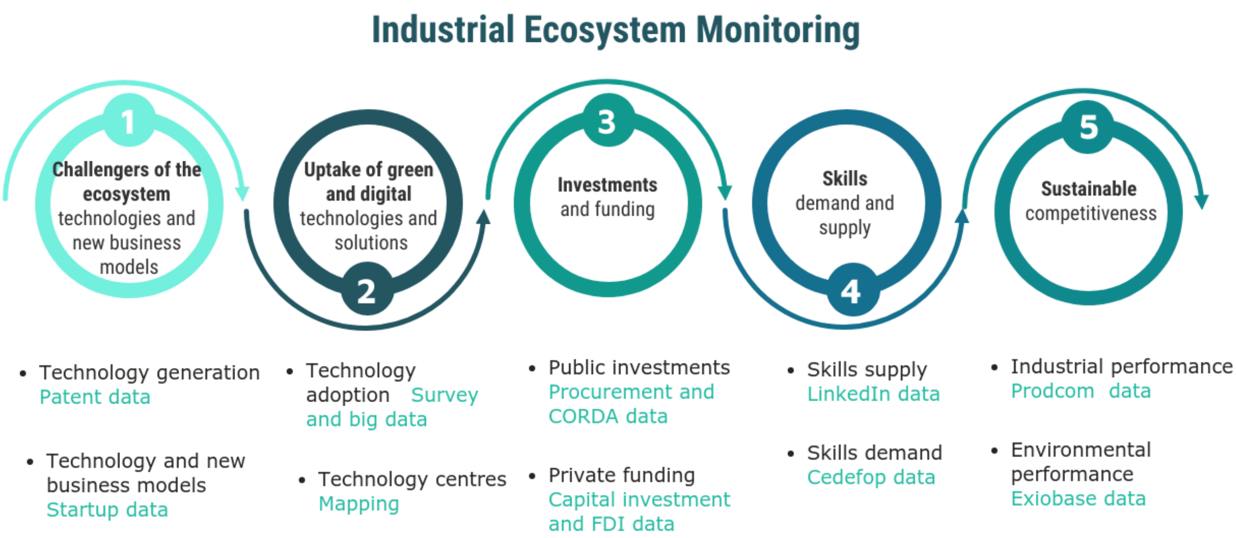
1.1. Objectives

This report has been prepared within the '**European Monitor of Industrial Ecosystems' (EMI)** project, initiated by the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency (EISMEA). The overall objective of the project is to **contribute to the analysis of the green and digital transformation of industrial ecosystems** and progress made over time.

The EU's updated industrial strategy[1] has identified 14 industrial ecosystems[2] – one of them being **'Textiles'** - that is in the focus of this report. The industrial strategy defined industrial ecosystems as encompassing all players operating in a value chain: from the smallest startups to the largest companies, from academia to research, service providers to suppliers. The notion of ecosystems captures the complex set of interlinkages and interdependencies among sectors and firms across the EU. Industrial transition is driven by technological, economic, and social changes, and in particular by green and digital technologies and the shift to the circular economy. The process is however characterised by complex, multi-level, and dynamic development. To make transition sustainable, technological change needs to be coupled with new business models, the necessary investments, skills, regulatory framework conditions and behavioural change across the ecosystem.

Measuring performance and change is vital to allow policymakers and industry stakeholders to track progress over time and get feedback whether the system is moving in the desired direction. To measure performance, a dedicated **monitoring and indicator framework** has been set up for the purposes of this project with an aim to capture them in regular intervals (see the overview of the monitoring framework in Figure 3).

Figure 3: Overview of monitoring industrial ecosystems and relevant data sources



Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

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[1] European Commission (2020). A New Industrial Strategy for Europe, COM/2020/102 final and European Commission (2021). Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery, COM(2021) 350 final
[2] The 14 industrial ecosystems include: construction, digital industries, health, agri-food, renewables, energy intensive industries, transport and automotive, electronics, textile, aerospace and defense, cultural and creative culture industries, tourism, proximity and social economy, and retail

The indicator framework includes a **set of traditional and novel data sources that allow shedding new light on ongoing transformation patterns.** The novelty of the analysis lies in the exploratory and innovative data sources used across the different chapters. Due to its effort to analyse industrial ecosystems using a more or less standardised set of indicators, the study cannot address all aspects of the green and digital transition. Therefore, additional analysis and industry-specific data sources should be used to supplement a full assessment.

The **methodological report** that sets the conceptual basis and explains the technical details of each indicator is found in a separate document uploaded on the EMI website[3]. Moreover, some of the specific industry codes used throughout this analysis have been also included in Appendix B. The green and digital technologies that have been taken into account in this study are presented in Figure 4.

Figure 4: Main technologies monitored in the project

Green transformation
Advanced Sustainable Materials
Biotechnology
Energy Saving technologies
Clean Production technologies
Renewable Energy technologies
Solar Power
Wind Power
Other (geothermal, hydropower, biomass)
Recycling technologies
Circular business models

Digital transformation
Advanced Manufacturing & Robotics
Advanced Manufacturing
Robotics
Artificial Intelligence
Augmented and Virtual Reality
Big Data
Cloud technologies
Blockchain
Digital Security & Networks/ Cybersecurity
Internet of Things
Micro- and Nanoelectronics & Photonics
Online platforms

Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

This report contributes to the analysis of the **key pillars put forward in the 'Blueprint for the development of transition pathways'**[4] of the Industrial Forum developed in 2022. It also complements the **'Transition pathway for the textiles industrial ecosystem'**[5] published by the European Commission in 2023.

1.2. Definitions

As defined in the European Commission Annual Single Market Report, the textile ecosystem includes the transformation of natural (cotton, flax, wool), man-made and artificial (synthetic polyester and viscose) fibres into yarns and fabrics, production of yarns, bedlinen, industrial filters, technical textiles, carpets and clothing and in addition it also covers the manufacturing of footwear and leather[6]. In a broader definition, the ecosystem encompasses "the manufacturing of intermediate goods and fashion goods, as well as the distribution of these products to the markets operated by wholesalers, agents, and

[3] https://monitor-industrial-ecosystems.ec.europa.eu/sites/default/files/2023-12/EMI%20Methodological%20Report.pdf
[4] https://ec.europa.eu/docsroom/documents/49407/attachments/1/translations/en/renditions/native
[5] https://op.europa.eu/en/publication-detail/-/publication/6392f189-0416-11ee-87ec-01aa75ed71a1/language-en
[6] European Commission, 2021 Annual Single Market Report Brussels, 5.5.2021 SWD(2021) 351 final

retailers." [7] Technical textiles have been defined as "*textiles, fibres, materials and support materials meeting technical rather than aesthetic criteria*".

The textiles ecosystem is very much linked to other ecosystems such as the healthcare, construction, and automotive sectors. It is also linked to the chemicals industry (e.g. producing adhesives) and to machinery (also important in terms of textile production or recycling capacities). The textiles ecosystem obviously also has close links with the retail ecosystem.

This report captures the textiles ecosystems as closely as possible in all indicators and concerns *both the fashion industry and technical textiles* related to various industrial applications.

1.3. Industry state of play

The European textile industrial ecosystem is a major contributor to the European economy, with a turnover of €163 bn and more than 267 000 enterprises located across EU countries. According to Eurostat, the gross value added of the ecosystem in 2019 was around €86.3 bn, accounting for 0.7% of the total EU value added. The textiles manufacturing industry employed 1.6 million people in 2020, but at ecosystem level, it employed around 4 million workers. SMEs are the backbone of the ecosystem and represent over 99.5% of all enterprises and employ 74.4% of the workforce.

The technical textiles industry represents around 30% of the total turnover in textiles in the EU27[8]. They are an input to other industries such as the automotive, medical devices and agri-food sectors. The technical textiles industry is commonly regarded as a top value-added growth industry, where Europe has a strong market position. In 2018, the European countries with the highest volumes of technical textiles production were Germany (32 000 tonnes), Italy (18 000 tonnes) and the UK (15 000 tonnes), with a total production share of 47%, followed by the Netherlands, Spain, Belgium, France, the Czech Republic, Sweden, Poland, Hungary and Romania, which together accounted for 43%.

The EU textile industry is facing major economic challenges. Since 2020, the global supply chain disruptions caused by the COVID-19 pandemic have resulted in fashion brands and retailers suffering production capacity shortages, bottlenecks in global logistics infrastructure, and fluctuating consumer demand[9]. The current geographical tensions and deteriorating economic environment dashed the hopes of recovery and new pressures arise due to rising energy costs and raw material prices.

In 2020, 6.9 million tonnes of finished textile products were produced in the EU27. EU production specialises in carpets, household textiles and other textiles (including non-woven textiles, technical and industrial textiles, ropes and fabrics). In addition to finished products, the EU produces intermediate products for textiles, such as fibres, yarns and fabrics[10]. Apart from the COVID-related drop in consumption in 2020, the estimated consumption of clothing and footwear stayed relatively constant over the last decade, with slight fluctuations between years.

[7] CSIL (2021). Data on the EU Textile Ecosystem and its Competitiveness
[8] https://ati.ec.europa.eu/sites/default/files/2021-01/Technological%20trends%20in%20the%20textiles%20industry.pdf
[9] https://textile-network.com/en/Business/The-impact-of-Covid-19-and-the-supply-chain-disruptions
[10] Köhler, A., Watson, D., Trzepacz, S., Löw, C., Liu, R., Danneck, J., Konstantas, A., Donatello, S. and Faraca, G., Circular Economy Perspectives in the EU Textile sector, EUR 30734 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-38646-9, doi:10.2760/858144, JRC125110

2. Challengers of the industry status quo: green and digital technological trends

Key findings

The textile industrial ecosystem has been witnessing a **rapid development of green and digital technologies** with both traditional and emerging links to fields such as *advanced sustainable materials, clean production technologies, recycling and waste management*.

There has been a **sharp increase in the number of textiles startups that challenge the industry status quo. These startups are particularly numerous in fostering the green transition** with technologies and new business models, and less so in digital technologies active within the textiles industrial ecosystem over the period from 2010 to 2021.

The majority of green textiles startups ventured into textiles products that are sourced from *sustainable bio-based, recycled or organic materials.* **Bio-based materials have been a popular topic. Durability, however, has been the least common.** Secondly, online marketplaces for sharing and renting have been dynamically growing. In the landscape of green textiles startups both the **use of advanced digital technologies for circularity such as artificial intelligence, virtual reality and blockchain has been rising steadily**. Recycling has witnessed a few recent scaleups in spinning and knitting facilities, however the examples are very recent. Clean production related startups are much less common.

A growing number of digital textile tech startups provide new services, opportunities for differentiation and new sources of revenue powered by *artificial intelligence, augmented and virtual reality, and blockchain*. Electronic textiles appear as a significant niche. **Startups often combine various digital technologies to create new value propositions** for the textiles industry. Robotics technology related startups specialised in textiles are rare despite the existing patent applications.

In the case of advanced digital transformation, the most important technological links are related to *additive manufacturing, augmented and virtual reality and artificial intelligence* as shown by patent data.

Green and digital textiles innovation is concentrated on a number of players (many from other sectors than textiles and including chemicals and information and communication) and a few countries such as Germany, France, Italy, Austria, Belgium, Netherlands and Sweden.

More interestingly, **green development has been increasingly linked to high value technical textiles such as for batteries, green buildings, and green transport** over the period from 2010 to 2020.

2.1. Technology development

The EU27 is a key provider of new technologies for textiles globally holding the highest share of patent applications (over 6,600 between 2015 and 2019) and high share of trademarks (around 700,000 in 2019)[11]. Both clean technologies and digital technologies are transforming the knowledge base and industrial practices in the ecosystem. Innovation comes not only from traditional textiles firms (that have been often characterised as relatively low R&D investors with little capabilities for innovation compared to other

[11] CSIL (2021). Data on the EU Textile Ecosystem and its Competitiveness

industries[12]) but also from companies related to the textiles industrial design and production including chemical companies and the information and technology industry.

Technological solutions to reduce the burden of the industry on the environment have been exponentially growing in the past years. The negative environmental impacts of the textiles industry are mainly related to the use of energy, water and chemicals, direct CO_2 emissions and solid waste[13]. Green technologies that affect the environmental performance of the industry include low carbon and circular economy models including the use of renewable energy-, recycling, advanced material-, resource-efficiency-, and clean production technologies.

Innovation for environmental sustainability is driven not only by technologies but by non-technological innovations, and even digital technological advancements are often coupled with new business model innovations that should be taken into account in monitoring industrial transition.

In this report, technological trends, emerging business models and the dynamics of change in the textiles industrial ecosystem have been captured by patent and startup data. Patent data is a traditional source of information about technological developments, but innovative ideas in the textile sector are not always patented or often used rather by larger companies due to the costly process. To monitor green and digital technological and non-technological trends, startups and trade fairs give a further insight about the latest technological and business trends particularly on the supply side of the market. Startups emerge often as new actors changing the status quo in the industrial landscape. Digital and green innovations are however often 'silent' and happening behind closed doors of the traditional brands and manufacturers. These transformations will be captured by a business survey launched in the framework of this project.

Textile patents usually cover innovations related to new materials, fabrics and fibres, innovative textile products, electronic textiles, new methods for production including dyeing, printing and sewing. In order to understand the specific patenting activities relevant for the digital and green transition, the analysis of textile patent applications was based on the analysis of the 2022 edition of the OECD REGPAT database. The industrial ecosystem was classified into a set of Cooperative Patent Classification (CPC) categories. A text mining algorithm was used in order to search for key words and their specific association in the text of patent documents as well as in the Cooperative Patent Classification nomenclature. By using this approach, we can representatively capture the patenting activity in textiles and observe trends in distribution and development as indicated in this section. It has to be noted that the focus is on the patent application that is related to textiles, but this does not mean that the patent application was submitted by a textile firm or organisation (as it is presented below, in several cases the applicant comes from another industry).

The results of the patent data first confirm the importance of advanced material related technologies in the industry that represent an area where European textile firms also tend to patent by far the most[14]. Close to **45% of the patent application sample is linked to advanced sustainable materials, followed by biotechnology** (see Figure 5). Material innovation is important in garment design and production, but high performance-low impact fibres represent a new growth market for technical applications, too as the related patent applications prove.

Digital transformation is much less present, but links have been identified regarding **additive manufacturing, augmented and virtual reality and artificial intelligence.**

[12] See for example Iacobucci and Perugini (2018). Changing Models of Innovation in the eu Textile and Clothing Industry

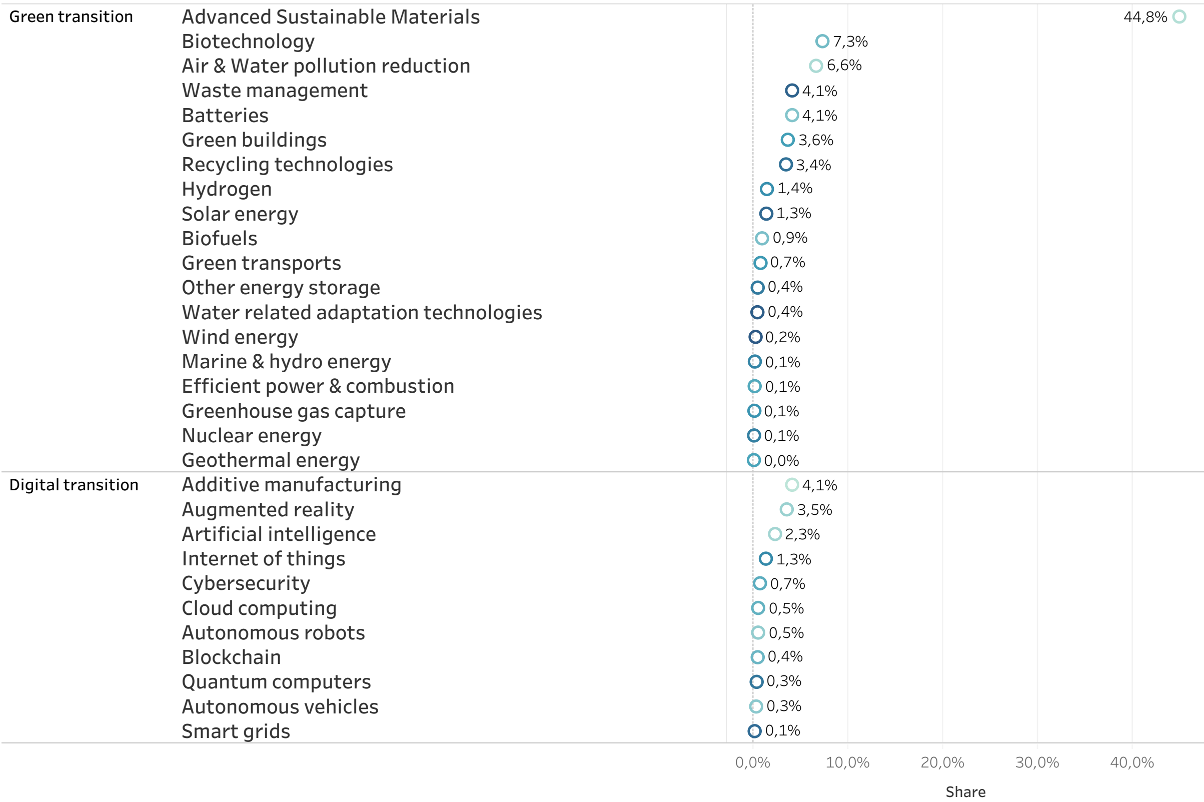
[13] EEA (2019). Textiles and the environment in a circular economy, Eionet Report - ETC/WMGE 2019/6 https://www.eionet.europa.eu/etcs/etc-wmge/products/etc-wmge-reports/textiles-and-the-environment-in-a-circular-economy/@@download/file/ETC-WMGE_report_final%20for%20website_updated%202020.pdf

[14] Izsak and Shaushuk, 2021, Advanced Technologies for Industry, Sectoral report on textiles, https://ati.ec.europa.eu/reports/sectoral-watch/technological-trends-textiles-industry

Many of the patent applications concern smart fabrics that integrate electronic components and rely on signal transmissions to create new value. In AR/VR, examples of claimed inventions include systems that carry out virtual, computer-simulated testing and inspection of garment assembly.

In the preparation of textiles materials, the use of bio-based and other alternative materials with sustainable properties plays a key role. **Innovations originate from biotech and chemical companies** in this specific area. One of the largest patent holders in this field is Novozymes from Denmark that produces biodegradable, environmentally friendly enzymes that helps creating a sustainable wet processing and superior fabric quality. The company is also active in textile recycling programmes with its solutions to give garments a second life[15]. Another player active in patenting is Henkel that provides sustainable adhesive solutions and non-sewing technology, with the advantage of high production efficiency, multiple base material options and flexible design[16].

Figure 5: Treemap of relevant technologies appearing in patent applications related to textiles (2017-2021)



Source: Balland, 2022 based on PATSTAT

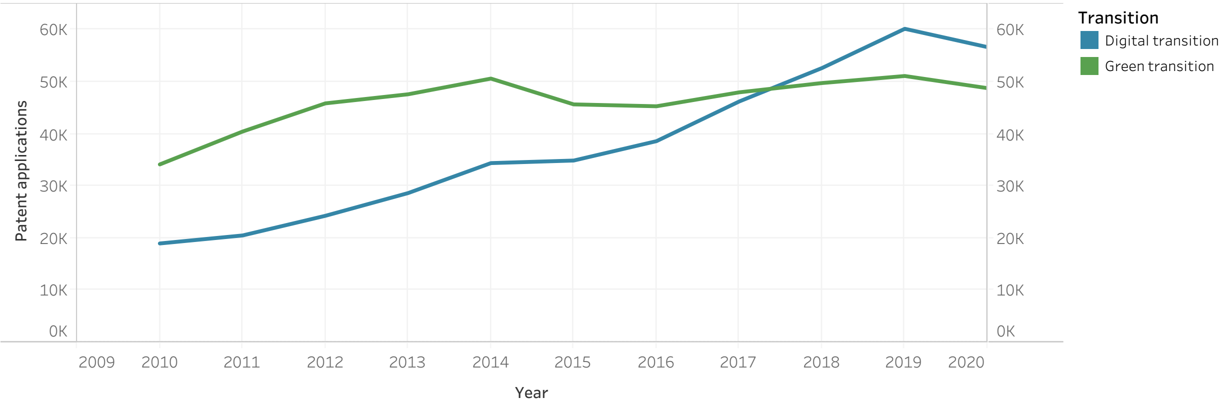
When further analysing the patent applications related to the topic of textiles, more specific connections between the textiles industry and green technologies can be revealed. Patent applications in the field of water and air pollution reduction and recycling/waste management have a relatively important share, reflecting efforts towards greening industrial processes. Beyond the direct environmental technologies, the analysis also shows how the textiles industry is affecting green transformation of other related industries. Most importantly, technology development is linked to batteries, green buildings, and green transport.

[15] https://biosolutions.novozymes.com/en/textiles

[16] https://www.henkel-adhesives.com/be/en/spotlights/all-spotlights/new-developments/sustainable-adhesive-solutions-for-textile-industry.html

To bring some concrete examples, inventions in the field of batteries include **laminar textile material for covering the battery** electrode and making it more efficient. Another example is **flexible textile battery** with positive electrode fibre sheets. The battery development also reflects the progress with **wearable power supply devices** and systems that are needed for emerging textile electronic applications. Patent applications can be tracked over time revealing technological trends. Figure 6 shows that both the number of green and digital patent applications has grown over the years and in particular in the case of the digital transition.

Figure 6: Trends over time



Source: Balland, 2022 based on PATSTAT

2.2. Tech startups and scaleups fostering the green and digital transition

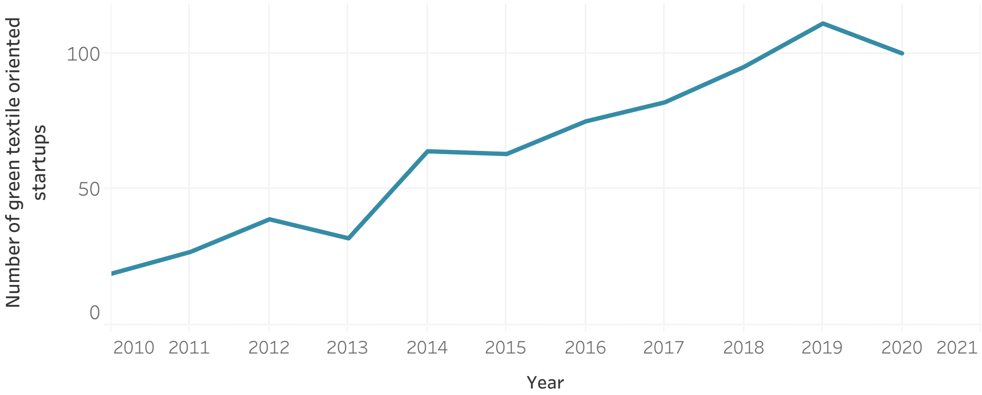
2.2.1 Startup initiatives for green textiles

Environmental startups are key building blocks in the transition towards a green economic model. Entrepreneurial activity helps accelerating the diffusion of technologies in industrial ecosystems and startups that provide green textile solutions are good indicators how the industrial ecosystem is transforming itself to reach environmental sustainability objectives.

In this section, the analysis of environmental startups is based on green technology and circular business model-oriented companies active in the textiles industrial ecosystem that have been sourced from the NetZero Insights database. NetZero Insights is specialised in capturing sustainability driven startups and therefore covers widely the innovations that are being developed in the context of the green transition.

By investigating the evolution of green textile companies created over time, the first observation to make is the **sharp increase in the number of startups with green technologies and green business models** active within the textiles industrial ecosystem over the period from 2010 to 2020. This indicates a progress towards the green transition by the increasing share of new solution providers emerging within the ecosystem and enabling the shift to a low carbon and circular economy model. Figure 7 displays the positive trend during the considered timeframe. For the period from 2020 to 2021, the data shows a downward trend that can be attributed to the time gap it takes for a startup to kick off its activities and be included in startup databases.

Figure 7: Evolution of textile green technology startups per year of establishment (2010-2020)

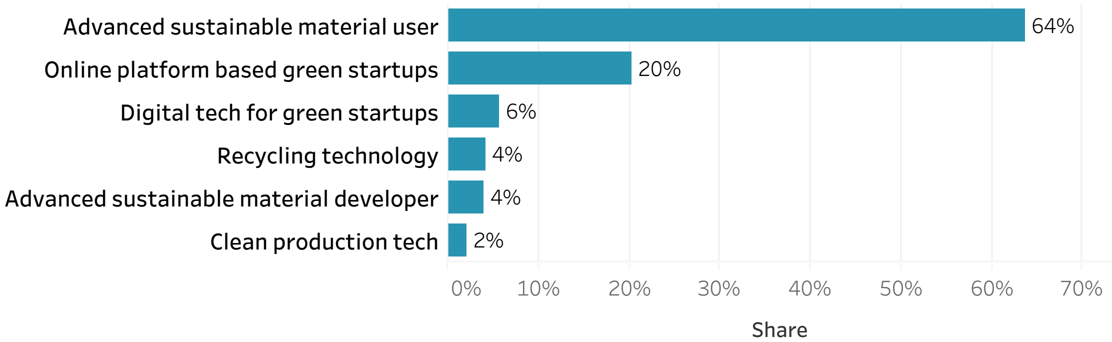


Source: Technopolis Group calculations based on Net Zero Insights, 2022

Type of green technologies and business models

Green technologies, circular business models and other clean solutions that startups offer in the textiles industrial ecosystem range from **sustainable materials, sharing economy business models, use of digital technologies to recycling and clean production** (see Figure 8). A difference is made between textile and fashion industry startups that rely on sustainable (recycled or bio-based) materials and those startups that develop organic fibres or other sustainable materials.

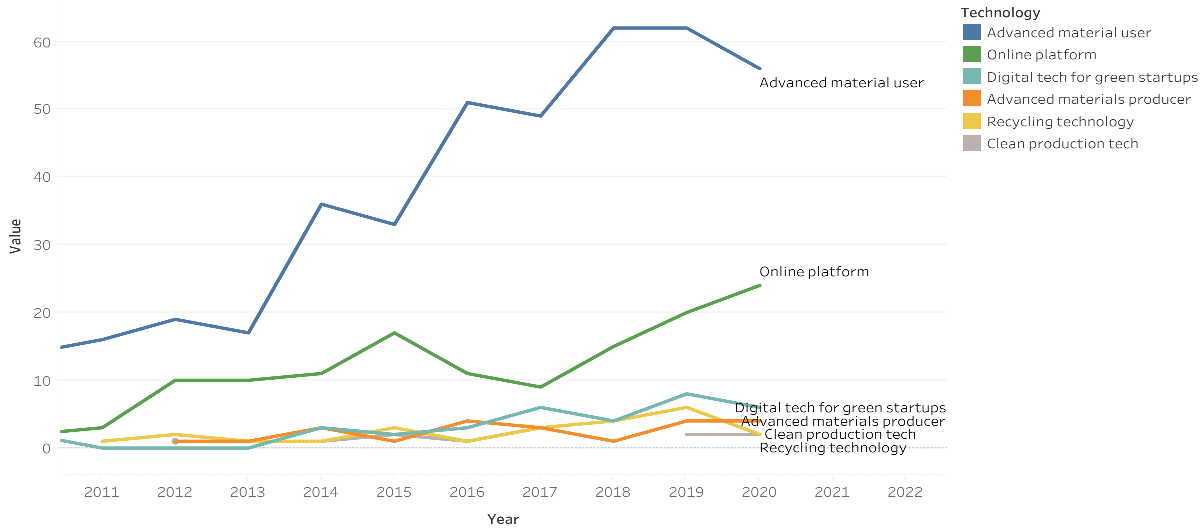
Figure 8: Type of green technologies and solutions provided by textile startups (founded after 2015)



Source: Technopolis Group calculations based on Net Zero Insights, 2022

The business models of positioning a new fashion/textiles company as green (sourcing sustainable materials) and offering circular services online (sharing, renting and repair) have been considerably more attractive for startups than the more capital-intensive business of producing circular materials, recycling processes or clean production solutions. On the other hand, the sharply increasing number of textile companies relying on bio-based, organic and recycled materials indicates that solutions developed elsewhere such as in technology centres are taken up and there is a demand for sustainable textiles. Another trend that can be observed in the landscape of green textiles startups is the significant **increase in the use of advanced digital technologies** since 2013 notably in augmented and virtual reality, artificial intelligence and blockchain (digital authentication). Interestingly, we find very few startups that follow a non-technological innovation path and business model different than the six categories mentioned above. Some companies provide circular design and have ventured into upcycling, but these examples are rare. Deko Eko is cooperating with upcycling designers, startups and producers in order to create new consumer products from waste materials. The most dynamic startups with the highest total investment are illustrated per technological area in Figure 9 and are discussed in the subsequent sections more in detail.

Figure 9: Evolution of type of green textile startups

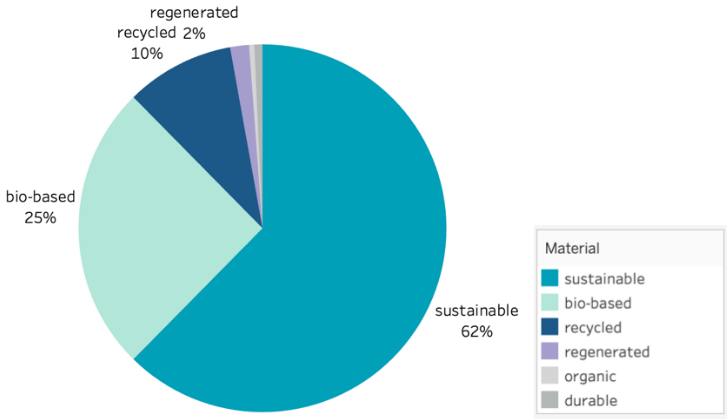


Source: Technopolis Group calculations based on Net Zero Insights, 2022

Alternative sustainable material users:

Within the sample, **64% of the startups are new textile companies incorporating recycled, bio-based or durable materials in the production process of their products** (mostly garments) and positioning themselves as ecological textiles firms. The majority of these companies are also fashion retailers that source their production materials either from textile factories that supply fabrics certified under voluntary schemes such as GOTS certified Organic Cotton, OEKO TEX or Global Recycled Standard, or from innovative advanced textiles providers such as ECONYL® or REPREVE. The number of newly created textiles companies and retailers relying on sustainable materials has been proliferating since 2013, which indicates a growing popularity among entrepreneurs venturing in this field and focusing on sustainable textile fibres and materials.

Figure 10: Types of sustainable materials sourced by green textile startups



Source: Technopolis Group calculations based on Net Zero Insights, 2022

Online platform-based circular business models:

According to the analysis, green textile startups increasingly rely on digital platforms to support their circular business models. Such **startups with an online circular solution represent 20% of all green textile companies**. Close to 50% facilitate the exchange of second-hand clothes by providing a digital marketplace (e.g. Vinted from Lithuania and Vestiaire Collective from France). The share of startups that operate an online clothing rental service is 20% (e.g. La Mas Mona from Spain or Hyber from Sweden). The rest of the online marketplace-based startups focus on collaboration along the value chain (enabling designer brands to make new value out of unsold inventory), strengthen supplier-buyer relations and promote textiles goods that are durable with longevity in mind.

Figure 11: Top 4-5 green textile startups with the highest total funding per type of technology

Technology	Name	Total funding (EUR)
Online platform	Vinted	478.000.000
	Vestiaire Collective	392.000.000
	Otrium	134.000.000
	Patatam	22.000.000
	Sellpy	18.790.690
Fabrication of fibres from bio-based raw materials	Spinnova	127.000.000
	Infinited Fiber Company	38.656.962
	Amsilk	34.000.000
	Carbios	17.800.000
	Fairbrics	6.650.000
Artificial Intelligence	Fit Analytics	106.000.000
	TiHive	11.972.500
	Spectral Engines	6.525.625
	Smartex	3.662.983
Recycling technology	Recover	94.615.620
	Renewcell	9.524.351
	Resortecs	3.500.000
	Bcircular	86.822
Blockchain	Material Exchange	31.807.299
	Trustrace	6.545.150
	HUUB	4.000.000
	Retraced	1.000.000
Circular dyeing process, biotechnology	Dyecoo Textile Systems	19.445.159
	Spindye	3.000.000
	Ecofoot	1.643.929
	Vividye Ab	417.146
Nanofibres	Gelatex	1.390.324
Big data	Reverse Resources	901.185
	Bcome	350.000
	Newbrands	131.987
	Scircula	49.810

Total funding (EUR): 49.810 – 478M

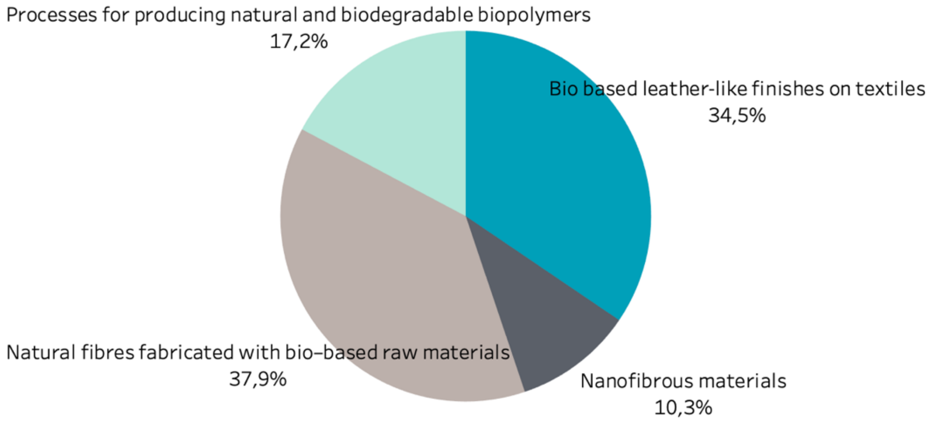
Source: Technopolis Group calculations based on Net Zero Insights, 2022

Alternative sustainable material developers:

There is relevant entrepreneurial activity around **the development of alternative sustainable materials** (4% of startups in the sample). These startups are often not labelled under the textiles NACE codes but originate from chemicals or research, however, they have direct links to the textiles industry. Diverse raw materials and methods are being used to develop these materials, including:

- Natural fibres fabricated with bio–based raw materials such as food production, aquatic biomass and biological waste streams like hemp, food waste, forestry (Treetotextile, Sweden; PYRATEX®, Spain).
- Processes for producing natural and biodegradable biopolymers (Lignopure, Germany)
- Techniques to develop technical textiles such as nanofibrous materials (Gelatex, Estonia)
- Bio-based leather-like textiles produced from diverse natural sources such as food waste or hemp (Beyond Leather Materials, The Apple Girl, Denmark)

Figure 12: Distribution of types of materials being developed by green textile companies founded after 2015



Source: Technopolis Group calculations based on Net Zero Insights, 2022

Recycling startups:

Recycling technologies are being developed only by 4% of the green startups and include chemical recycling (converting of cellulosic and synthetic fibre-based textiles), biotechnology based recycling solutions, sorting facilities and in some cases recycling machinery as well. Recycling is a capital-intensive activity, and the development of production capacities is still in its early stages in Europe with a few examples especially in the Nordic countries, Netherlands and Belgium. The establishment of facilities is very recent in most cases and often it is in a testing phase. There are a couple of initiatives that aim at bringing back recycled material production into the EU. The Dutch Circularity[17] has set up a recycling and spinning process with automated stitching tables in Etten Leur in 2021. Similarly, Rester[18] in Finland has established a recycling facility in 2020. Their technology helps removing buttons, zippers and cutting textiles into patches. Other startups include also:

- Resortecs[19] develops a dissolvable stitching thread intended for repair and recycling of garments.
- Carbios[20] from France develops industrial bioprocesses for recycling polymers and for biobased and degradable polymers.
- Examples also include upcycling textile waste into new products without industrial processes such as developed by Moot Eco[21] in Germany.

Clean production technology-oriented startups:

The data indicates that there are a low number of startups that develop clean production technologies such as **sustainable dying processes and pigments** (only 1% of all green startups in the database). Plasma technology, spin-dyeing, SC CO2 dyeing, digital printing, ozone bleaching, enzymatic treatments, electrochemical dyeing and ultrasonic treatment as emerging technologies for textile wet processing. Companies that develop bio-based dyes and colorants include for instance Pili[22] from France (developer of a bioengineering technology to obtain dyes from renewable carbon sources for the textiles industry) and the Netherlands-based Zeefier Zee Sea[23] that creates dyes from seaweed. Innovative dying

[17] https://circularity-works.com/en/about-circularity/
[18] https://rester.fi/en/questions-and-answers/
[19] https://resortecs.com/
[20] https://www.carbios.com/fr/
[21] https://moot.eco/
[22] https://www.pili.bio/
[23] https://zeefier.eu/

solutions that reduce water and chemical use are offered for instance by Ecofoot[24] from Portugal.

Digital technology startups enabling green development:

There are startups that have developed green technologies powered by advanced digital technologies particularly **artificial intelligence, blockchain and big data**. Blockchain and AI-based software tools ensure material and quality traceability and transparency among the actors operating within the supply chain. AI-based contactless sensor systems allow to identify fibre type, blend, colour and other criteria and support sorting and disassembly as part of the recycling process. Combined with augmented and virtual reality, there are AI-based fitting technologies that provide an online personalised experience and consultation to the customer. Specialised startups also rely on software platforms using SaaS and offering traceability of recycled products.

- Smartex.ai[25] develops a real-time textile inspection platform designed to reduce production cost and improve quality.
- Projectdresscode[26] attaches a crypto-enabled tag to each product determining its authenticity, tracing ownership and social value.
- TrusTrace[27] offers supply chain transparency and material traceability for global fashion and apparel brands. Thanks to their solutions, brands and suppliers can collaborate on product and materials traceability digitally with the use of SaaS and enhanced by artificial intelligence.

Green textile tech scaleups:

Following the definitions of the European Scaleup Monitor[28], data have been filtered for young fast-growing companies that are 10 years old or younger and have received at least €1 million within the past 10 years. This allowed us to estimate how many textile tech startups have managed to scale up so far. The analysis of Net Zero Insights and Crunchbase data identified **30 recent green textiles scaleups across various topics such as online platform for second hand textiles, recycling technologies, advanced sustainable materials and disassembly and sorting technologies.**

Country patterns:

Regarding the geography of startups, the country coverage of green textile startups shows disparities across Europe (see Figure 13). There are frontrunners such as Germany, France, the Netherlands, Spain and Italy, where around 68% of textile startups are concentrated as the data indicates. Further larger textile startup ecosystems are also found in Portugal, Denmark and Sweden. When looking at which countries have been growing the most in terms of number of green textiles startups, the data indicates that the Portugal grew 400% in 2020, compared to 2015 data, followed by the Netherlands (300%) and Italy (120%).

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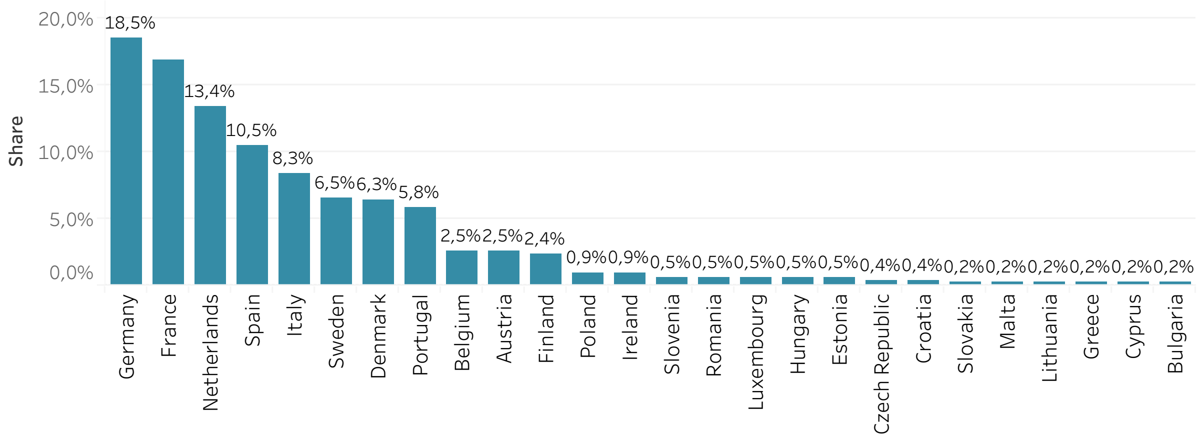
[24] https://www.ecofoot.pt/
[25] https://www.smartex.ai/
[26] https://projectdresscode.io/product/
[27] https://trustrace.com/about-us
28 European ScaleUp Monitor (2021). European scaleups got knocked down, but are up again, Erasmus Centre for Entrepreneurship, available at: https://www.eur.nl/media/100543

Figure 13: Number of startups (established after 2015) developing green textile technologies across the EU Member States



Source: Technopolis Group calculations based on Net Zero Insights, 2022

2.2.2 Digital tech startups

Besides the green transition, digitalisation has had a profound impact on the textiles industry in the past decade similarly to other industries. Digital technologies such as cloud computing, big data, artificial intelligence and connectivity promise new solutions to improve operational and production performance and help for instance remote factory monitoring and automated supply chains. Two digital technological models that have been increasingly common in textiles since the 2000s and now are established include e-commerce[29] and digital printing. The scope of e-commerce has been further expanding and embracing sustainability (as already seen in the previous section as part of online marketplaces for circular services) and got a boost during the Covid pandemic period.

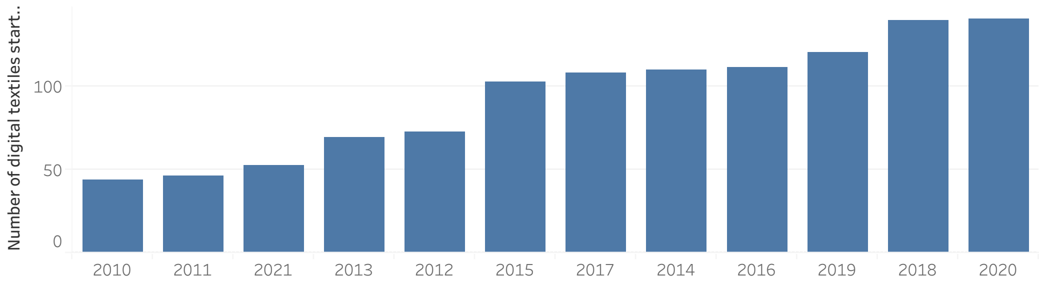
Digital transformation trends have been analysed based on a set of Crunchbase data. Startups have been selected by filtering for the 'Textiles' and 'Fashion' categories and by text-mining the business descriptions of companies with a filter for digital technology related startups[30]. This search resulted naturally not only in a list of textiles companies in the traditional sense, but also in a set of ICT companies that specifically mention supplying the textiles industry.

The results show a steady increase in the number of digital technology-powered textiles startups over time, but with a lower growth rate than in the case of green textiles startups. The data investigated includes a large share of companies established after 2010 focusing on e-commerce, adopting a digital strategy, and reaching out to customers directly, which shows the digital shift in the supply chain. Moreover, patterns related to e-commerce have been driven by the shift to online shopping behaviours. Diverse e-commerce applications are being implemented from simple web platforms, e-shops to specialised apps.

[29] Daly, L. and Bruce, M. (2002) The Use of E-Commerce in the Textile and Apparel Supply Chain. Journal of Textile and Apparel, Technology and Management, 2, 1-12.

[30] Startups have been defined as companies established not longer than 5 years taking into account existing official definitions, although more broadly trends have been captured since 2010.

Figure 14: Digital technology-based and textiles industry related startups founded since 2010



Source: Technopolis Group calculations based on Crunchbase, 2022

Besides the use of online marketplaces and digital printing, the analysis of textiles technology startups show that the main digital technologies that allow the creation of new added value products and services include **artificial intelligence, augmented and virtual reality** (AR/VR), **and blockchain,** moreover also the specific segment of **electronic textiles.** Internet of Things is integrated as part of electronic textiles in the company cases captured via Crunchbase, although the technology is important for textiles production and retail. Despite these technological advancements, the use of big data and machine learning, AR/VR and distributed authentication systems are still in an early stage of development although have a massive potential (see also the analysis of the European Textiles Technology Platform, 2022).

Startups often combine various digital technologies; hence a strict delineation is not possible. For instance, AR/VR in personalisation is often supported by AI technologies. AI also plays an increasing role in electronic textiles and smart wearables. Blockchain and AI technologies often go together in textiles applications. An even more complex case is visual quality inspection of textiles, a process that can be atomised and simplified by the integration of sensors, artificial intelligence (for pattern recognition) and virtual reality with the help of a digital twin.

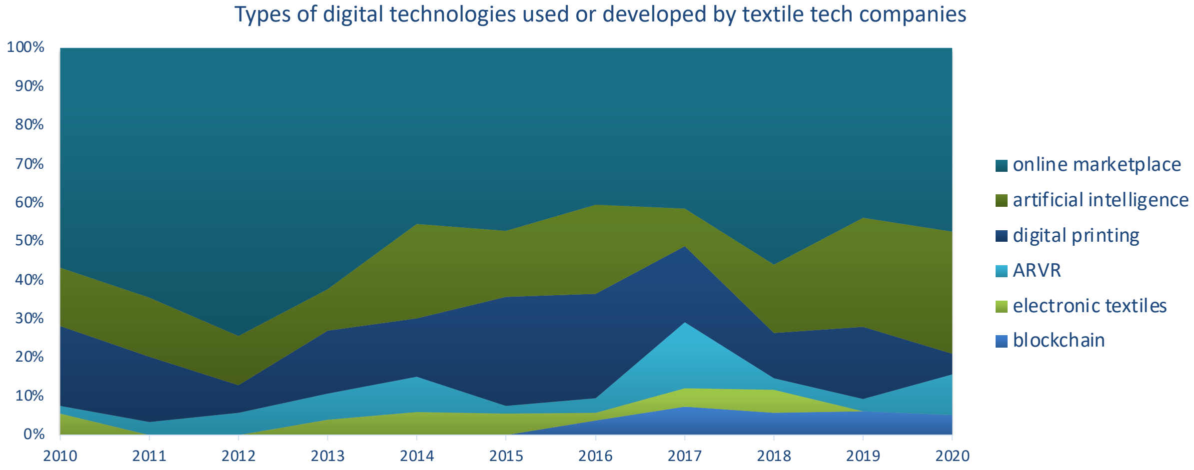
Overall, it can be observed that:

- 53% of textile tech startups offer an online platform for e-commerce, supply chain collaboration or sharing model
- 17% provide artificial intelligence powered data and other personalisation solutions
- 5% is related to augmented and virtual reality
- 3% develop electronic textiles/smart wearables

Interestingly, **robotics technology startups specialised in textiles are rare**, even if such applications have been observed in patent statistics (see Section 3.1). Euveka[31] develops robot mannequins, controlled by data management software, capable of reproducing an infinite number of morphologies. There are also a few recent innovations from the UK such as Clobot that builds autonomous apparel production robots to help the textiles industry to reduce the cost of clothing production.

[31] https://www.euveka.com/en/

Figure 15: Type of digital textile tech startups



Source: Technopolis Group calculations based on Crunchbase, 2022

Artificial intelligence is harvested more and more in applications that can help meet customer demand, personalisation, foresight and data analytics. **The contribution of artificial intelligence** to the textile industry is multifaceted and can be applied throughout the whole industrial value chain. In the design phase, AI can help textile firms create new patterns and styles based on existing datasets. During production, it can be applied to recognise fabric patterns and fabric colours, to detect visual defects and measure wrinkles in the fabric. Machine learning can identify previously hidden patterns from raw data to help businesses improve efficiency and maintenance, and can optimise inventory and supply chain management or AI-based yarn fibres for new designs prototypes and materials.

AI-powered data analytics startups in the textile industry include various examples. AI applications offer several benefits to textile industry companies including dashboards to provide quantified real-time data of the market, trend feed with trend reports and market analysis and also access to the product images on the market.

- The **French Livetrend**[32] is an innovative fashion solution providing data-driven trend analysis & competitive intelligence. Leveraging Big data and Artificial Intelligence, Livetrend helps to create best-selling collections and maximize businesses.
- As an international example, **SoftWear Automation**[33] is a US-based machine vision and advanced robotics startup offering an automated Sewbot technology. Their solution enables on-demand manufacturing for sustainable apparel and reducing the carbon footprint since it will be only produced what is consumed eventually.
- **Sizolution**[34] is an AI-powered application for perfect size & fit. It helps fashion stores boost sales and reduce returns by bringing personalisation to the customer experience.

[32] https://livetrend.co/
[33] https://softwearautomation.com/
[34] https://www.sizolution.ai/

Box: Example of an AI startup in the textiles ecosystem

Senstile is a Spanish AI company working in the field of fashion technology. It aims to integrate technology such as hardware, AI, and platform into the textile supply chain by digitalising textile materials and products. Via the use of sensors and AI, it creates 'digital fingerprints' such as the touch and feel, the thickness or the thermoregulation properties of the materials. The textile digital fingerprints can be crossed with other data from external departments such as marketing or e-commerce and promote personalisation. Source: https://www.senstile.com/

Augmented and virtual reality (AVR) can be used in various stages of the value chain including design, textile production, maintenance, retail and customer engagement. For example, focusing on the customer experience and brand enhancement, digital sampling and virtual showrooms enhanced by AVR aim at improving cost-efficiency and marketing efforts. An ordinary T-shirt can be transformed into a virtual 3D animation and upgraded for the digital world allowing the engagement of a new segment of customers.

Box: Example of an AVR startup in the textiles ecosystem

Future Fashion is an Italian omnichannel platform that helps fashion brands to virtualise and customise their collections in 3D by reducing sample costs and increasing customer experience. They optimise the use of technology in order to realistically convey the lines of a model, the shades of a material or the texture of a fabric. Source: https://www.futurefashionsolution.com/en/

Digital twins:

Digital twins combine various digital technologies to create a system that mirrors the physical world. In the textiles manufacturing industry sensors can collect machine data that can be fed into a digital software and thus allow the monitoring of machines. For example, temperature and vibration can be tracked and in case of problems addressed quickly. Digital twin solutions can detect errors at an early stage and reduce downtime.

Digital twins are also used in the context of digital labelling and giving each garment or textile product a digital identity. Digitalised products enable the key stakeholders of the value chain such as brands and retailers to track the product and its lifecycle. This has also relevance for the circular economy and transparent value chains.

Interestingly, this analysis has not identified startups or scaleups specific for the textiles industry in this field. Nonetheless, there are software companies that offer digital twin solutions for the textiles industry even if they are very limited for the moment. For example, Lectra, a French company provides integrated technology solutions for the fashion industry. Via its digital twin platform called Kubix Link it enables brands, retailers and manufacturers to create, manage and share product data across the entire value chain. Kubix Link allows users to create digital twins of their products, from design to production, and to collaborate with their partners in real time.

Electronic textiles/smart wearables:

Since late 2015, they have dedicated to bring to the market an intelligent thermal technology that knows exactly how and when to keep people warm. The three Clim8 co-founders saw a tremendous need to create an ingredient brand – Clim8 – that would combine both Textile and Digital industries. While until now most of intelligent wearables were able to track user's activities, Clim8 provides a technology that monitors, analyses, activates and regulates accordingly to the user's specific needs. The Italian QOOWEAR builds wearable hardware & software technologies to boost safety and productivity of industrial workers into extreme environments. **Wearable electronics** is a field to be specifically highlighted within the textiles industry. E-textile technologies are facing exponential growth in a multidisciplinary research field. The wearable e-textiles can be made with several materials using different fabrication methods. It covers many aspects of cutting-edge R&D and provides an opportunity for textile manufacturers and fashion designers to innovate with a range of advanced technologies. Integrating the Internet of Things and electronics into clothing is a dynamically developing concept, which opens up a whole array of multi-functional, wearable electro-textiles for sensing/monitoring body functions, delivering communication facilities, data transfer, individual environment control and many other applications.

Digital product passports:

The proposal for a Regulation on Ecodesign for Sustainable Products including the introduction of a Digital Product Passport, has established the framework for setting ecodesign requirements for specific product categories in order to improve their circularity, energy performance and other environmental sustainability aspects. The European Commission will look into design requirements for specific products in the foreseen implementation of the ESPR (through the adoption of delegated acts). Textiles is one priority area, however, the exact scope of products is still to be determined after consultation with relevant stakeholders and conducting the necessary impact assessments.

3. Uptake of green and digital technologies and business models by SMEs

Key findings

The results of the survey conducted with 326 textiles companies in this project show that close to 42% of the respondents adopted a green technology or implemented a new green business model, which is a promising result. The detailed survey results demonstrate that SMEs in the ecosystem have been most active in the use of recycled materials and to a lesser extent adopting recycling technologies within their own operation. Clean production technologies are a further important technology cluster in terms of adoption. The least cited green technologies include carbon capture and hydrogen.

The text mining of company websites shows that around 65% of textile companies in the sample have a website and approximately 54% of the companies with a website had a website with more than 10 pages. This indicates a moderate online presence and overall digitalisation of the industry. Textile companies have been active on social media with 57% of the companies in the sample found to have an account on one of the major platforms. Overall, online platforms and cloud technologies are indicated as the most relevant, followed by advanced software and the Internet of Things. Big data and artificial intelligence have been adopted by a low share of SMEs so far. Blockchain has been the least adopted among the digital technologies.

With the objective to monitor the status in the uptake of digital and green technologies and related business models, this study adopted a mixed-method approach including a **business survey and text mining of company websites**. The survey was based on using Computer Assisted Telephone Interviewing (CATI). The final sample included 8 987 companies in all industrial ecosystems and 326 interviews for the textiles ecosystem in particular. The mainstage fieldwork was conducted between 15 January and 15th May 2023. The survey respondents come from a mix of micro-enterprises (less than 10 employees), small enterprises (10-50 employees) and medium-sized enterprises (50-250 employees). The text mining of textiles company websites leveraged natural language processing and information extracted from 1 456 068 webpages of 29 158 textile companies. The analysis was based on the assumption that companies that adopt green or digital technologies and practices want to differentiate themselves from competitors and will announce this on their websites. The sample size of the web analysis represents 13% of all textile companies in the EU27. The analysis compasses both fashion and technical textiles for industrial applications.

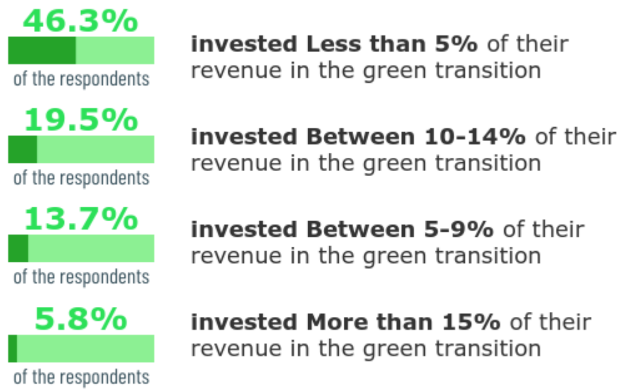
The results of other existing surveys have been also taken into account such as the Flash Eurobarometer 498 on SMEs, green markets and resource efficiency, and the ICT-usage in enterprises survey[35]. The different time of the field work for each survey can give some insights about progress even if the questions were not exactly the same. The Flash Eurobarometer 498's field work took place in November-December 2021. The last ICT usage survey results date from 2020.

[35] https://ec.europa.eu/eurostat/cache/metadata/en/isoc_e_esms.htm

3.1. Green transformation of SMEs

Textiles SMEs have taken some recent first steps in adopting environmental actions, technologies and business models as indicated by the EMI survey results and the scraping of company websites. The web analysis found that **23% of the textile firms referenced at least one type of green technology on their websites.** As part of the survey, respondents were asked whether they **had increased their investments dedicated to the green transition** and environmental sustainability during the past five years, and **51% of the respondents answered** positively. These results indicate that there is a promising momentum to make a real change, even if there is still a lot to be done.

Figure 16: Share of revenue invested in green transformation by SMEs in textiles ecosystem on average annually



Source: Technopolis Group and Kapa Research, 2023

Nonetheless, a further question was related to the percentage in terms of the revenue that SMEs invested in green transformation on average annually. The responses show that a large share (46%) **invested below 5% of their revenue** (see Figure above). This indicates that there is still a moderate actual action despite the interest to increase spending on clean technologies and on sustainability. Similarly, the Flash Eurobarometer in 2021 found that **only 17% of the textiles SMEs surveyed had a concrete strategy in place to reduce their carbon footprint and become climate neutral** or negative and 12% was planning to prepare one. Textiles was one of the industrial ecosystems with the lowest result.

The detailed survey results demonstrate that SMEs in the ecosystem have been most active in the **use of recycled materials and to a lesser extent adopting recycling technologies** themselves. Some SMEs are also concerned about **their energy use** with close to one third of the respondents indicating the uptake of energy-saving technologies in the past years. **Clean production technologies** are a further important technology cluster in terms of adoption. The least cited green technologies include carbon capture and hydrogen (see Figure below).

Figure 17: Adoption of green technologies in the textiles industrial ecosystem

Technologies	Already using	Planning to adopt
Recycled materials	32,0%	6,0%
Energy-saving technologies	27,8%	7,0%
Recycling technologies	24,3%	8,0%
Clean production (water, chemical reduction, waste reduction technologies/solutions)	24,3%	2,5%
Bio-based materials	23,3%	2,5%
Renewable energies	18,0%	12,3%
Biotechnology	8,3%	2,5%
Additive manufacturing	6,8%	5,7%
Carbon capture technologies	6,0%	5,7%
Hydrogen	1,3%	2,5%

Source: Technopolis Group and Kapa Research, 2023

Sustainable material sourcing

According to the EMI survey results, **32% of the textile SMEs indicated the use of recycled materials** (at least to some extent), **but a lower share notably 23.3% the use of bio-based sustainable materials**. In the Flash Eurobarometer 47% of the respondents indicated overall to take action and switch to greener supplier of materials. Recycled materials have also ranked at the top of green transition technologies that had been mentioned the most often on textiles company websites (11% of companies referring to recycled materials).

Recycling is an area that attracts attention as sustainable material sourcing promises not just circularity but also lower costs, as highlighted by some of the interviewees. Most recycled textiles materials represent polyester and were sourced from plastic bottles and other plastic waste. Other recycled fibres mentioned include regenerated nylon, regenerated cellulose, cotton and wool. As the price of virgin polyester depends on the cost of petroleum and can vary, recycled polyester is considered to become an increasingly valuable alternative. Recycling starts with sorting, disassembly, removal of contaminants, and finally processing of recycled fibres to new textile materials.

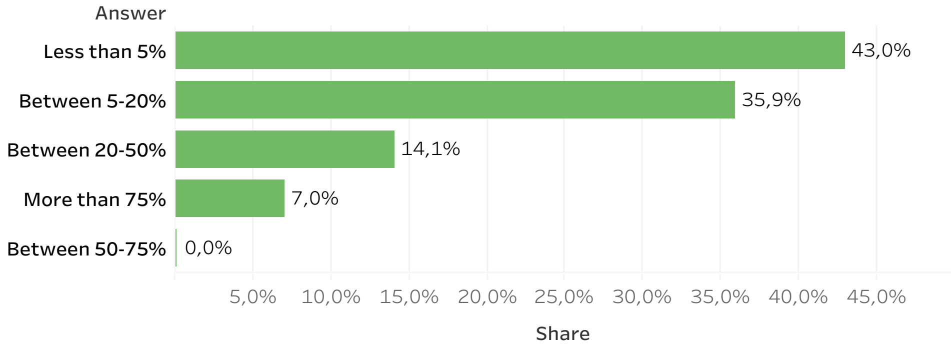
When discussing the shift to sustainable material sourcing in the textiles industry, the role of the different types of players needs to be taken into account such as the yarn producers, textile material producers and final product manufacturers. During the stage of yarn and fabric production, instead of virgin material, recycled yarns can be used based on recycled fibres and textiles. To date, there are only a few recycled yarn manufacturers in the EU, such as for example in Catalonia that recycle either pre- or post-consumer waste into new yarn. The garment or industrial textiles manufacturers are further key stakeholders that can foster the green transition and change to the sourcing of sustainable materials.

The text-mining also revealed that **recycled materials represented 43% of the textile trademarks identified, which shows the role green transition plays for branding, reputation and competitiveness.**

Despite these positive steps, **the share of recycled materials used within the products/production of textile companies surveyed is below 5%** in close to half of the cases. **This suggests that the adoption of recycled materials is still in an early stage.** Strengthening this argument, an analysis of textile products sold online on

Zalando[36], an online clothes retailer, shows that only 2% of the clothing items are claimed to include recycled materials with usually less than 30% of recycled content within one product. Only 7% of the EMI survey respondents indicated using recycled materials as a share more than 75% of their textile products.

Figure 18: What is the share of recycled materials that you use within your products/production? (Share of respondents that use recycled materials)



Source: Technopolis Group and Kapa Research, 2023

Box: Example of the use of recycled materials

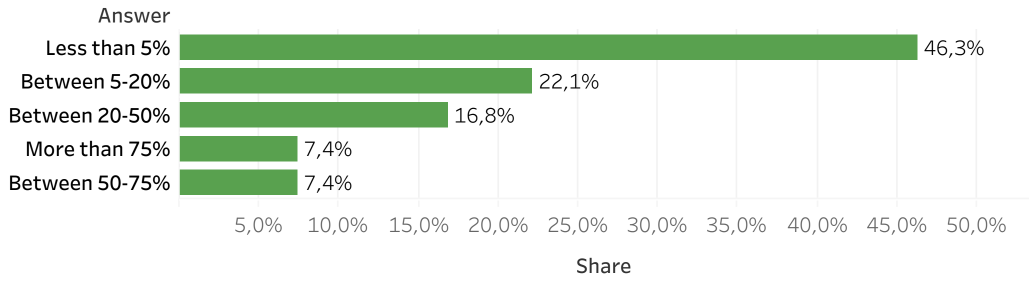
The ECONYL® regeneration process gives a new life to waste materials that would otherwise be sent to landfill, transforming them into a new source of opportunities. Nylon waste – such as fishing nets, fabric scraps, carpet flooring and industrial plastic – is recovered and converted into new yarn, which has the same qualitative characteristics as traditional nylon. Source: https://www.aquafil.com/environment)

The adoption of **bio-based sustainable materials was found to be much lower than of recycling both in the EMI survey (23%)** and when text mining company websites (referenced only on 6% of the websites). It is also only 3% of the trademarks identified on textiles company websites that are about bio-based materials. Synthetic fibres such as polyester still dominate the market globally with a share of around 62% followed by cotton (24%) as indicated by Textile Exchange (2021). Other natural plant fibres represent 6%, while animal fibres account for 2% (EEA, 2023).

The share of bio-based materials within total production is very low notably less than 5% as indicated by close to half of the respondents. The bio-based materials mentioned the most include cellulosic fibres (eg. lyocell that is a regenerated fibre consisting of cellulose, mainly obtained from wood) and organic cotton.

[36] Zalando.com

Figure 19: What is the share of bio-based materials that you use within your products? (Share of respondents that use bio-based materials)



Source: Technopolis Group and Kapa Research, 2023

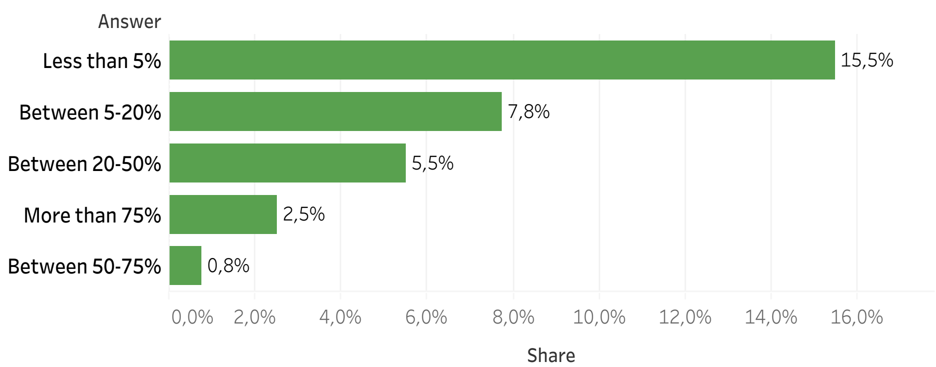
Box: Example of the use of bio-based materials

Shoemakers post on their website the use of materials that come from fungi, algae, bacteria, and other biodegradable elements. The most recent development concerns the upper made of kombucha, the tea leaves which, through a fermentation process and a particular processing. They search for organic, biodegradable products or even vegan-certified, preferably accredited, to comply with the increasing consumer demands in developed economies. Source: https://felipefiallo.com

Recycling

Recycling does not only mean closing the loop of post-consumer textiles. There is significant waste created during production even before a textile product gets to the market. Textile manufacturers can play an important role in reducing pre-consumer textile waste and get engaged directly in the recycling process. **The EMI survey found that 38% repurposed their fabric waste at least to some extent,** although the share of reused fabric material is still very low. Nonetheless, **68% of the companies do not take actions regarding textiles waste at all,** which is still a large share of the textiles industry. Reusing and repurposing textiles waste already at the stage when the final products are being prepared can have a significant impact, since it was estimated that between 10-15% of the fabric can go unused as a result of damaged yarn, cut out or rejected fabrics or excess stock (as assessed by some interviewees).

Figure 20: What is the share of fabric waste that you have repurposed within your production?



Source: Technopolis Group and Kapa Research, 2023

Box: Example of launching a recycling business by textile companies

CIBUTEX is a circular business startup established in 2022, as a cooperative of several industrial textiles companies Blycolin, Dibella, Edelweiss, Lamme and Nedlin. CIBUTEX works with upcyclers who need larger quantities of B2B post consumer waste/resource textiles for their upcycling process. The textiles required by the upcyclers must be white and made of 100% cotton or blends of maximum 50% polyester. The profit is passed on to our members on a pro-rata basis and is invested in research and development. (Source: https://www.cibutex.eco/en/about-us/)

Circular business and service models

SMEs were surveyed about the **adoption of circular business models and other circular practices** such as circular design, repair, renting, leasing or design for durability. The results indicate that the largest share notably **20% of the respondents adopted repair and maintenance service models** including for example cleaning services and laundry. These services are relevant to keep products longer in use. As highlighted, a growing number of brands and technical textile companies are introducing repair centres as part of their business portfolio, but naturally large companies have been more active in this area. Some companies offer online instructional videos and guides for do-it-yourself repairs.

Renting, leasing and related service models were adopted by 17.8% of the respondents. Examples include on the one hand garment renting and on the other hand leasing of industrial textiles provided for example for hotels, restaurants and hospitals. Industrial customers can select a range of lease-ready textiles linen and other products for specific purposes and occasions.

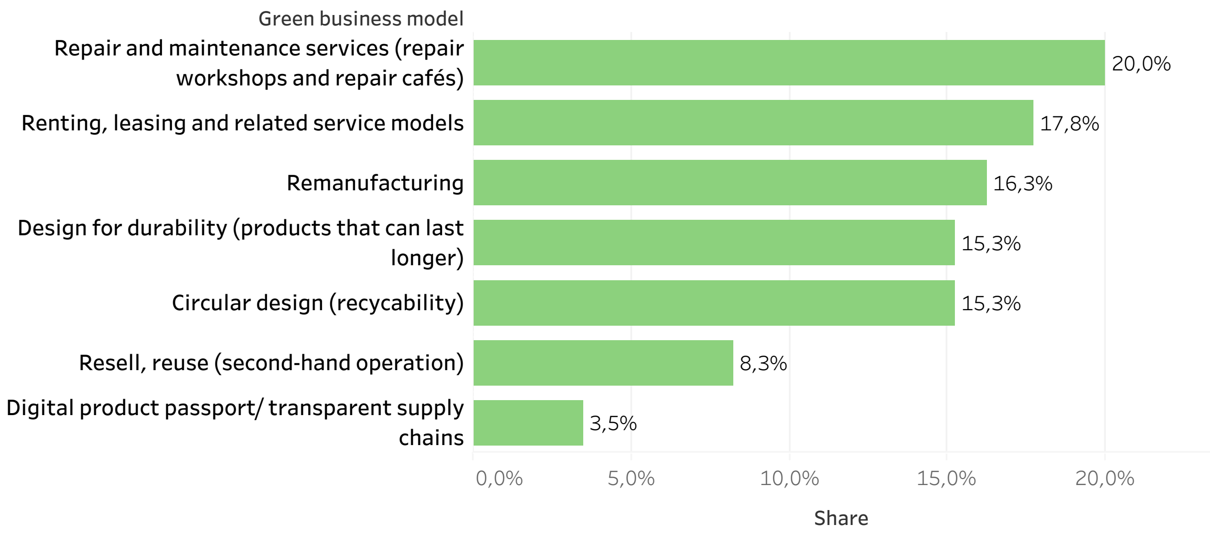
Remanufacturing is still a niche activity with only 16.3% of the textiles SMEs indicating the adoption of such practices. Remanufacturing is used to reconstruct used textiles products and items to create new ones.

Circular design at the very start of the supply chain is critical in order to ensure that textile end products remain in use for a long time, can be recycled and thus reduce waste. Nonetheless, only **15% of the survey respondents stated that they applied sustainability criteria at the design stage**.

Actions in order to **increase transparency in the supply chain and be prepared for a digital product passport was indicated by 2.3% of the respondents**. Digital product passports as highlighted in the sustainable products initiative[37] of the European Commission will be the norm for all products with tags identified and linked to data relevant to their circularity and sustainability.

[37] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en

Figure 21: Adoption of green business models and non-technological solutions in textiles in the EU27



Source: Technopolis Group and Kapa Research, 2023

Resell and reuse services were indicated by 8.3% of the respondents, which is a low share. Nevertheless, these services are mainly dominated by social enterprises that take care of the sorting and reuse of textiles. **Takeback programmes offered directly by textile companies are very limited,** as found also by the text mining of company websites. Barely any textile company that we scraped, and text mined has a service to collect back old textiles and reuse them. There is also a lack of clothes renewal shops.

A further clear issue is that circular services still do not seem to be profitable. Companies using them in order to increase the attractiveness of their brands and enhance their marketing campaigns, but in essence **75.9% of the textile companies surveyed said that the use of circular service models is not yet cost-effective for their business**.

Clean production

Little information was found on clean production technologies on companies' websites in general. The survey results show that **24% of the respondents adopted clean production technologies that help reduce water, waste and chemical use** during the manufacturing or business operation process. Technologies mentioned are sustainable dyeing technologies, use of pigments and enzymes, and biocatalytic processes. It was stated that the switch to clean production brings both economic and environmental benefits for the SMEs. Besides technologies, more is being done through organisational and service innovation, as indicated by the Flash Eurobarometer in 2021. Around 72% of textiles SMEs were found to take actions to minimise waste, although only 38% had measures in place to reduce water use.

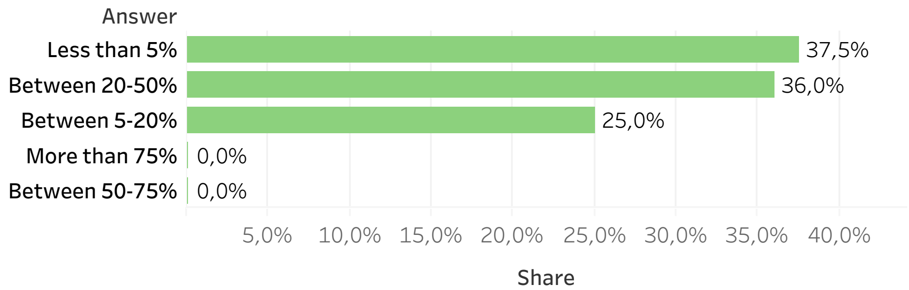
Box: Example of clean production technologies

A case worth mentioning is the use of foam an indigo dyeing technology that is an environmentally sustainable technology certified by AITEX (Spain's research centre providing advanced technical services for the textile, garment and technical textile industries). Tejidos Rojos developed a Dry Indigo®, a new indigo yarn dyeing process which eliminates the use of water, so it achieves zero wastewater discharge, which drastically minimises its impact on the environment. It also reduces energy use by 65% and 89% less chemicals. The company's history is marked by the development of advanced industrial process techniques. The company has been a forerunner in foam dyeing technology as well as being the first textile company in Europe to use low impact raw materials (post-consumer pre-consumer, Tencel® and fibres of organic origin) for the creation of their fabrics. Source: https://www.tejidosroyo.com/en/royofashion/denim_collection

Renewable energy and energy efficiency

Rising energy costs represent a key challenge for textiles SMEs. The EMI survey found that **18% of the respondents invested in renewable energy technologies over the past five years** as displayed in Figure 22 at the beginning of this chapter. The results indicate that 37.5% of those that responded positively, cover less than 5% of their energy consumption by renewable energies with another 36% indicating a share between 20-50%. Solar energy has been one of the type of sources invested in directly for heating, cooling and lighting. There are however limitations since there are high upfront costs.

Figure 22: Share of renewable energy use within total energy consumption by textiles companies surveyed in the EU27



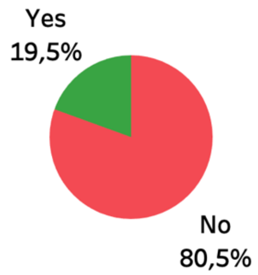
Source: Technopolis Group and Kapa Research, 2023

Environmental standards

When asked about the certification on any environmental standards, it is **only 19.5% of the respondents indicated that they had been certified** (see Figure 23) by a third party. There are a number of certificates and standards that aim to reduce energy consumption, improve energy efficiency, and promote sustainable energy practices in the textiles industry. Standards also play an important role as they can also help distinguish sustainable fashion from greenwashing.

There are various environmental certifications common in the textiles industry, including the EU Ecolabel (that can be awarded to all kinds of textile clothing and accessories, interior textiles, fibres, yarn, fabric and knitted panels); the Global Organic Textile Standard (GOTS) that was developed to define world-wide recognised requirements for organic textiles; OEKO-TEX 100 (certifies that all products are free of harmful substances for the human health). Nevertheless, recent data show that the overall number of eco-labelled textile products remains moderate even if with a growing trend. For instance, there were 3 281 GOTS certified textiles facilities in the EU in 2021[38].

Figure 23: Share of survey respondents indicating that they have obtained a third-party verified environmental certificate



Source: Technopolis Group and Kapa Research, 2023

ISO 14001 includes a set of standards that any company can follow to implement an effective environmental management system. By adopting the good practices suggested by the standard, firms can substantially reduce their environmental footprint. The number of environmental certificates issued in the industry indicates the progress towards the application of environmentally friendly business practices and production methods. For the purposes of this report, ISO data were accessed via the ISO survey of certifications to management system standards[39]. For the purposes of this report, ISO data were accessed via the ISO survey of certifications to management system standards[40]. The analysis of the data shows that textiles companies increasingly adopt environmental management practices measured by the number of ISO 14001 certificates issued per year. **The annual ISO survey indicates that there were 468 certificates issued to textiles companies in the EU27 in the year 2010, which number grew to 1734 certificates issued in 2020 (meaning a 271% increase).** Despite this progress, the overall number relative to the size of the industry is still low. It is worth noting that ISO updated its environmental certificate with new requirements (ISO 14001:2015 environmental management systems) in 2015, hence the most recent certificates have a stronger positive environmental impact. The revised certificate integrates management practices and the life cycle perspective throughout the operation of the company.

3.2. Digital transformation of SMEs

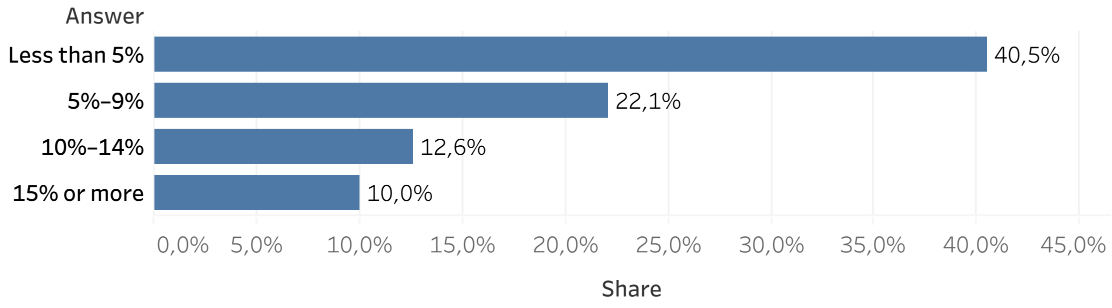
SMEs in the textiles industrial ecosystem have been less engaged in digital technologies than in the green transition. It is a lower share of SMEs, notably **47%, that indicated the increase of their investments dedicated to digital technologies during the past five years**. A further question was related to the percentage in terms of revenue that SMEs had invested in digital transformation on average annually. The responses show that **40% of the respondents invested less than 5% of their revenue** in digital technologies, which is very low.

[38] https://global-standard.org/images/resource-library/documents/GOTS-Annual-Reports/GOTS_Annual_Report_2021_WEB.pdf

[39] ISO (2022) ISO Survey of certifications to management system standards. Accessed on https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&sort=name&viewType=1

[40] ISO (2022) ISO Survey of certifications to management system standards. Accessed on https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&sort=name&viewType=1

Figure 24: Share of revenue/income invested in digital transformation on average annually



Source: Technopolis Group and Kapa Research, 2023

The text mining of company websites shows that around **65% of textile companies in the sample have a website** and approximately 54% of the companies with a website had a website with more than 10 pages. This indicates a moderate online presence and overall digitalisation of the industry (see Figure 25). Textile companies have been active on social media with 57% of the companies in the sample found to have an account on one of the major platforms. Among the different social media platforms, approx. 50% of the companies used Facebook followed by Instagram (38%). Youtube, LinkedIn and Twitter are relatively less used, notably by 14% and even less of all the textile companies text mined.

Figure 25: Basic digitalisation of textiles companies in the EU27

Source: Technopolis Group and Kapa Research, 2023

The level of adoption of specific digital technologies relevant for the ecosystem is presented in Figure 26. Overall, online platforms and cloud technologies are indicated as the most relevant, followed by advanced software and the Internet of Things. Blockchain has been the least adopted among the digital technologies.

Figure 26: Adoption of digital technologies by SMEs in the textiles industrial ecosystem following the EMI survey results

	Answer	
Technology	Already using	Plan to start using in the next 12 months
Online platform	38,3%	2,3%
Cloud software and cloud computing	32,3%	1,3%
Advanced software (business intelligence; production)	21,0%	7,0%
Internet of Things	14,0%	2,3%
Robotics	13,0%	4,0%
Big data	12,8%	2,5%
Augmented and virtual reality	8,0%	1,3%
Artificial Intelligence	8,0%	6,0%
Digital twin	4,8%	1,3%
Blockchain	3,5%	3,3%

Source: Technopolis Group and Kapa Research, 2023

The use of online platforms by 38.3% of the SMEs in the ecosystem reflects the importance of the platform economy and e-commerce in the industry. In particular since the Covid-19 pandemic, textiles sales moved extensively online as already discussed in the previous chapter.

Cloud technologies in this project have been defined as the **use of cloud-based software and related cloud platform services. The results show that 32.3%** of the respondents in the EMI survey covering the textiles industrial ecosystem adopted these technologies. Most of the companies use cloud services to support their supply chain management and store, for digital product development and more specifically to share and process their data. Cloud platforms are particularly important for e-commerce, but also underpin the application of other digital technologies such as IoT and AI. Regarding the narrower textiles manufacturing sector Eurostat statistics[41] reveals that 15.6% of the companies in the manufacturing of textiles wearing apparel, leather and related products bought high cloud-computing services such as CRM (customer relationship management) software and accounting software in 2020. When looking at cloud technologies in a broader term, Eurostat statistics shows that 34.8% of the textiles manufacturing companies adopted cloud computing services over the internet.

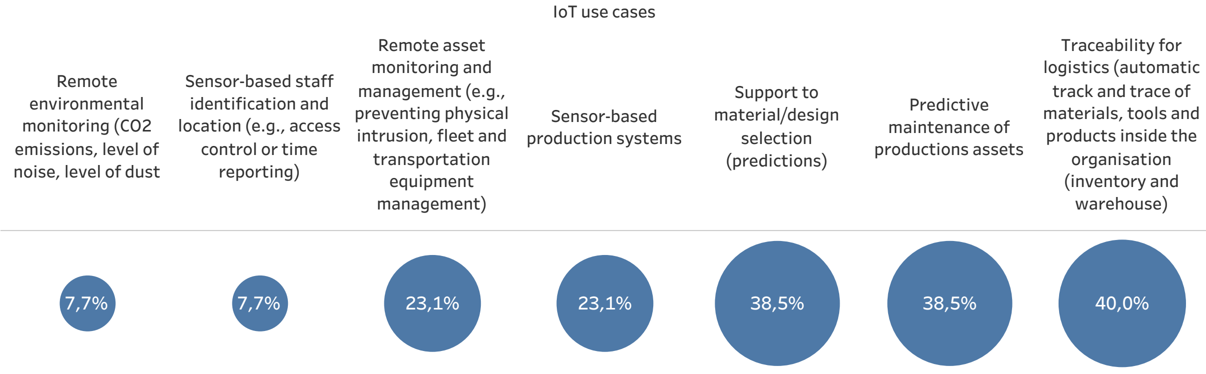
Digital printing is a digital technology specific to textiles with a high adoption rate (referenced by 9% of the companies). Digital printing has various applications as it is applied for all sorts of fabrics (man-made, organic) and purposes (print on fabric, garment, leather, indoor and outdoor furniture, automotive). The technology is mature and allows companies to easily shift from screen printing. Efficiency gains in terms of waste and customer expansion with smaller lots represent drivers contribute to their uptake.

Internet of Things technologies have been indicated by 14% of the survey respondents and are on the top of the list among the advanced digital technologies in use. Textiles companies connect most often their products and materials to the internet with the objective to track their inventory. They are also using IoT for predictive maintenance. Some respondents indicated to integrate IoT into the production process and monitor machines. Remote monitoring thus allows the optimisation of production and

[41] https://ec.europa.eu/eurostat/databrowser/view/ISOC_CICCE_USEN2__custom_7042248/default/table?lang=en

reduction of errors. To support IoT applications, there is a need for reliable, scalable cloud infrastructure, hence there is a strong link between the uptake of cloud and IoT technologies. Besides using IoT in the process of traditional textiles production, this technology is more particularly the basis for smart textiles products such as smart garments that can monitor their users including their behaviour, heart rate, temperature, and movement. The market of smart textiles would deserve a specific analysis that is not in scope of this report.

Figure 27: Use cases of Internet of Things (share of companies within those that already use IoT)



Source: Technopolis Group and Kapa Research, 2023

Robotics technologies are important for textiles SMEs. Within the ecosystem, **13% of the respondents expressed the use of this technology**. Eurostat[42] indicates that 7.1% of the enterprises (10 persons employed or more) in manufacturing of textiles, wearing apparel, leather and related products used industrial or service robots in 2022 (see Figure below). Unsurprisingly, the most important use case of robotics is in product assembly. Robots can print and draw designs on fabrics, can inspect products and enhance textiles machines. Automated sewing robots have been pointed out that help creating custom design. Besides textiles manufacturing, robotics helps the broader textiles ecosystem in inventory management and handling their warehouses.

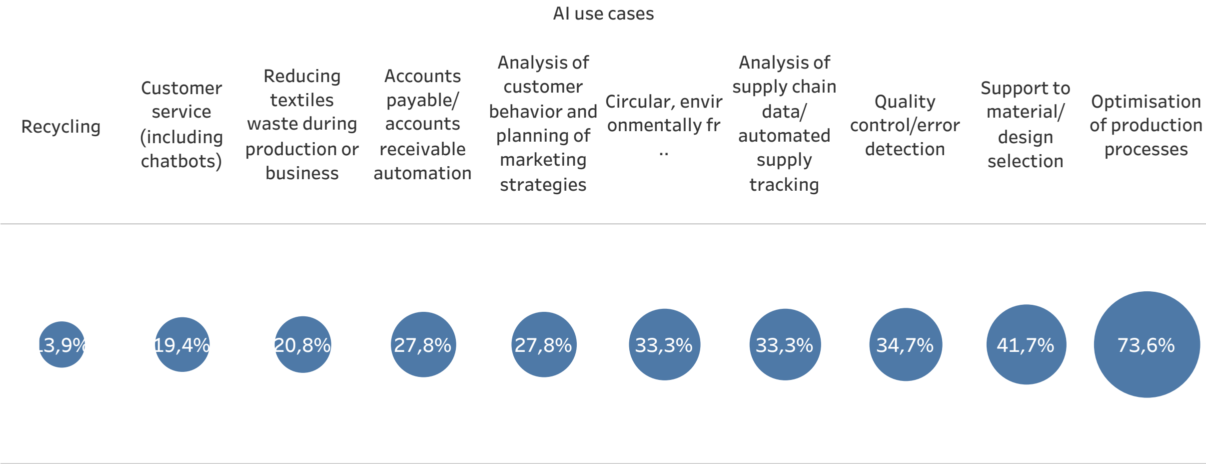
Big data and related data analytics have been adopted by **12.8% of the SMEs** in the ecosystem as found by the EMI survey. Eurostat[43] concludes that 5.2% of the companies in the manufacturing textiles, wearing apparel, leather and related products (10 persons or more) analysed big data internally from any data source or externally in 2020. The higher adoption rate within the broader textiles ecosystem is due to the application opportunities both at the stages of design and sales where a wealth of data is being created. Some firms gather information about fabric structure, colours and customer preferences. Data analytics have been indicated to be used for optimising the supply chain and targeting specific customer segments.

Artificial Intelligence has an uptake of 8% among SMEs in the textiles ecosystem. The related indicator in Eurostat[44] that measures the use of AI by enterprises by economic activity found that **4.6% of enterprises in manufacturing of textiles** adopted at least one Artificial Intelligence technologies in 2021. These results suggest that both AI and big data are used more broadly in the wider ecosystem than in the manufacturing part of the value chain. Indeed, the interviews suggest that AI plays a relatively stronger role in design and analysis of supply chain data. Additional questions of the survey revealed that AI is being used extensively across the full value chain with various use cases, but most importantly has been applied within the **production process notably for optimisation**

[42] https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_P3DN2__custom_7043183/default/table?lang=en
[43] https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_BDN2__custom_7043241/default/table?lang=en
[44] https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_AIN2__custom_7043502/default/table?lang=en

and automation. Secondly, AI has been used in the **design phase of the value chain** notably for material selection and design.

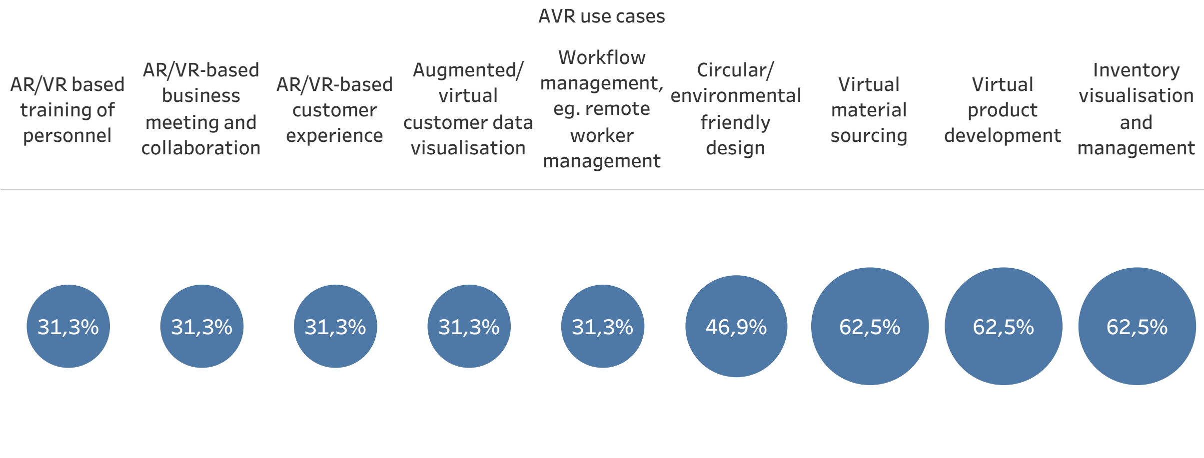
Figure 28: Use cases of AI among textiles SMEs



Source: Technopolis Group and Kapa Research, 2023

Augmented and virtual reality has been mentioned by 8% of the respondents. AVR is used most in inventory visualisation and management, virtual product development and virtual product sourcing. Virtual prototyping enhances product design as designers can create models and the fittings virtually.

Figure 29: Use cases of augmented and virtual reality



Source: Technopolis Group and Kapa Research, 2023

Digital twins create a virtual replica of a physical product, process or system and allow for real time analysis. Virtual garment - The survey concluded that **4.8% of the respondents adopted this technology within the textiles ecosystem** that is still a low result. Digital twins in textiles are used not only in production to improve testing and maintenance, but also during design. By creating virtual replicas of new textiles designs, users can review and suggest changes during the design process almost real time. Such practice is expected not only to enhance efficiency but to reduce material waste and speed up time to market. In this sense, **digital twins and the use of virtual sampling are considered to be key for the green transition of the industry**.

Box: Example of using digital twins in textiles

FibreGuard, a Belgian fabric manufacturing company, has implemented digital twins with the aim to enhance product design and prototyping. It created the digital fabric twin of its physical fabric via a high-quality, ultra-high-resolution scanning process that mapped the finest detail of each fabric in 3D, including true-tone colour, pattern, and texture. These digital twins allow a better and real time collaboration with customers and contribute to minimising waste. Source: https://fibreguard.com

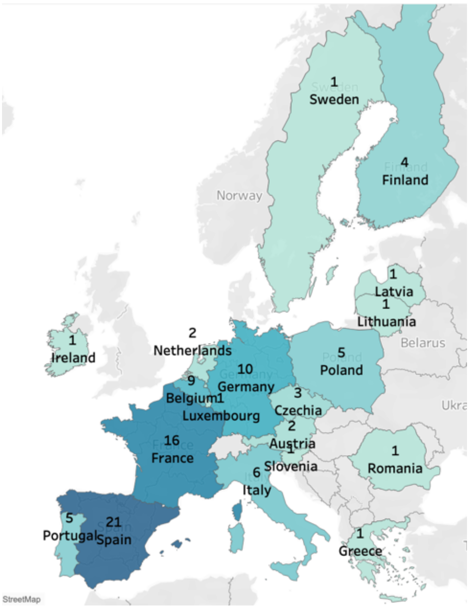
Establishing digital micro-factories is a further trend within the textile industrial ecosystem, although it is only **3.5% of the SMEs participating in the survey indicated that they have shifted to a digital factory model.**

3.2 Technology centres mapping

Innovation actors are at the core of industrial ecosystems and gathering and sharing information about them in a structured way is crucial to detect gaps, improve collaboration, foster innovation, and strengthen innovation ecosystems. Within this project, systematic information is collected on technology centres[45] that are key actors in innovation ecosystems due to their technical expertise and their ability to bring together and steer collaboration among various types of actors in their own ecosystems and beyond.

Figure 30 presents the number of technology centres that are active in the textile industrial ecosystem per European country and shows that Spain is the country with the higher number of technology centres in Europe (26), followed by France (16) and Germany (10). The top 5 is further complemented by Belgium (9) and Italy (6). These countries might host additional technology centres active in the textiles, which are currently not registered to the technology centres mapping.

Figure 30: Number of technology centres active in the textile industrial ecosystem per country



Source: analysis based on Advanced Technologies for Industry Technology Centre Mapping, 2023

[45] https://monitor-industrial-ecosystems.ec.europa.eu/technology-centre/mapping

The following examples serve to illustrate the activities and scope of technology centres active in textiles, their links with the broader ecosystem as well as examples of recent activities in which they are involved. Two examples concern technology centres, located in countries where textile is recognized to be a strong industry: Footwear Technology Center (ES) and DIFT Denkendorf (DE). A third example serves to illustrate the intersectoral approach that some technology centres apply, with specific services targeting the textile indstury: CeNTI, Center of Nanotechnology and Smart Materials (PT).

Box 1: Example Technology Centre

Name of the Centre	**Footwear Technology Centre, CTCR (ES)**
Location and scope	
The Footwear Technology Centre of La Rioja (CTCR) is a private non-profit association founded in July 2006. Its main objective is to be at the forefront of the footwear sector in La Rioja and the north of Spain by fostering technological innovation within the footwear industry.[46] The CTCR has more than 110 partners and over 400 customers[47]. It is a member of the Spanish Federation of Technological Centres (Fedit).[48]	
Main services and equipment	
CTCR offers various technological services in the design and digitalisation process of soles and lasts (3D laser scanners) and it is able to produce prototypes, lasts and molds. The CTCR has, among others, a Department of Nanotechnology with specialists in nanotechnology and new materials. It also has laboratories to carry out several tests like slip resistance, as well as voluntary quality and safety tests on raw materials, semi-finished and finished products. Furthermore, the environmental department focuses on environmental indicators and measures to ensure sustainable growth and reduce the environmental impact of companies, aiming at fostering eco-innovation. The ICT Department focuses on improving the competitiveness of companies´ processes by improving business management and sales opportunities. CTCR seeks at providing tailored trainings adapted to various professional profiles. The centre offers footwear companies support to consolidate international trade relations and to increase exports. It also provides experience in all areas of project management at a regional, national, and European level. Finally, they offer TrendHelp services to provide companies that highly value fashion and trends with real time update.[49]	
Recent projects related to textiles	
• **DigitalFabLab Project** (Erasmus+, March 2021- February 2023): This project focuses on on-the-job training using Augmented Reality[50]. • **RECLAIM Manufacturing Project** (Horizon 2020, October 2019-September 2023): Demonstration of strategies and technologies that enable the re-use of industrial equipment in old, renewed, and new factories alike. CTCR leads a demonstration case on the textile (shoe making) sector.[51]	

Source: Technology Centre Mapping, 2023

[46] https://www.ctcr.es/
[47] Technology Centre Mapping: https://ati.ec.europa.eu/
[48] https://www.ctcr.es/
[49], https://www.ctcr.es/en/trendhelp-eng
[50] https://www.digitalfablab.eu/#project
[51] https://www.reclaim-project.eu/project/

Box 2: Example Technology Centre

Name of the Centre	German Institutes for Textile and Fiber Research, DITF Denkendorf (DE)
Location and scope	
DITF, located in Germany constitute one of the largest textile research centers in Europe with about 300 scientific and technical staff. Located in an area of more than 25,000 m², the centers perform interdisciplinary, public research (regional, national and EU) and industrial projects and services for all organizations involved in fibers and textiles in many sectors (e.g., mobility, construction and architecture, health care and medicine, fashion and functional clothing, interior and outdoor objects, and energy, environment, and resource efficiency). DITF concentrates on three research areas: Textile Chemistry and Chemical Fibers, Textile and Process Engineering, and Management Research. It is member of several networks, such as ETP Textiles, Textranet, Carbon Composites, Medical Mountains, CompetenceNetworkBioMimetic, InnBW, Techtera and AFBW.[52]	
Main services and equipment	
The DITF facilities comprises testing laboratories and offers a portfolio of services for testing fibers, yarns, fabrics, and textiles, including among others laboratories for medical products, environmental simulation and electrostatic behaviour. The DITF also operates a pilot plant, where technologies along the textile value chain are implemented. Moreover, they have their own in-house development and design department for prototype construction. Finally, the centre provides support in the process of idea generation.[53]	
Recent projects related to textiles	
• DITF and Arburg GmbH + Co KG are developing an energy and material-efficient 3D printing process for manufacturing of lightweight bio-based fiber composites. • DITF is part of the consortium behind 'WhiteCycle', an initiative led by Michelin aiming at converting complex waste containing textile made of plastic into other products.[54] • DITF received the 2022 annual award from the 'Discover Natural Fibres Initiative' (DNFI) for the development of 'PureCell', a pure fiber composite made of cellulose. This prize is awarded for innovative products, processes, and scientific achievements in the field of natural fibers.[55]	

Source: Technology Centre Mapping, 2023

Box 3: Example Technology Centre

Name of the Center	Center of Nanotechnology and Smart Materials, CeNTI (PT)
Location and scope	
CeNTI is a private non-profit R&D Institute, located in the North of Portugal and founded in 2006. It explores advanced technologies enabling the developing, testing, prototyping and scaling-up of nanotechnology solutions for the market, surface functionalization and smartization of materials using	

[52] https://www.ditf.de/
[53] https://www.ditf.de/
[54] https://www.michelin.com/en/press-releases/whitecycle-a-european-consortium-to-recycle-plastic-waste/
[55] https://renewable-carbon.eu/news/ditf-are-winners-of-the-dnfi-innovation-in-natural-fibres-award/

printed electronic technologies. It is active in various industries, including textiles.[56] It includes the Technological Centre of the Textile and Clothing Industries of Portugal and the Technological Centre of the Leather Industries. Partners and clients are, among others: Amorim, Revigres, Borgstena Textile Solutions, Tintex, Famalicao, C&S.[57]
Main services and equipment
CeNTI offers various services related to bi/tricomponent fibres, smart textiles, functional coating, and technologies & equipment to characterize product performance. They offer prototyping and testing services, based on international standards, internal test methods or specific protocols developed for a particular product / customer. Specific test procedures are designed for products in the following areas: Clothing, Shoe, Car, HVAC systems, Construction materials, technical textiles, among others[58].
Recent projects related to textiles
• **Fiber4Fiber Project**: This ERDF-funded project focuses on the development of optimized dissolving pulps from Portuguese Eucalyptus globulus trees, to produce man-made cellulosic fibres that can be traced along the value chain. This will allow distinguishing products with a sustainable origin from others that come from less responsible management sources[59].   • **ImpacTEX Project**: This ERDF-funded project aims at the development of protective clothing textiles for sporting activities with improved impact resistance properties.[60]

Source: Technology Centre Mapping, 2023

[56] https://www.centi.pt/
[57] https://www.centi.pt/en/about/partners-clients
[58] https://www.centi.pt/en/services/prototyping-pre-series
[59] https://www.centi.pt/en/projects/advanced-textiles/fiber4fiber-en
[60] https://www.centi.pt/en/projects/advanced-textiles/impactex-en

4. Investment and funding

Key findings

Textile industry innovation in the EU27 has seen an **increasing share of private equity and venture capital (VC) investment** since 2010. The total investment in **green textile innovation** amounted to **€1.6 bn** and in textiles companies powered by digital technologies **to €3.8 bn** over the period from 2010 to 2022. Investments into green textile startups witnessed a sharp increase, while digital tech startups had a more flattened growth curve. Most **VC went into online marketplaces** both environmentally oriented and not.

Green textile technology entrepreneurs are still kick-starting within the ecosystem. Nevertheless, 2021 saw a peak in late funding and exits that is an indication that some of the European **green textile startups managed to scale up and prove their business models (in recycling and bio-based materials)**.

The link between digital and green technologies are demonstrated by the fact that **green textile startups using digital technologies such as artificial intelligence or blockchain have attracted €172 m venture capital investment** in 24 funding rounds over 2010-2022.

The EU27 was a net foreign direct investor in the rest of the world in the field of textiles and over the period from 2010 to 2022. It **invested €10.3 bn** in non-EU countries and was the destination of a **total of €4.4 bn FDI capital investment** from third countries in textiles. Intra-EU FDI amounted to a value of €6.7 bn. Recent FDI often concerns the establishment of new distribution and logistics centres. Trends can be observed that some non-European textile brands and manufacturers set up new facilities in the EU with a **motivation to be closer to the end-user market**.

It is estimated that **21% of FDI investment destined to EU countries** (in 2015-2022) has a digital component either as **digitally enabled factory, digital showrooms, digital ID system** or **online commerce**. Some of the investment projects aim at the rehabilitation of craft skills combined and upgraded with digital technologies. In some of the investment projects extra-EU investors such as from China bring in automation and digital knowledge. Green innovation has been observed only in 12% of the EU related investment projects but include interesting examples of **new factories powered by renewable energy**.

The value of **public procurement on textiles as the main object of procurement in the EU27 amounted to € 1.071 bn in the period 2015-2020**. Within the total amount of textiles related public procurement, **3.3% is related to the green transition and 0.5% to the digital transition**. Results show that public procurement of textiles is concentrated on traditional procurement notices on supplies and services while green and digital public procurement is limited.

The textiles industrial ecosystem[61] had experienced an increasing share of investments in new textile technologies over the past ten years. According to the survey of the European Industry and Research Exchange on Technical Textiles (IVGT) conducted in April 2022, 71% of manufacturers plan to continue investing in new technologies in 2022[62]. However, there are various challenges about how to scale up investments into textiles production that reduces resource use and eliminates waste. The recent report of the global innovation platform 'Fashion for Good' pointed out that the amount of capital available in textiles is still small in comparison to the magnitude of the problem or in comparison to the aggregate financing requirement of the most promising innovators.

Investment data have been captured from various sources including private equity investment, venture capital investment into new technologies, foreign direct investment and public procurement. The scale of venture capital and private equity investment in

[61] https://euratex.eu/wp-content/uploads/EURATEX_FactsKey_Figures_2022rev-1.pdf
[62] https://eutt.net/

green and digital textile startups has been calculated using data from the Net Zero Insights and Crunchbase sources already presented above[63].

4.1. Venture capital and private equity investment in green and digital textile tech

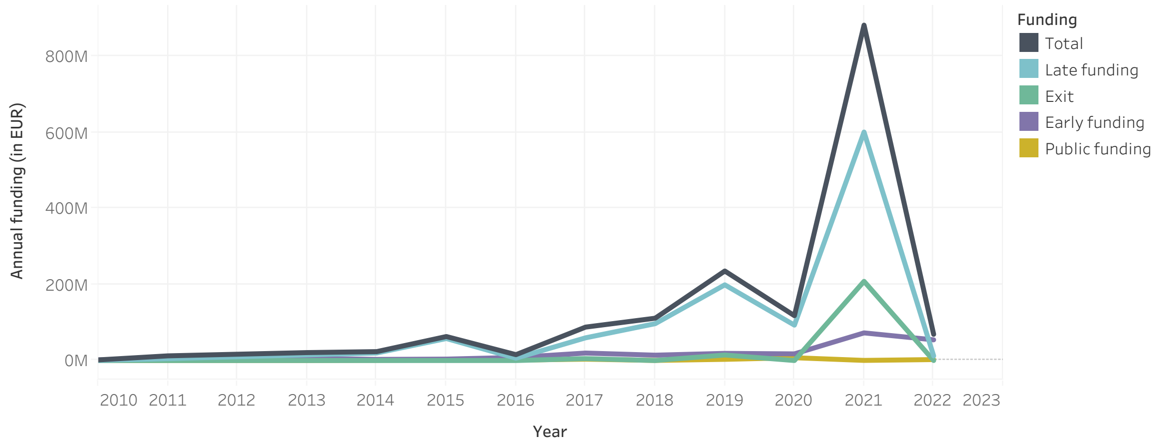
Europe's textile industry has seen an increasing share of private equity and venture capital investment since 2010[64], even if access to early and mid-stage venture capital funding has been an issue and only a limited number of funds have been active in textile technology. Venture capital investment that is relevant for the textile industrial ecosystem is not necessarily investment into traditional textile companies, but it often concerns startups active in chemicals, engineering or information technology and telecommunication and developing new solutions for the textile industry.

The analysis of NetZero Insights and Crunchbase allowed to capture investment information for 260 funding rounds of 120 green textile startups and 539 funding rounds of 295 digital textile tech companies. The investment figures presented in this section refer only to the funding rounds where a value has been disclosed.

4.1.1. Green textiles

In line with the increasing number of green textiles startups, the annual investment into sustainable textiles have been growing steadily during the period 2010-2022 **with a total amount of €1.6 bn.**

Figure 31: Annual funding of green textile startups since 2010

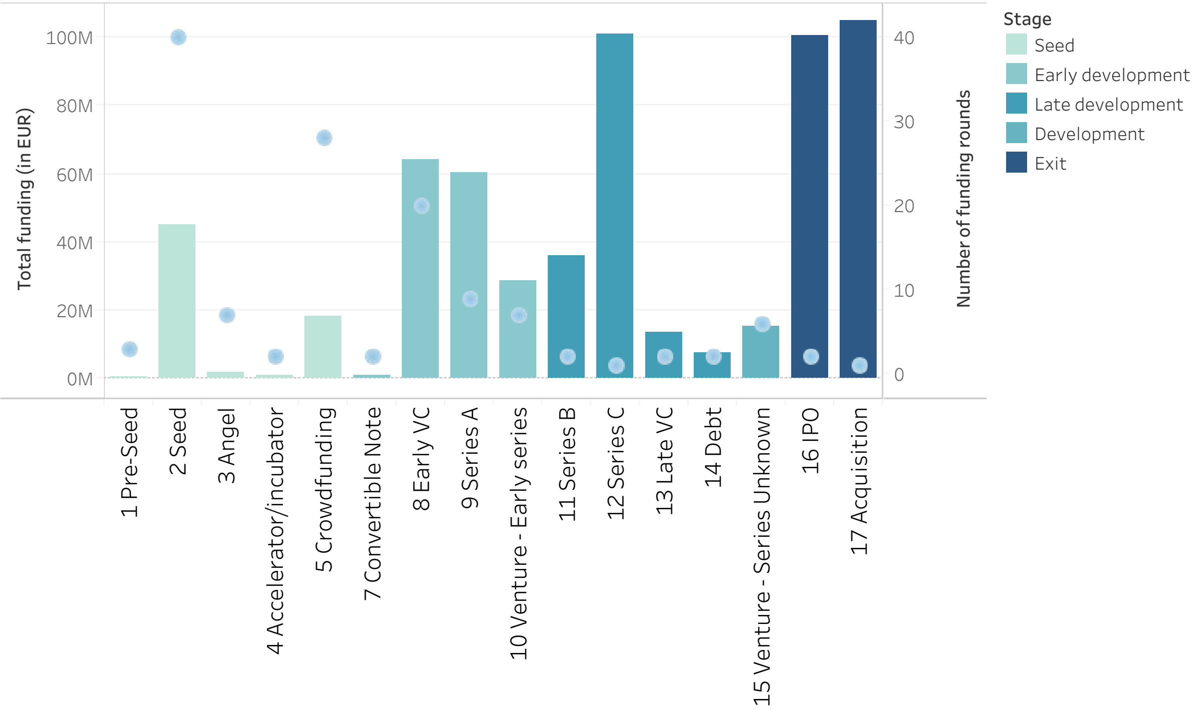


Source: Technopolis Group calculations based on Net Zero Insights, 2022

In most of the funding rounds startups attracted seed stage[65] type of funding such as seed capital, angel investment or crowdfunding, which demonstrates that green textile technology entrepreneurs are still kick-starting within the ecosystem. It is also notable that **2021 saw a peak in late funding and exits that is an indication that many of the European green textile startups managed to scale up and prove their business models**. The first IPOs as exit funding appeared in 2017.

[64] ATI (2021) Textiles report
[65] For the purpose of this study the following categories have been considered early type of funding: Accelerator/incubator, Angel, Crowdfunding, Early VC, Pre-Seed, Seed, Grant and Series A

Figure 32: Total amount by stage and type of funding for green textile companies during the period 2010 - 2022



Source: Technopolis Group calculations based on Net Zero Insights and Crunchbase, 2022

The analysis of funding figures per type of technology in the period from 2010 to 2021, shows that most venture capital and private equity funding went into less capital-intensive startups providing an online platform or marketplace for sharing, renting and exchanging.

Textile material companies producing alternative sustainable materials have been involved in 35 funding rounds. This category includes mainly companies with bio-based, natural fibres and man-made cellulosic materials, but sometimes they develop a mix of bio-based and recycled materials. Within this group, the Finnish Spinnova that develops sustainable textiles materials from wood or waste, opened its stock via an IPO operation of €100 m in 2021. In addition, it has launched the construction of its new spinning facility in Finland. AMSilk in Germany produces and distributes high-quality silk biopolymers and had Series C funding in 2021.

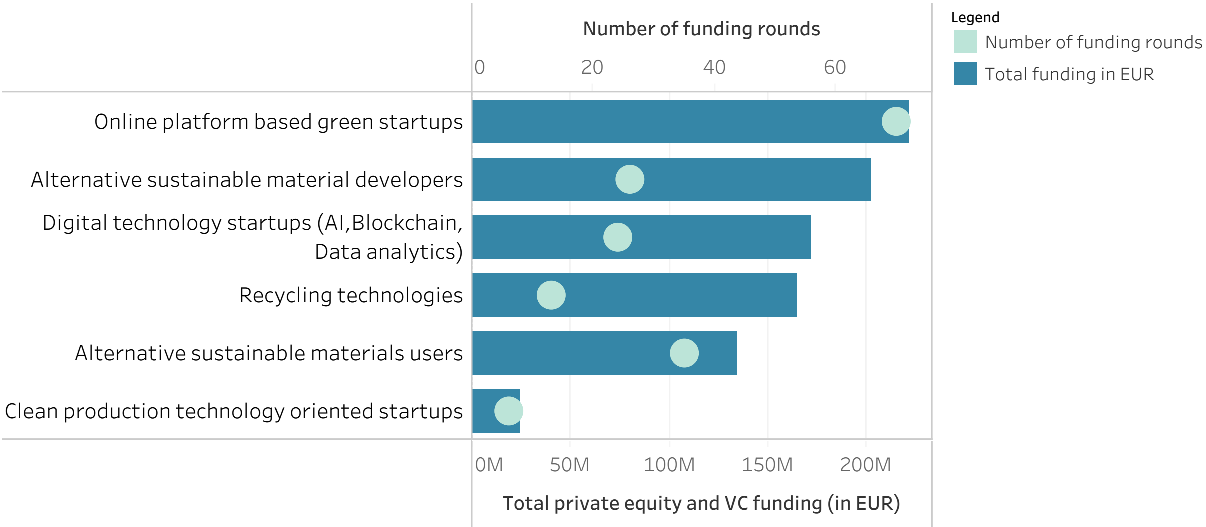
Interestingly, recycling technologies have received a lower amount of investment compared to bio-based materials according to the results of the data analysis, which indicates a relatively slower progress in this field even if showing positive trends. Examples include Recover, a material science company and producer of recycled cotton fibre that raised a total of €90 m in funding (the last is a private equity round raised in 2022). Another example is Infinited Fiber that has raised Series B round funding in 2021 and has selected a new site for a facility for producing Infinna fibre. Carbios[66] is a French company that develops enzymatic processes for recycling and has recently announced the launch of €105 m capital increase to finance its innovation in the end of life of plastics. It has partnership agreements with manufacturers of sportswear and outdoor wear.

The analysis of the venture capital landscape indicates that VCs value digital technologies increasingly a lucrative business to address environmental challenges (overall even a higher amount of VC went into digital tech related textiles startups than into recycling). Green textile startups using **digital technologies such as artificial intelligence or blockchain have attracted €172 m investment via 24 funding rounds**. The Swedish

[66] https://www.carbios.com/en/carbios-announces-the-launch-of-c-e105-million-capital-increase-to-finance-its-industrial-development-plans-representing-a-major-innovation-in-the-end-of-life-of-plastics-and-textiles/

Material Exchange makes use of digital technologies to empower designers, materials teams, product developers and material vendors to develop better products (e.g. via a digital showroom) and collaborate. Material Exchange has raised close to €30 m investment over 5 rounds; the last one from 2022.

Figure 33: Total funding received by type of technology/solution that green textiles startups offer



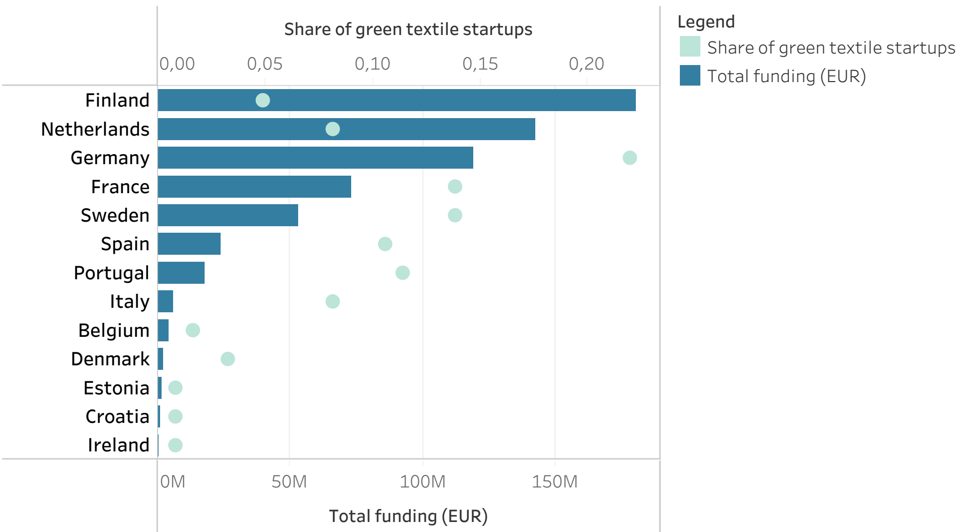
Source: Technopolis Group calculations based on NetZeroInsights and Crunchbase, 2022

Country patterns

The geography of green textile startups in terms of the highest volume of venture capital and private equity investment indicates that 82% of the funding is concentrated in Finland, Netherlands, Germany and France. It should be taken into account that 94% of the funding allocated to Dutch companies went into the online platform called Otrium, which is an online fashion outlet marketplace enabling designer brands to turn unsold inventory into a new opportunity.

Although Germany ranked 3rd regarding total investment, it ranks first in terms of number of companies that received funding. Indeed, the number of funded firms has been the highest in Germany, Sweden and France, followed by Portugal and Spain.

Figure 34: Total investments in green textile startups by country, 2014 -2021

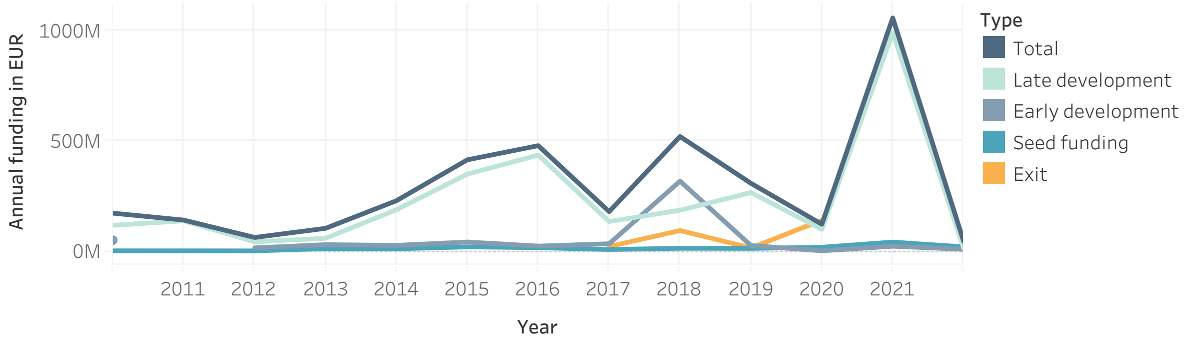


Source: Technopolis Group calculations based on Net Zero Insights and Crunchbase, 2022

4.1.2 Venture capital investment in digital textile tech startups

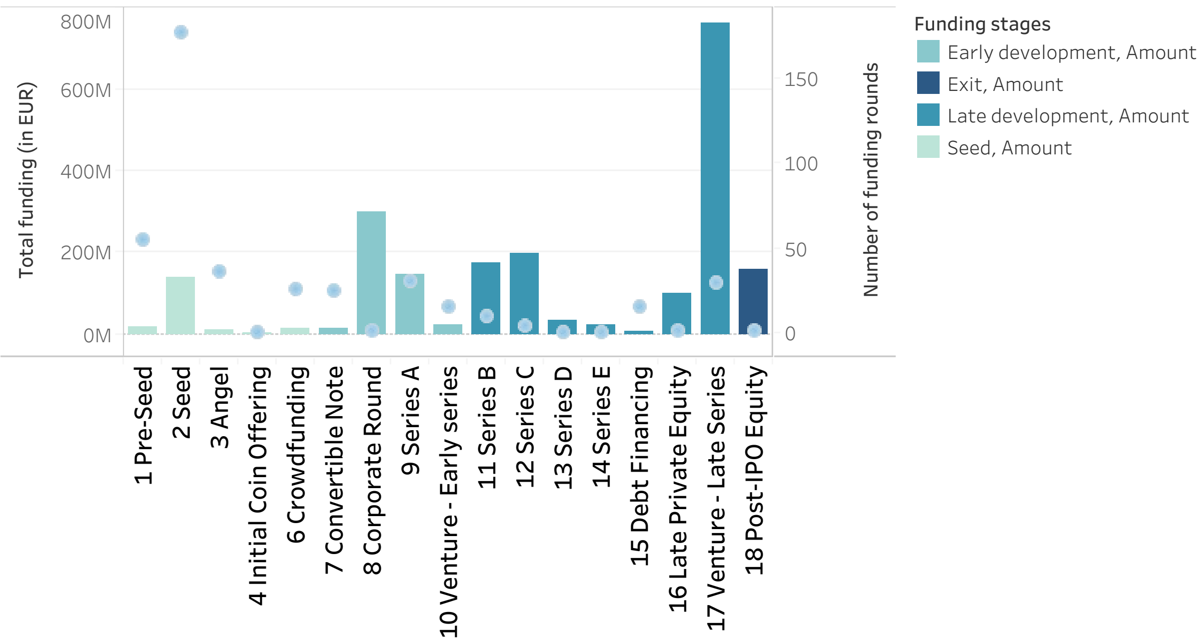
The funding data indicates a positive evolution in the annual funding of textile technology startups powered by advancements in basic and advanced digital technologies during the period 2010-2022. The use of digital technologies is more prominent in fashion and retail than in textile manufacturing as part of the textiles industrial ecosystem. Early stage[67] type of funding is the most frequent in terms of number of rounds, although their share has fluctuated, ranging between 2% (2011) and 43% (2013) of the total funding. Late-stage funding[68] has naturally the highest share within the total funding amount as depicted in Figure 34. As of 2016, data indicates several exit operations reaching approx. €130 m in total in 2020[69].

Figure 35: Annual funding of digital textile startups since 2010



Source: Technopolis Group calculations based on Crunchbase, 2022

Figure 36: Total amount by stage and type of funding for digital textile companies during the period 2010 – 2022



Source: Technopolis Group calculations based on Crunchbase, 2022

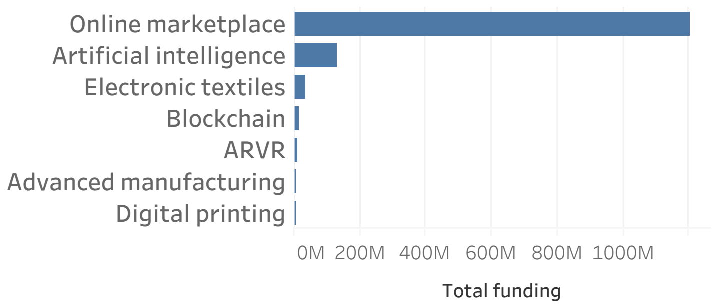
[67] For the purpose of this study the following categories have been considered early type of funding: Angel, Crowdfunding, Convertible Note, Initial Coin Offering, Pre-Seed, Seed, Grant and Series A

[68] For the purpose of this study the following categories have been considered late type of funding: Equity Crowdfunding, Equity rounds, Late VC, Private equity, Series B,C,D,E, F, G, H and I, and unknown series of VC

[69] Post-IPO Equity operation for the company Global Fashion Group.

Investment into online marketplaces has been the most common type of funding. Regarding advanced digital technologies, ICT startups developing artificial intelligence technologies have been raising more and more funding for textiles since 2010, although the recent years (2021-2022) saw less investment rounds compared to green innovations analysed in the previous section. Examples include Smartex.ai from Portugal (also mentioned as part of green textiles startups) that has raised a total of €20 m in funding over 6 rounds, the latest in 2022 from a Series A round. Sizekick has raised a total of €1.3 m in funding in 2022 and develops solutions with artificial intelligence and computer vision technology to recommend clothing size in fashion e-commerce.

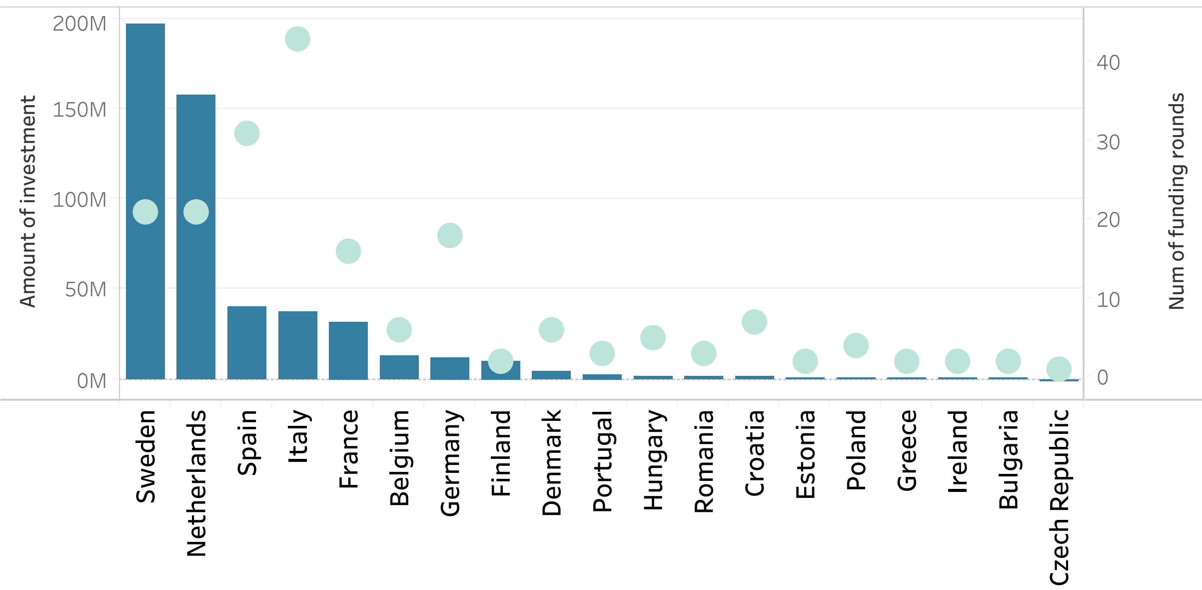
Figure 37: Total investments in digital textile startups by tech, 2015 -2021



Source: Technopolis Group calculations based on Crunchbase, 2022

The geography of private equity and VC funding in digital textile tech shows that the most active countries in terms of VC activity are Sweden and Denmark. Although Italian startups ranked 4th regarding total investment, they rank first in terms of number of companies that received funding. Indeed, the number of funded firms has been the highest in Italy, Spain, Sweden, France and the Netherlands.

Figure 38: Total investments in digital textile startups by country, 2015 -2021



Source: Technopolis Group calculations based on Crunchbase, 2022

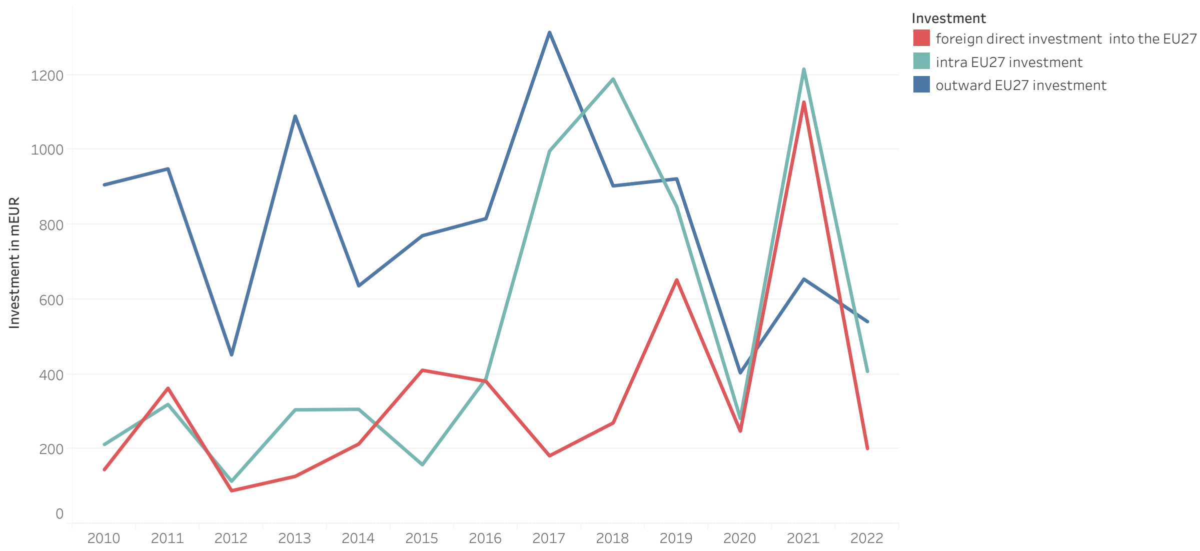
4.2. Intra EU and extra EU foreign direct investment in textiles

fDi intelligence[70] tracks cross-border greenfield investment both intra EU, extra EU and of course globally, covering the textiles industrial ecosystem among other industries. It provides real-time monitoring of investment projects, capital investment and job creation with powerful tools to track and profile companies that are active investors in the field. The data source tracks projects that are expected to create new jobs and do not cover merges and acquisitions (already part of the VC data analysis above).

Europe's textile sector is a clear 'destination' for foreign investors outside the EU27[71], showing significant growth in the majority of countries since 2013. Portugal, Sweden and Bulgaria experienced the largest increases.

The EU27 was a net investor in the rest of the world in the field of textiles and over the period from 2010 to 2022. **It invested €10.3 bn** in non-EU countries and was the destination of a **total of €4.4 bn FDI capital investment** from third countries. **Intra-EU FDI amounted to a value of €6.7 bn**. Recent FDI often concerns the establishment of new distribution and logistics centres. Trends can be observed that some non-European textile brands and manufacturers set up new facilities in the EU with a motivation to be closer to the end-user market. The largest third country investors originate from the USA and the UK, but they also include Turkish, Swiss and Chinese companies among others.

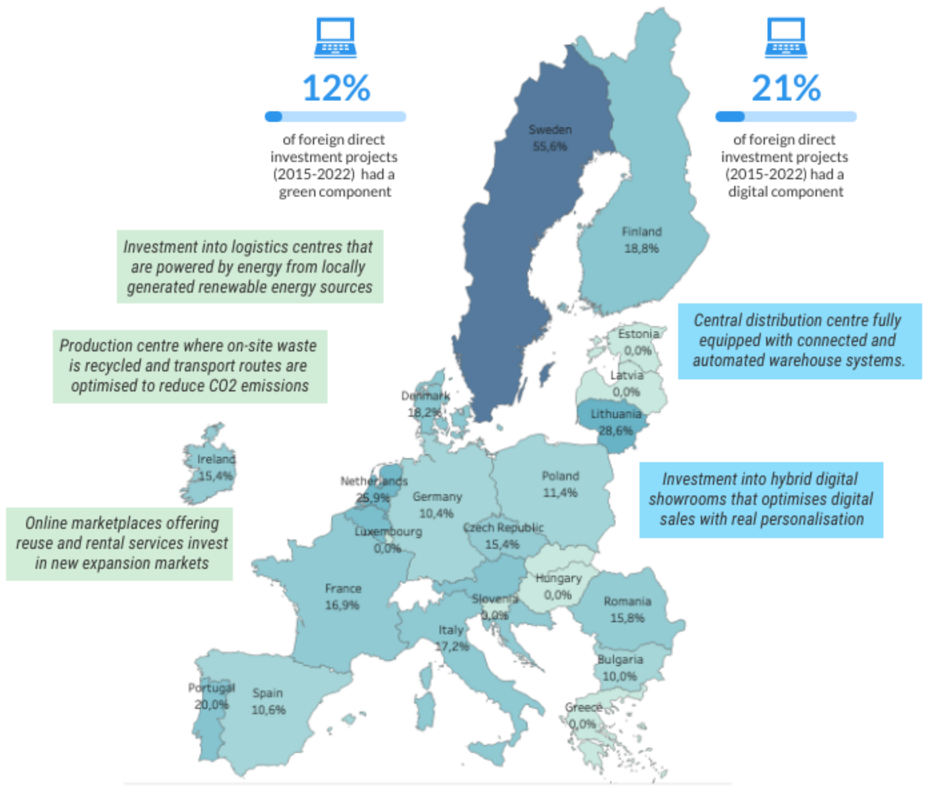
Figure 39: Trends in FDI investment in the EU27 as a source and destination in the textiles industry



Source: Technopolis Group based on fDi intelligence, 2022

[70] https://www.fdiintelligence.com/
[71] Investment of foreign companies in affiliates located in European countries over which foreign companies have control.

Figure 40: Share of digital and green transformation related FDI investments in the EU27 as a source and destination in the textiles industry (2010-2022)



Source: Technopolis Group based on fDi intelligence, 2022

Out of the 793 investment projects where the EU27 has been the destination 65 included an explicit digital component such as robotisation of the factory and automation of the logistics centre, digitally upgrading production processes, implementing remote solutions, online commerce and creating digital showrooms. Companies from the EU27 were the investors in 956 projects in 2010-2022 where 60 were related to the digital transformation of the industry. Several investment projects in the field of luxury fashion include textile companies investing in facilities that rely upon digital design, digital cutting and other digital enabled techniques especially in Italy and France.

Examples of digital transformation related investments:

- Triumph International[72] has transformed its production centre in the Austrian Wiener Neustadt into a fashion logistics and central distribution centre for Europe. The new logistics centre has been fully equipped with connected and automated warehouse systems.
- The Test and Innovation Laboratory in Prato is expected to provide chemical, physical and biological tests on finished and semifinished products as well as raw materials for the apparel, leather and other goods. The related ArtLab is a state-of-the-art industrial complex.
- Freudenberg Performance Materials, a manufacturer of technical textiles, and a subsidiary of Germany-based Freudenberg, will open a new competence centre in Sant'Omero, Italy. The facility will be used for the finishing and coating of base material for insoles manufactured at the company's site in Winheim, Germany.
- Investments include the integration of Nedap's iD cloud technology - platform enables to automate processes in distribution centres with RFID technology. Examples are incoming and outgoing shipments, counting, returns, picking &

[72] https://www.flowprime.de/en/references/triumph/

packing. As a consequence, brands and retailers benefit from item-level insights, higher efficiency, and better accuracy.
- Digital ID – a transformative innovation that uses data to inform customers of sustainability credentials of their purchases – along with a circular data protocol. This technology will unlock new opportunities for circularity at scale as key players in the fashion value chain will be able to provide unprecedented transparency and traceability of their products.
- Turkey-based iSKO Textiles, a denim manufacturer, has announced that it will open a new production facility in Hamburg, Germany. The new creative room production centre will focus on the entire denim manufacturing process, from the fabric to the final product. Together with machine technology partner Jeanologia, they develop innovative washing and finishing techniques that meet high quality and sustainability standards with a significantly lower environmental impact.
- The Norwegian Tomra and Swiss Stadler delivered an automated sorting plant for Sysav Industri AB, which sorts pre- and post-consumer mixed textile waste in southern Skåne, in Sweden.

Out of the 793 investment projects where the EU27 has been the destination 37 included an explicit green component such as using renewable energy, implementing energy efficiency measures, investing in sustainable materials, promoting a zero-emission policy. Companies from the EU27 were the investors in 956 projects in 2010-2022, where 30 were related to the green transformation of the industry.

Examples of green transformation related investments include the following:

- Nike's new European Logistics Campus in Flanders (investment made in 2021) uses energy from five locally generated renewable energy sources. These include six wind turbines – with heights of 150 meters and generating enough power to sustain 5,000 households – and a solar panel array with a surface equivalent to three soccer fields. In addition, 95% of on-site waste is recycled, while transport routes are optimized to reduce CO_2 emissions by 30%.
- Infinited Fiber in Finland has received an investment of €100 m from the Spanish Inditex and will supply them with the Infinna fibre made out of regenerated cellulose.
- Meryl Medical is a medical textiles manufacturer has opened a new design and operations hub near Frankfurt, Germany in 2021. The new hub will encompass a design centre, ordering and bespoke commissioning facility, and a comprehensive logistics operation. The new centre will offer a major gateway for the supply of its sustainable fabric into European markets, and the rest of the world, whilst working closer with German-based recycling facilities to fill the circular economy.
- Austria-based Lenzing, producing cellulose fibres, has opened a new R&D centre in Indonesia that will conduct research and development on new yarns, with laboratory and analytical facilities to conduct trials and analyses of various types of materials.
- Swap.com, an online trader of pre-owned items and subsidiary of Finland-based Netcycler, has expanded its warehouse operations and headquarters in the USA.

4.3. Public procurement supporting the digital and green transition of textiles

Public authorities are major consumers and can use their spending power to transform the market of many industries. By procuring environmentally friendly goods, solutions, and services public authorities can contribute to the green transition of economies. Through innovative public procurement governments can foster the uptake of innovative goods and services. Given the role public procurement can play in accelerating the transition and the expectation of its increased uptake by EU countries, it is an important building block of the analysis about investments and funding.

To monitor the twin transition in public procurement, the procurement notices/awards of relevance to the industrial ecosystem and green and digital products, goods or services procured have been filtered for. The approach was based on a combination of the Common Procurement Vocabulary (CVC) classification system and keywords. The main source for this analysis has been the Tenders Electronic Daily, the online version of the 'Supplement to the Official Journal' of the EU, dedicated to European public procurement. The period in focus from 2015 until today allowed an analysis over time including up to date information.

Figure 41: Public procurement in textiles related to the green and digital transition over the period from 2015-2022

Source: Technopolis Group, 2022 based on an analysis of TED

The analysis found that the value of public procurement on textiles as the main object of procurement in **EU27 countries amounted to € 1.071 bn in the period 2015-2020**. Results show that public procurement of textiles is concentrated on traditional procurement notices on supplies and services while green and digital public procurement is limited. Within the total amount of textiles related public procurement, **3.3% is related to the green transition** representing 7% of the total number of notices published. The value and number of notices procured by governments for the digital transition in negligeable.

Despite the overall low numbers, the **most notable growth in numbers of notices is in durability and recycling of textiles with an average annual growth of 37% and 15% respectively**. The growth in recycling is also observed in terms of value with a very high average annual growth of 162% in the period 2015-2020.

- Sustainability, recycling and waste are the most common references made in notices covering textiles as main or secondary object of procurement
- Waste often refers to waste management where textiles are listed along with many other materials

The main government function under which the largest expenditures were made were general public services (42%). Environment only accounts for 5.5 % in the period 2015-2022.

Recycling notices are split between those on larger recycling systems and those textile specific notices e.g. on the collection and processing of textiles for reuse or recycling. Notices are not only technical, but examples cover dimensions such as collaboration with parties regarding the collection, sorting, processing and marketing of source-separated textile flows (the case of the Netherlands).

Sustainability covers diverse dimensions of e.g. foreign services for sustainable economic growth in the textiles industry outside the EU or innovative public procurement e.g. the selection of startups to develop innovative solutions onto circular textiles with the participating authorities having the option to privately purchase or otherwise invest in the innovative solutions over a defined period.

The environmental management requirements are often referenced only as qualification conditions of suppliers.

Digital transition in public procurement of textiles is limited to basic IT services. Wearables and smart textiles are found in notices covering digital transition in textiles as main or secondary object of procurement only in the UK. More specifically they are often associated to

- health
- IT innovation projects
- Fashion Technology Emerging Futures

The transition is led by green rather than digital procurement. The green transition is commonly expressed via environmental requirements for suppliers rather than explicit notices on advanced technologies for green textiles.

Given the role public procurement can play in accelerating textiles transition and the expectation of its increased uptake by EU countries the data is promising for continuous monitoring and therefore inclusion in the monitoring of the transition pathway of textiles.

5. Skills

Key findings

The textile industrial ecosystem encounters skill gaps due to rapid technological transformation, low mobility, an ageing workforce, and a mismatch between education and the needs of the industry. In this report, the supply and demand for green and digital transition related skills were investigated by analysing LinkedIn data and job vacancies published online.

Within the registered professionals on LinkedIn employed in the textile industrial ecosystem, 1.61% claimed having skills related to the green transformation and 1.42% advanced digital skills. This is a low share, however, in both cases the number of professionals with digital and green skills are growing since 2019 despite the overall decline in the number of professionals in the overall industry. There have been **29% more professionals in the textiles industrial ecosystem claiming to have an advanced digital skill and 20% more with a green transformation skill in 2022 than in 2021**.

Among the more specific green skills, recycling related skills tops the list in the EU27 following the share of professionals with general environmental skills. Recycling is followed by energy efficiency and renewable energies. Part of digital skills, cloud technology related skills are found to be the most widespread, followed by artificial intelligence and big data.

Textiles professionals with green transformation skills are most often the founders, co-founders and owners of textile companies, this is followed up by managing directors and sales managers. Digital skills are most widespread among model makers and pattern makers.

On the demand side based on the analysis of online job advertisements, **there were 129 744 unique job advertisements from companies in textiles between 2019-2022** in the EU27. The share of online job advertisements that required any form of moderate digital skills (excluding basic IT office skills) was 18.25% over the period from 2019-2022, while this percentage was 9.09% for advanced digital skills. Requirements related to the green transition appear less often on the advertisements notably in a very small share 0.68% of the cases. It is interesting to observe that while the absolute number and share of job ads with digital skills requirement increased over time, the share of green transition related job ads stayed stable (although in absolute numbers it increased slightly from 2021 to 2022).

Figure 42: Share of online job advertisements in the textiles industrial ecosystem requiring a skill relevant for the green and digital transition

Source: Technopolis Group based on Cedefop data

The challenges of finding talent with green and digital skills are intertwined since future recycling plants, recycling infrastructure and systems that can track the origin and composition of products will not only require technicians with an environmental profile but also extensive digital skills.

5.1. Green and digital skills supply in the textiles industry

The transition pathway for the textiles ecosystem[73] concluded that the lack of workers and adequate skills are critical for a successful green and digital transition. Nonetheless, the textile industry encounters skill gaps due to **rapid technological transformation, low mobility, an ageing workforce, and a mismatch between education and the needs of the industry**[74]. According to European Labour Force Survey, only 13% of the workforce of the textiles industrial ecosystem has high-level qualifications[75]. The Covid pandemic has put the industry under pressure to adapt to an increasingly digital environment and provided an opportunity to upskill workers[76]. New skills are demanded across the entire textile industry, especially in areas such as production processes, design, finance, product development, logistics, marketing, sales, and customer service. At the same time of the pertinent need for new green and digital skills, the industry is also grappling with the difficulty in attracting young talent which further aggravates the situation for the transition.

The challenges of finding talent with green and digital skills are intertwined since the need for more recycling plants, infrastructure and capabilities to follow up the origin and composition of products does not only require technicians with an environmental profile but also with digital skills.

This section aims at analysing trends in the supply and demand of skilled professionals relevant for the green and digital transition based on LinkedIn data. LinkedIn is the largest professional network platform with rich information like profile summary, job title, job description and field of study, which can be used for the identification of skilled professionals in advanced technologies and both in digital and green transition. It represents the single most comprehensive source currently available for the construction of technology-specific skills related indicators. To harvest the data from LinkedIn, keywords capturing skills by advanced technology have been defined and reviewed by technology experts. Queries have subsequently been constructed to filter the database by location and industry. To capture the textiles industrial ecosystem the 'Textiles' and 'Apparel and Fashion' categories have been used. In order to capture the number of professionals working in the sector, occupations related to the industrial ecosystem have been taken into account.

Green skills have been identified as skills related to environmental protection, environmental services, low carbon technologies, renewable energy, the circular economy and clean production technologies and business models related skills.

(Advanced) Digital skills have been defined in the context of the main digital technologies captured in this project notably in artificial intelligence, cloud computing, connectivity, robotics, Internet of Things, augment and virtual reality and blockchain.

Green and digital skills

Based on the analysis of LinkedIn data, Figure 42 provides a picture of the supply of professionals with green and digital technological skills relevant to the textile industrial ecosystem (including the manufacturing of textiles, industrial textiles, fashion, apparel and the related retail) in 2022. Within the registered professionals on LinkedIn employed in the textile industrial ecosystem, only **1.61% claimed having skills related to the green transformation. The LinkedIn data indicates that 1.42% of textiles professionals have advanced digital skills.** The lower level of available advanced digital skills confirms the importance of up/reskilling activities, where according to a recent Euratex survey, 61 % of the respondents are already implementing one. Green skills development is an ongoing activity in 40% of the respondents.

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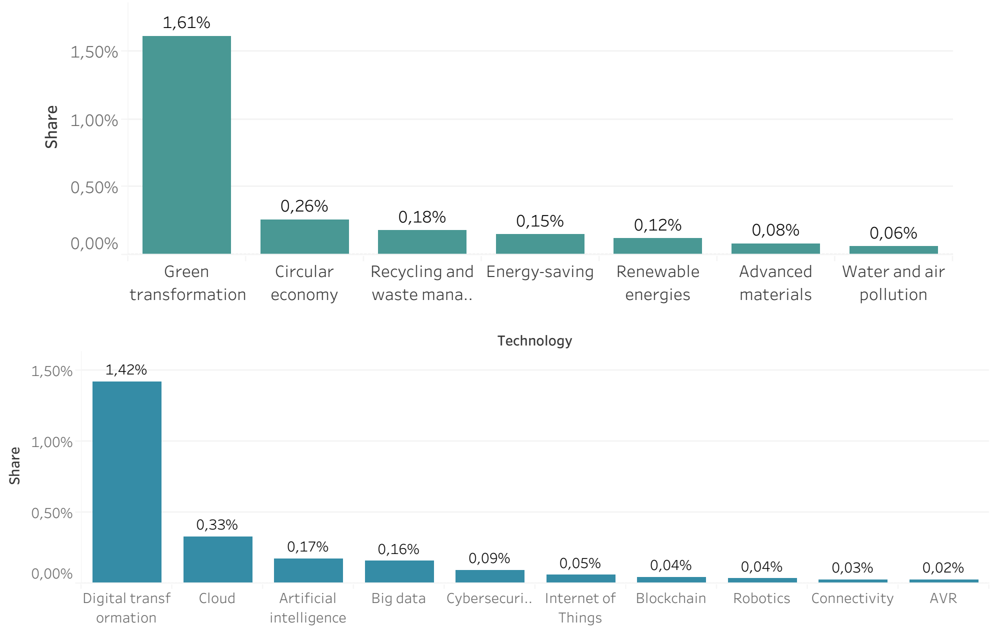
[73] https://single-market-economy.ec.europa.eu/sectors/textiles-ecosystem/textiles-transition-pathway_en
[74] Eurostat, New Skills Agenda, 2016: https://ec.europa.eu/growth/content/new-skills-agenda-blueprint-sectoral-cooperation-skills-1_en
[75] https://euratex.eu/news/an-effective-pact-for-skills-should-be-an-essential-pillar-of-the-new-eu-textiles-strategy/
[76] https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/briefingnote/wcms_741642.pdf

Among the more specific green skills, recycling related skills tops the list in the EU27 following the share of professionals with general environmental skills. Recycling is followed by energy efficiency and renewable energies.

Part of digital skills, cloud technology related skills are found to be the most widespread, followed by artificial intelligence and big data.

Figure 43: Share of professionals with green and digital skills employed in the textiles industry and with a profile on LinkedIn

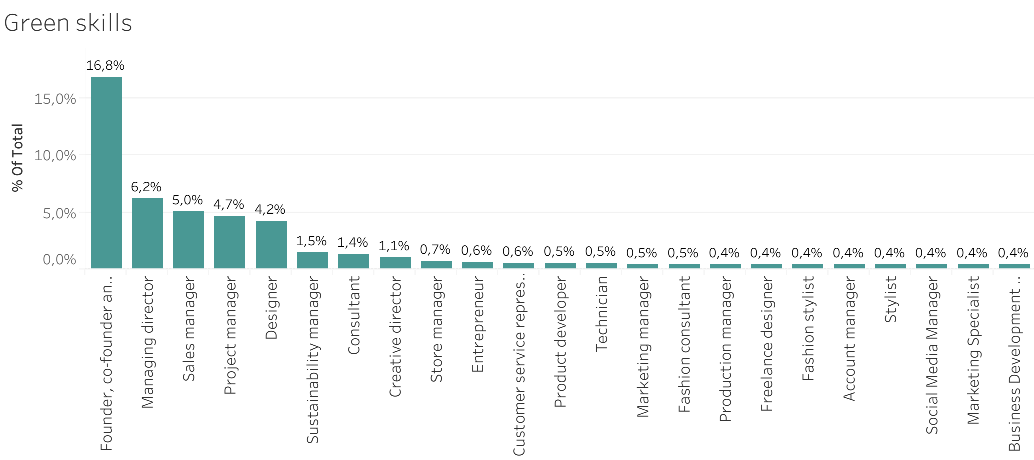


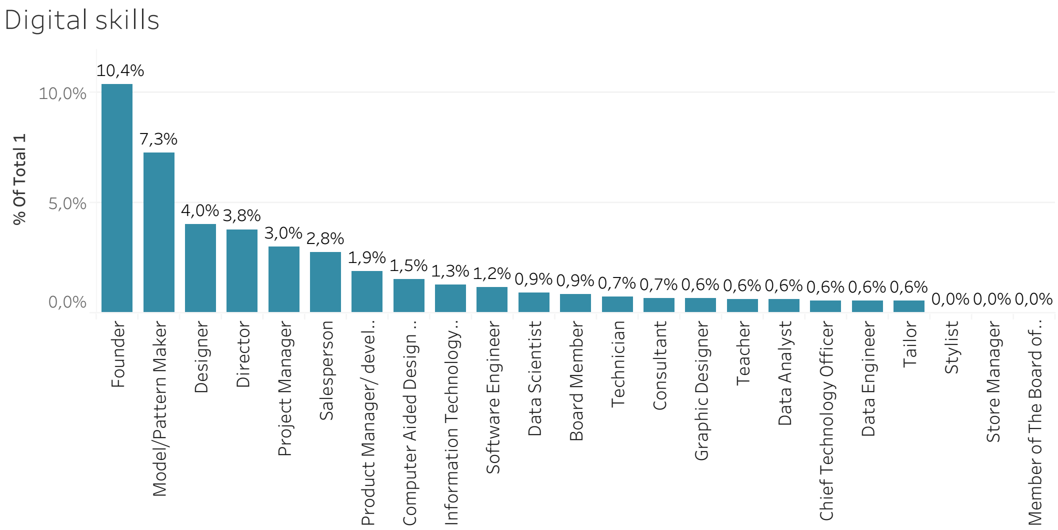
Source: Technopolis Group calculations, 2022

Textiles professionals with green transformation skills are most often the founders, co-founders and owners of textile companies, this is followed up by managing directors and sales managers. Designers also possess important green skills that are particularly relevant in order to create products according to the principles of design for disassembly and design for durability.

Digital skills are most widespread among model makers and pattern makers, followed by founders and co-founders. Digitally skilled people are more often employed in specific positions, most importantly (and not surprisingly) related to IT development such as data scientist or IT manager. Moreover, digitalisation has created further new positions such as digital marketers, e-commerce specialists, digital designers, digital textile technicians.

Figure 44: Type of positions with green transformation and digital transformation skills





Source: Technopolis Group calculations, 2022

The change in the number of professionals with digital or green skills have to be put in the context of the overall employment patterns. As highlighted above, the total number of professionals in textiles on LinkedIn has decreased over time and in particular during the pandemic period, which is in line with official statistical figures. Compared to this, the share of professionals with digital or green skills has witnessed a steady growth over the past years.

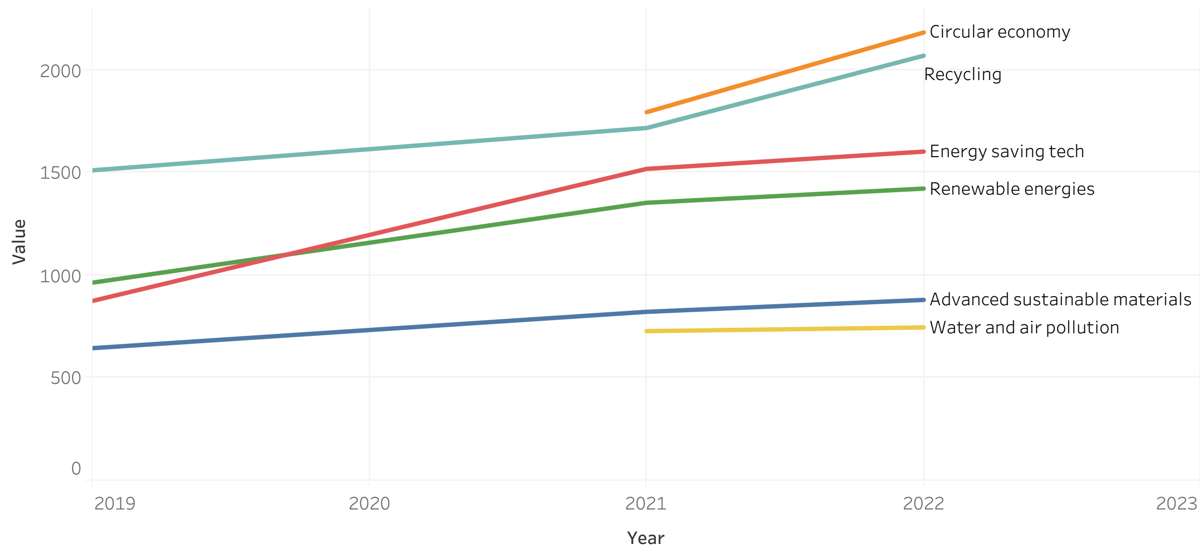
There have been 29% more professionals in the textiles industrial ecosystem claiming to have an advanced digital skill and 20% more with a green transformation skill in 2022 than in 2021. In a broader context, available Eurostat figures show that the number of ICT specialists in the EU grew by 50.5 % from 2012 to 2021, almost 8 times as high as the increase (6.3 %) for total employment[77].

Figure 45 visualises the green and digital skills that showed the highest growth in the last year among EU27 countries. In the field of digital technologies, we see augmented and virtual reality on top followed by big data and artificial intelligence related skills and also to some extent the Internet of Things.

In the field of green skills, the broader category of the circular economy has witnessed an increase driven by patterns in recycling and waste management. In the case of energy saving technologies and renewable energies there is a sharp increase to be observed from 2018-2022.

[77] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=ICT_specialists_in_employment

Figure 45: Trends in the number of professionals with green skills



Source: Technopolis Group calculations, 2020 and 2022

5.2. Skills demand for digital and green skills

Skills demand in the textiles industrial ecosystem has been analysed following the skills intelligence insights of Cedefop. This dataset covers 28 European countries and is based on the collection and analysis of more than 530 online job advertisement sources (424 distinct websites) which are open-access sites. The dataset provides information on most requested occupations and skills across European countries based on established international classifications, e.g., ISCO-08 for occupations, ESCO for skills, and NACE rev. 2 for sectors. The textiles industrial ecosystem is represented in the tool including the following NACE codes: manufacture of textiles, wearing apparel and leather and related products (C13, C14 and C15)

Specific to the textiles industrial ecosystem[78], **there were 129 744 unique job advertisements from companies in textiles between 2019-2022.** The number of online job advertisements within textiles in EU27 countries amounts to 39 880 in the year 2022. Skills have been analysed related to the green and digital transitions. The European multilingual classification of Skills, Competences, Qualifications and Occupations (ESCO) is used as follows:

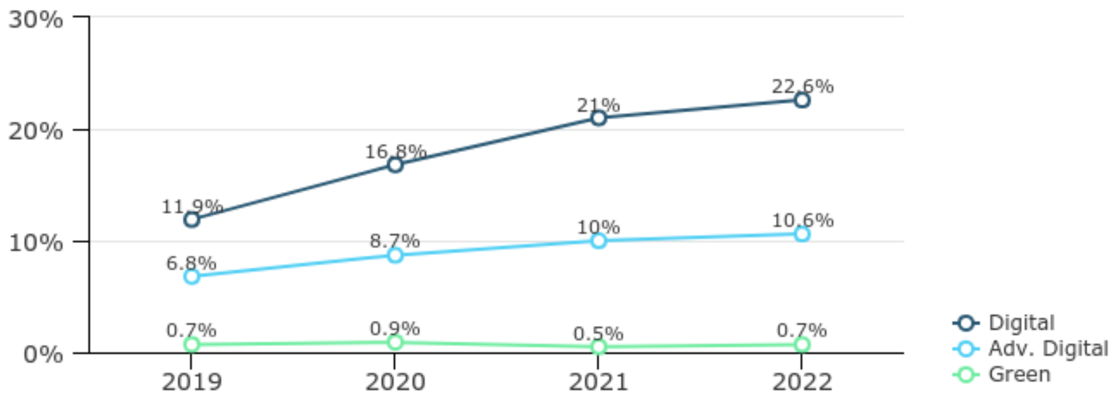
- **Green transition related skills** (ESCO v1.1.) are those knowledge and skills which reduce the negative impact of human activity on the environment. The labelling of skills and knowledge concepts as green follows a methodology based on a 3-step process, which combines human labelling and validation, and the use of machine learning algorithms.
- **Moderate and Advanced Digital skills** (ESCO v1.1.1 which is currently being updated) are competences which involve the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. The labelling of skills and knowledge concepts follows a 5-steps methodology, which combines human labelling and validation with the use of machine learning. Within digital skills, we distinguish between moderate digital skills (that do not include basic Microsoft office skills but include specialised software used in the industry, the use of statistical software etc) and advanced digital skills (a category that is filtered for digital technologies highlighted in the methodological

[78] In the case of the tourism industrial ecosystem the dataset was filtered for the NACE industries as defined in the Annual Single Market Report: H49, H50, H51, I55, I56, N79, N82, R90, R91, R92, R93).

report including AI, big data, robotics, IoT, cloud, augmented and virtual reality, blockchain).

The share of online job advertisements that required any form of **moderate digital skills (excluding basic IT office skills) was 18.25%** over the period from 2019-2022, while this percentage was **9.09% for advanced digital skills**. Requirements related to the **green transition** appear less often on the advertisements notably in a very small share **0.68%** of the cases. It is interesting to observe that while the absolute number and share of job ads with digital skills requirement increased over time, the share of green transition related job ads stayed stable (although in absolute numbers it increased slightly from 2021 to 2022).

Figure 46: Share of online job advertisements that demand digital and green transition related skills in the textiles industrial ecosystem within the total number of textiles job ads



Source: Technopolis Group calculations based on Cedefop data, 2023

In terms of geographical coverage, the top countries are also the ones having the highest share of online job advertisements that contain transition skills with France leading (35.36%) followed by Italy (28.63%) and Germany (13.96%).

The more sought after advanced digital skills (top 5) are:

- Classification of databases (their purpose, characteristics, terminology, models and use such as XML databases, document-oriented databases and full text databases)
- Computer and web programming
- Robotics
- Cloud technologies
- Object-oriented modelling
- Computer programming
- Development of animations

The green skills are significantly more limited compared to digital with only 251 online job advertisements in 2022. Among those 251, the more sought-after green skills are:

- Application of transport industry management concepts in order to improve transportation processes, reduce waste, increase efficiency, and improve schedule preparation
- Corporate social responsibility in terms of responsibility towards environmental and social stakeholders. This is probably linked to snippets of company advertisements where the company values are described.
- Energy efficiency, which is linked to the energy demand of the industry.

6. Green performance of the ecosystem

Key findings

The textile ecosystem is a resource-intensive sector with important environmental impacts, using natural resources and emitting pollution throughout the different stages of the value chain. The most relevant environmental concerns generated by the textiles industry are **water pollution, greenhouse gas emissions, and the production of waste**. Water and energy demand is especially high in the textile processing stages of the supply for dyeing, printing and finishing. A large share of the environmental impact is caused outside Europe where most of the manufacturing takes place. This report **assessed the environmental impact of the broader industrial ecosystem** beyond the core industries based on Exiobase data. The results indicate a mixed trend in the environmental impact of the textiles industry over time.

The **textile industrial ecosystem has decreased its GHG emissions** with a reduction of 0.75% in the period of 2010 to 2021 embodied in the textile industry's trade in 2010. The data analysis also found that the substances released to the environment by the textile industry has somewhat decreased from 2010 to 2020 but had again a recent surge. Despite these trends in reducing materials extraction from 2010 to 2021, other **resource use such as land use and water consumption experienced further negative environmental pressures from the textiles industry**. The embodied materials extraction for the textile industry decreased by 2.26%, from 2010 to 2020, however, the embodied land use increased by 3.2%. The use of blue water notably surface water or groundwater consumed or evaporated during irrigation, industry processes or household use has increased by 1.4% from 2010 to 2020. **The textile industry has been causing damage to the ecosystem and to biodiversity with increasing impacts over time**. In addition, the textiles industry has high energy demand in each stage of its value chain from processing yarn, producing fabric, and fabricating textiles, to transporting and selling clothes to customers.

Figure 47: Environmental impact of the CCI

Environmental impact	Change 2010 to 2021 (CAGR)
GHG emissions	-0.04%
PM emissions	-1.4%
Material use	-0.3%
Land use	+3%
Water use	+1.6%
Damage to the environmental ecosystem	+1.3%

Source: Technopolis Group, 2022, based on Exiobase data

The textile ecosystem is a resource-intensive sector with important climate and environmental impacts as it has been analysed in detail by the European Environmental Agency[79]. The negative impacts start at the sourcing of materials such as natural and synthetic fibres that need land, water, chemicals and energy. Manufacturing processes use again energy, water and chemicals. Further greenhouse gas emissions (GHG) emissions are produced while transporting the materials and products across the supply chain and to customers. The environmental impact is also substantial during use in terms of microplastic pollution and other chemical release in the environment. At the end of the lifecycle, textiles waste represents a critical challenge to solve. Energy recovery from textile also causes GHG emissions. The assessment of the environmental impact of the textiles industrial ecosystem is complex given the fact that most of the textile production and hence most environmental impact happens outside Europe[80] (according to some estimates this represents 80%[81]).

The EU Strategy for Sustainable and Circular Textiles[82] (2022) has also underlined the significant impact of the production and consumption of textile products on the environment.

Resource use

With the aim to monitor trends in the environmental impact of industrial ecosystems, this report draws upon the data sources of Exiobase that is a source of information used by the European Environmental Agency[83], the EC/JRC community[84], Eurostat[85], and by the European Commission[86]. Pressure to environments refer to trade-embodied resource utilisation, and trade-embodied impacts. Resources utilisation is captured with four main dimensions are considered for cross-industry comparisons: embodied land use, embodied water consumption, and embodied materials consumption. Air emissions (incl. GHG), damage to the ecosystem and waste production are also monitored.

The following table shows the environmental performance of the textiles industrial ecosystem at EU level over the period from 2010 to 2021. The ecosystem contributed to 5.91% of the materials extracted and 4.65% of the water consumed by all the 14 industrial ecosystems monitored in this project. It decreased its GHG emissions and its material use over time, however, the impact on land use, water consumption and damage to biodiversity increased.

The main contributor to these environmental impacts within the industrial ecosystem is the **manufacturing of wearing apparel**. Manufacture of apparel relies heavily on petrochemical products, but the reliance on cotton is also not sustainable. The use of polyester, which is plastic from oil, increased substantially during the last decades. The largest share of end-of-life treatment of clothing in the EU is incinerated or sent to landfills. This implies considerable stress to the environment in terms of resources extraction, emissions and discharges, and damage to natural ecosystem.

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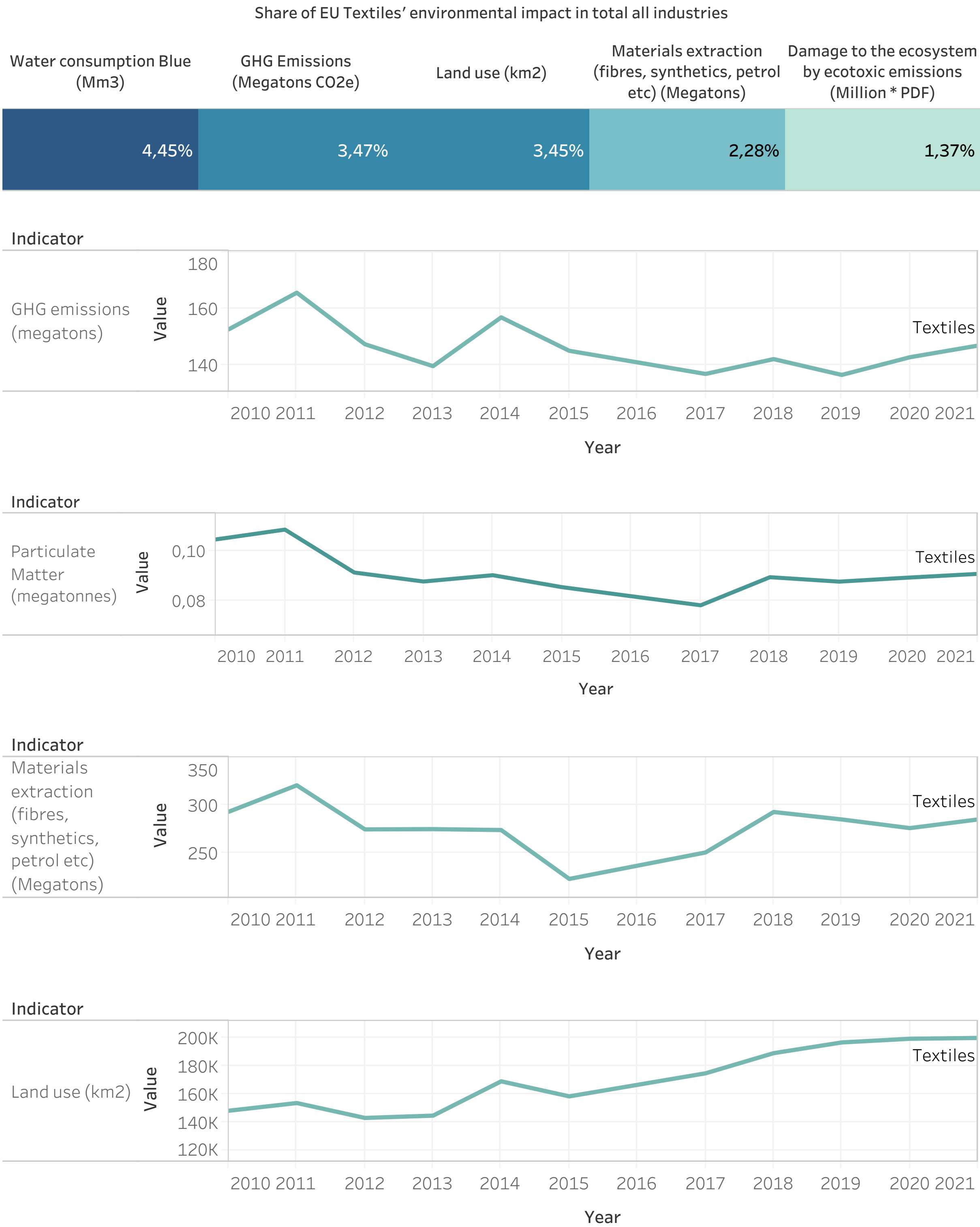
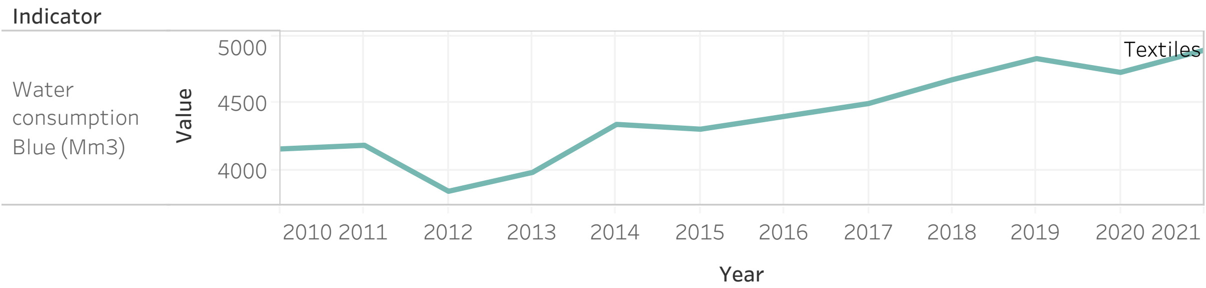
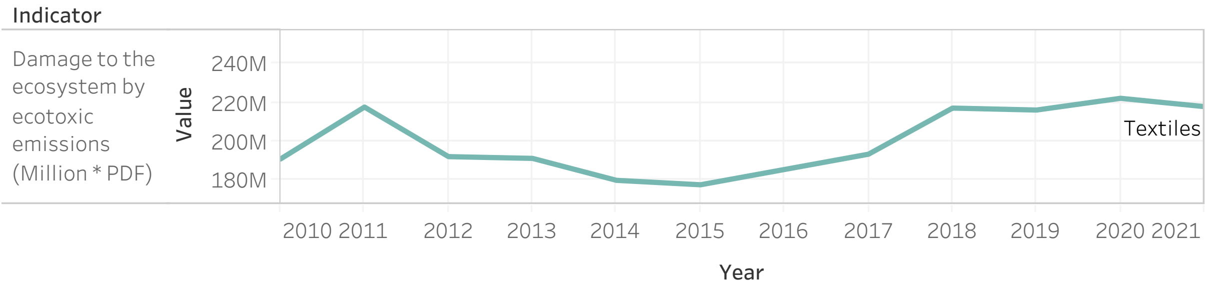
[79] https://www.eea.europa.eu/en/topics/in-depth/textiles
[80] EEA briefing Textiles in the environment: the role of design in Europe’s circular economy (EEA, 2022a)
[81] https://www.eea.europa.eu/publications/textiles-and-the-environment-the
[82] https://environment.ec.europa.eu/publications/textiles-strategy_en
[83] EEA 2022. Visit 12/10/2022. https://www.eea.europa.eu/data-and-maps/data/external/exiobase
[84] Beylot, A., Secchi, M., Cerutti, A., Merciai, S., Schmidt, J. and Sala, S., 2019. Assessing the environmental impacts of EU consumption at macro-scale. Journal of cleaner production, 216, pp.382-393. https://doi.org/10.1016/j.jclepro.2019.01.134
[85] Remond-Tiedrez, I. and Rueda-Cantuche, J.M. eds., 2019. EU Inter-country Supply, Use and Input-output Tables: Full International and Global Accounts for Research in Input-output Analysis (FIGARO). Luxembourg: Publications Office of the European Union.
[86] EC (2021) REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Establishing a carbon border adjustment mechanism. COM(2021) 564 final.

Table 1: Environmental impact indicators of the textiles industrial ecosystem, including both production and consumption accounts







Source: Technopolis Group, 2022, based on Exiobase data

Emissions

In 2021, greenhouse gas emissions generated by the textiles industrial ecosystem in the EU amounted to **147 million tonnes of carbon dioxide equivalent** (CO2e) in total, as found by the analysis of Exiobase data. Almost half of these emissions are produced by clothes, 30% by household and 20% by footwear[87].

The results of the analysis show **a general tendency of the textile industry in the EU towards reducing its trade embodied GHG emissions**, with a reduction of 15% in 2021 compared to how much GHG it emitted in 2010. This finding is in line with the data presented in the Annual Single Market Report (2022), that says the textile ecosystem has decreased its GHG emission intensity between 2015 and 2019.

An additional embodied emission monitored is the particulate matter (PM10 and PM2.5)[88], which has a local impact where industrial activities take place. The trade-embodied particulate matter (PM) of the textile industry has been in a downward trend over the period from 2010 to 2017, with a total decline of 5.9 percentage points compared to 2010. However, an increase can be observed since 2018.

Resource consumption

According to the report of the European Environmental Agency, textiles was the consumption area with the third highest impact on water and land use, and the fifth highest in terms of raw material use[89] in 2020. The **embodied materials extraction for the textile industry decreased between 2010 and 2015 but shows an increase since then**. The embodied land use increased by 3.2%. **The use of blue water** notably surface water or groundwater consumed or evaporated during irrigation, industry processes or household use **has increased by 9.7% from 2010 to 2021**. These negative environmental pressures from the textiles industry are critical to tackle.

[87] EEA, 2022. Textiles and the Environment: The role of design in Europe's circular economy
[88] EEA (2022) Particulate matter definition. https://www.eea.europa.eu/themes/air/air-quality/resources/glossary/particulate-matter
[89] https://www.eea.europa.eu/publications/textiles-and-the-environment-the

Biodiversity

The overall negative impact in terms of **trade-embodied biodiversity loss by the textile industrial ecosystem has increased from 2010 to 2021 by 23%.** This means a substantial risk of damage to the ecosystem due to ecotoxic emissions. Biodiversity loss is generated for example when producing cotton that is one of the most damaging agricultural crops globally. To make cotton, pesticides and fertilisers are being used that emit toxic chemicals to the groundwater[90].

Waste production

The volume of total textiles waste generated by all industrial activities and households was 1.95 m tonnes in 2020 according to data from Eurostat[91]. The volume of total EU textile waste has been increasing over the period from 2010 to 2018 with a drop from 2018 to 2020 most probably due to the impacts of the Covid-19 pandemic. The study of the Joint Research Centre in 2021 concluded that the majority of the collected textile waste has been exported to third countries with inadequate waste management systems[92].

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[90] K.J., Pyburn, R., Termorshuizen, A.J. (2006). The sustainability of cotton. Consequences for man and environment, Wetenschapswinkel Wageningen Universiteit en Reseachcentrum. Rapport No. 223. ISBN: 90-6754-90-8585-000-2.
[91] https://ec.europa.eu/eurostat/databrowser/view/ENV_WASGEN__custom_7064007/default/table?lang=en
[92] https://publications.jrc.ec.europa.eu/repository/handle/JRC125110

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Köhler, A., Watson, D., Trzepacz, S., Löw, C., Liu, R., Danneck, J., Konstantas, A., Donatello, S. and Faraca, G. (2021). Circular Economy Perspectives in the EU Textile sector, EUR 30734 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-38646-9, doi:10.2760/858144, JRC125110.

K.J., Pyburn, R., Termorshuizen, A.J. (2006). The sustainability of cotton. Consequences for man and environment, Wetenschapswinkel Wageningen Universiteit en Reseachcentrum. Rapport No. 223. ISBN: 90-6754-90-8585-000-2.

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Appendix B: Methodological notes

Startup data and venture capital data analysis

Selected fields from Crunchbase and Net Zero Insights: Textiles, Fashion, Lingerie, Shoes

Survey

The table below presents the overview of the sub-sectors included in the sampling frame, with corresponding sections according to NACE industrial classification. The survey respondents come from a mix of micro-enterprises (less than 10 employees), small enterprises (10-50 employees) and medium-sized enterprises (50-250 employees). In terms of geographical coverage, the survey has a balanced coverage of all EU countries.

Table 2: Survey sampling strategy

NACE		Sample size of the survey
C13	Manufacture of textiles	150
C14	Manufacture of wearing apparel	150
C15	Manufacture of leather and related products	67

Source: Technopolis Group and Kapa Research, 2023

Foreign direct investment data analysis

Table 3: Concordance between NACE and FDI Intelligence data

NACE		Code in FDI Intelligence
C13	Manufacture of textiles	Leather & hide tanning and finishing Clothing & clothing accessories Other (Textiles) Apparel accessories & other apparel Textiles & Textile Mills Footwear Apparel knitting Cut & sew apparel Other leather & allied products
C14	Manufacture of wearing apparel	
C15	Manufacture of leather and related products	

Source: Technopolis Group and Kapa Research, 2023

CORDIS data analysis

TED data analysis

Table 4: Concordance between NACE and TED

NACE		CPV values
C13	Manufacture of textiles	
C14	Manufacture of wearing apparel	

C15	Manufacture of leather and related products	

Source: Technopolis Group and TED

LinkedIn data analysis

Table 5: Concordance between NACE and LinkedIn

NACE		LinkedIn industry categories
C13	Manufacture of textiles	Textiles
C14	Manufacture of wearing apparel	Apparel and Fashion
C15	Manufacture of leather and related products	Apparel and Fashion

Source: Technopolis Group based on LinkedIn

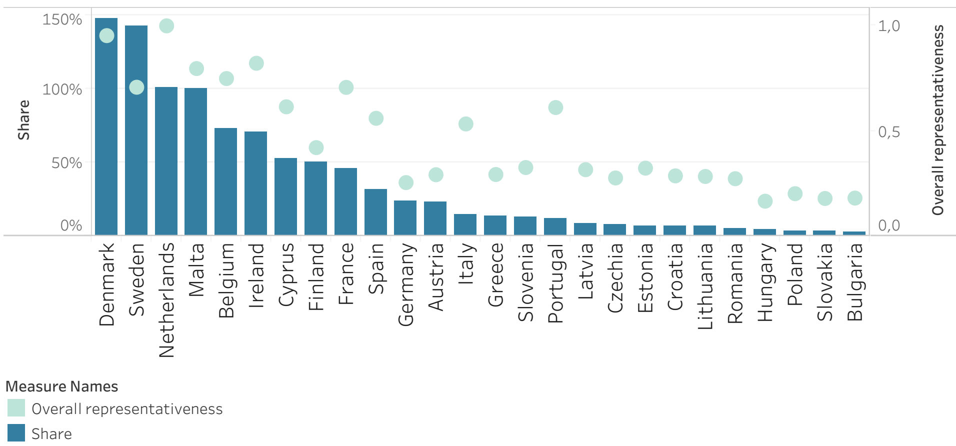
Green skills – keywords used: Cleantech, Sustainability, Sustainable Development, Sustainable Business, Energy Efficiency, Clean Energy Technologies, Renewable Energy, Wind Energy, Biomass, Biomass Conversion, Solar Energy, Solar Power, Urban Forestry, Forest Ecology, Sustainable Communities, Organic Farming, Organic Gardening, Urban Agriculture, Organic Food, Waste Management, Waste Reduction, Recycling, Water Treatment, Water Resource Management, Water Purification, Green Marketing, Green Printing, Environmental Biotechnology, Environmental Science, Environmental Engineering, Environmental Management Systems, Environmental Protection, Wastewater Treatment, Ecology, Circular Economy, Zero Waste, Waste to Energy, Plastics Recycling, E-Waste, Carbon Reduction Strategies, Carbon Footprinting, Carbon Neutral, Energy Retrofits, Biodiversity, Biodiversity Conservation, Nature Conservation, Advanced Materials, Nanomaterials, Biomaterials, Reuse, Separation Process, Sorting, Equipment Repair, Natural Resource Management, Sustainability Reporting, Green Development, Sustainable Cities, Energy Conservation, Energy Management, Environmental Awareness, Environmental Impact Assessment, Environmental Compliance, Leadership in Energy and Environmental Design (LEED), Environmental Policy, Green Technology, Sustainable Design, Sustainable Architecture, Environmental Consulting, Maintenance and Repair, Solar PV, Solar Cells, Wind Turbines, Wind Turbine Design, Carbon Capture, Low Carbon Technologies, Low Carbon, Renewable Fuels, Renewable Energy Systems, Renewable Resources, Integrated Water Resources Management, Natural Resources, Biodiesel, Bioplastics, Waste Treatment, Waste Water Treatment Plants, Electric Vehicles, Hybrid Electric Vehicles, Multi-modal Transportation, Energy Efficiency Consulting, Recycled Water, Adaptive Reuse, Ecodesign, Life Cycle Assessment, Energy Optimisation, Alternative Fuels, Green Building, Green Infrastructure, Green Purchasing, Biodegradable Products, ISO 14001, EMAS, Environmental Standards

Digital skills – keywords used: data analytics, tourism flow management, online platforms, digital payment, online ticketing, Cybersecurity, Intrusion Detection, Malware Detection, Cloud Security, Cybercrime Investigation, Cyber Threat Intelligence (CTI), Cryptography, DLP, Malware Analysis, IDP; Vulnerability Assessment, Certified Information Security Manager (CISM), Computer Forensics, Cloud Infrastructure, Cloud Services, Google Cloud Platform (GCP), SAP Cloud Platform, SAP HANA, Everything as a Service (XaaS), Software as a Service (SaaS), Platform as a Service (PAAS), Infrastructure as a Service (IaaS), Private Clouds, Hybrid Cloud, Cloud Computing, Edge Computing, High Performance Computing (HPC), Serverless Computing, Robotics, Robot, Robotic Surgery, Human-robot Interaction, Drones, Connected Devices, Internet of Things (IoT), Robotic Process Automation (RPA), Wireless Sensor Networks, Embedded Systems, Cyber-Physical Systems, Smart Cities, Artificial Intelligence (AI), Biometrics, Cognitive Computing, Computer Vision, Deep Learning, Machine Learning, Natural Language Processing (NLP), Natural Language Understanding, Natural Language Generation, Reinforcement Learning, Speech Recognition, Supervised Learning, Unsupervised Learning, Big Data Analytics, Hadoop, Real-time Data, Yarn, Teradata Data Warehouse, Blockchain, Ethereum, Bitcoin, Cryptocurrency, Crypto, Distributed Ledger Technology (DLT), Hyperledger, Augmented Reality (AR), Virtual Reality (VR), Mixed Reality, Computer-Generated Imagery (CGI), Connectivity, M2M, 5G, SD-WAN, Home Automation, Flexible Manufacturing Systems (FMS), Smart Manufacturing, Smart Materials, Quantum Computing, Smart Devices, Intelligent Systems, Big Data, Computer-Aided Design (CAD), Computer Science, MATLAB, C (Programming Language), Python (Programming Language), Digital Strategy, Digital Printing, Digital Marketing, Online Journalism, Revit, Building Information Modeling (BIM), JavaCard, R (Programming Language), Digital Imaging, Digital Media, C++, Collaborative Robotics, Industrial Robotics, Medical Robotics, Mobile Robotics, AutoCAD, Automation, Autodesk 3ds Max, Lumion, Data Analysis, Data

Mining, 5G Core, Integrated Security Systems, Cloud Applications, Cloud Computing IaaS, Cryptocurrency Mining, CryptoAPI, Automated Machine Learning (AutoML), Machine Learning Algorithms, Virtual Reality Development, Virtual Data Rooms, Intelligence Systems, Robot Programming, Predictive Analytics, Data Lakes, Blockchain Analysis, Digital Publishing, Enterprise Software, Software Development, SAS (Software), SAP Products, SAP ERP, Online Payment, Online Payment Solutions; Online Travel, Online Marketing, Online Business Management, Online Advertising, Online Gaming, Web Services, Mobile Applications, Mobile Marketing, Java Database Connectivity (JDBC), Data Warehousing, Statistical Data Analysis, Data Modeling, Databases; Electronic Data Capture (EDC), Data Centers, Oracle Database, SAP Solution Architecture Data Entry, Data Management, Data Mapping, Web Applications, GIS Applications, Oracle Applications, Visual Basic for Applications (VBA), Computer Hardware, Computer Maintenance, Computer Network Operations, Computer Networking, Computer Graphics, Online Communications, Social Media Marketing, Digital Direct Marketing, Digital Illustration, Digital Video, Digital Photography, Xero, GPS Applications, GPS Devices, GPS Tracking, GPS Navigation, Microsoft Power Apps, Social Networking Apps, Google Apps Script, Social Media, E-Commerce, Data Intelligence, Online Platforms, Mobile Payments

To perform a representativeness analysis of LinkedIn, the available industry-specific dataset has been compared to Eurostat figures regarding the active population. Nevertheless, there are several limitations in conducting a robust representativeness analysis due to the fact that the two datasets have different origins, classification systems and hence there are mismatches in the definition of some categories[93]. There are 149 industries available on the LinkedIn platform and categories are allocated according to the individual choice of the user or the affiliation to a company registered on LinkedIn as a company profile. In this sense, LinkedIn captures the broader industrial ecosystem by labelling as textiles also activities of textile brands that are part of retail under traditional NACE classifications. We can however observe a bias towards fashion brands far way more represented on LinkedIn than technical textiles companies. Regarding the country profiles, there is an important heterogeneity in the national use of LinkedIn among EU Member States. The largest users are Netherlands, Denmark and Sweden where LinkedIn is the most popular, with more than 75% of the active population registered. In other EU countries, the number of LinkedIn users is marginal such as in Hungary, Slovakia, Bulgaria and Poland that display the lowest use of LinkedIn, with less than 20% of the population registered on the platform.

Figure 48: Representativeness of textiles industry professionals



Source: Technopolis Group calculations based on LinkedIn vs Eurostat - annual enterprise statistics for special aggregates of activities (NACE Rev. 2)

Keeping the above in mind, overall, it can be estimated that approximately 30% of textile industry professionals have a profile on LinkedIn. Countries that are the most

[93] See more in detail ATI Methodological report: https://ati.ec.europa.eu/reports/eu-reports/advanced-technologies-industry-methodological-report

representative both overall on LinkedIn and in the textiles industry include Denmark, Sweden, Netherlands, Malta and Belgium (Figure 19). The data shows that the professionals employed in the textiles ecosystem and with a profile on LinkedIn has decreased by 0.8% in textiles and by 2% in apparel and fashion compared to one year ago, which trend is in line with the findings of Eurostat data also indicating a shrinking of industrial employment.

Exiobase

Exiobase is a time series of environmentally extended multi-regional input-output (EE MRIO) tables. Its coverage is by country and industry from 1995 to 2021 and has EU and extra rest of the world coverage. Source: Stadler, Konstantin, Wood, Richard, Bulavskaya, Tatyana, Södersten, Carl-Johan, Simas, Moana, Schmidt, Sarah, Usubiaga, Arkaitz, Acosta-Fernández, José, Kuenen, Jeroen, Bruckner, Martin, Giljum, Stefan, Lutter, Stephan, Merciai, Stefano, Schmidt, Jannick H, Theurl, Michaela C, Plutzar, Christoph, Kastner, Thomas, Eisenmenger, Nina, Erb, Karl-Heinz, … Tukker, Arnold. (2021). EXIOBASE 3 (3.8.2) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.5589597