Monitoring the twin transition of industrial ecosystems

CULTURAL AND CREATIVE INDUSTRIES

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 **Cultural and Creative Industries (CCI)** industrial ecosystem.

The CCI industrial ecosystem is characterised by a wide range of diverse subsectors that are all based on cultural values and creative expression. They include architecture, archives, libraries and museums, artistic crafts, audio-visual (including film, television, video games and multimedia), tangible and intangible cultural heritage, design (including fashion design), festivals, music, literature, performing arts (including theatre and dance), books and publishing, radio, and visual arts. They are mostly composed of a high number of small and micro-companies and freelancers. A widely adopted common definition of the CCI is still lacking on a European level and various Member States use different definitions. Combined with poor or inadequate data collection mechanisms for specific indicators, and outdated statistical classifications that do not fully capture the diversity of this ecosystem, this creates challenges in providing uniform monitoring data on the CCI and how the ecosystem is performing in the green and digital transition.

According to Eurostat, the CCI employed 7.7 million people across Europe in 2022, representing 3.8% of total employment. Compared with 2021, this is a 4.5% increase from 7.4 million. Both the COVID-19 pandemic and energy crisis have placed this industrial ecosystem under a lot of pressure. The COVID-crisis accelerated ongoing trends of digitalisation in the CCI, while the high cost of energy has steered various subsectors to renewable energy sources.

Meanwhile, and in the wake of these crises, the CCI are also more and more seen as a driver in a resilient recovery (e.g. the role of CCI in health, wellbeing and social cohesion) and as a catalyst for the digital and green transition of society at large.

Key findings about the green transition in the CCI

In relative terms, the environmental **impact of the CCI** (with the exception of the fashion industry, which is analysed in the ecosystem report on textiles) is low: it is responsible only for around 1-3% of the impact of all industries in total. However, the impact of the CCI on the environment in absolute terms increased over time (from 2011 to 2020) and had a further surge during the pandemic period. An important factor driving this increase is the shift to digitalisation and the increased use of digital technologies and online services such as streaming and cloud technologies in the CCI, which depend on data centres that use a lot of resources and energy.

In terms of green transition, **a broad range of technologies** are of interest to the CCI, such as the use of 3D-technology to visualise and analyse cultural heritage assets in a non-destructive way; the use of solar energy as an alternative to traditional power sources on production sets in the audiovisual industry or the use of recycled materials in design and architecture.

According to the survey conducted in this project on the status of the **uptake of green and digital technologies in the CCI**, 51% of the respondents indicated to have increased their investments dedicated to green transition and environmental sustainability over the past five years. However, 23% of these respondents invested only 5% of their average annual share of revenue in green transformation and another 19% invested between 10-14%. The highest adoption of green technologies by SMEs featured recycled materials

(20.4%), energy-saving technologies (18.8%), recycling technologies (17%) and renewable energy (14.1%). while there is a larger share of SME's in CCI that have adopted green technologies, the overall investment in green technologies remains small.

The share of people with **skills relevant for the green transition** employed in the CCI varies between 1 and 14% as suggested by LinkedIn data analysis in the project. It is the highest in architecture (14%) and the lowest in music, film, and the performing and visual arts (1%). To support the green transition, developing skills and knowledge to identify the best or most efficient areas to invest limited resources is key for the mostly small and micro-sized companies in the CCI ecosystem, combined with sector specific capacity building, as skills differ from subsector to subsector.

Key findings about the digital transition in the CCI

Advanced **digital technologies** are transforming the whole CCI ecosystem at an increasingly rapid pace, as it impacts the entire value chain from creation to distribution and audience engagement. For example, generative artificial intelligence is causing disruptions in the creation process; augmented and virtual reality is driving change in content presentation and production; and experiments with the metaverse, non-fungible tokens and blockchain technology allow new business- and revenue models to emerge. These technologies however influence sub-industries to different extents. The CCI ecosystem is composed of diverse industries where some are operating predominantly digital by now (video games, news media, advertising) and adopt these advanced technologies, while others are lagging behind in the uptake of basic digital technologies (e.g. performing arts, cultural heritage, visual arts) – although the COVID-19 pandemic has boosted the uptake of digital technologies also there. In these sectors basic software and cloud solutions are still a key driver in the sector's digital transformation. Analysis of **tech startup activity** in the CCI show that the highest percentage of startups is focused on software solutions (54%), followed by online platform technologies (13%), augmented and virtual reality (12%) and artificial intelligence (10%).

Regarding **investments**, survey results of this project show that 65% of SMEs in the CCI have increased their investments in digital technologies during the past five years, which is a high result across all industrial ecosystems. According to the survey results, the technologies that have been adopted the most by SMEs in the CCI, are online platform technologies (23.1%), cloud software (19.7%), big data and artificial intelligence (10.5%). Overall investment in CCI tech companies saw an increase between 2015-2020, with a sharp rise between 2019 and 2020, followed by a decrease towards 2022. The highest capital investment went into video games, followed by media technology and book publishing. The pandemic, energy crunch and cost-of-living crisis caused an overall slowdown, but on top of that the CCI in general struggle, due to their characteristics (micro-sized companies often producing intangible intellectual property assets which are difficult to value) to access (private) debt and equity finance. Traditionally, public authorities play an important role in financing the CCI, including in their innovation/transformational capacity. Instruments include public grants, tax incentives, guarantee schemes, etc. Post-COVID-19, several national recovery and resilience plans provided an important investment boost in the digital and green transition of the CCI.

In terms of **digital skills**, the analysis of LinkedIn data shows that – depending on the subsector - 4 to 36% of professionals in the CCI possess at least one type of advanced digital skill; the video games and architecture sector featuring the most digital skilled professionals, whereas the performing and visual arts the least. To respond to the digital transformation the CCI need both highly specialised skills as well as more generic skills, ranging from technical skills to use digital technology to entrepreneurial and digital leadership skills to develop new business models around new technologies, and creative skills to explore the artistic and creative possibilities of new technologies. The CCI however is characterised by a high proportion of micro-companies, self-employed and freelance workers that have a limited absorptive capacity to learn how to use or adapt to new technologies compared to larger companies.

CCI as catalyst in the digital and green transition of society at large

Finally, beyond the green and digital transition of the CCI itself, the CCI are also increasingly seen by European policy makers as catalyst in the digital and green transition of society at large. As artists and creative people have the ability to think beyond the functional aspects of technology, their goals and views naturally differ from those of researchers or engineers, a distinction that can often inspire new applications for technologies through co-creation and art-based innovation and that can also spark critical reflection and public debate on new technologies. Several recent European policy documents and studies have pointed out both the opportunities and the need to promote interdisciplinary cooperation between the CCI and the environment and technology sectors, to spur the twin transition in Europe, fostering innovation in both the CCI and other domains.

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 '**Cultural and Creative Industries**' - 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.

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 1).

Figure 1: Overview of monitoring industrial ecosystems and relevant data sources
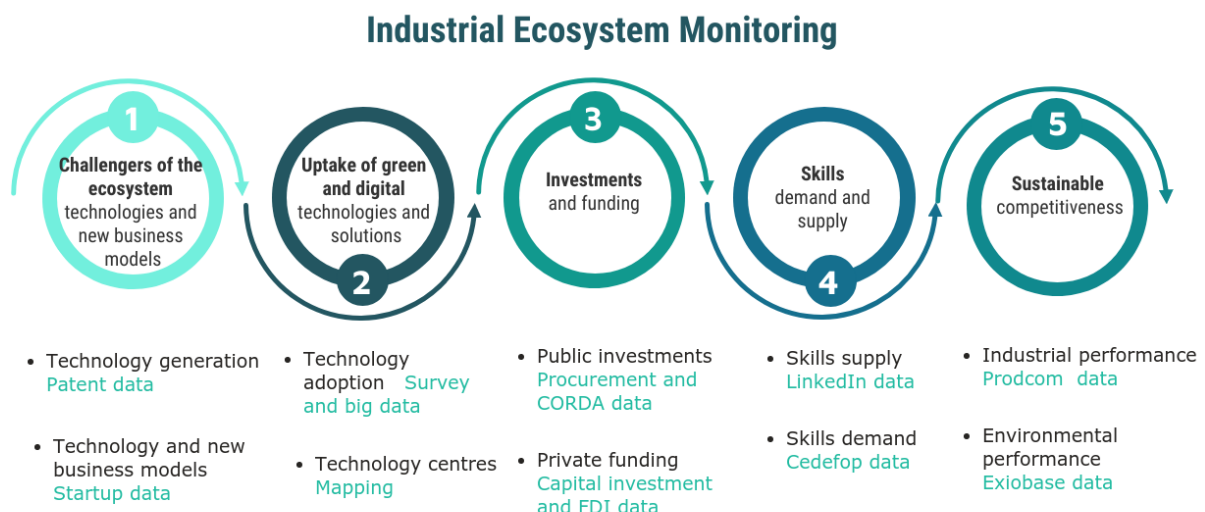
Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

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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. 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 2.

Figure 2: Main technologies monitored in the project

Green transformation	Digital transformation
Advanced Sustainable Materials	**Advanced Manufacturing & Robotics**
Biotechnology	Advanced Manufacturing
Energy Saving technologies	Robotics
Clean Production technologies	**Artificial Intelligence**
Renewable Energy technologies	**Augmented and Virtual Reality**
Solar Power	**Big Data**
Wind Power	**Cloud technologies**
Other (geothermal, hydropower, biomass)	**Blockchain**
Recycling technologies	**Digital Security & Networks/ Cybersecurity**
Circular business models	**Internet of Things**
	Micro- and Nanoelectronics & Photonics
	Online platforms

Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

This report contributes to the **key pillars put forward in the 'Blueprint for the development of transition pathways'[3]** of the Industrial Forum developed in 2022.

There are still a number of gaps in terms of holistically and quantitatively monitoring the performance of the CCI ecosystem in the green and digital transition. The problems to collect data on culture and creative industries have been summarised in the report of KEA published in 2015[4] still prevail:

- Culture is not a sector from a statistical viewpoint, meaning that the sector and related occupations are not readily sized by international statistical standards: NACE17 and ISCO18 codes often aggregate;

- the sector is composed of a high number of small and micro-companies and freelancers, which are difficult to measure statistically as they may be 'informal';

- Estimates from countries are often difficult to compare.

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[3] https://ec.europa.eu/docsroom/documents/49407/attachments/1/translations/en/renditions/native
[4] KEA (2015), Feasibility study on data collection and analysis in the cultural and creative sectors in the EU.

1.2. Definitions

As described in the European Commission 2021 Annual Single Market Report, the cultural and creative industries are composed of multiple sub-industries. '*The biggest industries are audiovisual (TV, video games, VOD, cinema, VR/AR), music, books and press publishing, advertising, cultural heritage (museums, historical sites), performance (theatre, dance) and visual arts. In Europe, culture and creativity are regarded as a public good and may receive public support (e.g. public funds play an important role in the AV industry or the heritage sector) while many creative entrepreneurs are driving the creative economy (e.g. music, publishing and media, architecture, design). Cultural education is considered part of the ecosystem*'[5].

The cultural and creative industries are also described in the EU Regulation (EU) 2021/818 establishing the Creative Europe Programme (2021 to 2027) [6] as sectors that are based on cultural values and artistic and other individual or collective creative expressions. These sectors include '*architecture, archives, libraries and museums, artistic crafts, audiovisual (including film, television, video games and multimedia), tangible and intangible cultural heritage, design (including fashion design), festivals, music, literature, performing arts (including theatre and dance), books and publishing, radio, and visual arts*'.

A widely adopted common definition of the CCI is still lacking on a European level and various Member States use different delineations where they may or may not include some subsectors under the definition of the CCI. Combined with poor or inadequate data collection mechanisms for specific indicators, and outdated statistical classifications this creates challenges in providing uniform statistical data on the CCI. In this analytical report, mainly Eurostat figures are used. The European framework for cultural statistics (based on the 2009 UNESCO description) was developed by the European Statistical System (ESS) network on culture and presented in the ESSnet-CULTURE final report[7]. It covers heritage (museums, historical places, archaeological sites, intangible heritage); archives, libraries; books and press; visual arts (plastic arts, photography, design); performing arts (music, dance, drama, combined arts, and other live shows); audiovisual and multimedia (film, radio, television, video, sound recordings, multimedia works, video games); architecture; advertising and arts/crafts.

1.3. Industry state of play

The cultural and creative industries are crucial for the European economy in terms of the employment they generate, and their value added to a wide range of other industrial ecosystems. According to Eurostat, cultural and creative industries employed 7.7 million people across Europe in 2022[8].

Recently, both the COVID-19 pandemic and energy crisis have placed the industrial ecosystem under a lot of pressure. At the same time, the lockdowns accelerated ongoing trends of digitalisation in the CCI.

Looking at employment, **a recovery in the CCI is taking place after the severe impact of the pandemic**. At the height of the lockdowns, the number of people at EU-level working in culture fell to 7.14 million employees in 2020. It increased again to 7.7 million in 2022. However, this growth varies across Europe. In 2022, cultural employment increased in 19 EU countries compared to 2021. Cyprus (21.5%), Luxembourg (14.5%) and Ireland (14.0%) recorded the highest increases. Croatia (−6.3%), Czechia (−7.3%)

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[5] European Commission Annual Single Market Report 2021
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32021R0818&from=EN
[7] https://ec.europa.eu/eurostat/cros/content/essnet-culture-final-report_en
[8] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Culture_statistics_-_cultural_employment#Cultural_employment_.E2.80.94_overall_developments (Please note that the European Commission Annual Single Market report published in 2021 indicates another estimate notably 8.02 million people employed in the cultural and creative industries.)

and Bulgaria (−7.7%) had the most significant decreases in cultural employment [9] It should be noted that a large group of professionals in the CCI are multiple job holders and/or non-standard workers which are underrepresented in official statistics and particularly vulnerable in the CCI ecosystem[10].

Numerous CCI professionals have demonstrated their capacity for experimentation and innovation during COVID-19. Many **CCI companies and organisations adapted to new digital distribution methods** when the containment measures caused them to cease their regular operations. They explored new digital ways of reaching audiences and developed innovative digital projects during the pandemic. Today, cultural and creative professionals increasingly rely on the use of digital platforms (such as: social media, e-commerce, app and streaming platforms) for social and economic interactions. While these platforms provide opportunities to reach new audiences and customers, they also lead to more precarious working conditions, gaps in worker protection and imbalanced revenues for creators[11]. The increasingly dominant role of platforms in the production and distribution of content creates the threat of having a few dominant players as global gatekeepers, leading to less (access to) cultural diversity. Protecting this diversity, developing sustainable working conditions, ensuring fair remuneration and respect for the intellectual property rights of professionals in the CCI remain important elements to further allow the sector to grow.[12]

The energy crisis is also taking its toll on the CCI. According to a survey by Pearle Live Performance Europe, the largest European federation representing music, performing arts and live-performance organisations, the energy bill for live performance organisations increased up to 600% in 2022.[13]

The Network of European Museum Organisations also mapped the impact of the energy crisis on museums throughout Europe. As an example, based on the data gathered from 79 museum institutions in Hungary, the most common energy price increase in 2022 was estimated to be between 100 and 1,000 percent[14].

Combined with the rising cost of living due to inflation, this puts companies, organisations and professionals in the CCI at risk.

Rapidly emerging advanced digital technologies (such as artificial intelligence, extended reality, blockchain) offer new opportunities in terms of content creation, improved accessibility, interaction with the end user, and new ways of monetising cultural and creative content, but they also introduce fresh challenges. These will be analysed in the following chapters.

Access to these advanced technologies remains difficult or costly for the majority of micro-companies and self-employed entrepreneurs in the CCI (which make up the bulk of the industrial ecosystem) and require a mix of skills and expertise. New technologies linked to artificial intelligence (AI) or new practices linked to the use of smart contracts in blockchain

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[9]https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Culture_statistics_-_cultural_employment#Cultural_employment_.E2.80.93_current_state_and_latest_developments. Eurostat Cultural Statistics do not follow the exact same definition as the CCS ecosystem in the Annual Single Market Report, but cover most of the same sectors. The European framework for cultural statistics (based on the 2009 UNESCO framework) was developed by the European Statistical System (ESS) network on culture and presented in ESSnet-CULTURE final report (2012).

[10] IDEA Consult, Goethe-Institut, Amann S. and Heinsius J., Research for CULT Committee – Cultural and creative sectors in post-Covid-19 Europe: crisis effects and policy recommendations, European Parliament, Policy Department for Structural and Cohesion Policies (2021)

[11] Voices of Culture, The status and working conditions of artists and cultural and creative professionals (2021)

[12] See e.g. IDEA Consult, Goethe-Institut, Amann S. and Heinsius J. 2021, Research for CULT Committee – Cultural and creative sectors in post-Covid-19 Europe: crisis effects and policy recommendations, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels
https://www.europarl.europa.eu/RegData/etudes/STUD/2021/652242/IPOL_STU(2021)652242_EN.pdf

[13] https://www.pearle.eu/positionpaper/energy-crisis-an-urgent-call-to-the-eu-and-member-states-to-secure-live-performance-events-and-support-cultural-organisations

[14] https://www.ne-mo.org/news/article/nemo/nemo-mapping-of-museums-in-the-energy-crisis.html

to sell or distribute cultural/creative content also bring new complexities concerning the management and ownership of their related intellectual property rights (IPR).

Meanwhile, following these crises, the **CCI is increasingly recognised as a key factor in promoting a resilient recovery for society as a whole**. This includes its role in areas such as health, wellbeing, social cohesion, as well as its ability to drive the digital and green transition.

Council Conclusions on the recovery, resilience and sustainability of the cultural and creative sectors (2021)[15] have therefore pointed out the need to promote interdisciplinary cooperation between the cultural and creative sectors and the environment and technology, fostering innovation in both culture and industry. A recent study published by the European Commission (DG RTD) analyses how arts and cultural organisations contribute to the promotion of knowledge derived from academic and industry research.[16]

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[15] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021XG0602(01)&from=NL
[16] https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/eu-valorisation-policy/knowledge-valorisation-platform/thematic-focus/fostering-knowledge-valorisation-through-arts-and-cultural-institutions_en

2. Technological trends and new business models as drivers of the digital and green transition

Key findings

Advanced digital technologies are transforming the cultural and creative industrial ecosystem at an increasingly rapid pace, although they influence its sub-industries to differing extents. Digitalisation has a **profound impact on all elements of the value chain within the CCI** and almost all subsectors. For example: artificial intelligence is causing disruptions; augmented and virtual reality is driving change in content presentation and production; experiments with the metaverse, non-fungible tokens and cryptocurrencies allow new business- and revenue models to emerge. This is shown by the **increasing number of CCI-related tech startups** getting a further boost during the pandemic period.

Digitalisation is not new to the CCI. Industries such as video games, news media and recorded music have gone through a transformation already. **Basic software and cloud solutions are still a key driver in the sector's digital transformation** with **54% of CCI tech startups focussing on software solutions**.

The **rise of generative artificial intelligence in particular is challenging human creativity** even if the future transformations cannot be fully grasped. Standard or repetitive tasks are increasingly automated by digital tools. The debate is ongoing whether this is a severe threat or an opportunity that creates breathing room (by making basic creative tasks more efficient) for new forms of creativity.

The CCI also represents a (critical) reflection on the impact of all digital technologies in society as they stimulate debate and **challenge purely technology-driven innovation**.

Figure 3: Share of CCI tech startups with a specific technological focus
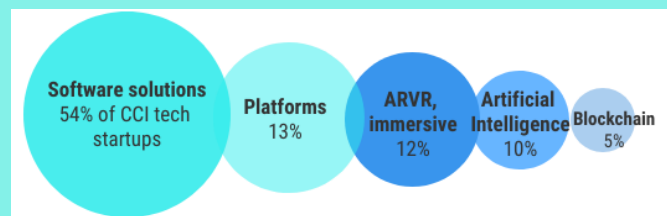
Source: Technopolis Group based on Crunchbase data, 2022

The green transformation has been a less marked trend in CCI. A broad range of clean technologies are however of interest to the CCI, such as **renewable energy sources (i.e. solar and wind power) in architecture and cultural infrastructure; eco-friendly materials in design**; virtual events, exhibitions, museums and historical sites, reducing the need for physical visits; sustainable production methods in film, music and performing arts; and cultural heritage assets digitised in 3D.

As shown by data on patent applications[17], the CCI has been influenced greatly by the **digital transformation**, particularly in **augmented and virtual reality** and **artificial intelligence**. Results on the evolution over time show that patenting in digital technologies has steadily increased except during the COVID-19 pandemic. Green technologies have been much less relevant mostly with renewable energy and circular design playing some role in CCI-related patenting.

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[17] See section 2.11 on the digital and green patenting landscape in the CCI.

2.1. Technological trends challenging the CCI ecosystem

Cultural and creative industries have been impacted in different ways by digital transformation trends. The CCI ecosystem is composed of diverse industries where some are operating predominantly digital by now (video games, news media) while others are lagging behind in the uptake of digital technologies (e.g. performing arts, cultural heritage). Besides the impact of technologies on the creative and cultural industries, the role of CCI should also be recognised in influencing the transformation of other industries (e.g. video games driving trends in the metaverse). Hence, it is difficult to fully reflect on technological transformation without discussing the individual patterns.

There is no systematic data collection on the overall digital transformation of the CCI, and even less information is available about the sector's green transition. Nevertheless, technological trends can be revealed through tech startup activities related to the CCI and via a business and organisational survey.

Trends in technology startups have been captured by analysing the Crunchbase data source and complemented by desk research. Crunchbase was originally founded in 2007 to track the data of startups featured in articles on the TechCrunch website. The analysis based on Crunchbase data explored tech startups activity related to the following sub-industries and disrupting digital technology activities in CCI:

- Advertising (advertising tech)
- Architecture
- Book publishing (e-books, audiobooks, tech for book publishing content)
- Design (design services, product design and graphic design)
- Visual arts and photography
- Film (motion picture, film production)
- Museums and historical sites (technology augmenting the museum experience)
- Music (music technology and music data analytics)
- News media (media technology)
- Performing arts (technology augmenting the experience)
- Video games

The top-3 ranking of CCI subsectors with the highest tech startup activity are news media, design and video games. The analysis of the technologies in which tech startups are active (Figure 4) highlights the importance of advanced technologies such as artificial intelligence and augmented/virtual reality, but also immersive content for various subsectors, including advertising, video games, news media, architecture, and design. Technologies such as software solutions are mostly linked to design, video games, news media, platform solutions for advertising, and streaming technology for music. The data also show that CCI subsectors with strong public support (museums, performing arts, visual arts, film) show low levels of tech startup activity.

The number of **CCI-related tech and innovative service startups (including digital technologies) has been growing over time and has further increased during the pandemic period,** except for some industries such as books, museums and performing arts.

Figure 4 presents the evolution of CCI specific tech startups created over time.

Figure 4: Evolution of CCI tech startups created over time
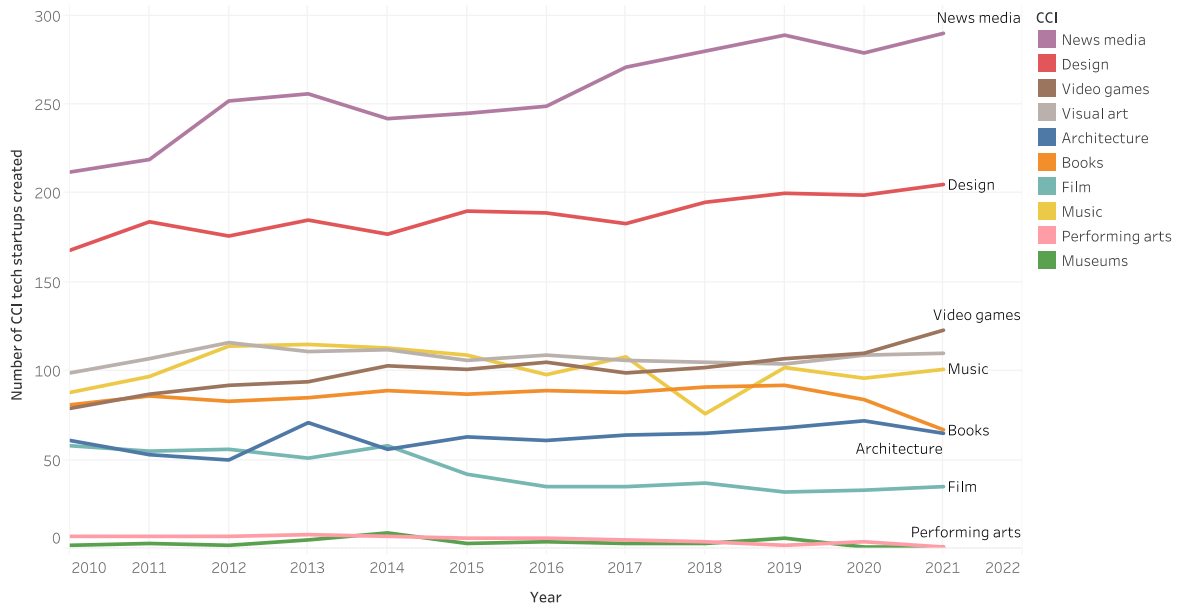
Source: Technopolis Group based on Crunchbase data, 2022

Figure 5: Relevance of digital technologies for the creative and cultural industries expressed by the share of tech startups specialised in the CCI and providing a certain type of technology-based solution, product or service

| | Advanced digital technologies | | | Basic digital technologies | | | |
CCI	Augmented, virtual reality and immersive content	Artificial Intelligence and advanced data ana..	Blockchain	Software solutions	Advertising platform	E-books	Streaming platform
Advertising	4,0%	8,4%	1,4%	1,3%	18,4%		
Architecture	2,4%	0,6%	0,1%	5,3%			
Books publishing	0,7%	0,5%	0,1%	2,4%		14,8%	
Design	2,4%	1,0%	0,2%	22,7%			
Film	1,1%	0,5%	0,0%	1,6%			0,7%
Museum	0,4%	0,2%	0,0%	0,4%			
Music	0,5%	1,9%	1,3%				4,8%
News media	1,1%	2,8%	1,5%	8,5%			
Performing arts	0,1%	0,0%	0,0%	0,1%			
Video games	4,8%	1,6%	2,3%	10,9%			
Visual art	1,8%	2,4%	0,7%	0,5%			

Source: Technopolis Group based on Crunchbase data, 2022

2.2. Augmented, virtual reality and immersive content

Augmented, virtual and extended reality (AVR) offer opportunities to create fully immersive, realistic digital environments and are gaining momentum in the various CCI. These technologies encourage new ways of telling stories, attract new types of creators to the CCI and provide new means of engaging with cultural content. While the games industry was one of the early adopters, these technologies also are increasingly being used in various other branches of the CCI. 4DX, for example, is a state-of-the-art film technology which delivers an immersive multi-sensory cinematic experience. 4DX incorporates on-screen visuals with synchronised motion seats and environmental effects such as water, wind, fog, scent, snow and more, to enhance the action on screen. The COVID-19 pandemic has also accelerated the use of AR/VR in museums for virtual visits, while virtual prototypes offer new ways for designers and architects to interact with clients and other partners in the construction business. In combination with the use of high-quality LED screens, virtual backdrops/locations can be built in game engines to create a 3D model of a movie environment in film studios. Furthermore, VR can also provide great opportunities in communication and learning, via virtual trainings, classes, meet-ups and tours.

Immersive technology also raises issues, such as a potential widening of the digital divide if certain end users cannot keep pace with these technological developments and/or cannot afford the headsets or a high-end PC to be able to use it. The use of immersive technology should also be in balance with the wellbeing of the end user. Immersive technology can be very engaging and increase the time spent on screen-based interactions, but the prolonged use of headsets can also cause physical and cognitive discomfort.

Immersive content is changing how we consume culture

The experience a company or organisation offers has become as important as the product or service itself. It has become a key differentiator to stand out and strengthen consumer engagement. Immersive approaches expand the possibilities of digital storytelling beyond traditional conventions, by offering a multi-sensory experience and emotional connection. They also give users a more dynamic role to play. For organisations and companies in the CCI, immersive content can increase visibility, appeal to new audiences, allow for more meaningful participation, facilitate better engagement, and provide additional revenue[18]. For museums and exhibitions, immersive experiences create the possibility to augment physical objects and places with additional graphics and animations, transforming the visitors' understanding or appreciation of exhibits. Immersive experiences also allow personalisation by adapting storylines to consumers' preferences and interests, which also enhances insights in possible future developments of a service or product.

Startups are a good indicator of upcoming disruption in an industry. In the EU27, Crunchbase identified 287 companies established after 2010 and developing or using augmented and virtual reality in relation to the CCI. Some of the examples include:

- **Adverty[19]** from Sweden is an advertising platform that invented the BrainImpression™ algorithm to solve viewability in digital advertising and use augmented and immersive virtual experiences for brands to connect with consumers.

- **Books & Magic**[20] is a publishing house that develops augmented reality storybooks for children. It produces physical books complemented with an app that allows children to travel through the story and explore the fairy tale with an immersive experience.

- **zLense[21]** headquartered in Budapest produces a digital lens add-on to professional broadcast and film cameras. The technology enables producers and filmmakers to

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[18] Creative Industries Policy & Evidence Centre, Immersive Experiences in Museums, Galleries and Heritage Sites: A review of research findings and issues (2019).
[19] https://adverty.com/
[20] https://booksandmagic.com/
[21] https://zlense.com/

utilise virtual and augmented reality effects in real time and recorded TV and video productions in studio or on location.

- **Ready Player Me**[22] is an Estonian cross-game avatar platform for the builders, creators and residents of the metaverse.
- **ZERO10**[23] is an augmented reality fashion platform that enables brands and designers to create a virtual try-on experience.

Despite there being many dynamic AVR startups in the CCI in the EU27, the number of total US startups in this domain is significantly higher (as shown in Figure 6). Relative to the size of the EU27 market, the share of AVR startups within the total number of cultural and creative industry startups is still somewhat a higher share in the EU27 than in the USA though. To illustrate some examples, several startups develop immersive content in the USA that aim at transforming the passive viewer into a co-creator of the cultural or creative product itself. This shift is expected to challenge traditional players in various subsectors of the industry. We also present the figures for China and Canada although the comparison is difficult due to the low level of representativeness of data for these countries.

Figure 6: Augmented and virtual reality tech CCI startups in an international comparison

Country	AVR	AVR share in total
USA	411.0	1,05%
EU27	254.0	1,25%
China	53.0	2,41%
Canada	52.0	1,54%

Source: Technopolis Group based on Crunchbase data, 2022

2.3. AI disrupting the cultural and creative industries

From creation to production and distribution of cultural and creative content, artificial intelligence and especially language technologies[24] have a profound impact along the whole value chain of the CCI. AI-related technologies can empower the CCI with machine learning for data analytics, deep learning for predictive insights, recognition tools to support image search, and so on. These technologies offer plenty of possibilities to boost efficiency (e.g. automated translation in book publishing, automated content curation in news media or AI-powered film editing), decision-making (e.g. predictive trend forecasting in design or AI-based data analytics in music to track upcoming artists), and content creation (e.g. AI-inspired music, image or text generation)[25].

At the same time, AI also leads to several challenges, such as copyright and related rights issues. There are challenges both on the input (issues around the use of protected content in data used for AI) and output sides of AI applications (concerning which rights may apply to cultural content resulting from the use of the AI application). AI technologies also come with a range of potential risks, e.g. that AI produces mostly monocultural, biased and low quality content, that it can amplify misinformation (by using false information as a source), that it can direct the consumer/audience to certain types of content, and threaten cultural diversity.

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[22] https://readyplayer.me/
[23] https://zero10.app/
[24] Language technology studies the methods of how computer programs or electronic devices can analyse, produce, modify or respond to human texts and speech. It consists of natural language processing (NLP) and computational linguistics (CL), many application-oriented aspects of these, and more low-level aspects such as encoding and speech technology.
[25] European Commission (2021). Opportunities and challenges of artificial intelligence technologies for the cultural and creative sectors, https://op.europa.eu/en/publication-detail/-/publication/359880c1-a4dc-11ec-83e1-01aa75ed71a1/language-en

Analysis of Crunchbase data identified 313 CCI companies established in the EU27 after 2010 that offer an AI-based solution or new product affecting the CCI. Companies with the highest funding (including unicorns) are found mostly in the field of visual art/photography and advertising, and a high number of startups also come from news media, video games and music.

Some of the **unicorns** include:

- **Meero**[26] based in France provides AI-based solutions to photographers in the field of visual arts such as supporting market research, invoicing, post-production, and delivery.

- **Seedtag**[27] from Madrid offers a contextual advertising solution based on machine learning and artificial intelligence. The contextual AI delivers solutions integrated within the content to power effective communications for brands. Their latest investment obtained in 2022 allows them to accelerate their US and international expansion.

Other examples:

- **Musixmatch**[28] is an AI company developing algorithms and tools for music discovery and recommendation.

- **Vionlabs** is a video discovery platform providing services and pay TV in the field of news media. It utilises computer vision and machine learning to generate sentiment data. Its recommendation engine and discovery platform supports the creation of a unique and extremely accurate personal viewer experience.

- **Artomatix** from Ireland works in the immersive 3D world and helps customers generate 3D content automatically with the support of AI algorithms. It was acquired by the US-based Unity in 2019.

In an international comparison, the EU27 is behind in generating AI startups in the CCI compared to the US (both in terms of absolute numbers – the USA has twice as many startups – and as a share of total CCI numbers).

Figure 7: AI CCI tech startups in an international comparison (established after 2010)

Country	AI startups	AI unicorns	Share of AI startups in CCI in total CCI tech
USA	634	8	1,62%
EU27	313	2	1,54%
Canada	54		1,57%
China	27	2	1,23%

Source: Technopolis Group based on Crunchbase data, 2022

One of the major business challenges for all subsectors in CCI is about finding the right combination of skills in terms of technical talent and innovative CCS professionals who can make use of AI technologies and manage change. On the one hand professionals in the CCI need to understand what AI technology can do for them and on the other hand AI tech developers need also more understanding how CCI work. Important other challenges that make it harder for the CCI to adopt and invest in AI technologies include access to appropriate data-sets (which are usually owned by individual companies and commercially

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[26] https://www.meero.com/en/
[27] https://www.seedtag.com/
[28] https://www.musixmatch.com/fr

sensitive), the quality/interoperability of these data-sets (tech startups need to make large investments to make the data 'AI and also purpose ready'), lack of transparency in AI algorithms (which are often protected by companies and platforms), and finding appropriate cloud solutions for a robust data infrastructure. Furthermore, the need for better cybersecurity and data protection across the entire data supply chain is likely to grow. There are also growing concerns that greater AI use may replace certain tasks/jobs in the CCI (e.g. certain forms of copywriting, music composing, film-editing).[29]

2.4. Non-fungible tokens and blockchain create new forms of creative ownership

Non-fungible tokens or NFTs are a unique certificate of a digital item lodged in a decentralised public blockchain which offers a way to provide proof of ownership. NFTs pave the way for a market in selling unique digital content in the arts, music, design and fashion or other creative fields.

NFTs (and Web3-technology) also offer a more direct and intimate connection between creators and their community and fans, giving creators the ability to bypass intermediaries and control the sale of created items to the end user. Blockchain technology allows creators to easily mint (a process in which the information of the NFT is recorded on a blockchain), help protect their intellectual property rights, and list it for sale on open marketplaces. Over time, NFTs can gain value, increasing rarity and driving even more demand for creativity. NFTs also offer a thriving resale market, allowing creators to earn income on secondary sales of their assets. Smart contracts (programs stored on a blockchain that run when predetermined conditions are met) can automate the actions required in an agreement or contract. Once completed, the transactions are trackable and irreversible.

While these evolutions open up plenty of new possibilities, they have also been associated with controversy due to cryptocurrency scams (NFTs are frequently bought and sold using cryptocurrencies), art speculation, and the environmental impacts of blockchain technology in general (in particular high energy demands).

2.5. Metaverse: experiments with a shared virtual world

In the last decade several companies, creative professionals, artists and designers in the CCI have been experimenting with the metaverse, the concept of a shared online virtual world, which exists in forms such as Roblox and NVIDIA'sOmniverse. Combined with the philosophy of a Web 3.0, where users create and control their own networks, make money directly and control their money flows (as opposed to previous web-versions where users only consume or where networks are in control and make money), the metaverse offers the possibility for entrepreneurs in the CCI to innovate with new business- and revenue-models.

Some examples of the use of the metaverse by the CCI:

- Voxels: a metaverse popular with art galleries and museums including San Francisco Museum of Modern Art and the FC Francisco Carolinum Linz, Austria. Players can buy land and build stores and art galleries.

- The Row[30]: metaverse community The Row launched in 2022 with 30 virtual properties created by artists including Arsham, Misha Kahn, Andrés Reisinger, Alexis Christodolou, design studio Six N Five and Hard Architects. Each has designed a '3D architectural landmark' that will be sold as an NFT, a non-fungible token. The virtual buildings can

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[29] European Commission, Opportunities and Challenges of Artificial Intelligence Technologies for the Cultural and Creative Sectors (2022)
[30] https://therow.everyrealm.com/

then be deployed on 26 different metaverse platforms on which metaverse real estate development firm Everyrealm, one of the developers of The Row, owns land.

- PlayChange[31]: Italian fashion brand Benetton combined the real and virtual worlds via PlayChange, through which they released a selection of their Spring-Summer 2022 collection across three worlds in different games on the Roblox platform.
- VOMA[32]: a fully immersive virtual art museum built to give anyone a chance to connect around art.
- Virtual concerts in the metaverse: several prominent musicians like Ariana Grande, Marshmello and Travis Scott are doing performances in the virtual world.

While further evolutions are still taking place, in recent years the big hype around the metaverse has diminished due to limited mainstream adoption and user engagement, technological issues[33] and a shift of big tech companies' attention more to artificial intelligence.

2.6. Role of basic digital technologies

Digital transformation is proceeding at different speeds across subsectors in the CCI. While some parts are rapidly taking up new technologies, others are still in more early stages of improving work efficiency with more basic digital tools and software to create, produce, organise and distribute their work. Desktop applications are often complemented or being replaced by cloud-based platforms and services. Digital tools for creation and production (such as software for graphic design, or composing music) have mutated into Software-as-a-Service (SaaS) hosted in the cloud. Creative agencies and cultural organisations also increasingly use cloud-based project management, planning and communication tools. Developments in cloud-computing are also essential to deploying technologies such as artificial intelligence, the Internet of Things (IoT), blockchain and, data analytics. The adoption of solutions in the cloud is also enhanced by the rise of remote work since the COVID-19 pandemic.

Some examples:

- Cultural and creative content is delivered via cloud-based streaming platforms to the end user.
- Cloud-based computing is being used for rendering content in the film industry.
- Cloud gaming enables gamers to play streamed games across devices.
- To help safeguard cultural treasures through a digital infrastructure the European Commission has launched a dialogue with Member States on the joint creation of a Collaborative Cloud for Cultural Heritage.[34]

The widespread use of cloud-based technologies creates economic benefits for companies in the CCI thanks to a reduction of IT costs. Conventional cloud computing, however, takes place in centralised data centres which require a lot of energy. In 2018, in the EU, data centres accounted for 2.7% of the electricity demand, a figure expected to reach 3.2% in 2030.[35] Initiatives are needed to make data centres climate-neutral, highly energy efficient and sustainable.

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[31] https://www.benettongroup.com/en/media-press/press-releases-and-statements/united-colors-of-benetton-debuts-in-the-metaverse-with-playchange/
[32] https://www.voma.space
[33] https://www.theregister.com/2023/06/28/metaverse_adoption_slow_gartner/
[34] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3855
[35] https://digital-strategy.ec.europa.eu/en/library/cloud-and-edge-computing-different-way-using-it-brochure

2.7. CCI subsectors offer a critical reflection on digitalisation and society

The CCI and its various subsectors are both a product of and reflection on the impact of all digital technologies across society, stimulating debates and challenging purely technology-driven innovation paradigms. As artists and creative people have the ability to think beyond the functional aspects of technology, their goals and overriding 'vision' will naturally differ from those of researchers or engineers, a distinction that can often inspire new applications for technologies through co-creation, but also offer a critical reflection on technology In a context where, on the one hand, there is a quasi-unlimited supply of digital technology that promises solutions to all kinds of problems and where, on the other hand, technological players can build monopolies of questionable size, the choice of technology is not always easy and innocuous.

Ars Electronica[36] is one example of an organisation that combines the talents of tech industry players and artists/designers. Their collaborations show the benefits of integrating art and design into company processes, stimulating innovation and future-looking mindset as well as critically reflecting on the impact of digital technology. By deliberately slowing down and experimenting with new digital technologies this can also help the CCI (and society in a broader context) deciding when which technology is ripe for deployment, with a realistic assessment of the effort - financial investment, training needed, long-term effects.

2.8. Cross-digital impacts among CCI subsectors and other domains

Advanced technologies lead to new ways of interaction and collaboration between the various subsectors in the CCI and other sectors. Some examples:

- The use of 3D graphics, AI and VR over the past decade has led to the intertwining of music and video games. Major music labels such as Sony Music and Warner partner with game platforms to deliver innovative musical experiences and reach out to fans via video games. In-game virtual concerts have become big business post-COVID, with greater attendances and fans willing to spend more on virtual experiences.

- Game Lab Graz[37] is a research group from the Graz University of Technology that introduces game technologies in other domains. By working with other fields, such as physics, Game Lab Graz simulates environments that cannot be seen in real life. They employ virtual reality technology to visualise and simulate energy-related processes and elements. For example, the research group developed a digital twin room where they can change certain conditions to analyse different energy properties, such as temperatures or materials, and see the effects of the atmosphere in the room.

- The Stadtgeist Karlsruhe brings cultural heritage and tourism together in an augmented history app that revives stories of associated with the German city.

- Ars Electronica Futurelab is a laboratory and workshop for future systems. It is committed to developing and evaluating technological innovation with a multi-disciplinary team of international artists and scientists from a wide range of disciplines. At the interface of art, technology and society, the Futurelab creates and shapes trends and visions together with cooperation partners from business, culture, research, and education.

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[36] https://ars.electronica.art/news/en/
[37] https://gamelabgraz.com/

2.9. Examples of CCI sector-specific digitalisation trends in tech startups

Books

One of the most significant and visible applications of digital technology used by tech startups is related to e-books and to some extent audiobooks. We observe a downward trend in the number of startups especially in the case of e-books, which might indicate that the market reached a saturation point and new types of innovations need to shake up the industry. Advanced digital technologies that are relevant for this industry include augmented and virtual reality and artificial intelligence. Interactive e-books and immersive reading are areas still showing growth. There are also new service models emerging on social networks around books and communities of reading, also including related mobile applications. A number of new tech startups focus on new services such as interactive books, and books connected to games. They also offer solutions that facilitate reading or help people with disabilities. Other services include digital reading platforms with a social reading experience.

Film

Most relevant digital technologies featured in tech startups in the film industry include mobile applications, software and cloud-based solutions, as well as augmented and virtual reality. Among the examples are mobile applications for crew members that increase efficiency (i.e. apps for crew onboarding) and flexibility (i.e. light simulation apps for cinematographers) in film productions. Cloud technology provides flexible data-storage, cloud-enabled editing, the rendering of scenes or cloud broadcasting, and streaming of content. With virtual reality, production sets and film studios can combine real-life scenes with virtual assets. This can also lead to a new variety of interactive films with viewers immersed in or forming part of the storyline. Artificial Intelligence-based tools help save time and reduce production costs by automating repetitive tasks in i.e. the editing, visual effects and animation processes

Museums and historical sites

In the case of tech startups related to museums and historical sites, the most relevant technologies used include software solutions and augmented and virtual reality. New applications that have recently emerged in museums and around heritage venues include digital twins to preserve and replicate delicate objects or sites. Combined with immersive technology they offer new opportunities for audience engagement and help to reach a broader audience. In museums, virtual content is also being used in combination with projection mapping on existing surfaces to highlight features or to bring objects to life. Furthermore, cloud-based solutions are used in the context of the digitalisation of analogue content/collections and the storage of relevant digital-borne content. Artificial intelligence is being used in software that enables search and access to ancient cultures across multiple interconnected museums. Digital platforms can distribute and manage storytelling scenarios directly through visitors' mobile devices, including innovative features such as AI object recognition, augmented multilingual audio description, and audio storytelling for video screens.

Music

Music tech startups continue to push the boundaries with innovative products and services. Technologies that are relevant for this industry include artificial intelligence, blockchain – and more specifically music information technology – streaming platforms, and other online applications. Despite the overall growth dynamic, some areas such as streaming platforms appear to have peaked. The use of green technology in music industry business models has yet to be identified in the Crunchbase data.

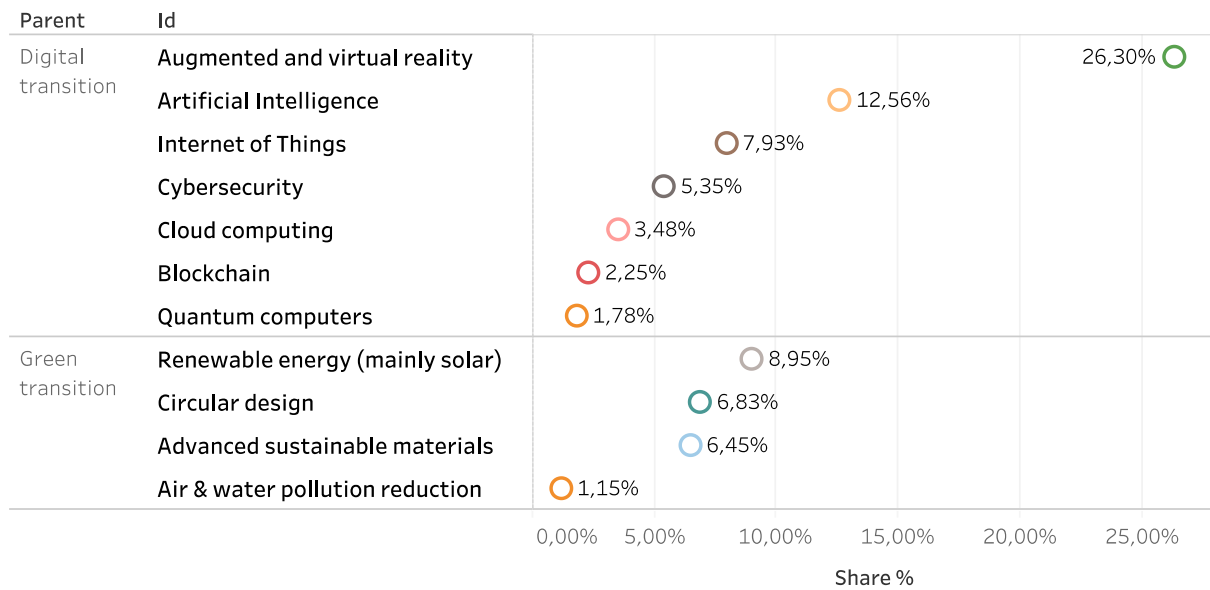## 2.10.   Digital and green patenting landscape in the CCI

In order to further examine the **specific patenting activities related to the green and digital transition**, an analysis of the OECD REGPAT database was carried out. Specifically, the analysis of the industrial ecosystem built upon the Cooperative Patent Classification (CPC). A text-mining algorithm was used to search for keywords and their specific association in the text of patent documents as well as in the CPC nomenclature. By using this approach, we can representatively capture the patenting activity in the CCI industrial ecosystem. It has to be noted that the focus of this analysis is on the patent applications related to the CCI industry, but this does not necessarily mean the patent was submitted by a CCI firm or organisation.

The classification of green and digital technologies underpinning these transitions builds on both the OECD green patents classification and work by Balland and Boschma (2021) and includes additional technologies particularly relevant to the CCI industrial ecosystem. It should be noted that the CCI are, by their nature, not the most patent-intensive sectors, as their main focus is on creating creative and cultural value. As such they do dominate the list of copyright-intensive sectors and are quite apparent in design- and trademark-intensive sectors, according to the 2019 report of the European Union Intellectual Property Office (EUIPO) and of the European Patent Office (EPO) on 'IPR-intensive industries and economic performance in the European Union'. The association with patents is, however, mostly noticeable at the level of ancillary goods and services in the CCI.

Results for **digital technologies appearing in patent applications from 2017-2021 related to cultural and creative industries** (as presented in Figure 8) show that AVR, AI, and IoT are currently the leading technologies in the digital transformation of the CCI. AVR has helped to enrich video games, film, media and the design industries as well as museums and heritage sites with new immersive experiences. Artificial intelligence is being applied more and more in content creation, curation, and distribution across various CCI subsectors (media, music, film, games...). Meanwhile, the web of internet-connected devices, or IoT, is improving customer experience and operations in CCI companies, venues, museums, libraries, and in retail. Furthermore, there are also visual artists using it to create new media art via connected devices.

Overall, the share within the total percentage of patents related to the CCI ecosystem is clearly focused on technologies supporting the digital transition. As for the **green transition,** the top three patent applications themes are related to renewable energy (mainly solar), circular design, and advanced sustainable materials. Some of the patent applications also reveal the innovative spill-over effects of the CCI in other sectors, such as the role of design in green mobility (patent applications for autonomous vehicles) or the contribution of architecture in the use of advanced sustainable materials in the construction industry.

Parent	Id							
Digital transition	Augmented and virtual reality							26,30% ⬤
	Artificial Intelligence				12,56%			
	Internet of Things			7,93%				
	Cybersecurity			5,35%				
	Cloud computing		3,48%					
	Blockchain		2,25%					
	Quantum computers		1,78%					
Green transition	Renewable energy (mainly solar)			8,95%				
	Circular design			6,83%				
	Advanced sustainable materials			6,45%				
	Air & water pollution reduction	1,15%						

0,00%   5,00%   10,00%   15,00%   20,00%   25,00%

Share %

Source: Technopolis Group based on Crunchbase data, 2022

Results on the evolution over time show that patenting in digital technologies in the CCI ecosystem almost quintupled between 2010-2020, underlining the impact of digital transformation in the CCI. The dip in 2019-2020 is related to the pandemic causing a general slowdown in patent applications, but it can be also related to a time lag in patent data.

Figure 9: Green and digital patenting trends in the CCI ecosystem over time (2010-2020)
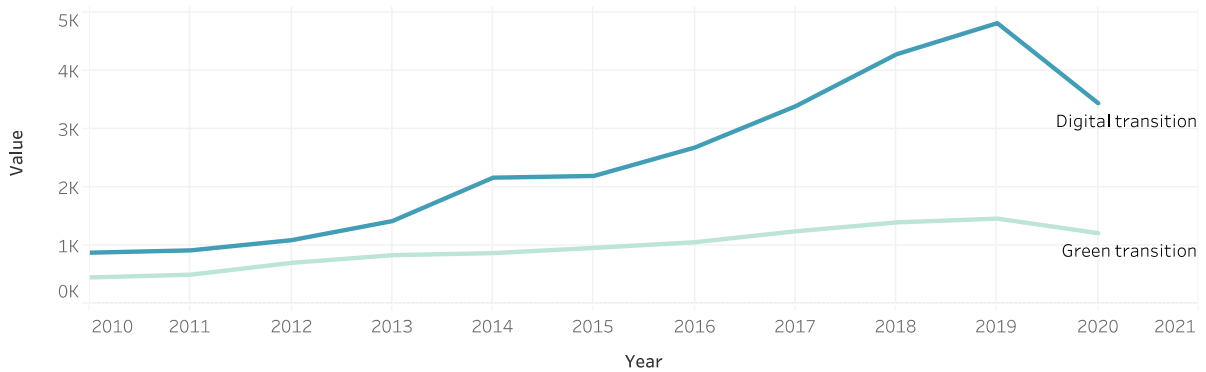
Source: Balland, 2022 based on PATSTAT

3. Uptake of green and digital technologies and related business models

With the objective to monitor the status in the uptake of green and digital technologies and related business models, a business survey has been implemented in the framework of this study. The survey collected data about the progress towards the green and digital transition of European SMEs across industrial ecosystems such as the CCI. The survey was based on using Computer Assisted Telephone Interviewing (CATI). The final sample included 8 987 companies in all industrial ecosystems and **647 organisations for cultural and creative industries in particular.** The mainstage fieldwork was conducted between 15 January and 31st May 2023. A prerequisite for each reach-out and interview was to have a respondent with adequate capacities and knowledge to answer the questionnaire (for more details please see the methodological report of the project).

The EMI survey complements existing surveys that inquired about similar questions such as the **Flash Eurobarometer 498 on SMEs, green markets and resource efficiency of March 2022, and the ICT-usage in enterprises survey**[38]. 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.

3.1. Green transformation

The information and data needed to map the adoption and use of green technologies in the CCI is fragmented and dispersed. Yet, related to green transition a broad range of technologies are of interest to the CCI, such as:

- Renewable energy sources like solar and wind power in architecture and cultural infrastructure
- Eco-friendly materials in design
- Digital technology for virtual events, exhibitions, museums and historical sites, reducing the need for physical visits
- Sustainable production methods in film, music and performing arts
- Cultural heritage assets digitised in 3D

The cultural heritage example can be a source of relevant knowledge on climate-related impact, adaptation and resilience (e.g. 3D allows non-destructive analysis of assets, visualisation of damage, and information for restoration, conservation, etc.)[39]. Indeed, cultural heritage can also support awareness of sustainability issues today by showing visitors how historical construction techniques and materials were built to last. These sites display the skills and knowledge of previous generations well suited to dealing with climatic challenges. During their lifetime, they have been adapted and transformed to meet constantly changing uses and requirements. The buildings are reparable, recyclable and reusable[40].

According to the results of the EMI survey, when CCI organisations were asked if they had increased their investments in the green transition and environmental sustainability over the past five years, 51% responded positively, while 49% responded negatively. A further question was related to the percentage in terms of revenue that CCI organisations had

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[38] https://ec.europa.eu/eurostat/cache/metadata/en/isoc_e_esms.htm
[39] Commission Recommendation (EU) 2021/1970 of 10 November 2021 on a common European data space for cultural heritage (2021).
[40] OMC report on Strengthening cultural heritage resilience for climate change (2021).

invested in green transformation on average annually. The responses show that **23% the respondents invested less than 5%,** which may be explained by the dominance of economic fragile micro-companies and organisations in the CCI, that face difficulties in getting access to investment money. **Another 19% invested between 10-14%,** which is a relatively good result.

Figure 10: Share of revenue invested in green transformation by SMEs in the CCI industrial ecosystem on average annually
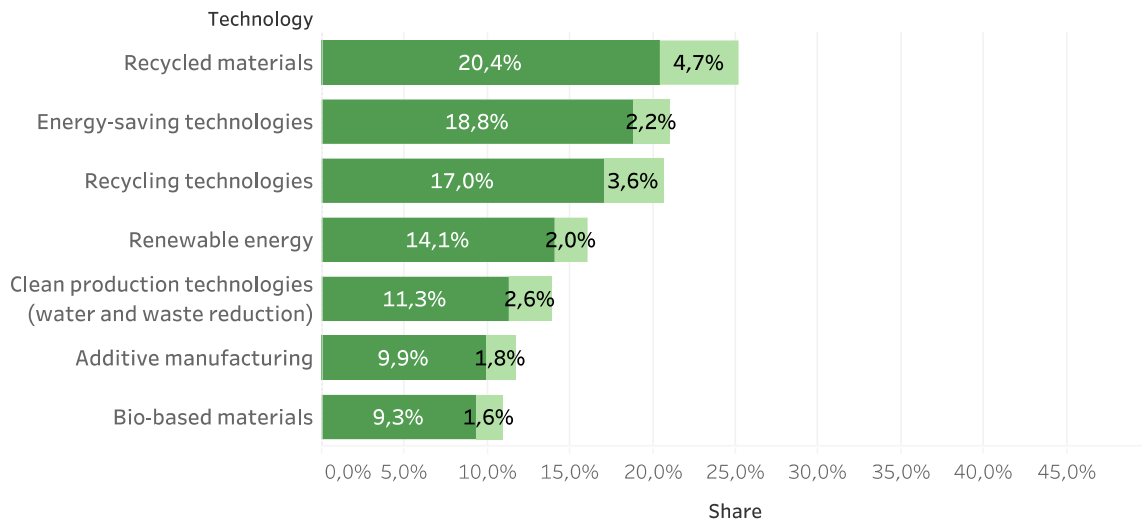

23%
of the respondents
invested Less than 5% of their revenue in the green transition

19%
of the respondents
invested Between 10-14% of their revenue in the green transition

15%
of the respondents
invested Between 5-9% of their revenue in the green transition

14%
of the respondents
invested More than 15% of their revenue in the green transition

Source: Technopolis Group and Kapa Research, 2023

The detailed results demonstrate that **20.4% of the organisations surveyed in the CCI industrial ecosystem adopted recycled materials** and another 4.7% is planning to use recycled materials. **Energy-saving technologies** have been taken up by 18.8% of the organisations. This finding is not a surprise since energy-saving has become very important since the start of soaring energy prices in 2021. In addition, the Flash Eurobarometer (2021)[41] found that CCI organisations are implementing further measures to reduce their environmental impact that are not necessarily linked to technologies. 63% of the surveyed CCI organisations undertook actions to minimise their waste, 58% to save energy, 52% to recycle materials and waste, 48% to save materials and 41% to save water. The difference in the results demonstrate that while there is a larger share of CCI organisations that take some actions for the environment, there are much less that invest in more concrete technologies or technology-based products to reduce their environmental impact.

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[41] https://europa.eu/eurobarometer/surveys/detail/2287

Technology

Technology	Already using	Planning to adopt
Recycled materials	20,4%	4,7%
Energy-saving technologies	18,8%	2,2%
Recycling technologies	17,0%	3,6%
Renewable energy	14,1%	2,0%
Clean production technologies (water and waste reduction)	11,3%	2,6%
Additive manufacturing	9,9%	1,8%
Bio-based materials	9,3%	1,6%

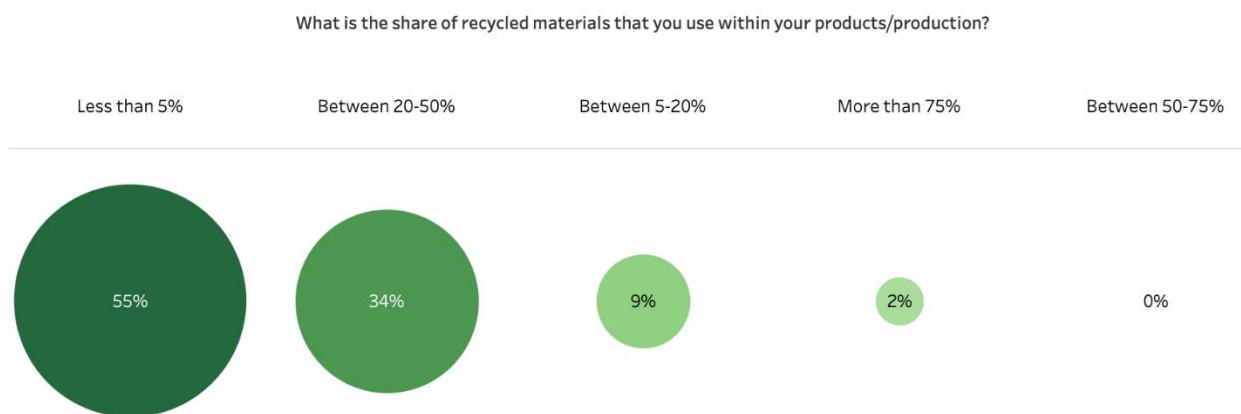0,0% 5,0% 10,0% 15,0% 20,0% 25,0% 30,0% 35,0% 40,0% 45,0%

Share

Answer
■ Planning to adopt
■ Already using

Source: Technopolis Group and Kapa Research, 2023

Recycling and recycled materials

A further question shows that the share of recycled materials which is effectively used is low. As shown in the figure below, 55% of the respondent SMEs declare to use or plan to use less than 5% of recycled materials. The Flash Eurobarometer 489 indicates that across most industrial ecosystems, the most common resource efficiency actions undertaken are minimising waste, saving energy and saving materials. This is also the case for CCI where companies primarily focus on minimising waste and saving energy, and only then on the use of recycled materials.

Figure 12: Share of recycled material that is used by respondents in CCI projects

What is the share of recycled materials that you use within your products/production?

Less than 5%	Between 20-50%	Between 5-20%	More than 75%	Between 50-75%
55%	34%	9%	2%	0%

Source: Technopolis Group and Kapa Research, 2023

Research has shown that some 80% of the impact of any product or service is determined at the design stage. CCI subsectors such as design and architecture can have a very important impact on the green transition in other industries, making use of greener materials, and making designs more energy-efficient (energy-neutral), including in other CCI subsectors that make substantial use of materials and physical resources, for instance film and theatre set design.

Some examples:

- Facadeclick: an innovative and circular building system. It is a hollow brick with connectors made of recycled plastic that you can click together like Lego bricks.

- Repeat headphones: their modular design allows 85% of components to be reused. The use of durable, standardised designs means fewer virgin materials are needed to create new headphones.

- Takt: Danish furniture brand using design to eradicate carbon emissions from its products.

- Fairphone: produces smartphones with a focus on durable design using fair and recycled materials; the Dutch company also places more emphasis on bringing sustainability and fair labour practices into the electronics industry.

Many designers are also making progress in materials-based research and innovation, using approaches such as biomimicry, seeking sustainable solutions to human challenges, or by mixing natural fibre composites (as lineo, jute, hemp) with conventional material, such as carbon or glass fibre, which significantly improves the damping properties of the material while ensuring good mechanical properties.

Some examples:

- Circular Matters: uses plants to create materials that replace fossil-based plastics and resins.

- EcoLogicStudio: architecture office uses photosynthesis in algae to remove air pollution with a living curtain, designed to rest over building facades; micro-algae feed on daylight and air, capturing and storing carbon dioxide molecules, while producing oxygen and releasing it back into the surrounding air.

- EU's WORTH Partnership Project[42] creates and supports transnational collaborations between designers, creative people, manufacturing enterprises (SMEs), crafters/makers and technology firms looking to develop design-driven and innovative products. To date, it supported around 250 partnerships working among others on circular design or advanced sustainable materials and their use in fashion and lifestyle industries. Some examples: BioChromatic[43] – image - a biannual capsule collection with biogenic dyes; Modifiable Vegan Bag Collection - 3-piece bag collection made of bio/vegan apple waste leather[44]; GEOM - small home items and furniture made from new, sustainable materials[45].

Renewable energy

The EMI survey found that renewable energies have been taken up by 14% of the respondents, however, the Flash Eurobarometer had a higher result notably 25% of the surveyed organisations said that they use predominantly renewable energy. The results also indicate that 62% of the respondents cover between 20-50% of their total consumption with renewable energy. Shifting to renewable energies not only reduces the carbon footprint of companies and organisations in the CCI, but also allows to reduce energy costs.
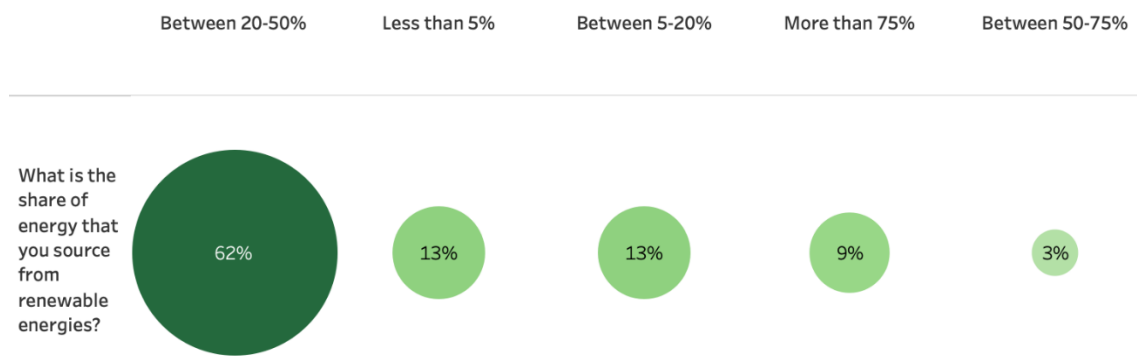
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[42] https://worth-partnership.ec.europa.eu/index_en
[43] https://worth-partnership.ec.europa.eu/projects/biochromatic-image_en
[44] https://worth-partnership.ec.europa.eu/projects/modifiable-vegan-bag-collection_en
[45] https://worth-partnership.ec.europa.eu/projects/geom_en

Figure 13: Share of renewable energy use within total energy consumption

| Between 20-50% | Less than 5% | Between 5-20% | More than 75% | Between 50-75% |

What is the share of energy that you source from renewable energies?

62% 13% 13% 9% 3%

Source: Technopolis Group and Kapa Research, 2023

All digital activities require electricity, which in turn needs to be generated. It has been estimated by the Swedish KTH Royal Institute of Technology that internet use is around 10% of the world's total electricity consumption.

One of the biggest sources of carbon emissions on a film set is the energy required to power lights, cameras, and other equipment. Solar energy has become increasingly popular among film production companies, providing an alternative to traditional power sources.

The use of LED lighting and energy-efficient audio systems can significantly reduce the amount of electricity consumed during live performances, tours, and other music and performing arts-related events as well as in cultural infrastructures. For example, the SWG3[46]: a Scottish nightclub tested a new system using the body heat from ravers to power the venue's lights, music, and electricity.[47] Dyaqua, an Italian company has developed a way to produce solar panels so that they resemble the barrel clay tiles common on the roofs of historical buildings in Italy. The panels consist of common monocrystalline silicon cells that are placed underneath ceramic housing and made from non-toxic materials.
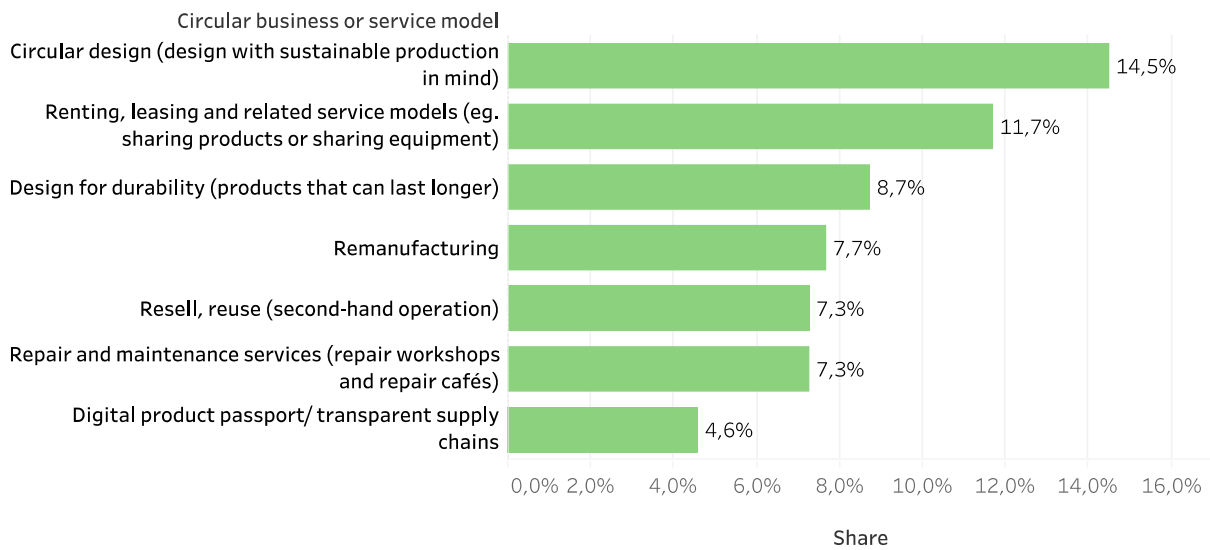
Circular business models and service models

CCI organisations were surveyed about the **adoption of circular business models** and other environment-focused service models. The results indicate that 14.5% of the respondents adopted circular design models and 12% implemented renting, leasing, and related service models. However, a lower share of 7% of the respondents declared the adoption of resell and reuse practices, or of repair and maintenance services. This may be explained by the nature of several subsectors in the CCI rather being service- than product-oriented and mainly revolving around the creation intangible Intellectual Property-assets.

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[46] https://www.weforum.org/agenda/2021/11/glasgow-nightclub-uses-dancers-body-heat-swg3-power-venue/
[47] https://www.theguardian.com/music/2022/oct/10/hot-moves-how-a-glasgow-venue-harvests-heat-from-dancers

Figure 14: Adoption of green business models and non-technological solutions within the CCI ecosystem

Source: Technopolis Group and Kapa Research, 2023

Designers can help reduce emissions by creating circular business models that reduce the need to produce new products with new materials by extending the life of products through reuse and repair; by sharing products through rental or subscription services; and by using renewable resources and recycling.

Environmental standards

When asked about the certification on any environmental standards, 34% of the respondents indicated that they had been certified (see Figure 15).

Figure 15: Percentage of respondents SME certified on environmental standards
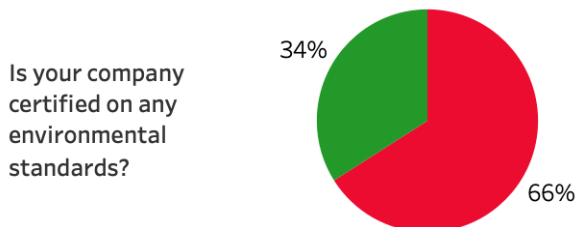

Source: Technopolis Group and Kapa Research, 2023

ISO 14001 is a set of standards that any company can follow to implement an effective environmental management system. By adopting the good practices suggested in 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[48]. The analysis of the data shows that organisations and business from the cultural and creative industries obtained less ISO environmental certificates over the period from 2014-2021. **The annual ISO survey indicates that**

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[48] 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

there were 4,042 certificates issued to cultural and creative industry organisations in the EU27 in the year 2021, which is an increase since 2010, when the yearly figure was 3,521. The CCI has a somewhat higher number of certificates obtained as the average of all industrial ecosystems in the focus on the project.

Figure 16: Number of environmental certificates issued
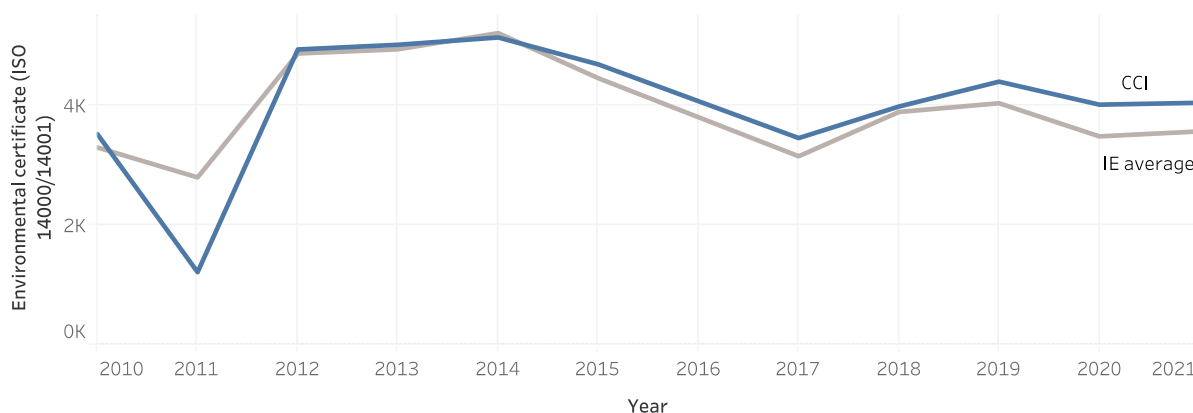
Source: Technopolis Group, 2022, based on ISO

Another standard, ISO 20121, for event sustainability management helps event organisers identify (and mitigate) the damaging social, economic and environmental impacts of their event. It has been adopted in event-related CCI-activities (such as music festivals).

Sustainable transport

According to the Art of Zero report by Julie's Bicycle, a rough estimate of the total global carbon footprint of the arts is around 70 million tonnes of CO_2e per year. 26% (18 million tons of CO_2e) is due to buildings, art shipments and business travel. The majority (74%) of the sector's footprint is related to emissions caused by visitor travel (~52 million tCO_2e).

Cultural and creative professionals can reduce the environmental impact of travelling and/or touring by using low-emission vehicles, optimising tour routing to minimise travel distances, and using carbon offset programmes to mitigate the impact of their travel.
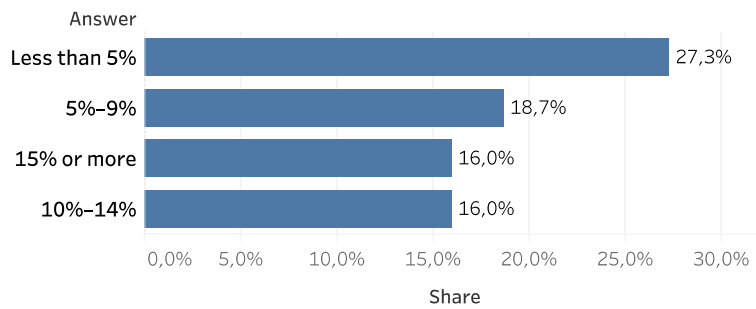
Some examples:

- Coldplay: announced its world tour 'Music of the Spheres' would have a net-zero carbon footprint and released a sustainability plan that includes direct-air carbon capture technology by Climeworks, whose machines remove carbon dioxide from the air and store it safely or package it for commercial use in products such as fizzy drinks. The band has used a kinetic dance floor that uses human movement to create electricity.

- Studio Olafur Eliasson: the studio around the contemporary visual artist Olafur Eliasson writes a no-fly rule into contracts, transporting its artworks by train and remote installing them via video calls in a bid to become carbon neutral in the next decade.

3.2. Digital transformation

The CCI industry has been making advancements on the digital scene over the past decade. When asking CCI SMEs, whether they had **increased their investments dedicated to the digital technologies** during the past five years, **65%** responded positively, which is a high result across all industrial ecosystems. A further question was related to the percentage in terms of revenue that the CCI enterprises had invested in digital transformation on average annually. The responses show that **27% of the respondents invested less than 5% in revenue** in digital technologies and altogether 62% invested less than 15%.
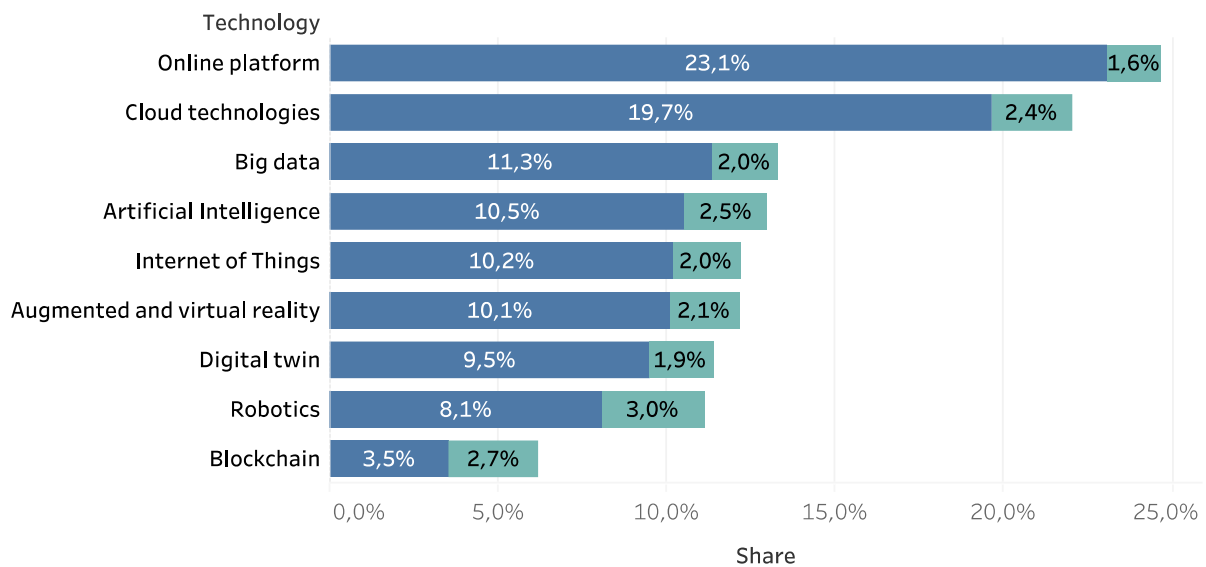
Figure 17: Share in revenue is invested in digital transformation on average annually

Answer

Less than 5%	27,3%
5%–9%	18,7%
15% or more	16,0%
10%–14%	16,0%

0,0% 5,0% 10,0% 15,0% 20,0% 25,0% 30,0%

Share

Source: Technopolis Group and Kapa Research, 2023

The figure below details the adoption of specific digital technologies. The detailed results demonstrate that **online platforms** (23.1%) and **cloud software and cloud computing (used by 19.7%** of the respondents) have been adopted the most. Moreover, **big data and artificial intelligence** are already in use across the CCI sector, indicated respectively by 11.3% and 10.5% of the respondent organisations. The use of **augmented and virtual reality has been pointed out by 8%** of the respondents. Moreover, according to the survey results, **Internet of Things solutions have been already adopted by 8% of the respondents.**

Figure 18: Adoption of digital technologies within the CCI industrial ecosystem

Technology

Technology	Already using	Planning to adopt
Online platform	23,1%	1,6%
Cloud technologies	19,7%	2,4%
Big data	11,3%	2,0%
Artificial Intelligence	10,5%	2,5%
Internet of Things	10,2%	2,0%
Augmented and virtual reality	10,1%	2,1%
Digital twin	9,5%	1,9%
Robotics	8,1%	3,0%
Blockchain	3,5%	2,7%

0,0% 5,0% 10,0% 15,0% 20,0% 25,0%

Share

Answer
- Planning to adopt
- Already using

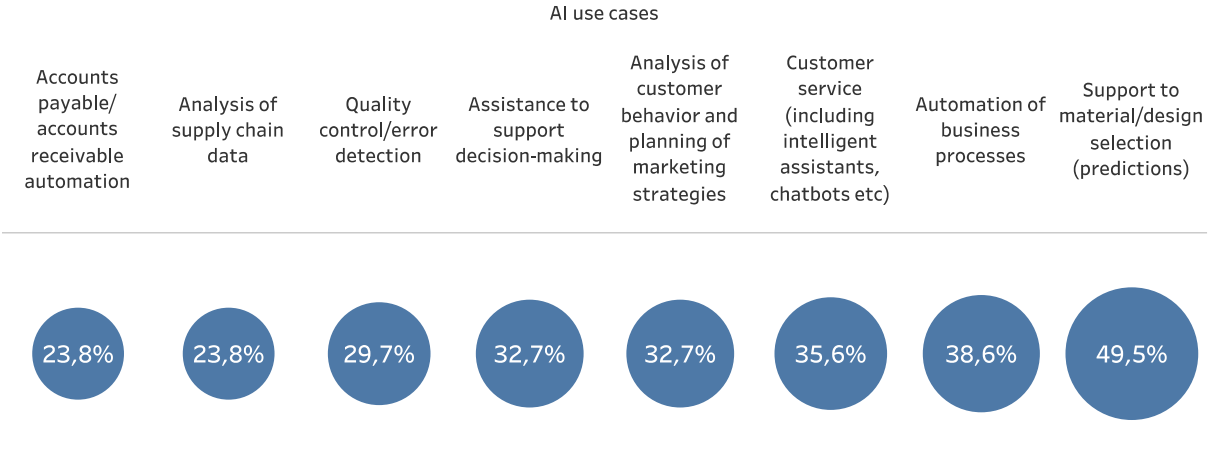*Source: Technopolis Group and Kapa Research, 2023*

Both tailor-made and more generic existing online platforms are widely used in the CCI for a variety of purposes such as content creation, presentation, distribution, the hosting of virtual cultural/creative events, performances and exhibitions, e-commerce and merchandising, archiving and preservation, audience interaction and engagement as well as for funding (through generic or sector-specific crowdfunding platforms).

One of the cutting-edge digital technologies that is revolutionising the creative industries is cloud computing. Large volumes of data and content can be processed and stored using cloud technology in a scalable, flexible, and economical manner. Examples for cloud computing in the CCI are platforms for streaming that provide users with high-quality audio

and video content across devices; management systems that make it easier to create, share, and monetise digital material and collaboration technologies that let distributed teams work on projects remotely. Eurostat statistics[49] reveals that **40% of companies in 'publishing, motion picture, video, television programme production; sound recording, programming and broadcasting activities' bought high cloud-computing services such as CRM software and accounting software in 2020**. This percentage is higher than found in the EMI survey, but it is due to the narrower focus on a specific segment within the CCI industries. When looking at cloud technologies in a broader term, Eurostat statistics shows that 67% of companies in publishing, motion picture, video, television programme production; sound recording, programming and broadcasting activities and 57.7% in advertising and market research; other professional, scientific and technical activities; veterinary activities adopted this technology in 2021.

Additional questions revealed the areas where **Artificial Intelligence and big data have been focused in the CCI sector**. The most popular responses include the support for material and design selection (indicated by 50% of SMEs), automation of production processes (39%), and customer service and new service delivery (36%). Eurostat[50] concludes that 27.8% of the organisation in publishing, motion picture, video, television programme production; sound recording, programming and broadcasting activities (10 persons or more) analysed big data internally from any data source or externally. The related indicator in Eurostat[51] that measures the use of AI by enterprises by economic activity found that **18.1% of organisations in** publishing, motion picture, video, television programme production; sound recording, programming and broadcasting activities (10 persons or more) adopted at least one Artificial Intelligence technologies in 2021.
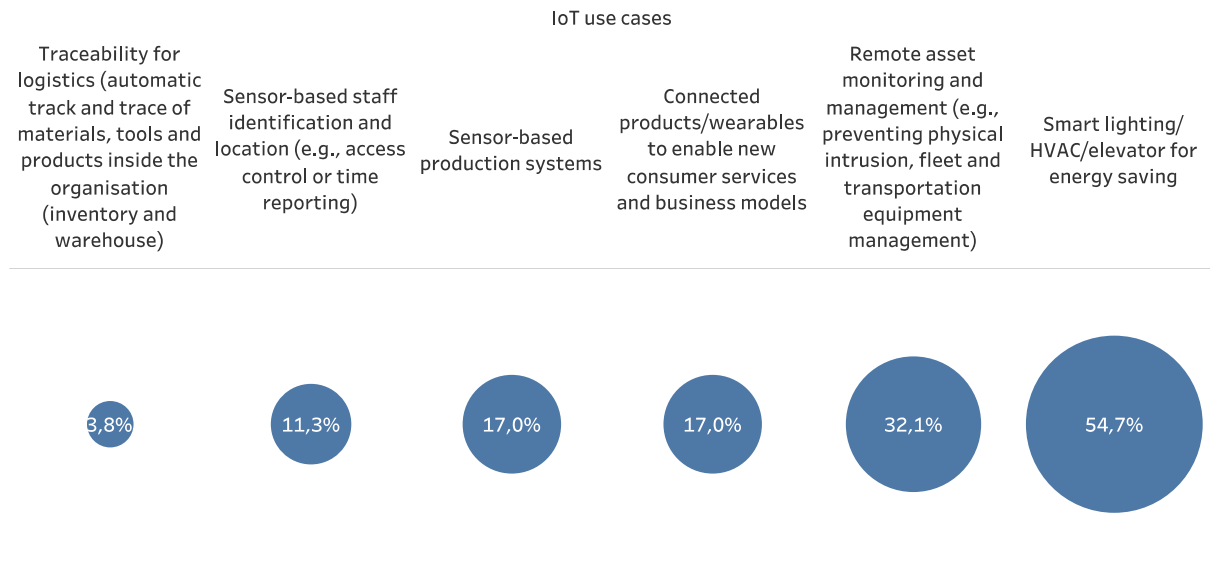
Figure 19: Use cases of AI and big data of CCI SMEs

AI use cases

Accounts payable/ accounts receivable automation	Analysis of supply chain data	Quality control/error detection	Assistance to support decision-making	Analysis of customer behavior and planning of marketing strategies	Customer service (including intelligent assistants, chatbots etc)	Automation of business processes	Support to material/design selection (predictions)
23,8%	23,8%	29,7%	32,7%	32,7%	35,6%	38,6%	49,5%

Source: Technopolis Group and Kapa Research., 2023

Figure 18 indicated that **the Internet of Things is used by 8% of the respondents.** Further questions specified that IoT is often used for smart lighting, sensor-based production, and connected products, as shown in Figure 20 below.

[49] https://ec.europa.eu/eurostat/databrowser/view/ISOC_CICCE_USEN2__custom_6993742/default/table?lang=en
[50] https://ec.europa.eu/eurostat/databrowser/product/view/ISOC_EB_BDN2
[51] https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_AIN2__custom_6994022/default/table?lang=en
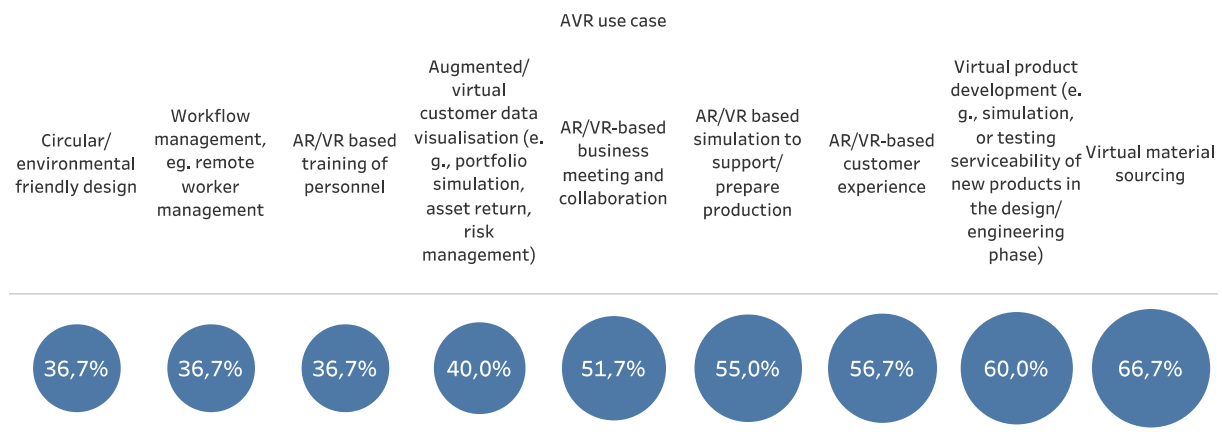
Figure 20: Use cases of Internet of Things of CCI SMEs

IoT use cases

Traceability for logistics (automatic track and trace of materials, tools and products inside the organisation (inventory and warehouse)	Sensor-based staff identification and location (e.g., access control or time reporting)	Sensor-based production systems	Connected products/wearables to enable new consumer services and business models	Remote asset monitoring and management (e.g., preventing physical intrusion, fleet and transportation equipment management)	Smart lighting/ HVAC/elevator for energy saving
3,8%	11,3%	17,0%	17,0%	32,1%	54,7%

Source: Technopolis Group and Kapa Research, 2023

Finally, **Augmented and Virtual Reality** has been mentioned by a low number, notably **8%** of the respondents (see Figure 18). Those few that responded, pointed out the use of AR and VR for virtual material sourcing (indicated by 66.7% of respondents) and virtual product development (60%).

Figure 21: Use cases of augmented and virtual reality of CCI SMEs

AVR use case

Circular/ environmental friendly design	Workflow management, eg. remote worker management	AR/VR based training of personnel	Augmented/ virtual customer data visualisation (e. g., portfolio simulation, asset return, risk management)	AR/VR-based business meeting and collaboration	AR/VR based simulation to support/ prepare production	AR/VR-based customer experience	Virtual product development (e. g., simulation, or testing serviceability of new products in the design/ engineering phase)	Virtual material sourcing
36,7%	36,7%	36,7%	40,0%	51,7%	55,0%	56,7%	60,0%	66,7%

Source: Technopolis Group and Kapa Research, 2023

Regarding the adoption of basic digital technologies

While some subsectors and actors in the value chains of the CCI are at the forefront of uptaking advanced digital technologies, most others are still very much at the early stages of adopting basic digital technologies and tools, such as using an online newsletter system, social media or a ticketing or e-commerce platform. Small companies and organisations in less tech-savvy CCI subsectors such as performing arts, visual arts or heritage often lack the resources to invest time, budget skilled people and digital leadership (having the ability to reflect on using tools and understand how to review their digital practice in an informed way within the contexts of their own institution, networks, sector and society)[52].

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[52] Culture 2024, The Digital Transformation Agenda and GLAMs: A Quick Scan Report for Europeana (2020).

4. Investment and funding

Key findings

Overall, private equity and venture capital **investment in CCI tech companies saw an increase between 2015-2020, with a sharp rise between 2019 and 2020,** followed by a decrease towards 2022. The COVID-19 pandemic, the energy crisis (and related inflation), caused an overall slowdown as investors showed more caution.

Over the period from 2015-2022, the **highest capital investment went into video games, followed by media technology and book publishing**. Despite the buoyant startup scene in music and design, the overall disclosed investment figures were much more moderate. Interestingly, the film industry had a very low number of investment deals in technology.

Despite the many examples of highly profitable companies, **the CCI in general still struggle to access debt and equity finance**. Traditionally, public authorities play an important role in financing the CCI, including in their innovation/transformational capacity. **Instruments include public grants, tax incentives, guarantee schemes**, etc. Several national recovery and resilience plans provide an important investment boost in the digital and green transition of the CCI.

In recent years, financing opportunities for the CCI have broadened. There is a growing body of literature documenting the transformational power of arts and culture, and **there is a growing interest from social impact investors in the CCI**, including in the transition of the sector towards more sustainability.

4.1. Investment in the CCI

Cultural and creative industries in general face difficulties gaining access to debt and equity finance. Financiers have concerns about several aspects:

- The CCI are characterised often as small or micro-businesses, both profit-oriented and non-profit, alongside a strong presence of individual entrepreneurs and freelance workers.

- The CCI produce goods which are inherently creative or symbolic in nature. As such, assessments of value are often subjective and face high levels of uncertainty. As the CCI rely heavily on intangible assets it can be difficult to determine an objective market value of a firm's assets.

- Few CCI organisations show a high growth pattern, something that especially venture capitalists are looking for.

- The project-based nature of many creative ventures also limits their capacity to access private finance.

At the same time, public authorities are an important financier of the cultural and creative sectors, primarily by providing public grants for the creation, production, presentation, and preservation of arts and culture. Public authorities are also important investors in the professionalisation and innovative capacity of the CCI, and as such also in the digital and green transition of the sector.

Public authorities – both at EU level and other government levels – also provide several instruments to lower the financial risks of financiers and investors in the CCI.[53] These

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[53] See e.g. OMC report on Innovative instruments to facilitate access to finance for the cultural and creative sectors (2016), https://op.europa.eu/en/publication-detail/-/publication/f433d9df-deaf-11e5-8fea-01aa75ed71a1

instruments include, among others, tax incentives and public guarantee schemes. One such example is the Cultural and Creative Sectors Guarantee Facility introduced by the European Commission in 2016, which covers up to 70% of financial intermediaries' potential loss on individual loans to CCI projects, and up to 25% of investors overall CCI loan portfolio. The EU guarantee is provided free of charge to selected financial intermediaries and can be accessed by CCI SMEs or small public enterprises in EU Member States. As of 2019, EUR 424.4 million of debt financing had been made available through the scheme, supporting projects worth over EUR 1.08 billion in total.

The European Investment Fund (EIF) also provides capacity building to financial intermediaries operating under the Cultural and Creative Sectors Guarantee Facility. The objective is to improve the ability of financial intermediaries to assess the risks associated with SMEs and micro-, small- and medium-sized organisations in the cultural and creative sectors. In the wake of the COVID-19 pandemic several EU countries also provided guarantees and investment incentives in their recovery plans targeted towards the impacted CCI domains.

Lastly, governments also sometimes assume the role of the private sector in financing the CCI through debt and equity finance. An example is MediaInvest[54], designed by the European Commission and managed by the EIF. With EUR 400 million earmarked for the period 2022-2027, it is a dedicated equity investment instrument designed to strengthen the competitiveness of the audiovisual sector by investing in European audiovisual productions and distribution businesses. It belongs to the broader InvestEU Equity programme, under the area 'Creative and Cultural Sectors', whose goal is to mobilise private investors and increase equity investment volumes.

Although these investment funds and guarantee facilities have no specific focus on the CCI's digital and/or green transition, it is clear from the latest 'Market analysis of the CCS in Europe' report (2021) commissioned by the EIF under the CCS Guarantee Facility Capacity Building programme[55] that the uptake of digital technologies in the CCI – leading to new digital products, services and business models – comes with interesting opportunities for investors in the CCI.

In the last decade, interesting alternative finance models such as crowdfunding[56], community finance, impact investing, and venture philanthropy have broadened the possibilities of CCI ventures to access finance. These new types of finance are often purpose- or impact-driven rather than (only) driven by financial return.[57] As there is a growing body of literature documenting the transformational power of arts and culture in society[58] (through its power to imagine radical futures, stimulate critical reflection and foster debate, gather people and channel emotions, boost radical innovations, etc.), there is also growing branch of investment in environment/society/governance (ESG) themes, which could include or extend to CCI's sustainable transition.[59]

4.2. Venture capital investment in creative industry tech startups

The analysis of venture capital funding into creative tech startups can reveal the forces of transformation that can disrupt the cultural and creative industries. The boom in music tech, as well as audio, media and entertainment developments reflects how digital

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54 https://digital-strategy.ec.europa.eu/en/policies/mediainvest
55 https://www.eif.org/what_we_do/guarantees/cultural_creative_sectors_guarantee_facility/ccs-market-analysis-europe.pdf
56 See https://crowdfunding4culture.eu/study-reshaping-crowd%E2%80%99s-engagement-culture-now-available
57 See e.g. IDEA Consult (2021), So You Need Money? A guide for cultural and creative entrepreneurs through the financing jungle, Creative FLIP publication
58 Example: CultureForHealth report (2022), EC (2022), Fostering knowledge valorisation through the arts and cultural institutions
59 See e.g. https://www.evpa.ngo/insights/fertiliser-and-pollinator-ecosystem

technologies create new value added. Building further on the tech startups information presented in the previous chapter, this section presents the trends in capital investment that these startups attracted. The investment figures are based on Crunchbase and refer only to the funding rounds where a value has been disclosed. Overall investment in CCI tech companies (Figure 22) saw an increase between 2015-2020, with a sharp rise between 2019 and 2020, followed by a decrease towards 2022. The pandemic, energy crunch and cost-of-living crisis caused an overall slowdown.

Figure 22: Total annual venture capital and private equity investment in cultural and creative tech companies since 2015
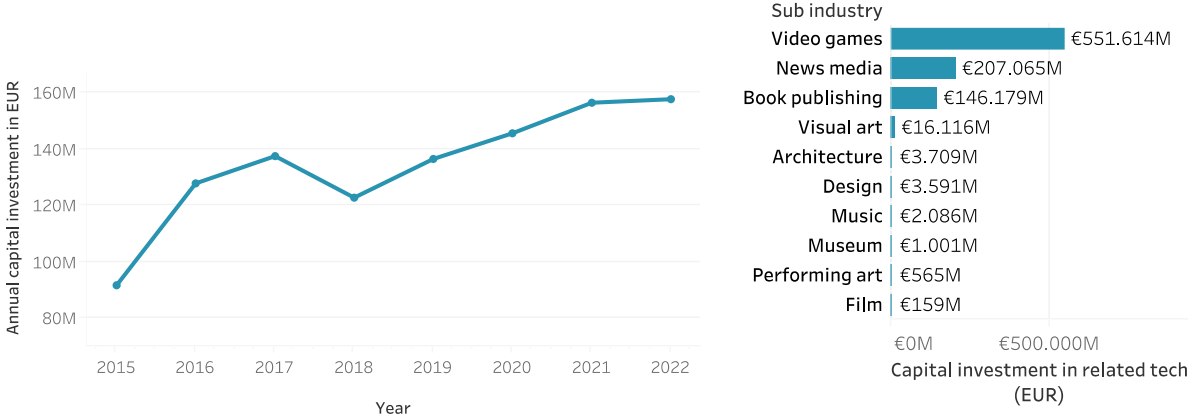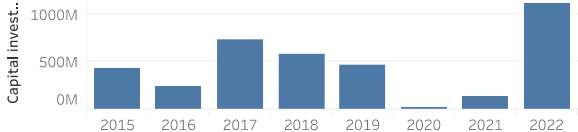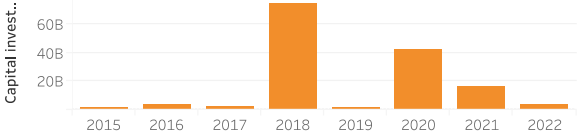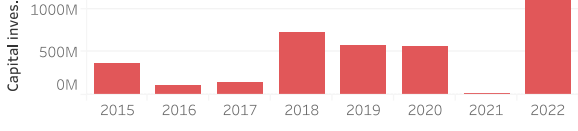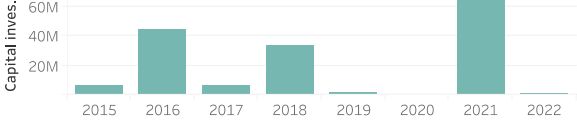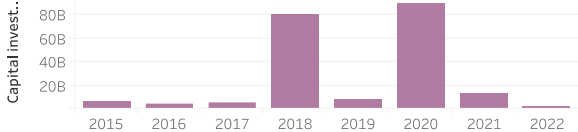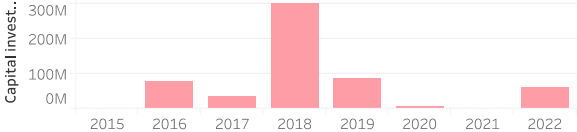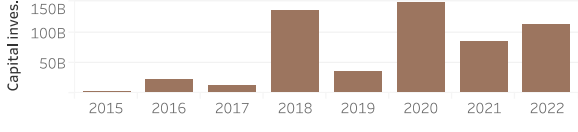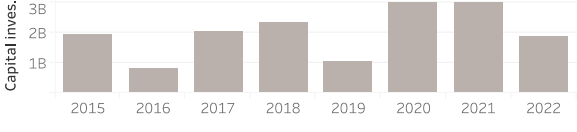

Source: Technopolis Group based on Crunchbase data, 2022

Over the period from 2015-2022, the highest capital investment went into video games, followed by media technology and book publishing (i.e. the success of e-books in education and audiobooks, one of the fastest-growing formats in publishing). Despite the buoyant startup scene in music and design, the overall disclosed investment figures are much more moderate. Interestingly, the film industry has seen a very low number of tech investment deals. Arguably, this is not because the film industry is less influenced by digital technologies but rather due to the fact that technological development is driven by large streaming platforms and film studios, and less so by tech startups.

There are a range of **video game-specific VC funds** that are backing up the development of the video games industry and continued to complete high value venture capital deals during the COVID-19 period. The crisis caused a drop, but investment levels have been maintained in the most recent years, in particular in augmented and virtual reality and artificial intelligence.

Investment patterns in the **music industry** have been largely influenced by Spotify, which raised close to EUR 1 billion in 2016. Besides Spotify, a range of other music streaming platforms have been active on the VC scene, such as Deezer, Epidemic Sound, SoundCloud, and Idagio. Other music data analytics and music app companies that continued attracting VC attention throughout COVID included Music World Media, Musixmatch, Viberate, and Neural DSP. These companies often make use of artificial intelligence technologies to create new products and services. Neural DSP is using biomimetic AI technology to replicate the sonic characteristics of any physical amplifier, overdrive, and cabinet. Several music production companies also concluded a funding round. For example, Musiversal, a global platform designed to make music creation and production more accessible to musicians and studio producers, announced it had closed a EUR 1.36 million seed financing round. The funding was led by Shilling, a venture capital firm.

In **museums**, the highest recent investment deals include Tiqets, Youseum, SonoBeacon, AerariumChain, WeGoTrip, and Wetime. Tiqets is a marketplace for tours, activities, and attractions founded in 2014 in Amsterdam. The company is focusing on venue-based experiences and museums by offering a smooth booking process and instant ticket delivery. Another example is the Hamburg-based startup called SonoBeacon. National museums in Berlin are now using the company's technology to offer visitors the most intensive museum experience possible.

In **performing arts**, there are some interesting startups with relevant investment deals especially related to AVR and transformative lighting/optics technologies in the entertainment sector. Minuit has developed a patented laser technology that is being used by various theatres. Dronisos provides indoor or outdoor drone light shows.

4.3. Investment in green and digital transition of the CCI

In recent years, substantial investments have also been made to support the CCI's green transition, but mainly from public finances.

At EU Member State level, the Recovery and Resilience Scoreboard thematic analysis on culture and the creative industries shows that **16 out of 22 Member States have included in their recovery and resilience plans a range of reforms and investments to support their cultural and creative industries and to drive their green** and digital transition in the post-pandemic era.[60]

These CCI support measures total around EUR 10 billion, which is approximately 2.3% of the estimated cost of the 22 recovery and resilience plans adopted in 2021.[61] The measures support the green and digital transition in several ways. Several reforms foresee

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[60] Recovery and Resilience Scoreboard thematic analysis on culture and creative industries, April 2022.
[61] The figure takes into account measures contributing to the cultural sector and partly include measures related to tourism.

renovations aiming at increasing the energy efficiency in cultural buildings (HR, IT, PT, SK), safeguarding cultural heritage against climate change (EL), and the introduction of minimum environmental criteria for cultural events (IT). Funds for climate-friendly projects by cultural sectors have also been created (AT, FR). As for the digital transformation of the sector, the measures include support for artefact digitisation efforts, as well as for the production and distribution of digital content (AT, BE, FI, LV, ES, LT, PT, SI, CZ). Some Members States have focused measures on digital skills and capacity building (IT, CZ).

Good practices of measures supporting the green and digital transition at Member State level include the following[62]:

- Austria will set up an investment fund to provide support to cultural institutions, services and cultural businesses for investments in a more ecological design of their operational structures.

- The Belgian recovery and resilience plan supports the creation of 100% digital events, with the aim of enabling artists and cultural partners to gain access to new markets and boost access to culture. The plan also provides measures aimed at the energy efficient renovation of cultural buildings.

- The Latvian plan includes investment focused on the digital transformation of the media sector and to support uptake of innovative technologies and approaches, such as artificial intelligence and machine learning.

Meanwhile, the European Union finances the green and digital transition of the cultural and creative sector through its funding programmes, some of which are aimed at the cultural and creative sectors while others are broader and address twin transition horizontally.

The **New European Bauhaus** (NEB)[63], for example, has been launched as a comprehensive initiative to break down silos and go beyond innovation within specific sectors. EUR 85 million has been dedicated to NEB projects from EU programmes in 2021-2022. In 2022, the first six NEB demonstrators were chosen and started operating. In 2023, the next ten will follow. Although the NEB has no specific EU funding programme at its disposal, over EUR 100 million has already been invested in NEB projects supported by different EU Multiannual Financial Framework (MFF) programmes such as Horizon Europe, the ERDF, LIFE, the Single Market Programme, and Digital Europe. The NEB put a special focus on the support of smaller initiatives and projects, for example with the NEB Prizes that already awarded 38 projects.[64]

The European Parliament's report, 'The Green Deal ambition: Technology, creativity and the arts for environmental sustainability' (May 2022), examined the projects that applied for a NEB grant and the results of conversations about the NEB taking place in local territories and online. The main finding is that the initiative is providing an umbrella for already existing practices to advance a radical 'circular approach' to building. Yet, there is still room for enhancing the role of artists and other cultural players in the NEB process, through disruptive and even grassroot actions, localised as well as expanding across Europe.

The **Digital Europe** programme (mobilising EUR 7.6 billion for the 2021-2027 period) also offers opportunities for the cultural and creative industries to improve and professionalise access to and use of digital technologies. One of the priorities of the programme is the '*deployment and best use of digital capacities in areas of public interest and interoperability, including culture and education'.* The programme aims at providing European creators and creative industries access to the latest digital technologies, from AI to advanced computing, and at capitalising on European cultural heritage to promote cultural diversity, social cohesion and European citizenship, among others. In particular,

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[62] Recovery and Resilience Scoreboard thematic analysis on culture and creative industries, April 2022
[63] https://new-european-bauhaus.europa.eu/index_en
[64] European Commission, New European Bauhaus Progress Report (2022)

within **Priorities 4 and 5**, there will most likely be connecting factors for the cultural and creative sector.

For example, under **Focal Point 4, 'Advanced digital skills'**, projects are supported in which new training formats and methods are developed and tested. These are designed to improve digital skills and professionalisation and are aimed at students, IT employees, self-employed people, and small businesses. These projects also offer cultural and creative professional opportunities, both as participants in training initiatives and for those who develop these programmes in the first place.

Focal Point 5, 'Introduction and optimal use of digital capacities', is about bridging the digital gap and ensuring that the public sector and areas of public interest have access to and can use digital technologies. This also applies to the education system and the cultural and creative sectors, which are to receive support in the introduction and advanced use of digital technologies – from AI to high-performance centres and cybersecurity. In addition, Digital Europe **contributes to the creation of new data spaces or systems**. This includes, among other things, the 'European Common Data Space for Cultural Heritage' – using digital developments to make it more accessible in the future.[65]

A recent analysis conducted by the European Commission on the '**Creative Europe culture' project portfolio** in the 2014-2020 work programme (WP) shows that, although the green and digital transition was not explicitly mentioned during that WP, a number of projects involving cultural and creative operators across Europe picked them up independently and made them the focus of their projects (23 cooperation projects tackling environmental sustainability and 33 tackling digitalisation, respectively 3.5% and 5% of the total of funded cooperation projects).[66] The analysis offers valuable insights into how the CCIs have picked up green and digital topics in their projects as part of an overall shift towards greater sustainability.

Selected cooperation projects have covered digital topics in many different ways, as depicted in Figure 23; empowering the sector to develop digital skills, digitise content and/or create online artistic content, promote 'digital' as an access point to the arts and, although to a minor extent, promote social innovation.

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[65] https://digital-strategy.ec.europa.eu/en/activities/digital-programme
[66] Creative Europe 2014-2020 – Gender equality, sustainability and digitalisation: cultural cooperation projects for a Union that strive for more, 2022

Figure 23: Main thematic focus of projects on digital topics (Creative Europe Culture portfolio – 2014-2020)
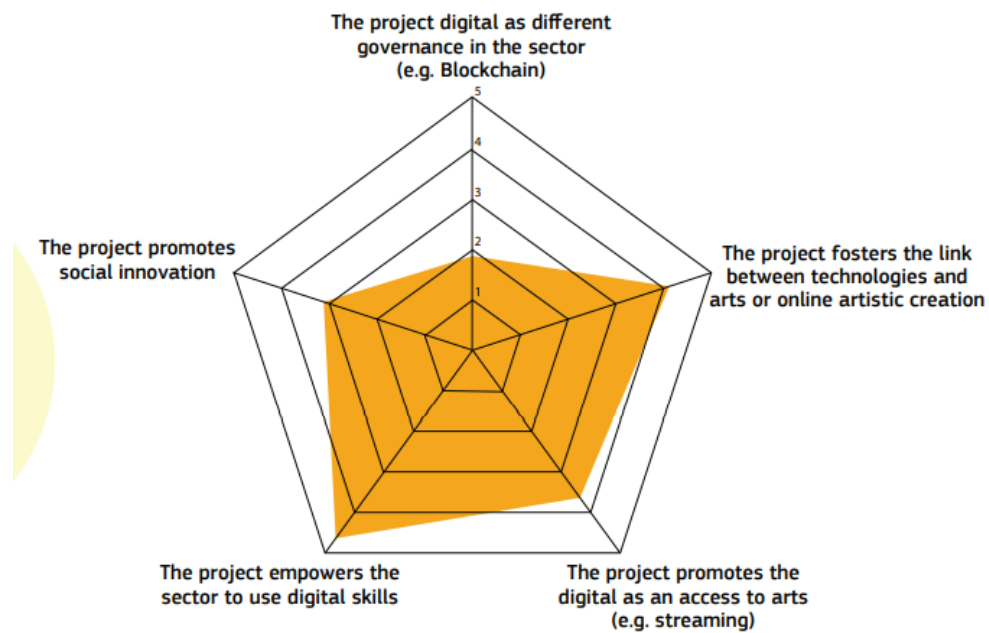
As illustrated in Figure 24, the variety of approaches and topics proposed by projects focused on green topics is wide as well, although four main recurring areas can be identified:

- Questioning the environmental impact of the sectors (new ways of organising value chains to reduce environmental impact, new business models to integrate circularity)
- Contributing to awareness raising on the urgency of topics linked to the environmental crisis
- Experimenting strategies for a sustainable management of the resources in urban and rural spaces (shared governance, citizen engagement)
- Building new imaginaries and narratives for the future.

Figure 24: Main thematic focus of projects on green topics (Creative Europe Culture portfolio – 2014-2020):
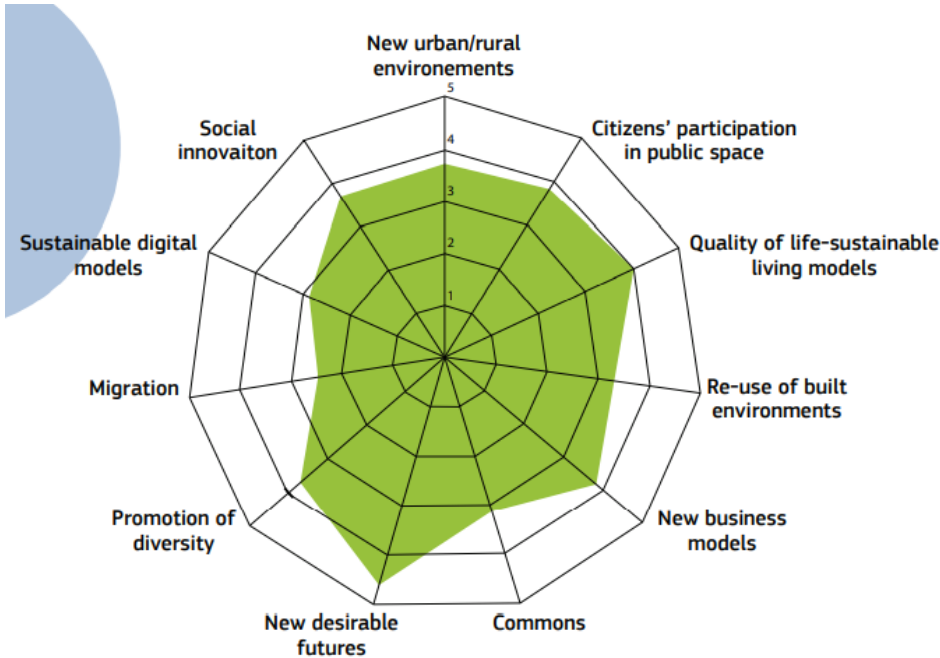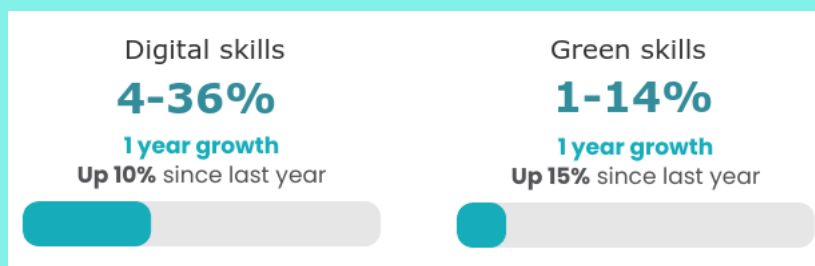
5. Skills

Key findings

The **CCI need both highly specialised skills, as well as more generic skills to respond to the digital and green transformation, to remain competitive, resilient and face the challenges ahead**. Developing technical, digital and green skills as well as management skills, leadership and entrepreneurial skills, and soft skills (such as innovative thinking) are important..

The share of people with skills **relevant for the green transition and employed in the CCI in the EU27 varies between 1 and 14%** as suggested by LinkedIn data. It is the highest in architecture (14%) and the lowest in music, film, and the performing and visual arts (1%). The **share of professionals who indicated possessing at least one type of advanced digital skill ranged from 4-36%. The video games and architecture domains are the most digitally skilled** – video game development is computer-based, and architecture is often supported by computer aided design (CAD) software and applications.

Figure 25: Share of professionals employed in the CCI with advanced digital or green skills

Digital skills	Green skills
4-36%	**1-14%**
1 year growth	**1 year growth**
Up 10% since last year	**Up 15%** since last year

Source: Technopolis Group calculations, based on 2022 LinkedIn data

There are persistent skills gaps in the CCI. Self-employed and freelance workers in the CCI often lack the resources to develop their digital and entrepreneurship skills.

To support the **green transition,** increasing awareness on the causes and impacts of climate change combined with **sector-specific capacity building** are needed.

Creative professionals and artists are important for tech companies to **ensure human-centric design**, **but their cross-sectoral skills are mostly self-taught**. More formal training combining design/art-based/creative thinking with technology is needed.

5.1. Skills challenges related to the digital and green transition

In order to adapt to the digital transformation, the cultural and creative industries require a combination of highly specialised skills and more general skills[67]:

- **Technical and digital skills** are needed to design, refine and use digital solutions. But as technology evolves at a rapid pace, the capacity to learn continuously and to integrate new knowledge has become critical in the CCI.

- **Management skills** are needed to develop and implement new digital processes. As many CCI professionals have studied creative/arts courses with little emphasis on managerial subjects, there is often a lack of business-related skills.

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[67] Creative FLIP, Skills needs and gaps in the CCSI (2021).

- **Leadership and entrepreneurial skills** are key to developing new business models and a vision on how to deal with new technologies. These skills seem to be the most critical and challenging for CCI organisations and companies to master.

- **Creative skills** are vital to push boundaries and provide original content in the digital environment.

- **Soft skills**, such as critical thinking, problem-solving, teamwork, communication, etc., are critical for the emergence of new ideas.

There are persistent skills gaps in the CCIs, particularly regarding digital solutions and entrepreneurship. These skills are particularly important for work in the CCI which is characterised by a high proportion of self-employed and freelance workers who are increasingly adopting digital practices for both the production and dissemination of cultural and creative work. Yet this class of workers often lack the resources (time, budget) and frameworks that exist in bigger companies around skills and training, to learn how to use or adapt to new technologies.

Skills needs related to fostering the green transition in the CCI are primarily related to:[68]

- **Developing awareness on the causes and impacts of climate change**, and what actors in the CCI can do to mitigate change. This includes developing a good understanding of what 'green' means in each sector by researching and adopting widely accepted field practices to work more sustainably (i.e. on monitoring carbon footprint or adapting/reducing certain practices). This also includes embedding green ambitions in the company mission/vision and daily operations/governance.

- Developing knowledge **to identify the best or most efficient area to invest limited resources (time, budget, effort)**. This is key for the small and micro-companies which predominately found in the CCI space. This knowledge differs from subsector to subsector and often requires specific capacity building. For instance, to develop innovative sustainable solutions for heritage sites, diverse skills are needed for materials identification, analysis of deterioration processes, and more[69].

In the context of the EU Pact for Skills, an EU high-level roundtable on skills for the CCI was organised (2021) by Commissioner Nicolas Schmit and Commissioner Thierry Breton to mobilise stakeholders to commit to upskilling. Representatives of the CCI ecosystems underlined the need for more **creative, cross-sectoral and wider digital skills, but also specific technological skills and a solid foundation in mathematics and logic**. Creatives are needed by tech companies and often employed as consultants from early stages on for product/service development. At the same time, creative companies need **polyvalent employees which are able to use and often also develop specialist software and interdisciplinary teams developing products together, from the early stages of design onwards**. While creatives are important to the tech industry, their cross-sectoral skills are mostly self-taught. More formal training in the arts and technology at undergraduate level and senior secondary is needed.[70] Furthermore, stakeholders indicated that Europe's leading CCI companies often struggle to find experienced professionals. They would benefit from an extended pool of leading tech companies in Europe, as this would boost the multidirectional flow of employees with diverse experience

The Commission mobilised the Cultural and Creative Industries stakeholders to set-up a large-scale skills partnership for the CCI ecosystem under the EU Pact for Skills (Creative

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[68] Creative Carbon Scotland's Guide to Green Champions: Building Competency and Capacity (2020)
[69] European Cultural Heritage Skills Alliance, factsheets: families of competences (2022)
[70] European Commission, Pact for Skills for the cultural and creative industries (CCI) ecosystem
– Roundtable with Commissioners Schmit, Gabriel and Breton (2021)

Pact for Skills) [71]. The partnership gathering over 100 committed to upskilling organisations identified priority skills needs to be addressed: digital, green, business/entrepreneurial, transformative skills for cross-sectoral innovation, technical skills/arts and crafts, as well as creativity.

EU plans and initiatives such as the Digital Education Plan (2021-2027) and the EU Pact for Skills are already in place to address the skills needs as a catalyst for developing the whole economy. In 2022, with the support of the Commission, a large-scale skills partnership[72] for the Cultural and Creative Industries ecosystem was set up. The Creative Pact for Skills (C-P4S) is focusing on addressing the most urgent horizontal skills needed by the CCI. Skills and competences for the digital environment and to support the green transition are a priority across all CCI occupations, both for the further acquisition of indispensable skills to operate in the digital environment (copyrights protection, engagement with audiences, online marketing and social media communications, etc.) and for increasing capacity of the CCI to engage in more tech-intensive development trends (AI, AVR, data analytics, etc.). Skills to support and integrate the green transformation are important in the day-to-day activity and the green transition of CCI organisations themselves, as well as to reinforce the capacity of CCI subsectors to creatively impact societies through artistic interventions and innovations, or to reinforce European identity, citizenship, democracy and social cohesion.[73]

5.2. Insights into the digital and green skills of CCI professionals

This section analyses trends in the supply and demand of skilled CCI professionals relevant for the green and digital transition, based on LinkedIn data. The LinkedIn platform is a global professional network often containing rich information on each member's background – work and educational profile, current job title, job description, education, additional studies and training – which can be used for the identification of skilled professionals in advanced technologies relevant to both the digital and green transition. To harvest the data from LinkedIn, 'keyword capturing' (using advanced technology) has been developed by experts and the database queries have subsequently been constructed to filter the findings by location and industry.

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

Advanced digital skills have been defined in the context of the main digital technologies captured in this project, notably related to: artificial intelligence, cloud computing, connectivity, robotics, Internet of Things, augmented and virtual reality and blockchain, as well as more general digital skills such as the ability to use certain software and online platforms.

On top of the identified green and digital skills, there is also a need to identify and develop strategic leadership skills on how to adopt technologies for (new) business development throughout the whole value chain.

Based on the analysis of LinkedIn data, Figure 25 provides a picture of the supply of professionals with green and digital technological skills relevant for the creative and cultural industries.
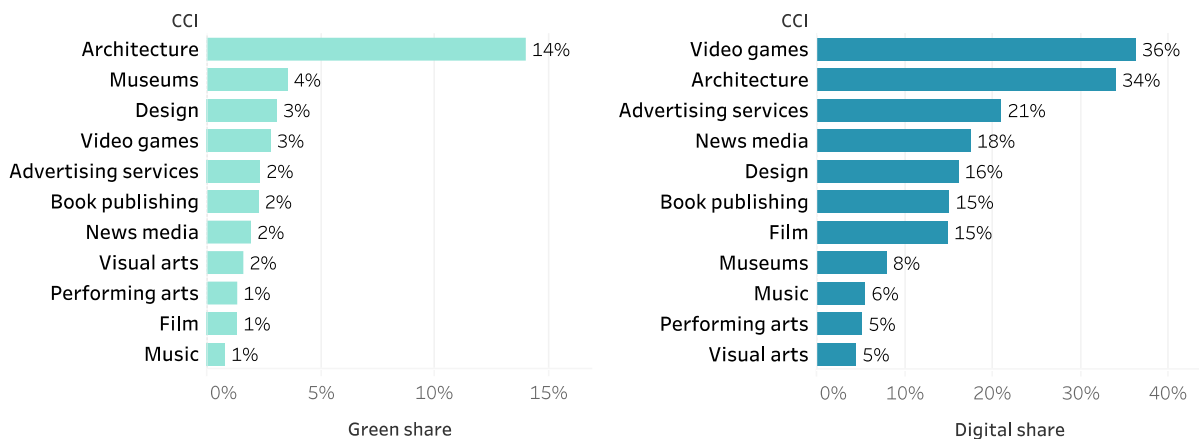
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[71] https://ec.europa.eu/social/main.jsp?catId=1534&langId=en

[72] https://ec.europa.eu/social/main.jsp?catId=89&furtherNews=yes&newsId=10241&langId=en
[73] Creative Pact for Skills (C-P4S) Manifesto (2022)

Within the registered professionals on LinkedIn and employed in the CCI, the share of people with skills relevant for the **green transition varied between 1 and 14%** (architecture at 14% and music, film, performing and visual arts at 1%). Professionals indicating they possessed at least one type of advanced digital skill ranged from **4-36%.** As stated earlier, architects and video game developers typically have more advanced digital skills by the nature of their profession.

Figure 26: Share of professionals employed in the creative and cultural industries with green and digital skills and with a profile on LinkedIn

CCI	Green share		CCI	Digital share
Architecture	14%		Video games	36%
Museums	4%		Architecture	34%
Design	3%		Advertising services	21%
Video games	3%		News media	18%
Advertising services	2%		Design	16%
Book publishing	2%		Book publishing	15%
News media	2%		Film	15%
Visual arts	2%		Museums	8%
Performing arts	1%		Music	6%
Film	1%		Performing arts	5%
Music	1%		Visual arts	5%

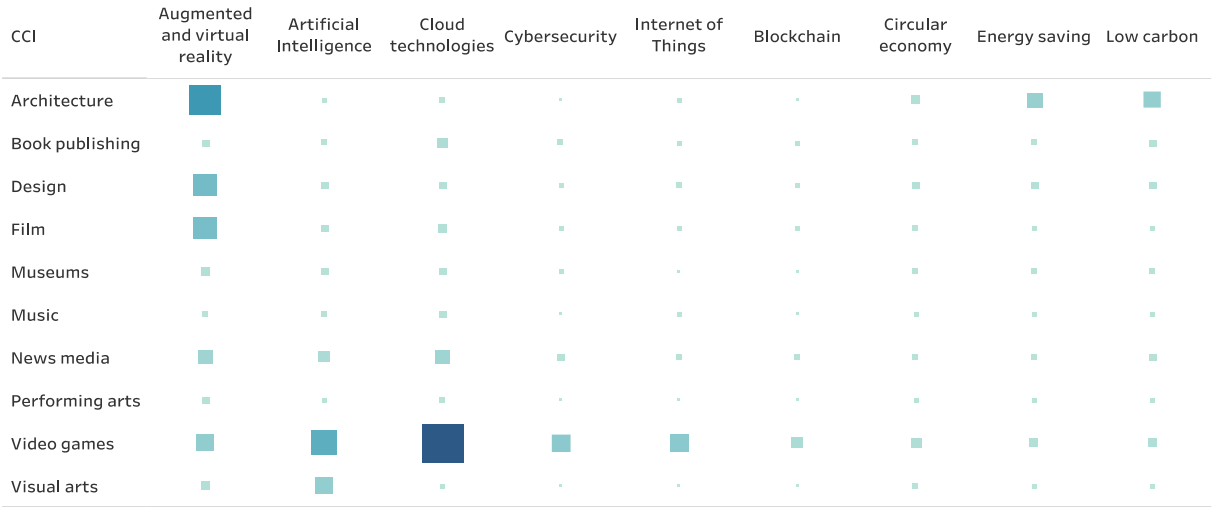*Source: Technopolis Group calculations based on LinkedIn data, January 2023*

More specifically, concerning digital skills the data show :

- For the CCI in general, cloud-related skills are reported as the most common among the professionals employed across the CCI, followed by AVR and AI.

- Video games is the CCI with the most digitally skilled professionals.

Architecture – skills related to augmented and virtual reality stand out. Concerning green skills the data show:

- Green skills are possessed by a low number of professionals across the CCI except for architecture.

- Among green skills, low-carbon and energy-related skills are present to some extent but the circular economy is generally not highlighted in the skills profiles.
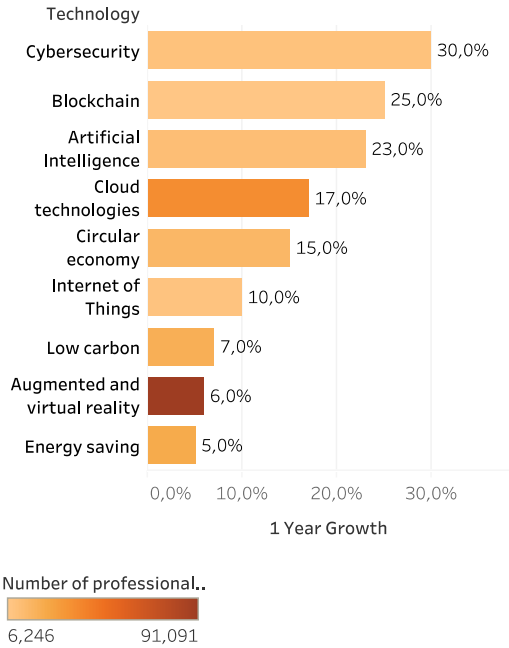
Figure 27: Share of professionals employed in the creative and cultural industries with green and digital skills and with a profile on LinkedIn

CCI	Augmented and virtual reality	Artificial Intelligence	Cloud technologies	Cybersecurity	Internet of Things	Blockchain	Circular economy	Energy saving	Low carbon
Architecture	■	▪	▪	·	▪	·	▪	■	■
Book publishing	▪	▪	■	▪	▪	▪	▪	▪	▪
Design	■	▪	▪	▪	▪	▪	▪	▪	▪
Film	■	▪	▪	▪	▪	▪	▪	▪	▪
Museums	▪	▪	▪	▪	·	·	▪	▪	▪
Music	▪	▪	■	·	▪	·	▪	▪	▪
News media	■	■	■	▪	▪	▪	▪	▪	▪
Performing arts	▪	▪	▪	·	·	·	▪	▪	▪
Video games	■	■	■	■	■	■	■	■	▪
Visual arts	■	■	▪	·	·	·	▪	▪	▪

Source: Technopolis Group calculations based on LinkedIn data, January 2023
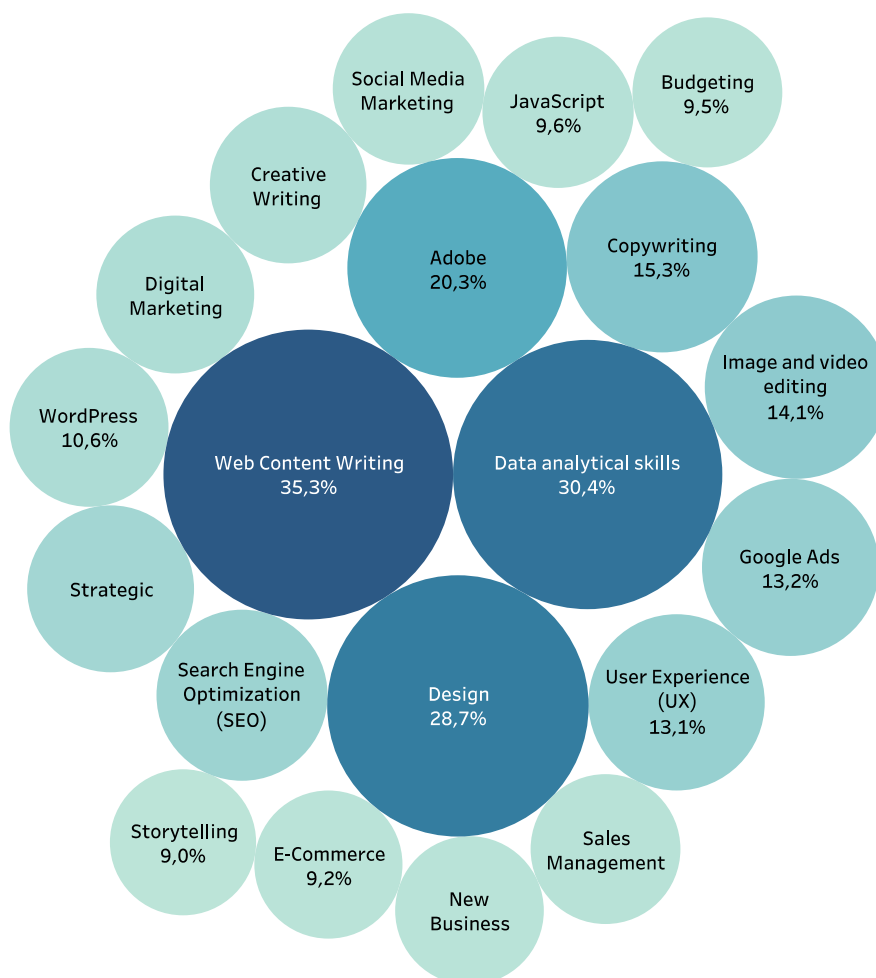
Trends in the importance of skills for the industry can be tracked by analysing the change over time and reflecting on the types of skills that have developed the most among the professionals employed in the industry. When comparing the results regarding the most dynamic digital technological and environmental skills over time, we see that skills in managing cybersecurity featured the highest growth over the last year, followed by skills related to using blockchain-technology. This is a change compared to the results in 2019-2020 when AI-related skills were the leader. Skills related to applying AVR shows lower growth but this domain has a much larger overall number of professionals with these skills in the CCI.

Figure 28: Percentage change in the number of professionals with digital and green skills pre-identified

Technology

	1 Year Growth
Cybersecurity	30,0%
Blockchain	25,0%
Artificial Intelligence	23,0%
Cloud technologies	17,0%
Circular economy	15,0%
Internet of Things	10,0%
Low carbon	7,0%
Augmented and virtual reality	6,0%
Energy saving	5,0%

Number of professional...

6,246   91,091

Source: Technopolis Group calculations based on LinkedIn data, 2020 and 2022

Source: Technopolis Group calculations based on LinkedIn data, 2020 and 2022

5.3. Insights into the digital and green skills of CCI professionals

Skills demand in the cultural and creative industrial ecosystem has been analysed following the skills intelligence insights of Cedefop, the European Centre for the Development of Vocational Training[74]. This dataset covers the EU27 (plus UK) 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.

Specific to the cultural and creative industrial ecosystem[75], there were **3 557 536 unique job advertisements** from organisations between 2019-2022 in the EU27. These job advertisements have been text-mined and the required skills analysed from the perspective of the green and digital transitions. The green pre-defined skills are from ESCO v1.1 and the digital are predefined from ESCO v1.1.1 which is currently being updated.

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[74] https://www.cedefop.europa.eu/en/tools/skills-online-vacancies
[75] In the case of the retail industrial ecosystem the dataset was filtered for the NACE industries as defined in the Annual Single Market Report.

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 algorithms.

The share of online job advertisements that required any form of **moderate digital skills (excluding basic IT office skills) was particularly high, notably 53.32%** over the period from 2019-2022 (explained by the high relevance of digital marketing and use of social media tools), while this percentage was **31% for advanced digital skills.** Requirements related to the **green transition** appear less often on the advertisements notably in a very small share **2.28%** of the cases.

It is interesting to observe that while the absolute number of job ads with digital or green skills requirement increased over time, the share within the total number of retail job ads experienced a drop in 2020 and in particular in 2021 but bounced back strongly in 2022.

Figure 30: Share of online job advertisements that demand digital and green transition related skills in the retail industrial ecosystem within the total number of retail job ads
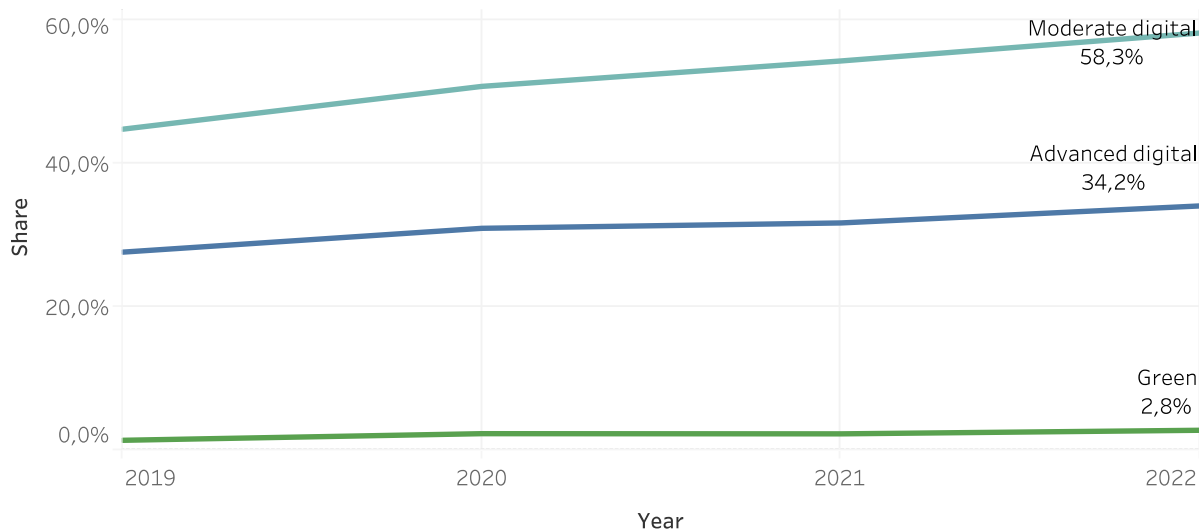
The more sought after advanced digital skills include the following:

- Database management
- Computer programming
- Cloud technologies

The more sought after moderate digital skills include the following:

- Web analytics
- Social media analytics
- Digital media

The more sought-after green transition related skills are in line with what has been highlighted in the analysis of the survey (retail SMEs putting a high emphasis on energy efficiency):

- corporate social responsibility

- energy efficiency

- environmental regulations

6. Green performance of the ecosystem

Key findings

In relative terms, the **environmental impact of the cultural and creative industries is low: compared to other industrial ecosystems it is responsible only for around 1-3%** of the impact of all industries in total as found by the analysis of Exiobase data.

The **impact of the CCI on the environment** in absolute terms **increased over time** (from 2011 to 2021) and had a further surge during the pandemic period. **The increase is also related to the shift to digitalisation and the increased use of online services such as streaming.**

Within the CCI, the largest environmental impact originates from two subsectors, notably **publishing activities and IT/ICT-related activities (including broadcasting, video games).** These are followed by creative, arts and entertainment activities and retail sale of cultural and recreation goods. The Figure below summarise the main environmental impacts and the change over the period from 2010 to 2021.

Figure 31: Environmental impact of the CCI

Environmental impact		Change from 2010 to 2021 (CAGR)
GHG emissions		-1.1%
PM emissions		constant
Material use		-1.4%
Land use		+0.6%
Water use		+0.7%
Damage to the environmental ecosystem		+2.5%

Source: Technopolis Group, 2022, based on Exiobase data

With the exception of the fashion industry (which is analysed in detail in the ecosystem report on textiles), cultural and creative industries are not typically or overly associated with negative environmental impacts. Nevertheless, **there are notable activities that produce significant waste, pollution and emissions, such as music festivals, concerts, and tours** (i.e. litter and damage to nature on-site, high audience/crew carbon footprint, etc.).

Also production of films is generating considerable CO2 emissions. The report of the British Film Institute and Arup showed that the average tentpole film production '*generates 2,840 tonnes of CO2, the equivalent amount absorbed by 3,709 acres of forest in a year*'. Other reports, such as one by *The Guardian* (2020), finds that the average film produces around 500 tonnes of CO2eq. Data from the Swedish series Bäckström shows a carbon footprint of 240 tonnes CO2 for the full production, 40 tonnes per episode of 45 minutes. Out of the full impact, transport accounts for approximately 51% of carbon emissions, electricity and

gas use around 34%, and diesel generators for the remaining 15%. Unnecessary material waste is also produced at every scale. Pre-pandemic, the theatre industry in London has been shown to have a carbon footprint of 50,000 tonnes a year[76]. This is roughly equivalent to driving a car 1.5 million times round England's M25 motorway.

Storing and processing digital content in the cloud depends on data centres that use a lot of resources and energy. According to the IEA (2020), one hour of streaming video typically uses around 0.08 kWh, but actual consumption depends on the device, network connection, and resolution[77]. Research by the University of Glasgow and the University of Oslo found that the environmental impact of streaming outweighs the plastic use of physical products, and in this sense, the shift to digital might have been a bad choice from an environmental perspective[78].

Finally, book publishing is, for example, among the largest industrial greenhouse emitters when it comes to pulp and paper. There are plenty of operations within the CCI that are not circular yet.

Figure 32: Main waste streams and emissions of cultural and creative industries

Architecture	Book publishing	Design	Film and cinema	Music
Linked to construction in terms of choice of design	Paper and pulp consumption Energy use of e-books	Materials consumption	Transport costs (linked to film locations) Material waste	Litter in festivals and concerts GHG emission of streaming online
Museums	News Media	Performing arts	Visual arts	Video games
Waste linked to tourists Energy use of cultural heritage buildings	Energy use of digital content	Waste generation Energy use during performance Emissions of touring	Paper consumption	Energy use

Source: Technopolis Group

Beyond greening their activities, themselves, the CCI need to be recognised also as a medium to **promote environmental-conscious behaviour**. For instance, musicians can have the power to educate and engage their fans on environmental issues. UNEP and REVERB initiated a platform where fans can learn about helping the planet and take actions such as the #CleanSeas pledge[79].

Moreover, the sector of design plays a key role in the twin transition. Design adds value to products, services and processes and is integral to the value chains of many CCI subsectors and other industrial ecosystems. Impact of design is particularly crucial for the green transition. Product design dictates up to 80% of its life-cycle environmental impact. Designers and design associations are actively engaged in and contribute to the New European Bauhaus movement[80].

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[76] https://www.london.gov.uk/sites/default/files/green_theatre_summary.pdf
[77] https://www.iea.org/commentaries/the-carbon-footprint-of-streaming-video-fact-checking-the-headlines
[78] Devine (2019). Decomposed, The Political Ecology of Music
[79] https://www.cleanseas.org/about?_ga=2.192781039.439469432.1659900534-1670272921.1659900534
[80] https://beda.org/news/new-european-bauhaus/
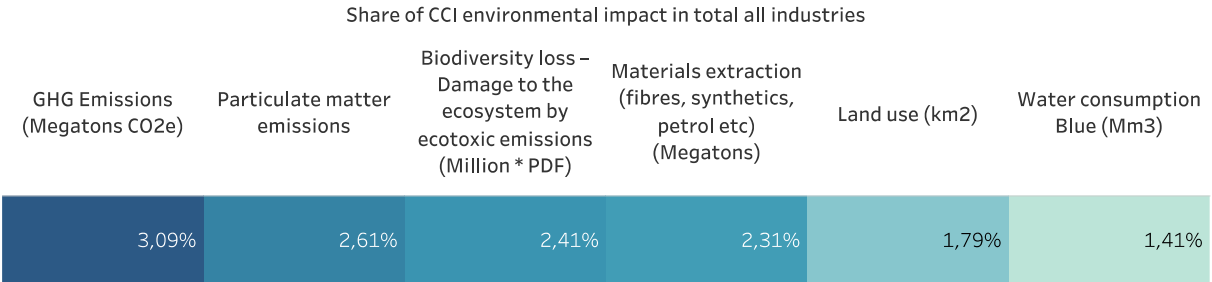
6.1. Resource use

With the aim of analysing the trends in environmental impacts of the CCI, this report draws upon the data sources of Eurostat and Exiobase 3.8[81]. While Eurostat represents the official statistics, Exiobase is a legitimate source of information used by, for example, the European Environmental Agency[82], the Joint Research Centre (JRC) community[83], Eurostat[84], and by the European Commission to propose the regulation on carbon border adjustment mechanisms[85].

Pressure to environments refer to trade-embodied resources 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, embodied Materials Consumption, and Energy mix supplied to the industrial activity. In terms of impacts, there are three dimensions monitored: air emissions (incl. GHG), waste generation, and damage to the ecosystem.

The following table shows a summary of green performance indicators at EU27 level and the change from 2010 to 2020. **The CCI's environmental impact is relatively low compared to other industrial ecosystems. The sector is responsible for a mere 1-3% of the total industrial impact.** The highest relative impact is in greenhouse gas emissions that represents 2.69% of all industries' GHG emissions.

Within the CCI, the largest environmental impact originates from two subsectors, notably **publishing activities and IT/ICT-related** activities (including broadcasting, video games). These are followed by creative, arts and entertainment activities and retail sale of cultural and recreation goods.

Figure 33: Indicators to capture the green transition of the CCI industry, including both production and consumption accounts

Share of CCI environmental impact in total all industries

GHG Emissions (Megatons CO2e)	Particulate matter emissions	Biodiversity loss – Damage to the ecosystem by ecotoxic emissions (Million * PDF)	Materials extraction (fibres, synthetics, petrol etc) (Megatons)	Land use (km2)	Water consumption Blue (Mm3)
3,09%	2,61%	2,41%	2,31%	1,79%	1,41%

[81] 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 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
[82] EEA 2022. Visit 12/10/2022. https://www.eea.europa.eu/data-and-maps/data/external/exiobase
[83] 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
[84] 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.
[85] EC (2021) REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Establishing a carbon border adjustment mechanism. COM(2021) 564 final.

Environmental impact of the CCI on various indicators
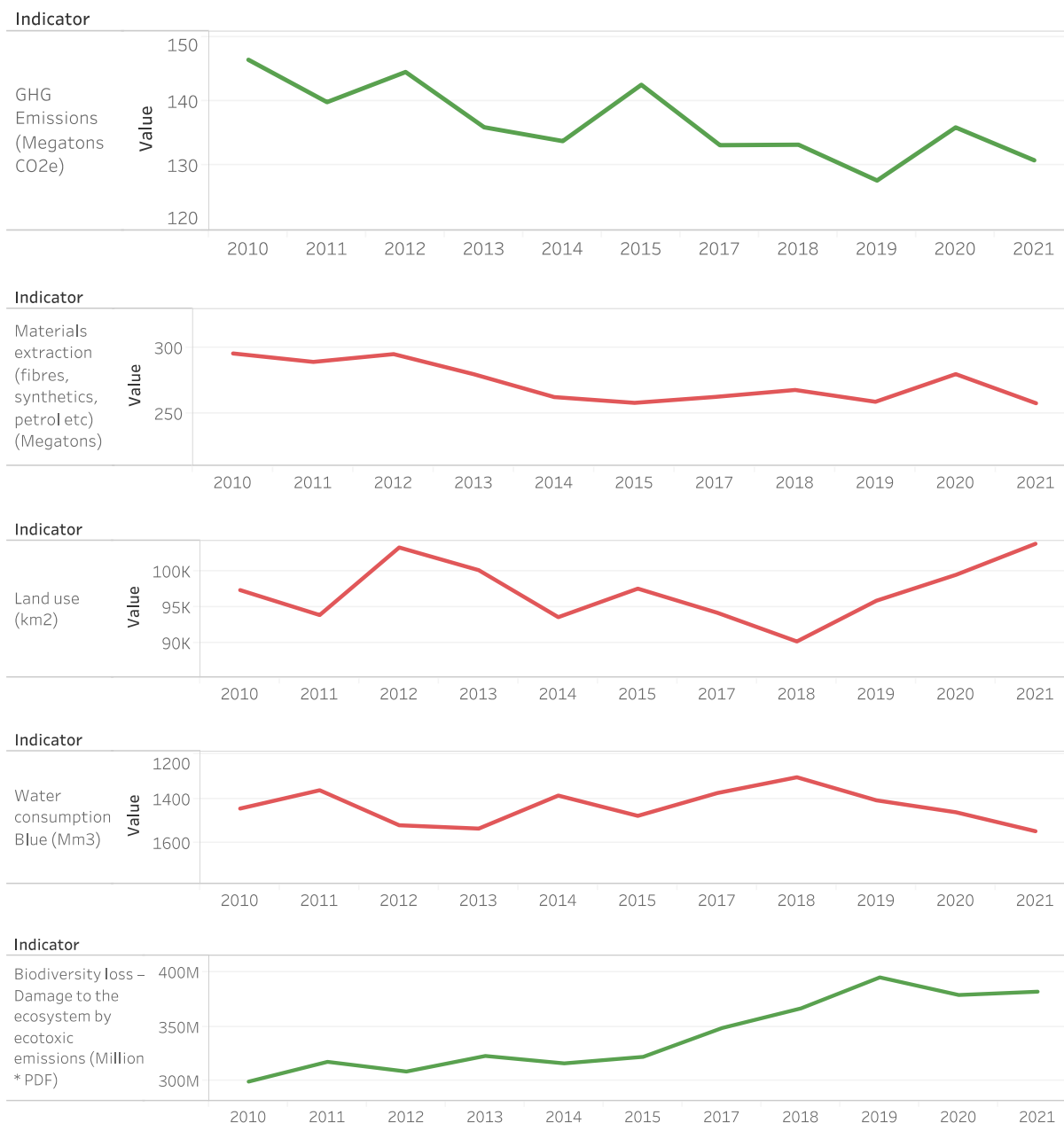
Source: Technopolis Group, 2022, based on Exiobase data

Emissions

The level of greenhouse gas emissions is measured in megatons of CO_2 equivalent. Between 2010 and 2021, greenhouse gas emissions from the CCI decreased to around 130 megatons of CO2 although with some fluctuations. Emissions can originate from heating and electricity bought by a CCI organisation or company to run offices, computer equipment, venues, museums[86]. Greenhouse gas emissions are generated mostly by publishing activities and ICT-related activities within the CCI.

Resource consumption

Indicators for the resource consumption feature materials extraction (fibres, synthetics, petrol, etc.), land use (km^2) and water consumption (Mm^3), respectively. The results regarding the CCI show a decrease in materials extraction, however an increase in land use over the period from 2010 to 2021. Water consumption increased until 2018 but decreased since then.

Biodiversity loss

The impact of the CCI on biodiversity loss by ecotoxic emissions has increased between 2010 and 2021. Biodiversity loss is generated in areas where the extraction and processing take place of raw materials for the production of materials in construction (related to architecture) and design products (i.e. wooden objects, ceramics). Publishing activities are contributing the most to the damage to the ecosystem.

6.2. Ecosystem resilience

The COVID-19 crisis, the energy- and subsequent economic crisis exposed a range of pre-existing **structural challenges in the CCI** that have a strong impact on their resilience as an ecosystem:

- Work in the CCI is often characterised by precarious and often short-term contracts, with a high prevalence of self-employed professionals (often combining multiple jobs). There is a persistent need for improved mechanisms to protect the social, economic and working conditions of cultural and creative professionals. They often work in survival mode and lack resources to develop or consolidate their activities.

- Large parts of the CCI rely on public funding, which can open doors for additional financing from private sources. In the last decade, however, trends in government expenditure for the cultural and creative sectors show an overall decline[87].

- The income of many artists and cultural creators increasingly depends on a few dominant global platforms through which they can distribute/sell their work. As individual players, they often have little bargaining power and face an uneven playing field. The business model of platforms usually consists of exploiting the resources of the creative sector while shifting all risks back to the ecosystem, leading to declining revenues for creators.

- The strengths of the CCIs contributing to their resilience include their potential of as a source of ideas and a means to create new solutions, reinforce social links, forge new solidarities, enliven spaces, and strengthen our ability to better face current and future challenges.

To strengthen the ecosystem's resilience in the future, actions are needed to overcome the fragmentation of the CCI and to increase the sector's competitiveness on a global level, while safeguarding cultural diversity. It is of crucial importance to equip and continuously upskill CCI professionals in digital, entrepreneurial, managerial and soft skills (such as creative thinking) to ensure innovative content and matching business models.

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Appendix A: References

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Appendix B: Methodological notes

Crunchbase and Net Zero Insights

Tags used in the analysis:

- Architecture
- Advertising
- Gaming, video games
- Music
- Internet radio
- News, Journalism, News, Printing
- Publishing, Audiobooks, E-books
- Photography
- Performing arts, Theatre, arts
- Design
- Film, Film production, Film distribution
- Museums and historical sites
- independent music, music label, music streaming, music venues, musical instruments, gamification, TV, TV production,

FDI

fDi intelligence[88] tracks cross-border greenfield investment both intra EU, extra EU and globally, covering the agri-food 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).

FDI sectors and sub-sectors selected for the analysis:

Advertising, PR, & related, Architectural, engineering, & related services, Motion picture & sound recording industries, Museums, historical sites, & similar, Newspaper, periodical, book, & directory publishers, Performing arts, spectator sports, & related, Radio & TV broadcasting, Specialised design services, Video games, applications and digital content

Survey

The table below presents the overview of the sub-sectors included in the sampling frame, with corresponding sections according to the NACE industrial classification.

Table 1 Survey sampling

NACE	NACE	Sample
C18	Printing and reproduction of recorded media	100
J58	Publishing activities	100

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[88] https://www.fdiintelligence.com/

J59	Motion picture, video and television programme production, sound recording and music publishing activities	100
J60	Programming and broadcasting activities	47
M73	Advertising and market research	100
R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	100
M74_M75	Other professional, scientific and technical activities and	100

Source: Technopolis Group and Kapa Research, 2023

LinkedIn

Use of LinkedIn industry codes:

- Architecture & Planning
- Music
- Museums & Institutions
- Marketing & Advertising
- Design
- Computer Games
- Newspapers
- Motion Pictures & Film
- Broadcast Media
- Publishing
- Writing & Editing
- Online Media
- Performing Arts
- Fine Art
- Arts & Craft

Environmental certificates

ISO annual surveys report the number of companies/organisations with environmental certificates. Environmental certificates were the ISO 14000, which was updated requiring more stringent standards and practices in the year 2015. The new standard was then named ISO 14000/2015. Holders of the ISO 14000, starting from the year 2015, had to be re-certified to gain the new ISO14000/2015 certificate. New sustainability and environmental practices had to be put in place; with organisational change and financial requirements implied. Accreditation bodies had also to adopt new verification procedures, with their corresponding time lag. This may explain the drop in number of certified companies/organisations from 2015 to 2017.

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