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DATA-DRIVEN INNOVATION FOR SUSTAINABLE PRACTICE IN THE CREATIVE ECONOMY

Ecological, social, and cultural aspects

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Abstract

Can data-driven innovation support the shift towards a more sustainable future? In this chapter, we present case studies from eight European cities to demonstrate how the creative sector is moving towards economic models that expand beyond the notions of growth alone and include ecological, social, and cultural benefits. Our focus is to highlight the opportunities and challenges for sustainable futures in the creative industries based on examples of data-driven innovation drawn from maker communities, small creative entrepreneurs, and creative organisations. Specifically, the case studies within this chapter highlight how creative, data-driven innovation processes can support 1) efforts to change patterns of ownership and consumption, 2) tools and training to support understanding of sustainability and 3) platforms for empowering sustainable and circular economy communities. Through this lens, we showcase some of the ways that the creative industries have used digital solutions to lead the way towards sustainable (and therefore social) innovation.

Introduction

The creative industries are integral to the production of new products and services and contribute to societal shifts in culture and innovation. Therefore, embedding sustainability in the creative industries is critical to a more sustainable, circular economy. Although culture is acknowledged as a key resource for mitigating and adapting to climate change (UNESCO, no date), it has not been mentioned in the latest Intergovernmental Panel for Climate

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Change (IPCC) Report (2022). Given this, adapting to climate change and transitioning towards a sustainable and circular economy requires a fundamental shift in how we live and do business. Yet the need for radical transformation is accepted to require not just technological change; but also requires social, cultural, and behavioural change as well as institutional and organisational change (Geels, 2005; Loorbach, 2010; Krupnik et al., 2022). This includes transformation of industries and institutions within a 'triangle of change' encompassing governments, consumers, and communities (Tukker et al., 2008, p. 1219). To be successful, this must include a cultural change (Light et al., 2019) to embed sustainability across all areas of public and private life. Cultural change, however, is not well understood, nor will it be easily achieved (Fazey et al., 2018).

In this chapter, we view (social) innovation, and data-driven innovation in particular, as contributing to sustainability not just from an economic perspective but also from environmental, cultural and societal perspectives, as embodied in the UN Sustainable Development Goals (SDGs) (UN, 2015). We argue that this multifaceted perspective on innovation could be used to support sustainability transformations in the creative economy. We pay close attention to how creative professionals, communities, and citizens embed sustainability in their practices and what role technology and data-driven innovation can have in supporting sustainability in the creative economy.

We demonstrate diverse ways in which data-driven innovation is helping creative businesses and organisations to become more sustainable and enabling them to support other communities to transition to sustainable practices. To do so, we present an analysis of case studies from two projects: Creative Informatics[1] in Edinburgh and the southeast of Scotland region and Pop-Machina,[2] composed of seven European cities: Leuven (Belgium), Venlo (The Netherlands), Istanbul (Turkey), Santander (Spain), Thessaloniki (Greece), Piraeus (Greece), and Kaunas (Lithuania). Together these projects illustrate how a wide range of creative businesses and organisations are exploring data-driven innovation to embed social, cultural, and environmental sustainability. Our analysis reveals that data-driven innovation can contribute to 1) efforts to change patterns of ownership and consumption; 2) tools and training to support understanding of sustainability; and 3) platforms for empowering sustainable and circular economy communities to connect, exchange, and learn.

This chapter presents insights into how data-driven innovation can support the decision making of creative professionals and communities by providing successful examples which can be transferred to other contexts and what challenges can hinder data-driven innovation's potential in contributing to sustainability transitions in the creative economy. We also demonstrate how enabling data-driven innovation in the creative economy is not straightforward and can carry a significant risk of failure. In summary, we demonstrate how data-driven innovation can be deployed to help both make smarter and better decisions and to inform and support social innovation by connecting communities to work together towards more sustainable business practices. We contend that data-driven innovation is an under-resourced lever for social innovation in context of climate mitigation.

Framing

Here we outline what we mean by data-driven innovation in the creative economy and how this relates to sustainability and social innovation.

Cultural and creative economy

The creative industries (CIs) as defined by the UK government's Department for Digital, Culture, Media and Sport (DCMS) are "those industries which have their origin in individual creativity, skill and talent and which have the potential for wealth and job creation though the generation and exploitation of intellectual property" (DCMS, 2001, p. 5, 1998). This definition contrasts with the United Nations' definition of the creative economy at large (UN, 2008), which considers the interrelation between economic growth, employment, trade innovation and social cohesion. Critically, the UN takes a holistic approach, beyond economics, which includes cultural identities, economic aspirations, social disparities, and technological disadvantages. In this chapter, we take the UN's broader definition of the creative economy as the basis of our understanding, as the part of the economy that is "at the crossroads of the arts, business and technology" (UN, 2008, p. iii). This view aligns with our expansive understanding of sustainability outlined in the following.

Sustainability

The UN Sustainable Development Goals (SDGs) are the global governance blueprint "to achieve a better and more sustainable future for all" (UN, 2015) and take a holistic approach to human development (UN, 2019). Alternatives to the orthodox linear economic model of indefinite growth, such as those offered by circular economics (Ellen Macarthur Foundation) and doughnut economics (Raworth, 2017), contend that the current economic model is not compatible with 21st-century needs (McDonough and Braungart, 2002) and that metrics such as gross domestic product (GDP) are no longer fit for purpose. This builds on earlier work, notably Meadows et al. (1972, 1992, 2004), and the UN's *Our Common Future* (Brundlandt Report) (WCED, 1987), asserting that economic growth should meet 'the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, p. 43). A circular economy argues for a systems solutions framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution. As such, a circular economy needs to operate in the safe space for humanity that avoids human deprivation and safeguards ecological limits (Raworth, 2017). This perspective on the circular economy thus aligns closely with the SDGs.

These heterodox economic models require alternative business models. One extensively used definition of sustainability in business is the triple bottom line (TBL), proposed by Elkington (1994). It posits that businesses which pay attention to not only financial sustainability but also to their societal and environmental impact are more likely to thrive. Elkington argued that the TBL is a catalyst to move beyond the current economic paradigm and requires different responses from government and civil society. In line with the TBL, the Framework for Strategic Sustainable Development[3] (Robert et al., 2002) focuses on the economic, social, and environmental dimensions of sustainability. It is seen as a 'source-oriented' rather than an 'effect-oriented' paradigm, focusing on 'estimating what nature can tolerate and then setting standards for emissions and resource use' (Tukker et al., 2008, pp. 19, 25–26). Finally, the UN's 17 Sustainable Development Goals (UN, 2015) provides an expansive list of targets touching upon all dimensions of sustainability, as discussed previously. In this chapter, we use the SDGs as a lens to analyse the examples from the Creative Informatics and Pop-Machina projects.

Data-driven innovation

The first industrial revolution was characterised by steam powered mechanisation, the second by electrification, and the third by electronics and information technology (e.g., the internet). In the present day, the fourth industrial revolution is blurring the lines between the physical, digital, and biological worlds driven by technology and data (Schwab, 2016). Data-driven innovation (see book introduction) is the next evolution of innovation processes, enabled by ubiquitous digitisation, increasing access to data, and advances in machine learning, artificial intelligence (AI), and computing technologies (Luo, 2023). Data-driven innovation is powered by ('Big') Data and technology and is affecting almost every industry in every country at an exponential pace.

Data-driven innovation can contribute to both positive and negative sustainability outcomes for the creative economy. On the one hand, access to data can empower creative professionals to reflect on their own alignment with the UN SDGs, thus providing an opportunity to facilitate sustainability transitions in the creative economy. Conversely, using Big Data can increase the footprint of the creative economy. For example, data-driven fashion trend prediction can accelerate 'fast fashion' (Funnell, 2022), whereas some AI-based digital art can have a significant carbon footprint given that modelling large amounts of data for AI requires large amounts of energy (Jääskeläinen et al., 2022). As such, utilising data-driven innovation in the creative economy requires reflection and criticality. Hence, it is crucial to explore both when data-driven innovation can support positive outcomes for sustainability in the creative economy (Lechelt et al., 2022) and when it exacerbates negative outcomes. In this respect, the concept of social innovation provides a relevant frame of reference.

Social innovation in the creative economy

Social innovation is described as the "agentic, relational, situated, and multilevel process" (van Wijk et al., 2019, p. 888) needed to develop and implement novel solutions to "wicked problems" (Churchman, 1967; Rittel and Webber, 1973) and produce profound change in institutional contexts. We refer to the concept of social innovation here in relation to the profound change required to shift to sustainable consumption and production (Tukker et al., 2008) as part of a circular economy. The 'three-cycle model of social innovation' (van Wijk et al., 2019) identifies the intrinsic dynamics of innovation and its innovators. At the micro level (first cycle), through reflexive interaction with other stakeholders, individuals (actors) can partially (or wholly) 'disembed' (van Wijk et al., 2019, p. 892) from governing institutional environments to create room for new perspectives to emerge. This innovation process is embedded and self-reflective, collaborative, and co-ordinated. At the meso level the actors then renegotiate existing patterns, structures, and beliefs to experiment with alternative proto-institutions (second cycle). The meso level connects to the macro level of institutional reform (third cycle), which is when innovation finally becomes embedded. This expanded view of innovation, which argues that social innovation is as much needed as technological innovation if a sustainable future is to be supported, underpins this chapter.

Our approach

We use the previous frameworks to demonstrate that data-driven innovation can provide tools to both support and evidence sustainability in the creative economy. Our case study approach was chosen to select specific examples from which we draw conclusions but does not seek to generalise across the creative economy.

The case studies were chosen from two large-scale creative economy R&D projects, which were financed through explicit research and innovation funding programmes: Creative Informatics was an outcome of the UK Government's Industrial Strategy (2017), and Pop-Machina was funded by EU Horizon 2020. Creative Informatics had an explicit focus on data-driven innovation, whilst Pop-Machina sought to reinforce links between maker movements and the circular economy. For both projects, we use the lens of data-driven innovation to examine sustainability.

We ask the following questions in our analysis of the case studies:

1. Do the projects utilise different data types (citizen driven, community driven, policy driven) to contribute to social and environmentally sustainable innovation in the creative industries?
2. Which Sustainable Development Goals are involved? We particularly focus on SDG 11: sustainable cities and communities and SDG 12: responsible consumption and production as the two key SDGs. However, we also note that SDG 9: industry, innovation and infrastructure and SDG 8: decent work and economic work are relevant to the examples. Finally, the more generic SDG 13: climate action and SDG 17: partnerships for the goals, are also implicit in the examples presented.
3. How do these projects create social change and transformation outcomes?

Case studies: data-driven innovation from Creative Informatics and Pop-Machina

Creative Informatics

Creative Informatics (CI) was a five-year (2018–2023) programme that supported data-driven innovation across the creative industries in Edinburgh and the southeast Scotland region. CI provided funding and support towards R&D activities for new 'data-driven' products and services to more than 350 creative practitioners, businesses, and creative and cultural organisations (see also Chapter 2). To be considered for funding, projects were asked to make use of data and data-driven innovation towards the development of new business models, access to new markets or audiences, the development of new audience/user experiences, or to support new insights. Whilst 'sustainability' was not a criterion for securing support and funding, a range of the funded projects have in fact engaged with sustainability in a diversity of ways (Lechelt et al., 2022). The *Creative Informatics Catalogue First Report* (2018–2020) (Elsden et al., 2021) was used as an initial method of selecting case studies (Lechelt et al., 2022) and applied a methodical coding approach, with affinity mapping and thematic analysis of 44 CI-funded projects. Subsequent funded projects were selected using the same parameters and coding methods (2020–2022). This was augmented with in depth semi-structured interviews with key partners.

This chapter provides examples of three CI projects: Custom Loop, an app to support bespoke knitwear production; Climate Friendly Culture, a system to support creative businesses in making environmentally sustainable choices; and Creative Cred, a project that explored how creative practitioners might be rewarded for embedding circular economy principles in their work through an alternative currency. Following this chapter, we also provide a more in-depth case study of the Edinburgh Tool Library, which details how R&D funding supported the development of a calculator tool to evidence the carbon saved by borrowing rather than purchasing a tool.

Pop-Machina

The four-year Pop-Machina Horizon 2020 project (2019–2023) aimed to promote environmental sustainability and generate socio-economic benefits in a diversity of cities by strengthening the connections between the maker movement and the circular economy. One key objective was to support the growth of makerspace ecosystems and the production of circular innovations in European cities. Pop-Machina focused on makers and makerspaces: community-led, open access spaces where individuals share resources and collaboratively engage in creative commons-oriented projects, utilising open-source software and hardware technologies. Makerspaces, which are also commonly known as micro factories, hackerspaces, fab labs, or media labs, and others (Gandini, 2015) embody a sharing-economy model through an open (and often free) distribution of knowledge, tools, facilities, infrastructure, methods, and ideas. Thanks to this community focus, the makerspace movement supports the democratisation of skills as well as social inclusion (Metta and Bachus, 2020). Pop-Machina highlighted, embedded, and reinforced the links between the maker movement and the circular economy via a European-wide network of makerspaces. To achieve this goal, the project pioneered the establishment of 'circular makerspaces' (Prendeville et al., 2017) in seven pilot cities. It also developed three digital platforms, namely Open Knowledge Tool,[4] Social Collaboration Platform,[5] and Data Collection Tool[6] to further support the collaboration among makers and makerspaces and monitor circular making activities in Pop-Machina pilot cities. Furthermore, Pop-Machina also developed Local Future Stories[7] to support the co-design process of makerspaces which spoke to each location's local values associated with circular making. In this chapter, we present how these digital tools and Local Future Stories were utilised by Pop-Machina makers and makerspaces to drive circular making activities in the pilot cities.

Thematic examples

The following examples have been implemented and developed to different levels of fidelity; not all projects are complete or ready to be used in practice. However, all represent conceptual innovation in the domain of sustainability. The examples demonstrate three themes of data-driven-supported sustainability in the creative economy: 1) efforts to change patterns of ownership and consumption; 2) tools and training to support understanding of sustainability; and 3) platforms for empowering sustainable and circular economy communities to connect, exchange, and learn. Through this lens, we reflect on what each project tells us about the use of data-driven innovation to support sustainability in the creative economy.

Theme 1: efforts to change patterns of ownership and consumption

It has been argued that the goal of reducing environmental pressures by challenging and changing patterns of consumption can be supported through three different avenues (Tukker et al., 2008): 1) greening production and products; 2) shifting demand to low-impact consumption (McDonough and Braungart, 2002); and finally 3) lowering material demand by reducing consumption, made more explicit in degrowth (Hickel, 2020). The examples that follow demonstrate how data-driven innovation can support efficiency and customisation in production to support more sustainable consumption.

Custom Loop

With the support of Creative Informatics funding, designer Jeni Allison used her extensive knowledge of the knitwear industry to develop an app, Custom Loop, for consumers to customise and order knitwear. The goal of the app is to advance a new 'slow' (Honoré, 2004) manufacturing model for knitwear, where only one garment is produced on demand: a direct antithesis to the bulk production that underlies fast fashion. This idea was enabled by the coupling of data-driven innovation and Allison's deep knowledge of the knitwear industry. Throughout her career, Allison observed that it is difficult and costly to develop knitwear samples and small production runs because of the high upfront cost. In developing Custom Loop, Allison decided to rethink and modify the traditional model of manufacturing to enable more sustainable, small-scale production, without increasing cost. To do so, she developed an app that provides 'guardrails' which enable users to adjust the design of a knitwear piece (e.g., a scarf or blanket) by moving and scaling 'data assets' (shapes, colour, initials, and others) which fit the parameters of industrial knitting machines on a digital canvas. The fact that the knit can be customised through a predetermined set of data assets means that the programming (and cost to) manufacturer is not substantially changed, but the appearance of the knit is. By enabling garment customisation, Allison also hopes to support owners' attachment to their garments, with the goal of extending the lifespan of the manufactured products.

Pop-Machina Social Collaboration Tool

One of the main objectives of Pop-Machina had been to engage citizens as circular makers, that is, by supporting individuals to perform reuse, repair, recycling, or refurbishing instead of disposing and purchasing. To support this, Pop-Machina developed the Social Collaboration Tool[8] intended to provide an opportunity for makers (and citizens) to collaborate on circular making projects digitally. Once established, makerspaces in each Pop-Machina city were registered to the Social Collaboration Tool. Makers who joined were able to exchange or share knowledge, skills, tools, and products. For example, a maker in Istanbul hoping to repair a chair could use a digital model of a plastic part shared by a maker in Leuven.

The novel aspect of the tool from a sustainability perspective is that it not only focused on consumers as end users, but it targeted existing consumption and production practices of makers, as well as citizens aspiring to be makers. The tool allows makers to record their projects by adding data about materials, parts, and components. These projects can be shared via the platform with other makers who are interested in replicating them. Alternatively, makers can request support from other makers and makerspaces (e.g., material, equipment use, 3D models, etc.) to finalise their projects. In other words, the tool serves as a site for both data collection and collaboration for makers and citizens, supporting alternative modes of production and consumption for both parties. That being said, the execution of the Social Collaboration Tool in the Pop-Machina project helped reveal two main challenges. First, due to COVID-19, the opening of Pop-Machina makerspaces was delayed, in turn delaying makers' registration to the tool. This meant that within the duration of the Pop-Machina project, makers did not have many opportunities to exchange with others across geographies. However, the Social Collaboration Tool enabled particularly local ecosystems of makerspaces to connect, exchange, and share. The second challenge was that the makers involved often preferred to adhere to their own techniques of recording data about the materials, parts, and components required to produce an artefact (commonly called the Bill of Materials in the maker movement) rather than using the Social Collaboration Tool. This is because they perceived the Social Collaboration Tool as too complex and instead chose to record this information through, for example, Excel spreadsheets, because of their familiarity with these tools.

Theme 2: tools to support understanding of sustainability

One way in which data-driven tools can help citizens and consumers understand their environmental impact is by calculating carbon footprints. The process of calculating a footprint often highlights structural inequalities, with much data incomplete or non-existent and sometimes only being available behind paywalls thus making it inaccessible for small and medium-sized enterprises (SMEs) or requiring a high threshold of data literacy not afforded to most. It also highlights problems in the ability to collect data in a coherent, transparent manner that does not demand too much time or effort. Data-driven innovation can help to navigate these complex challenges but requires intuitive interfaces and easy-to-use tools. The examples presented within this theme attest to how developing effective tools and technologies for supporting understandings of sustainability requires a deep understanding of the specific needs, values, and challenges of the intended audience.

Climate Friendly Culture

Climate Friendly Culture was a prototyped tool[9] funded by Creative Informatics that supports cultural organisations, creative practitioners, and small businesses to identify the carbon footprint of their work. This can be an especially onerous task for small businesses, organisations, or freelancers who may not have the capacity to carry out full environmental reporting. This tool aimed to promote actionable goals for empowering practical change by supporting their understanding of their carbon footprint. It also sought to demonstrate that not every detail about carbon footprints needs to be known to start making informed decisions about which changes to implement to manage and reduce emissions. For example, the tool asked users simple questions such as: what their creative practice entails (e.g., craft, music, theatre, and others), methods of work (e.g., freelancers, employ staff, work with audiences), information about buildings in which their practice and work is situated, and how transport was used for their work. The tool then collated an initial list of different types of emissions related to the work. The user was able to finetune by removing or adding other types of emissions, enabled by database searches of common activities. Critically, the tool helped the user sort the emissions into three categories: 1) the emissions over which the user can have *control* (usually those paid for, e.g. use of a car, taking a flight), 2) those the user can *influence* (e.g. heat and lighting in a rented building), and finally 3) those the user is *concerned* about but which may be more difficult to address (e.g. the carbon footprint of video streaming). From this guidance, users were able to devise an action plan to lower their emissions. It is worth noting that the tool has currently not progressed beyond prototype stage; a fully functioning tool would require a much more substantial development than the CI funding enabled. However, this pilot project outlined how data-driven innovation could empower better informed, and easier, decision making around carbon footprints by simplifying calculation.

Pop-Machina Data Collection Tool and Open Knowledge Tool

The Pop-Machina platform developed two separate tools that support the understanding of sustainability. The Data Collection Tool,[10] like Climate Friendly Culture, aimed to help makers and makerspaces understand their environmental impact. The platform enabled the calculation of the environmental impact of individual makers as well as larger makerspaces. For example, a footprint for a given project can be calculated by assessing the amount of secondary materials used, the type of fabrication machines used and duration of use. When makerspaces recorded all their fabrication and maintenance operations through the tool, it was possible to judge their overall environmental impact, as well as to identify how future activities could be structured to bolster positive impact. Despite these benefits, the potential of this tool has yet to be realised due to two reasons. First, as highlighted earlier, only a few Pop-Machina makerspaces were operational during the pandemic period (2020–22), and the maker communities around these spaces were still developing when the platform was launched. Second, makerspaces which were operational chose to use other tools to keep track of their projects. For example, Leuven makerspace had been using an Excel sheet to record data about circular projects, which was subsequently adopted by the Istanbul makerspace. Despite this, Pop-Machina's Data Collection Tool partially helped makerspaces to enhance their understanding of environmental impact at a neighbourhood level. We also expect the tool will be adopted to a further extent when the makerspaces reach their full maturity.

The Open Knowledge Tool[11] aimed at enhancing makers' knowledge about the circular economy. The Pop-Machina Academy, led by Fab Lab Barcelona, developed core courses during 2020 which give an overview of the skills and tools required for the next generation of circular makers. These courses traversed various topics, including becoming a circular maker space and maker,[12] community building and orchestration,[13] and usage of circular materials (e.g., from e-waste to new life, precious plastics, additive manufacturing) (Schmidt et al., 2021). The Open Knowledge Tool is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License, CC BY-NC-SA. Although the Open Knowledge Tool registration is still emerging, mainly because the communities around Pop-Machina are nascent (as noted with the Social Collaboration Tool and Data Collection Tool), it demonstrated the potential of a dedicated online tool for specific training and open knowledge to support sustainable practice. Meetings with the administrators of Pop-machina makerspaces reflected that these tools are valued within existing maker communities.

Theme 3: platforms for empowering sustainable and circular communities

Beyond digital platforms that support sustainable behavioural choices, other work in the creative industries is also increasingly seeking to inform broader sustainable decision making. This may include considering how to encourage the adoption of more sustainable financial models or adopt practices that have a social benefit. In this section, we highlight case studies that move beyond behavioural nudges to also support broader social innovation at scale.

Creative Cred

Creative Cred was a speculative project funded by Creative Informatics emerging from a collaboration between circular economy agency Ostrero, economic anthropologist Dr Juli Huang, and creative technologist Dr Tom Flint. Creative Cred focused on developing a complementary currency to incentivise people in the creative industries to take a circular economy approach to their business. The currency, enabled by a digital backend, supported the exchange of measures of value beyond the financial: from the use of circular design principles to the provision of circular services. Creative Cred also supported social responsibility because it favoured exchanges between creatives in a localised network, thereby keeping financial value within the immediate economy. This in turn supported economic sustainability as the mutual credit system can keep goods, services, and materials flowing: a particular benefit in times of economic hardship when people might not have access to cash but they can still exchange goods and services. The Creative Cred model was informed by existing and functioning alternative currencies (e.g., Dini and Kioupkiolis, 2019) but has so far remained a speculative prototype. The project has much scope to be transformed into a functioning alternative currency. However, to do so would require a substantial upfront investment in both developing the digital 'back-end' infrastructure and in building a community of Creative Cred adopters. As with Climate Friendly Culture, Creative Cred developed an interesting conceptual prototype to fill identified gaps in provision of suitable and easy to use tools to support better decision making, a space data-driven innovation is uniquely placed to support. However, the upfront costs of R&D make this a difficult terrain to develop.[14]

Local Future Stories and co-designing makerspaces with citizen-driven values

Pop-Machina strove to support the establishment of circular makerspaces in seven European cities, engaging citizens as makers in these spaces. To ensure the success of the project, it was crucial to gather the perspectives of multiple stakeholders and communities of practice. Thus, the project aimed at co-designing circular makerspaces with the participation of existing makers and local stakeholders. In line with this aim and to create pilot activities reflective of citizens' expectations, their visions about circularity were collected through a technique called Local Future Stories (Galleguillos et al., 2023). A website was created to collect these citizen-driven stories about circular makerspaces. Participants first selected a scenario from a list (e.g., repairing, producing, materials collection, and so on) and were then asked to create a story pertaining to the future of their neighbourhood if it were to have a circular makerspace. The analysis of all the stories collected (131 in total) demonstrated that citizens see circular makerspaces as social, inclusive, and economically supportive places for sharing skills and knowledge as well as for taking care of local problems. Local Future Stories thus enabled the identification of values each citizen prioritised and aligned the goals of the makerspace with these. This citizen-driven data tool enabled the planning and creation of makerspaces tailored to the unique needs of locals in each particular geography. For example, in the stories collected from Leuven, the prominent theme was community life and sharing. Citizens proposed to conduct repair café events regularly, and other hands-on workshops, in order to exchange knowledge and skills and to create deeper connections with the local community. These values were later reflected in Leuven's pilot activities, such as year-long activities of instrument making using various secondary materials to create a Leuven Makerspace Orchestra.[15]

Discussion

After undertaking our analysis, we reflect on how the case studies respond to particular Sustainable Development Goals, and whether they succeeded in achieving the transformational outcomes that would support social innovation to take place. In Table 11.1, we summarise how each of the projects aligns with our three questions. The examples align well with the SDG framework, specifically the following SDGs: fostering innovation (SDG 9), building resilient and sustainable communities (SDG 11), supporting responsible consumption and production (SDG 12), supporting climate action (SDG 13), and engaging in these processes through multi-stakeholder partnerships (SDG 17). These SDGs align mostly with social innovation (see Table 11.1).

The value of small data

The various types of data used in the presented projects ranged from user-driven data (e.g., values, visions, knowledge, skills), to design data (e.g., design patterns, records of makerspace projects) and material data (e.g., resources, equipment). As highlighted earlier, the fourth industrial revolution has predominantly focused on how data-driven innovation can be bolstered by Big Data – for example, large-scale datasets used to train AI and machine learning models. However, what is worth noting is that the types of data generated in our case studies were generally not Big Data. Rather, they focused on what can be called 'small' data, for example, the digitisation of locally embedded knowledge and experiences (e.g., in the Social Collaboration Tool, Local Future Stories, Open Knowledge Tool), supporting access to complex environmental data to enable situated decision making (e.g., Climate Friendly Culture, Data Collection Tool) and creating novel experiences to support changing consumption patterns (e.g., Custom Loop). Collecting data about

TABLE 11.1 Overview of Case Studies With Comparative Notes

Project/Case	*SDGs*	*Data Type generated*	*Environmental Innovation*	*Social Innovation*	*Transformation Aspirational Outcomes*
CI/Custom Loop	9 12 13	– design data: patterns – customer data	– tools to maximise efficiency	– increasing awareness – supports responsible ownership	– efficiency in production – tailored bespoke production – maturity in acceptance of principle
PM/Social Collaboration Tool	11 12 13	– user data – material database – skills database – resource database	– platform for sharing of skills, tools, and assets	– supporting community development	– impact at the local level – high-complexity application – low maturity in terms of usability and users' adoption
CI/Climate Friendly Culture	9 11 12 13	– carbon footprint – impact analysis – material database	– specific tool for measuring carbon footprint – tool to support climate action	– increasing awareness of environmental impact – support to prioritise deliverable change – support to enable informed conversations with stakeholders	– remains a speculative tool, so no measurable impact – in theory: what measures are deliverable versus all measures – no maturity yet in terms of data accessibility and culture

PM/Open Knowledge Tool + Data Collection Tool	9 11 12 13	– user data – ecosystem data (community) – carbon footprint – material database	– building capacity circular economy/ maker movement – general tool for data collection on circular economy in makerspaces	– support community building	Open Knowledge Tool – tailor-made content built from applied innovation cases – growing user database – engaging citizens in circular making Data Collection Tool – complex for systematic adoption – no measurable impact due to low adoption
CI/Creative Cred	9 11 12 13 17	– user data – material database – skills database – resource database	– system which rewards good environmental practice with ‘cred’ – system to support material exchanges and surplus	– system which rewards good social practice with ‘cred’ that can support more mutual benefit and exchange – skills share	– remains a speculative tool, so no measurable impact – in theory: by creating an alternative currency, external shocks are less impactful – no system maturity
PM/Local Future Stories	9 11 12 13 17	– user data	– a technique to integrate citizen generated data into the planning of a circular makerspace, facilitating citizen-driven innovation	– supporting community development – facilitating citizens’ sense of belonging to makerspaces through co-design	– contributed to the design of circular makerspaces and their activities by tailoring them to the needs of local context – citizens involvement in makerspaces

materials used in creative practice facilitated environmental impact measuring, while enabling people to share and manipulate design data allowed for optimisation of production. Furthermore, gathering user-driven data facilitated community and capacity building. In sum, gathering, analysing, and putting into practice these various types of 'small' data supported a range of environmental and social outcomes. This emphasises how data that is 'small' rather than 'big', situated rather than generalised, and co-negotiated with a community can be viewed as a particularly promising material for data-driven innovation in the creative economy when the goal is to foster sustainable practices.

The importance of supporting existing data practices and ease of use in tools that support data collection

Data-driven innovation is contingent on the availability and quality of data. Tools that navigate data collection should therefore engage with data of a high quality. What we have found, however, is that for such tools, the methods for collecting and utilising data should be matched to the expectations, skills, and preferences of the stakeholders who will use them. Pop-Machina's Data Collection Tool, for example, collects detailed and accurate data about makerspace projects, such as the quantity of materials used, the type of equipment used, use duration, and transportation medium used to acquire the material. However, in practice, this goal of creating a tool to collect data that was as detailed as possible resulted in the system being perceived as too complex by the intended users, thereby reducing system adoption and in turn reducing the quality of the data collected. This further highlights how the adoption of tools for data collection also requires a 'community of practice' (Lave and Wenger, 1998). Hence, the work presented in this chapter demonstrates that when data-driven innovation applications are not easy to use, the transformational outcomes of the tools in terms of promoting sustainable practices through collecting and utilising data can become limited. Furthermore, as noted earlier, the role of the social cannot be overstated in determining whether the first (micro) cycle of social innovation is successful. It is only when the second cycle of social innovation is adopted, where institutional structures are re-negotiated, that data-driven innovation can be fully embedded at macro level (third cycle).

The Custom Loop app appropriates available technology (the industrial knitting machine) by limiting design options and colour in ways not normally applied to prototyping and thus augments production cycles. Arguably, Custom Loop was an outlier in our analysis, representing a more commercially focused application of data-driven innovation in pursuit of sustainability in comparison to the other case studies, the majority of which were from the third sector.

Data-driven innovation as a tool in a larger toolbox

The nature of data-driven innovation changes depending on the context and goals which are important to situate innovation. As such, data-driven innovation is another tool in the toolbox for navigating complex datasets and wicked problems. For example, here we have shown how data-driven innovation can be used in experimental projects, which, for example, explore means of supporting communities to become more sustainable by encouraging and giving credit to collaboration (Local Future Stories and Creative Cred) and demonstrate the value of data-driven innovation beyond metrics such as efficiency or better decision-making. As such, data-driven innovation can support alternative economic models, such as a circular or sharing economy, in which metrics for success and failure are more nuanced than in a linear economy where financial sustainability is paramount.

It should, however, be highlighted that successful use and adoption of data-driven innovation often requires a deep understanding of a community as well as longitudinal work. For example, whilst Pop-Machina's Data Collection Tool was a powerful system to collect and track carbon data, it was not widely adopted due to the nascency of the target community. Similarly, Climate Friendly Culture and Creative Cred remained speculative projects requiring both a developed community of practice and a significant investment of R&D to deliver the technology envisaged. As such we see a gap between what is 'possible' with data-driven innovation and what is achievable without considerable investment and development of the social and technical infrastructure to support the possible to become adopted data-driven innovation.

We argue that further longitudinal evaluation is needed to provide useful insights if the pilot projects and tools listed previously supported and sustained long term change. However, given the urgency of the climate crisis, we do not have the luxury of time. Furthermore, we must also caution that any data-driven innovation also comes with an often significant carbon footprint associated with data storage and processing, and this needs to be fully accounted for. This implies that the tools to create data about circularity should be better resourced to be made accessible, easy to use, and easily adaptable to the needs of makers as creative communities.

The importance of funding for sustainable creative futures

Investment in social innovation such as these, which particularly address the climate emergency and work actively towards a more circular economy, should receive a significant amount of the funding currently being invested in innovation. We identified data-driven innovation as a key method to be able to support better decision making in complex interconnected systems. Implicit to the outcomes of many of the projects we have presented is the question of funding. A number of the projects remained speculative prototypes, as funding was not accessible to scale. It is possible that some of these projects might have developed into fully functional tools, given sufficient funding to develop minimum viable products (MVPs) and communities of practice. Like tech innovation, data-driven innovation for social good comes with risks. However, we suggest that in the context of the climate emergency, the risks of failure are worth it.

We also contend that the levers of social innovation have not been pulled by policy to the same extent as technological innovation in the context of a linear economy is being resourced. We thus propose that allocating resources, particularly using data-driven innovation, to unlock social innovation are opportunities that have been missed by policymakers. Nevertheless, independent circular makers or entrepreneurs may encounter challenges when seeking funding. This emphasises the significance of establishing active partnerships between creatives and supporting institutions (see also Chapter 2).

Conclusion

In this chapter, we have argued that data-driven innovation can support sustainability expectations in the creative economy. Specifically, we have demonstrated that data-driven innovation can enable social innovation in support of climate action. We argued that gathering and using data on existing (sustainable) practices in the creative economy, as well as accessing other forms of data external to the creative economy (e.g., supply chain information), is critical for creative practitioners to support sustainable activity. The gap remains in the development of credible and easy-to-adopt data gathering mechanisms and data literacy. Knowledge of and ability to work with data (Parkinson et al., 2020) is currently where the power resides and is critical for a future sustainable creative economy. We suggest that this indicates that data, data literacy, and access to data are critical to a sustainable creative economy agency.

We suggest that to further enable creative practitioners and creative communities to tap into the potential of data-driven innovation in context of sustainability, policymakers should work to ensure that these groups are supported in the following four ways:

1. Through *access to more funding to undertake R&D* in social innovation, including through the use of data-driven innovation for social good.
2. Through *resources, including funding, that enable the evaluation* of data-driven innovation for social innovation to measure the impact and effect of change.
3. By creating *scaffolding resources* to support creative practitioners and communities in forming complex partnerships and collaborations, as well as in upskilling in data-driven innovation.

4. By creating *signposting and routes to access* for follow-on funding to accelerate R&D.

We thus propose that data-driven innovation is a key tool to support sustainable social innovation, which is critical to enable a circular creative economy to fully develop. However, we argue that data-driven innovation at the intersection of a circular economy and collaborative production could be a much more powerful agent for change in support of embedding (social) innovation through the three-cycle model when data-driven innovation is given funding and time to be embedded.

Notes

1 Creative Informatics: https://creativeinformatics.org
2 Pop-Machina: https://pop-machina.eu
3 Framework for Strategic Development provides sustainability principles, practical tools and evaluative checklists that can be used in consulting and environmental management procedures. From The Natural Step: https://thenaturalstep.org/approach/
4 Pop-Machina Open Knowledge Tool: https://okt.pop-machina.eu/courses/becoming-a-circular-maker-space-maker/ but is accessible to members only
5 Pop-Machina Collaboration Platform: https://pop-machina.eu/the_platform
6 Pop-Machina Data Collection Tool is only accessible to members. For more info: https://pop-machina.eu/the_platform
7 Pop-Machina 'Local Future Stories': https://pop-machina.eu/news/news-items/local-future-stories
8 Social Collaboration Tool: https://popmachina.iti.gr/makerspaces
9 Climate Friendly Culture, short video explaining the tool: https://www.youtube.com/watch?v=260SoKK5O-s
10 Pop-Machina: Data Collection Tool: https://pop-machina.eu/project/abstracts/deliverable-4.7 or https://popmachina.iti.gr/tiles
11 Pop-Machina Open Knowledge Tools: https://okt.pop-machina.eu/courses/
12 Pop-Machina: Becoming a Circular Maker Space and Maker: https://okt.pop-machina.eu/courses/becoming-a-circular-maker-space-maker/
13 Pop-Machina: Community Building and Orchestration: https://okt.pop-machina.eu/courses/community-building-and-orchestration/
14 Ostrero: https://ostrero.com
15 Leuven Maakleerplek: https://maakleerplekleuven.be/?lang=en

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CASE STUDY

Constructing data-led social innovation: Edinburgh Tool Library

The following case study was informed by an in-depth interview with the Edinburgh Tool Library (ETL) which demonstrates how data-driven innovation can support sustainability expectations in the creative economy through social innovation.

The Edinburgh Tool Library[1] enables community members to borrow seldomly used tools rather than purchasing them. A tool library embodies a sharing economy where assets and knowledge are communal rather than accumulated individually. The key environmental argument for a sharing economy is that pooled assets reduce the need for production of expensive products or technology, thereby lowering emissions by producing less and making more of existing or fewer assets.

The key data-driven question for Edinburgh Tool Library was how much carbon was being saved by borrowing rather than purchasing a tool. They had been working on augmenting their tool management system in which data about tools and their uses is stored, with additional information about the environmental impact of sharing. The system was designed to inform its members about how they are reducing their own carbon footprint through borrowing but also to provide evidence about how Edinburgh Tool Library is reducing the community's climate impact more widely. Furthermore, Edinburgh Tool Library was looking for a 'dashboard' to bring all the data it collected through its tool management system together that would reflect its successes back to its membership, as well as existing and future funders. In other words, it wanted to make better use of the data it already had.

> We realised that the data wasn't actually . . . a bit like a tool on a shelf, wasn't working to its full potential, and there was lots of things with a few tweaks that we could find out, in terms of carbon footprint reduction.
>
> (ETL interview)

Edinburgh Tool Library uses a proprietary software platform called myTurn,[2] which is an inventory database used by rental companies to track their stock when out on loans. This North American software has been made available for free to many tool libraries internationally as part of the company's corporate social responsibility. According to Edinburgh Tool Library, 95% of tool libraries across the world use this system to keep track of their tools and keep records of its members. Edinburgh Tool Library wanted to access and combine data it already had (tool loans) with external data on the carbon released in the making of a new tool – 'cradle-to-gate' processes such as extraction of raw materials, transportation, refinement, and production of raw materials into a finished product. The new carbon calculation tool drew on data from three different databases:

1. The Inventory of Carbon and Energy (ICE) by Circular Ecology and the University of Bath.[3]
2. The Climate Impact Forecast – Life Cycle Assessment (LCA) for startups and impact entrepreneurs.[4]
3. Greenhouse Gas Reporting: Conversion Factors 2020, UK government.[5]

This created a new data set that was able to tell the story of how much embodied carbon was being prevented entering the atmosphere each time a tool was borrowed. The new dataset includes 12 common emission types, categorised by the materials in common tools (metal, plastic/rubber, mixed plastic/metal, mixed wood/metal, mixed plastic/wood, wood, aluminum, plastic, cordless power tool, corded power tool, petrol based, electron equipment). When the 12 common values are combined with the borrowing history of Edinburgh Tool Library's tool management system, the carbon saving for any time period, tool type, or member can be calculated. The calculation for each tool is 'number of times tool was borrowed instead of bought' × 'weight of tool' × 'emission factor' = 'carbon saved.' At this stage other carbon savings such as waste reduction, recycling, and material re-use are not part of these calculations.[6]

This project, funded by Creative Informatics, was further enabled by the unique circumstances of the global pandemic. In the UK many employees were put on a government-supported furlough scheme which compensated working people not able to work in these circumstances. The Scottish Tech Army[7] galvanized furloughed or unemployed people with IT skills to volunteer and supported Edinburgh Tool Library to help build this new user interface. A visible outcome of the software development has been the development of a 'carbon receipt':

> When you borrow a tool from the Edinburgh Tool Library, instead of having a . . . this costs three pounds, and so much is VAT, it'll come back saying, this costs you nothing, but you've reduced your carbon footprint by 8 kilograms. It's just those little tweaks that . . . we'd like to see filter into . . . a broader spectrum of society.
>
> (ETL interview)

The rationale of a tool library is that sharing equipment and know-how through a network of staff and volunteers makes an economic as much as social contribution. By having access to physical objects, access to knowledge, networks, and social infrastructures is enabled too.

The carbon tool developed by Edinburgh Tool Library, with R&D funding from Creative Informatics and in collaboration with myTurn, with additional support from the Scottish Tech Army, has enabled them to share this new tool through the international network of tool libraries. This small data-driven innovation project has thus enabled more than 400 libraries across the world to access and contribute additional data to the system, thereby finetuning the data through crowdsourcing. This example demonstrates how data-driven innovation is helping to embed social innovation by supporting the meso level of social innovation described in this chapter.

Together with the previous case studies, this example shows how – where the goal is to alter and reduce consumption and ownership – data and data-driven approaches support an understanding of motivations for the (dis)use of their objects, as well as how to augment their perceived and use value. For Edinburgh Tool Library, value is made visible by demonstrating how the objects they loan and maintain – when situated in a specific social and technical context – have impacted the community and worked to reduce climate impact.

Coda

The Edinburgh Tool Library case study was presented alongside seven other case studies in a short film, *Data-Driven Innovation for Sustainable Creative Practice*,[8] presented at the inaugural New European Bauhaus in Brussels in June 2022, which is a flagship policy by the European Union to bring creativity and interdisciplinarity to the New European Green Deal as a means to deliver on 2050 target of Net Zero.

Inge Panneels and Susan Lechelt

Case study notes

1 https://edinburghtoollibrary.org.uk
2 https://myturn.com
3 https://circularecology.com/embodied-carbon-footprint-database.html
4 https://climate.impactforecast.org/about/
5 https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020
6 See also https://edinburghtoollibrary.org.uk/carbon-data-for-sharing-libraries/
7 https://www.scottishtecharmy.org
8 Available at: https://vimeo.com/723299867