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REVIEW

Post-growth technologies: a scoping review of innovations related to degrowth, sharing economy and self-sufficiency

Åsa Isacson[1] · Marco Adelfio[1] · Liane Thuvander[1]

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Abstract

This review focuses on technological infrastructure to support small-scale groups immersed in the development of local post-growth systems. It is inspired by two premises: first, that such countercultures - from ecovillages to maker collectives - are uniquely positioned to pioneer systemic change; and second, that the tools available to these groups have been upgraded since the onset of networked computers. Therefore, this article scopes literature on network-enabled innovations associated with three post-growth terms to distinguish digital tools that can operationally strengthen countercultures. The findings reveal a tentative toolbox corresponding to four functions of supporting technological infrastructure: collaborative Commons, assisted Administration, peer Production, and egalitarian Economy (CAPE), and five impact areas: Value, Autonomy, Collaboration, Trust, and Self-organization (VACTS). The analysis frames a conscious selection of technology as infrastructure that can strengthen countercultures both as entities and as a movement - transcending local marginalization and supporting locally rooted as well as globally connected alternative futures.

Keywords Post-growth · Technological infrastructure · Conviviality · Countercultures

Introduction

As the world faces multiple interconnected socio-ecological challenges (Steel et al. 2022; Brozović 2023) a growing body of scholarship claims infinite economic growth is incompatible with planetary boundaries (e.g. Rockström et al. 2009; Steffen et al. 2015; IPCC 2023). Critics of the growth paradigm argue for a fundamental systemic

✉ Åsa Isacson
isacson@chalmers.se

[1] Chalmers University of Technology, Gothenburg SE-41296, Sweden

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shift, where economies instead of pursuing endless expansion prioritize long-term health and resilience (Jackson 2009). These ideas are part of the broader field of *post-growth*, describing a paradigm beyond growth which advocates for a reorganizing of society towards respecting planetary boundaries (Demaria et al. 2013). Trebeck and Williams (2019) frame this emerging paradigm as arrival, or the evolution towards a grown-up economy. Comparing continuous growth to a state of perpetual adolescence, they argue for a collective transition towards maturity - to *grow up* - where humanity enters a mature economic stage of development where the focus shifts from quantitative accumulation to qualitative flourishing (Trebeck and Williams 2019; Raworth 2017). Within post-growth, the academic and social movement of *degrowth* provides a critical space for debating and developing an agenda of action (Savini 2022). The movement argues for radical socioeconomical transformations that changes the nature of modern society (Kallis and March 2015; Martínez-Alier et al. 2010), aiming to live '… with enough for having a good life, and not more (for the sake of more)' (Demaria et al. 2019, p. 5). The goal is to establish a safe and just space for humanity to occupy in between the extremes of human deprivation and planetary degradation (Raworth 2017).

Degrowth scholarship is not ignorant to the complexity of changing the nature of modern society, and there is extensive debate around how solutions need to be underpinned by a fine-grained attention to what sort of sustainability and development is being pursued, for whom and how (Martínez-Alier et al. 2010; Hickel 2019; Steinberger et al. 2025). D'Alisa et al. (2014) illustrate the complexity and scale this entails, how '… in a degrowth society everything will be different: different activities, different forms and uses of energy, different relations, different gender roles, different allocations of time between paid and non-paid work, different relations with the non-human world.' (p.33).

Considering that the internet stands probably as humanity's biggest infrastructure (Blum 2013, cited in; Pansera et al. 2024), scholars such as Vetter (2018) and Kerschner et al. (2018) point out the equally important aspect of *a different type of technology.* The degrowth movement is only starting to explore what technologies in the service of a post-growth, rather than a growth, society may look like (Sharma et al. 2025). Distinguishing technology from other related terms such as 'techniques' - is the subject of extensive and sophisticated literature (Arthur 2009; Grunwald 2018; Illich 1973; Kerschner et al. 2018; Muraca and Neuber 2018). In this study we limit the scope of the term to technologies made possible by the network-enabled innovations of Web 1.0 onward; a brief history of technology in relation to growth and post-growth is outlined in Section "Technology in the service of a post-growth paradigm".

In terms of how to create a society where 'everything is different', even radical thinkers fail to come up with responses that are not articulated around growth and development (D'Alisa et al. 2014). Here, some scholars instead look towards grassroots movements already immersed in enacting their own small-scale, local, social, economic and ecological systems not dependent on growth, such as Intentional Sustainable Communities (Nogueira et al. 2019), Nowtopias (Demaria et al. 2019) or Makerspaces (Niaros et al. 2017). Calls as far back as 2007 have urged for reevaluating the role of large cities as drivers of change and considering the role of such small, diverse groups as pioneers of systemic alternatives (Seyfang and Smith 2007).

In this paper, we use the term *countercultures* to indicate such pioneers. Based on anthropological research by Dunbar and Sosis (2018), and research on intentional communities by Metcalf (2004) and Rubin et al. (2019), our definition denotes a group of between 5 and 500 people drawn from more than one family or kinship group, joined by an alternative claim on how society should be, and the creation of their own, living example of that claim. 'Countercultures' here acts as an umbrella term, purposefully denoting a wide variety of groups across the globe implementing locally anchored alternative systems. Despite providing some empirical insight into what a post-growth world may look like, such groups at present remain as marginal experiments (Pansera et al. (2024). When considered as laboratories of alternative practices to the growth model (Nogueira et al. 2019), it becomes essential to define how countercultures can emerge from this marginalization, to increase their impact as drivers of change.

This study builds on the work of Kerschner et al. (2018) in distinguishing the role and form technological infrastructure can have in a post-growth society. Specifically, it identifies functions and impacts of existing technologies associated with post-growth terms, with the goal of providing an outline of technologies that are inherently associated with post-growth and therefore show potential as technological infrastructure for post-growth countercultures. Although the need for evaluative practices has been established (e.g. Illich 1973; Garcia et al. 2018) and frameworks for this evaluation have been proposed (e.g. Vetter 2018), there is a knowledge gap in relation to which technologies to evaluate. To this effect, this study contributes a tentative toolbox of technologies, outlined according to specific infrastructural functions and associated operational impacts.

The two main objectives of the study are to identify: a) main functions of technologies related to post-growth, explicitly *degrowth* and the related terms *of sharing economy* and *self-sufficiency* (further expanded upon in Section "Defining a post-growth paradigm"), and b) specific operational impacts where the use of such technologies can strengthen countercultures as laboratories of systemic change. The study explores these objectives from an academic perspective, scoping existing literature to gather and examine technologies (network-enabled innovations) related to post-growth keywords (degrowth, sharing economy, and self-sufficiency) from the onset of Web 1 (~1992).

The content is structured as follows: Section "Context" situates this study within its context, expanding on key concepts and debates. Section "Method" defines the methodology, approach and limitations. Section "Findings" outlines findings followed by a discussion in Section "Discussion" of functions and impacts. Section "Limitations" discusses the limitations of the study. Lastly, Section "Conclusion" concludes by summarizing contributions, proposing next steps and suggesting future research.

Context

Technology in the service of the growth paradigm

Warnings regarding limitless growth were raised over 50 years ago in the report 'The Limits to Growth' by the Club of Rome (Meadows et al. 1972). In the 2020s the debate has moved from the fringes to centre stage, with the President of the European Commission stating that '… a growth model centered on fossil fuels is simply obsolete' (Von der Leyen 2023).

Despite this seeming agreement on the need for systemic change, prominent critical scholars such as Schmelzer (2015) have pointed out that growth is often still seen as incontestable and the only option. Scholars engaging with these challenges argue that systemic critiques are being hindered by the reframing of growth as 'green growth' or 'sustainable development', thereby obstructing sustainable transition (Pansera and Fressoli 2021). These terms are closely dependent on technological solutions and have thus been criticized for proposing a thinly veiled version of business-as-usual, rather than a radical shift towards a more sustainable economy that balances social, environmental and economic aspects - a process of paradigm 'fixing' rather than paradigm 'shifting' (Bina 2013).

Green growth frames growth as being compatible with ecological limits (OECD 2023). Despite evidence that absolute decoupling of Gross Domestic Product (GDP) from resource use remains elusive (Hickel and Kallis 2019) green growth promises technologies able to fix the 'grand challenges of society' such as climate change (Garcia et al. 2018; Samerski 2018). Such 'techno-solutionism' obscures the need to question root causes or explore multiple solutions (Garcia et al. 2018). As there tends to be inflated expectations in relation to technology (Grunwald 2018), this can result in viewing technology as the solution to socially complex problems rather than seeking to change dominant policies (Garcia et al. 2018).

Although being increasingly questioned within academia, the idea that the growth paradigm can be made sustainable through technological innovation remains prevalent in modern politics. Von der Leyen continued her above speech by describing how the new *European Green Deal* would enable continued growth through new technologies, stating how '… 50 years ago, the Club of Rome could not completely envisage (…) the potential of green hydrogen (…) today's electric cars (…) batteries from which we can recycle 95% of lithium, nickel and cobalt' (Von der Leyen 2023). Von der Leyen's speech reflects the intertwinement of technology in the modern world, and a tendency to see it as the solution - the so-called 'technological fix' (Weinberg 1966). The notion is still that GDP growth solves all kinds of societal challenges, is essentially limitless, and is equated with progress, well-being, and national power (Schmelzer 2015).

Defining a post-growth paradigm

Post-growth ideas can be traced back more than 50 years, when 'The Limits to Growth' first posed the question of whether there are limits to the Earth system (Kallis et al. 2025). Herman Daly - widely regarder as the father of ecological economics

- later argued that as the twentieth century was the century of economic growth; the twenty-first century must be the century of qualitative development, of learning to live better without growing (Daly 1996).

Defining this new qualitative development is a highly complex task, one that entails dramatic restructuring of the State (Kallis et al. 2012) as well as the development of new imaginaries that allow for envisioning the intricacies of another system (Kallis and March 2015; Kerschner et al. 2018; Demaria et al. 2019). The degrowth movement represents only one practical exploration of this shift, sharing affinities with movements beyond the Global North. For example, in Latin America groups are mobilizing with success around 'buen vivir' or 'sumaq kawsay' (the good life) (Thomson 2011, cited in; Kallis et al. 2012).

In this study, we have selected three key terms to identify practical explorations in relation to technology. Alongside 'degrowth', two terms that correlate with an emphasis on sufficiency in resource consumption and a shift towards alternative economic models (O'Neil et al. 2018), as well as community-focused alternative development models, are *self-sufficiency* and *sharing economy* (Andreoni 2020; Svenfelt et al. 2019).

Self-sufficiency is not a term agreed upon in practice by policymakers, researchers, or service providers; rather, it is 'frequently used without a clear common definition' (Hong et al. 2009, p. 357). This is partly because it can be interpreted from both a top-down (e.g., related to welfare policies) and bottom-up perspective (e.g., related to households and communities) … but overall, the definition of being self-sufficient is the ability to fulfil one's own needs without help from others. This is a notion similar to that of counterculture groups where '… like-minded people who are concerned about the environment and wish to share their skills and know-how through networking initiate self-sufficient living collectively' (Ali et al. 2012, p. 617).

Sharing economy can be defined as the practice of granting temporary access to idle capacity (Szemerédi and Tatay 2021). The term emerged in the 2000s as an economic model focused on changing production and consumption cultures as well as the interactions between producers and consumers (Gössling and Michael Hall 2019). At its core is the concept of redistribution according to need, prioritizing collective sharing over individual ownership. Sharing economy practices facilitate the acquisition and sharing of resources that would not have been economically feasible for an individual, improving access to and selection of available physical resources while reducing costs for the individual.

Countercultures as laboratories of systemic alternatives

Countercultures emerge in the wake of dramatic economic and social developments as a reaction to social dislocation and alienation, and are commonly defined as radical groups of people who reject established social values and practices to embrace a mode of life opposed to the mainstream (Cutler 2006). Unlike subcultures, they embody a desire to *change* the dominant culture (Cusick 2022).

A critique of the extant degrowth literature is that, although inherently Eurocentric, it nonetheless often claims universal applicability; for countercultures, this implies that models such as "nowtopias" may not fit all contexts (Demaria et al. 2019; Gearey

and Ravenscroft 2019). It is therefore important to stress the inherent *diversity* of countercultures as a strength in post-growth approaches. This variation manifests in locally anchored - and almost infinitely varied - contexts across the globe, from Baugemeinschaften in Germany to Zapatistas in Mexico, and from Ubuntu in Africa to Ecological Swaraj in India (Kothari et al. 2019). A commonality among such countercultures, despite their wide range of forms across the globe, is that they present alternative moral claims about the arrangement of society (Rubin et al. 2019).

Technology in the service of a post-growth paradigm

Despite technology often being associated with the growth economic paradigm (Solow 2002), Pansera and Fressoli (2021) highlight the role of innovation (specifically network-enabled innovations) in a post-growth era, and the potential to retarget technologies toward systemic change. Technology in the service of post-growth remains an emerging field; the first in-depth analysis of multiple perspectives was provided by Kerschner et al. (2018), and the topic remains subject to intense debate between enthusiasts and skeptics. A main theme is the need for a definition of technology not aimed at growth, which can be traced back to the first wave of growth critique in the 1970s and early 1980s (Vetter 2018). Two concepts of particular significance are *methodological luddism* and *convivial tools*.

In 2018, Garcia et al. outlined the need for a conscious evaluation of technology, discussing how *methodological luddism* could be used for this purpose. Methodological luddism advocates that any steps toward degrowth should bind technologies to an assessment '… whether at the point of design or in relation to their later consequences, in the light of a diverse set of values, with the aim of regulating, encouraging, inhibiting or reorganizing technologies in a proper fashion towards ends' (Garcia et al. 2018).

In regard to which framework such technologies would be evaluated by, a prominent word within degrowth is *conviviality*. Conviviality originates from Ivan Illich who in *Tools for Conviviality* (1973) proposed the idea of general convivial tools - including but not limited to technologies - that support human autonomy and creativity. This concept is foundational in discussions on post-growth technologies and serves as the basis in the work of Vetter (2018), who introduced 'convivial technologies' as a conceptual framework for technologies suitable to degrowth societies and a *matrix of convivial technologies* that allow for self-assessment of work and products.

The need for awareness regarding the non-neutrality of technologies is mirrored in civil society. A term which has stood out in recent years is *Enshittification*, coined by Cory Doctorow in (2022) and crowned 'word of the year' by the American Dialect Society in 2023 and Australia's Macquarie Dictionary in 2024. The term is used to describe the gradual deterioration of a service or product as the company seeks larger profits, a process of three steps: 1) drawing users in with quality service; 2) abusing user dependency for the benefit of business customers; 3) abusing business customers to reclaim value for stockholders (Doctorow 2025). Prominent examples of this process in action include Facebook and Google. Another example of trending technology perspectives is *Technofeudalism* (coined by Varoufakis 2023 – the former finance minister of Greece). Technofeudalism is the idea that capitalism has been

replaced by a modern version of feudalism, where technological platforms bind users through dependency on digital fiefdoms.

While a deep dive into these terms is beyond the scope of this study, they indicate an emerging public discourse regarding the conscious use of technology and an increased awareness of its inherent non-neutrality.

Method

A scoping review (Arksey and O'Malley 2005) was conducted in a sequence of methodological stages:

i) Define a research protocol that allows for a practical approach to the objectives. See a summary of this protocol and the steps involved with its implementation in Table 1.
ii) Identify and select relevant literature on network-enabled practices relating to degrowth, sharing economy or self-sufficiency. To structure this scoping review and guide the selection of papers the Arksey and O'Malley (2005) framework was applied, which recommends maintaining a wide approach in order to generate breadth of coverage, using Forooraghi et al. (2020) as a practical example of the method.
iii) Review and analyze the selection. As this study leans on inductive research, a structured approach based on the methodology developed by Gioia et al. (2012) was used, in order to bring qualitative rigor. The literature was systematically analyzed according to first-order *concepts*, second-order *themes* and aggregate *dimensions*. Concept, themes and dimensions are the result of looking for similarities and differences among the myriads of original categories in the original analysis of the material (a process similar to Strauss and Corbin's (1998) idea of axial coding) (Gioia 2021). A practical example of the process can be seen in Table 2.

Table 1 outlines the seven steps which allowed for a focused approach to the research objectives: defining research questions, deciding databases, setting up search criteria, screening method, exclusion criteria, and finally summarizing the selection and defining the goals for the analysis.

The below section outlines the selection process from 3188 sources to the final 10 included in the review (Table 1 outlines the full research protocol, including search strings, exclusion criteria, string return percentages and keyword prevalences). The base for the search was intentionally wide, and a stepped, iterative approach was used to distinguish which papers were of most relevance:

1. **Search.** An original search was conducted in January 2023 in Scopus and Web of Science (Table 1:2), focusing on the key terms 'Degrowth', 'Sharing Economy', 'Self-Sufficiency' and 'Innovation' (Table 1:1). The search strings were intentionally wide, not limiting the search to any discipline. At this stage the search was limited only by the criteria of scientific journal articles with combinations

Table 1 Research protocol

1. Research Questions
RQ1 - What technologies have emerged since Web 1.0 in relation to degrowth, sharing economy and self-sufficiency?
RQ2 - Which aspects of countercultures to growth may be impacted by the use of such technologies?

2. Databases
- Scopus
- Web of Science

3. Search Criteria
Search terms
Degrowth, Sharing Economy, Self-sufficiency, Innovation
Year of Publication
1992–2024
Language
English or Swedish
Subject areas
All
Document types
Journal articles
Date of original - final iterative search:
January 2023 - April 2024
Search strings:
1: All key terms anywhere in the texts degrowth AND sharing economy AND self-sufficiency AFTER 1992
2: Any key terms AND degrowth OR sharing economy OR self-sufficiency AFTER 1992
3: Any key terms and innovation AND degrowth OR sharing economy OR self-sufficiency AFTER 1992

4. Screening
Origin (Nr and percentage of papers)

Scopus	*Web of Science*	*String 1*	*String 2*	*String 3*	*Total*	*Duplicates*
2987	*201*	*2.3%*	*37%*	*60.7%*	*3188*	***2992***

Keyword prevalence (Nr of papers)

Degrowth	*Sharing economy*	Self-sufficiency	Innovation
109	*634*	*1121*	*1973*

5. Exclusion Criteria
- Can not be applied in small-scale, self-organized group contexts
- Does not relate to potential alternative development model (post-growth) applications
- No existing or potential practical purpose outlined
- Does not include a network-enabled innovation, breakthrough or updated/new practice
- Relates to non-relevant research domains, such as biology, hospitality, tourism, Airbnb/uber.
- Is irrevocably top-down

6. Selection (*Nr of papers*)

First selection - Containing at least 40% of the keywords (see section "Findings" above)	*3188*
Second selection - Screened papers	*2992*
Returned papers from searches	*487*
Returned papers from searches, minus duplicates	*63*
Iteration, additional potential papers found through scan of second selection	*+ 152*
Final selection based on the exclusion criteria - Reviewed papers	***10***

7. Analysis
1. Descriptive analysis
2. Content description and analysis
3. Synthesis into a tentative categorization

Table 2 Analysis scheme, example

Source Relevance	Innovation Terms	First order concepts	Second order themes	Aggregate dimensions
Kostakis et al. (2018) **The convergence of digital commons with local manufacturing from a degrowth perspective: Two illustrative cases** *Demonstrates the degrowth potential of designing locally and manufacturing globally using desktop and benchtop manufacturing technologies (peer production).*	• Design Global Manufacture Local (DGML) • Digital commons • Peer Production • Open Source • Open Hardware • Open Software • Open Design • 3d-printers • Laser cutters • Makerspaces	• Open data • Collaborative Production • Local manufacturing • Collaborative spaces	• Peer Production • Collaborative commons	• Collaboration • Autonomy

of the key terms published between 1992 to 2023, in English or Swedish (Table 1:3). This resulted in *3188* potential sources.

2. **Screen.** The results were then narrowed down in steps. First, excluding duplicates resulted in *2992* articles. Second, the results were extracted into a unified database in the project management software Notion where a formula was created to identify which of the papers contained at least 40% of the keywords in either title, abstract, or keywords. This was done to limit the number of sources to a manageable set with the most likely relevance to key terms. The formula was set through experimenting with percentages resulting in a maximum of 500 sources. This process narrowed the selection to *487* papers. Third, based on the exclusion criteria (Table 1:5), a visual scan of titles, keywords and abstracts excluded sources not relevant for the subject matter. This resulted in a selection of *63* papers.
3. **Iterate.** Following the recommendation by Arksey and O'Malley (2005) to '… not be linear but iterative and engage with each step in a reflexive way', and 'where necessary repeat steps to ensure that literature is covered in a comprehensive way' (p. 22), the title, tags, keywords, abstracts, and references of these 63 papers were scanned. This resulted in an additional 152 papers being identified as of potential interest, and the date of the review was pushed to the date of the last iteration (April 2024).
4. **Select.** As 'familiarity with the literature increased' (Arksey and O'Malley 2005, p0.22), the content of the potential articles (152) and previous set (63) were critically scanned in relation to the exclusion criteria (see 1:5), resulting in a final selection of 10 articles.

To organize the review, the 10 articles from the final selection were compiled in the information management platform Notion with an integration to the reference manager Zotero. A Notion template mirroring the functionality of NVivo - a software for qualitative data analysis - was created to structure the analysis. This template allowed for:

i) Extracting formal information from Zotero to Notion, namely a) authors b) country c) published year d) keywords used by authors e) abstracts f) affiliation
ii) Documenting crucial quotes from the papers as well as terms discussed
iii) Identifying first-order concepts
iv) Grouping concepts into second-order themes
v) Grouping themes into aggregate dimensions
vi) Gathering notes from the review of each article's particular relevance to the topic
vii) Overview and compile the resulting analysis

Table 2 illustrates how the analysis identified innovation terms, then first order concepts derived from the content, how these were grouped into second order themes, and finally aggregated dimensions.

Findings

The 10 selected review articles were written by 25 authors with affiliations to 12 countries, with a clear predominance of the EU (66%) followed by the US, Australia, Russia and the Middle East. The articles were published between 2013 and 2024 (the date of the last iteration, Table 1:6) representing a range of disciplines including economy, engineering, future studies, computer science and digital ethnography.

The keywords in this study were kept purposely wide to catch a wide net and capture general tendencies of the field. In selecting relevant articles, the exclusion criteria (see Table 1:5) was used to sort through the expectedly many ways 'technologies' can be formulated in the post-growth context (this tendency has been discussed by Kerschner et al. (2018)) as well as to determine the relevance identified technologies could have for countercultures. For example, the term 'sharing economy' and its iterations was often associated with initiatives such as Uber and Airbnb, and articles relating to these were excluded based on their low relevance to the context.

For clarity in relation to the subject, the Gioia methodology (Gioia et al. 2012) terms were updated to better reflect the findings: *First-order concepts* were defined as *Technologies* indicating clusters of specific terms related to network-enabled innovations - such as the innovations of open source and open software being grouped as the technology of open data. *Second-order themes* were defined as *Functions* indicating the general functionality of the contained technologies - for example, the technologies of open data and digital resources relating to the function of a collaborative commons. *Aggregate dimensions* were defined as *Impact areas* denoting specific ways technologies can support countercultures - such as collaborative commons influencing collaboration.

Table 5 (Appendix) summarizes the selected articles and lists each innovation term, technology cluster, function and impact derived from the coding process. Table 3 synthesizes the analysis of the selected articles into 51 terms associated with network-enabled innovations, 13 technology clusters, 4 functions (CAPE) and 5 operational impacts (VACTS).

The terms used in the articles to signify network-enabled innovations (the 'Innovation terms' in Table 3) were organized into 13 major technology clusters to make

Table 3 Identified terms, technologies, functions and impacts

Innovation terms	Technologies *1st order concepts*	Functions (CAPE) *2nd order themes*	Impacts (VACTS) Aggregate dimensions
1. 3d-printers	1. Digital resources	Community	**V**alue
2. Algorithmic governance	2. Open data	**C**ommons	**A**utonomy
3. Algorithmic management	3. Digital commons	Assisted	**C**ollabo-ration
4. Artificial General Intelligence (AGI)	4. Digital twins	**A**dministration	**T**rust
5. Artificial intelligence	5. Collaborative production	Peer	**S**elf-orga-nization
6. Backfeed	6. Local Manufacturing	**P**roduction	
7. Bitcoin	7. Collaborative spaces	Egalitarian	
8. Blockchain	8. Groupware	**E**conomy	
9. Cloud services	9. Web 3		
10. Collaborative document editors	10. Digital institutions		
11. Collaborative platforms	11. Decentral-ized currencies		
12. Collaborative software	12. Digital governance		
13. Collaborative technologies	13. Artificial Intelligence		
14. Commons-based peer production (CBPP)			
15. Common-pool resources			
16. Community currencies			
17. Corporate governance			
18. Cryptocurrencies			
19. Decentralized Autonomous Organizations (DAO's)			
20. Decentralized Cooperation (DC)			
21. Design Global Manufacture Local (DGML)			
22. Digital commons			
23. Digital governance			
24. Digital resources			
25. Digital transformation			
26. Digital Twins			
27. Electronic calendaring			
28. Ethereum			
29. Groupware			
30. Interoperability			
31. Interorganizational governance			
32. Knowledge commons			
33. Laser cutters			
34. Machine learning			
35. Makerspaces			
36. Online communities			
37. Open Design			
38. Open Hardware			
39. Open Software			
40. Open Source			
41. Peer Production			
42. Peer-to-peer payments			
43. Productivity/Collaboration tools			
44. Project management systems			
45. Public forums			
46. Smart Contracts			
47. Technology governance			
48. Timebanks			
49. Topic modelling			
50. Virtual currency schemes			
51. Workflow management systems			

general tendencies visible - but note that network-enabled innovations are rarely separate. For example, the various forms of *local manufacturing* would not be possible without having access to *open data* or *collaborative spaces*. Below, we briefly describe each cluster to provide an overview of the technologies involved, serving as the basis for the discussion of their functions and impacts in Section "Functions" and "Impacts".

Digital resources are a non-excludable, non-rival public good that can be copied and distributed with a marginal cost near zero. Dulong de Rosnay and Le Crosnier (2012) discuss how with the rise of the commercial internet a conflict arose where Digital Rights Management systems (DRM) let producers block usage and sharing. Copyright can in this way be used to produce artificial scarcity by controlling the reproduction and distribution of goods that could otherwise be copied, exchanged and reused. De Rosnay and Le Crosnier argue such attempts to control digital resources 'jeopardize the internet as a public good' (p.7, 2012) by effectively excluding open use - similar to the first enclosure movement which saw English private landowners introduce fences around physical commons, preventing the population from accessing their land and resources (p.4, 2012).

Open data indicates open source/hardware/software/design that is freely shared, edited, and improved upon through collaborative platforms and legal frameworks. To address the threat of legal, technical or commercially built fences around digital resources (such as copyright) alternative institutions and governance models (such as free/open licenses) were created. For example, distributing digital resources under a legal framework such as Creative Commons allows '… using the copyright system not to restrict usage, but on the contrary, to ensure access through installing a regime of collective ownership of the digital resources that are produced collectively' (Dulong de Rosnay and Le Crosnier 2012, p. 6).

Digital commons. One of the strongest tendencies found in the articles related to how access to free collaborations on producing open data has enabled a global digital commons (Kostakis et al. 2018; Nabben 2021; Niaros et al. 2017; Pazaitis et al. 2017). All the selected articles in one form or another touched on the current or potential sharing of information through online means, for example through the use of licenses such as Creative Commons. This prevalence indicates an opportunity for countercultures in using open online platforms for the co-creation and sharing of knowledge between themselves.

Digital twins. With gathering and sharing of data comes the option of constructing increasingly complex digital models of the physical. The concept of a digital twin is based on the theory that digital information about a physical system can be created as a separate entity, and that this virtual entity can be a 'twin' of the information embedded in the physical object or system (Kukushkin et al. 2022, p. 1). Digital twins are one way to (at least in theory) democratize access to, and potential action on, information. Similar to open data and digital commons, digital twins can provide access to actionable knowledge. Although the digital twins in the scope of this review were on a city level the concept gives rise to a question on what use *hyperlocal* digital twins might be to small-scale groups wishing to, for example, gain an overview of local energy systems.

Collaborative Production gathers related terms such as Commons-based Peer Production (CBPP) and the Design Global Manufacture Local model (DGML). CBPP is a term first used in 2002 by Yochai Benkler (Benkler 2002), indicating a way of value creation and distribution that appears within the ecosystems of commons-oriented communities, where open technological infrastructures allow individuals to communicate, self-organize and co-create non-rivalrous use value without the need to seek permissions (Kostakis et al. 2018). Commonly exemplified by Wikipedia and free software communities (Dulong de Rosnay and Le Crosnier 2012), CBPP concerns how open-source software involves thousands, or even tens of thousands, of individuals collaborating on large- and small-scale projects without traditional ownership of the resulting product. While the first wave of CBPP mainly focused on software and open knowledge the second wave seems to be moving towards hardware and open design, which is linked to production and manufacturing (Kostakis et al. 2018).

Local manufacturing is defined by Niaros et al. (2017) as 'anything from three-dimensional (3D) printers to computerized numerical control routers and laser cutters (i.e., hi-techs), to simple cutting tools and screwdrivers (i.e., low-techs)' (p0.1144). Digital resources, open data and digital commons allow for an abstraction and distribution of knowledge - CBPP takes this a step further towards collaborating on such global data, and local manufacturing turns it back into physical form. Kostakis et al. (2018) discuss how such a process can be based on a digital commons of design, software and know-how, allowing for a local production using low-cost desktop manufacturing technologies such as 3d printing. They exemplify this through wind turbines, which can be locally produced through global sharing of blueprints and the local manufacturing of spare parts.

Collaborative spaces. The need for new innovations to tackle sustainable production and consumption has led to the concept of the 'smart city', a term which has been criticized for not acknowledging the needs and desires of people and not being attuned to how people actually use technology and the messiness and diversity of urban reality (Niaros et al. 2017). An alternative, decentralized approach has emerged through Makerspaces, Hackerspaces, FabLabs and Living Labs 'community-run physical places where people can utilize local manufacturing technologies' (Niaros et al. 2017, p. 1144). These are physical collaborative spaces where local manufacturing can take place, moving away from top-down techno-utopias to promote sharing practices and CBPP. In the closing words of Niaros et al. (2017) '… makerspaces may be seen as spaces where people can engage in technology development for a more democratic and sustainable urban life, which is not subsumed to the dictates of economic growth' (p.1155)

Groupware. Collaborative spaces often involve alternative forms of organization enabled by groupware, which Altamimi (2015) describes as key enabling tools for communication, collaboration and co-ordination - technologies designed to allow users to communicate more effectively, improve productivity, provide access to knowledge repositories, and/or manage projects. Groupware had initial failures in the mid-1990's, where rather than enhancing group efficiency and cohesion, the use, design and evaluation of the systems hindered it (Cockburn and Jones 1995). Altamimi points out the need to explore the potential and shortcomings of modern groupware for different situations. Digitalization has enabled virtual teams and orga-

nizations, crowdsourcing, ecommerce, and more recently the sharing economy (Jarvenpaa and Teigland 2017). Software applications such as Slack, Teams, Trello, Jira, Notion, Google Docs, and Zoom are in 2025 used by teams and individuals to facilitate collaboration by providing features tailored to different aspects of teamwork.

Web 3. 'Groupware' most often relates to technologies based on Web 2 infrastructure - internet as we know it today. If Web 2 was a way for people to read as well as write information on the World Wide Web then Web 3 is an infrastructure to read, write and *own.* It involves emerging technologies full of both promises and controversy. Key differences between Web2 and Web 3 infrastructure lay in ownership. Simplified, one may look at Web 2 as associated with data and content being centralized in a small group of companies sometimes referred to as 'Big Tech', while Web 3 concerns decentralization, local ownership and agency. Such decentralized infrastructure seems to contain relevance for countercultures considering that, as paraphrased by Nabben (2022), a key sentiment of Web 3 is to not focus your energy on fighting the old, but on building the new.

Digital institutions refer to primarily Web 3 technologies such as blockchain and smart contracts. A blockchain is a distributed ledger or database of transactions recorded in a distributed manner by a network of computers (Wright and De Filippi 2015, as cited in; Pazaitis et al. 2017, p. 109). Public blockchain offer alternatives to failing institutions, enabling new modes of collaboration around economic mechanisms that enable peer-to-peer transactions without the need for trusted third parties (Szemerédi and Tatay 2021). Some technologies are argued to '… even replace the trust we now have in institutions as trust shifts from humans and central organizations to algorithmic processes' (Jarvenpaa and Teigland 2017, p. 5812). Blockchain can be used to set up peer to peer participatory self-organizing infrastructure, such as smart (self-executing) contracts (Szemerédi and Tatay 2021). There is an increasing interest in using blockchain technology in online voting, healthcare, and logistics, but it is best known as the infrastructure for virtual currencies (Szemerédi and Tatay 2021).

Decentralized currencies. (Community currencies, Cryptocurrencies) Bitcoin and its underlying technology, the blockchain, were developed to enable the digitalization of transactional trust through the replacement of trusted intermediaries and central authorities with algorithmically based trust (Jarvenpaa and Teigland 2017). Following Bitcoin's innovation, there has been an increasing interest to explore the potential of blockchain technology in other fields of human activity, including digital currencies (Pazaitis et al. 2017, p. 109). Virtual currency schemes are defined as digital money, issued by independent and decentralized entities and propose an alteration from the traditional design of the financial system. As of 2021, there were more than 600 cryptocurrency schemes based on blockchain technology (Szemerédi and Tatay 2021). Decentralized currencies have been described as potentially 'ultimately shift the entire basis of trust involved in any financial transaction' (Blundell-Wignall 2014: 3 in; Szemerèdi and Tatay 2021).

Digital governance has seen an evolution with the rise of blockchain technologies and decentralized currencies. Generally, it involves digital technologies such as advanced databases and complex algorithms for data processing and decision-making, aiming towards automated governance (Altamimi 2015). Hanisch et al. (2023)

points out that digital governance can automate control, coordination, incentives and trust, and that this can enable new and novel forms of organizing, including creating and capturing value. One use where digital governance may be upgraded through Web 3 and blockchain technology is being explored in Decentralized Autonomous Organizations (DAO's), where smart contracts programmed onto the blockchain enable self-organizing organizations without any formal governance other than the blockchain-enabled software code itself (Jarvenpaa and Teigland 2017). The potential of digital governance to encapsulate value and mirror it in the organization of a community is further expanded in Szemerédi and Tatay (2021) and critically evaluated by Nabben (2021).

Artificial intelligence. New collaborative dynamics are appearing where the use of AI supported data analysis can enable automatic checks on data that raises red flags early (Hanisch et al. 2023). It is worth noting that artificial intelligence and related concepts were not frequent in this review. This could indicate a research gap in the intersection of post-growth and AI. The question arises whether these kinds of innovations could be localized in order to help with e.g. knowledge retention and retrieval in a group, acting as a form of digital elder - a collective mind that can gathers lessons learnt, support feedback loops on previous actions and prevent organizational memory loss.

Discussion

The findings indicate network-enabled innovations functioning as infrastructure supporting alternative social, economic and environmental systems. In this section, we discuss specific functions and their potential impacts on countercultures, integrating broader scholarly debates with theoretical and empirical insights.

Functions

The technology clusters indicate four general functions of technological infrastructure, hinting at compartments of a tentative toolbox available to countercultures, namely: *i) collaborative Commons ii) peer Production iii) assisted Administration iv) egalitarian Economy* (CAPE).

Collaborative commons - democratizing access to shared resources

Within this review, collaborative commons refer to technologies and practices centered on the collective creation, governance, and sharing of resources, particularly knowledge, and is strongest related to digital resources, open data and digital commons.

The wider commons paradigm offers a possible direction forward in the search for alternatives to capitalism, representing a framework for understanding the activities of various social movements that actively resist the enclosure of public goods (Birkinbine 2018). Commons entail an appreciation of alternative definitions of value than currency, such as free information, co-creation, and interdependence with other

beings. Pazaitis et al. (2017) discuss how the commons define the "individual-in-relation-with-others" (p. 108). This politicizes the act of sharing, and as Varvarousis et al. (2020) have pointed out, the commons constitute political and politicizing actions for activists and users in everyday life, linking practices with broader, structural dynamics of injustice, inequality and exclusion.

The key distinction of this function lies in modification and access. While information is central to all societies, the contemporary information economy utilizes technology to forge new forms of social organization (Pazaitis et al. 2017). In a growth context, digital resources are controlled by regulations that prioritize consumption and passive usage; in contrast, commons-based rules authorize all participants as modifiers of the resource. Commons in this way are a holistic approach forming a third way of organizing society - an economy that differs from market-based approaches, with their orientation toward prices, as well as from bureaucratic forms of organization, with their orientation toward hierarchies and commands (Dulong de Rosnay and Stalder 2020). In terms of access, commons allow sharing of data that facilitate decision-making. Digital twins are commonly applied to large scale (city-wide) contexts, visualizing data for improved action, but as research on power grids and energy distribution increases (Kukushkin et al. 2022) and access to such data improves, this begs the question whether digital twins could be applied at the local scale by countercultures exploring alternative energy infrastructures.

Ultimately, the common denominators of technologies encompassed by Collaborative commons is an inclusive access to knowledge and the iterative, voluntary modification of such knowledge. The main innovation in relation to countercultures is how such infrastructure can underpin alternative definitions of value, autonomy, collaboration and trust outside growth-oriented systems, enabling both local experimentation and global sharing on a scale and convenience previously unprecedented.

Peer production - localizing manufacturing, globalizing collaboration

Peer production (from Benkler 2002) is here used to indicate technologies that enable decentralized, community-based manufacturing, with potential to fundamentally alter traditional production models. This function is primarily associated with collaborative production, local manufacturing technologies, and the collaborative spaces that host them, all drawing heavily from the technologies of open data and digital resources.

Kostakis et al. (2018) illustrate how decentralized production represents doing things 'differently and better' (p0.128), arguing the concept is of particular interest to degrowth theorists and activists because of how it differs from mass production (in scale, location, incentives and consumer-producer relationships), and how this indicates alternative modes of governance and collaboration. By utilizing local manufacturing techniques, communities can create a system that allows for on-demand instead of supply-driven production - reducing environmental impact. Consequently, decentralized production serves as a mechanism through which countercultures may design and collaborate globally with like-minded peers, as well as turn ideas into physical reality through decentralized, local manufacturing that do not require centralized production infrastructure. As Kostakis et al. (2018) point out; just as networked

computers enable information sharing, networked makerspaces enable the sharing of the means of production (p0.1). The maker movement has even been described as a harbinger of the next industrial revolution (Browder et al. 2019; Niaros et al. 2017).

In essence, the potential of technologies relating to this function primarily relates to increased autonomy in relation to production, enabling communities to collaborate and self-organize towards being less dependent on external supply chains and mass production for locally needed products.

Assisted administration - streamlining self-organization

Assisted administration includes technologies that facilitate governance, coordination, and organizational logistics, areas critical for countercultures relying on non-hierarchical or complex self-organizing principles. This function encompasses the technology clusters of digital governance, groupware, Artificial Intelligence (AI), as well as digital institutions and Web3 infrastructure.

Hanisch et al. (2023) discuss how traditional governance mechanisms seeks to *control* outcomes, processes, and relationships (p.2), however, countercultures tend to not operate with an aim to control but to support a form of constructive creative chaos (Isacson and Adelfio 2023), a parallel to how the creative energy of individuals organized in distributed networks tend to produce meaningful projects largely without traditional hierarchical organization or, quite often, financial compensation (Kostakis and Bauwens 2017). Pazaitis et al. (2017) describe a similar form of organizational structure they call *Decentralized Cooperation (DC),* described as any type of structure that allows autonomous agents to collaborate and achieve a common goal by making spontaneous contributions with no central coordination or ruling authority. The concept of DC is illustrated through the case of Backfeed - a social operating system based on blockchain. The Backfeed governance structure does not focus on a set of predefined roles and tasks, but on an open and meritocratic model where participants can contribute '… freely and in a spontaneous manner to the community's goal' (p0.111).

Similar systems include Decentralized Autonomous Organizations (DAO's), where 'smart contracts' give hints on how administration can be simplified, freeing up resources for under-staffed and under-financed community groups (Baden et al. 2020; Seyfang and Longhurst 2013). The potential capabilities of blockchain leading to significant social and economic changes is being studied by a rapidly growing number of interested parties ranging from academics to growth-oriented organizations such as the International Monetary Fund (IMF) and the Organization for Economic Cooperation and Development (OECD) (Liu et al. 2021; Szemerédi and Tatay 2021). Considering this association with the growth paradigm, the question arises whether DAO's may be appropriated for the use of countercultures to growth, simplifying administration and reducing the load of voluntary and often unpaid work. As succinctly phrased by a counterculture member: 'None of us are joining community so we can make more spreadsheets' (p.36, Isacson and Adelfio 2023).

The function of assisted administration includes technologies that augment, in particular, self-organization, autonomy and collaboration - in essence reducing administration load. However, the examples found regarded groups already technologically

oriented, such as maker collectives and communities versed in blockchain. Whether these technologies are accessible to less technologically advanced groups is to be seen.

Egalitarian economy - reimagining value exchange and self-sufficiency

The egalitarian economy function concerns technologies which enable alternative economic models, supporting financial self-sufficiency and new systems of value exchange outside the growth paradigm. This function encompasses digital institutions, decentralized currencies, digital governance, and Web3 infrastructure, as well as collaborative production and spaces that reduce costs.

Decentralized currencies and smart contracts challenge growth-centric economic models by embedding alternative value and trust systems into transactional infrastructures (Jarvenpaa and Teigland 2017). Unlike growth-centric systems which tend to use banks as middle-men, community currencies foster trust in peer-to-peer exchanges, enhancing transparency and reducing transaction costs (Szemerédi and Tatay 2021). Such mechanisms indicate a new field of socio-economic institutions founded on technological infrastructure such as, for example, decentralized blockchain technologies (Nabben 2023). Blockchain, DAO's and Web3 represent forms of alternative economic practices and institutions that can aid self-financing and crowdsourcing - as well as the process to decentralize economies, support economic self-sufficiency, self-define value systems and set up of independent trust mechanisms (Jarvenpaa and Teigland 2017). Such examples of 'designed' governance systems might have potential to channel degrowth values into the very operational foundations of a community, reflecting the '… perception of value stripped from its economic notion, viewed as a social coordination mechanism' (Pazaitis et al. 2017, p. 2).

However, Pazaitis et al. (2017) caution that the potential of blockchain hinges on its alignment with degrowth ethics. Besides a questionable alignment with post-growth, the idea of on-chain currencies (meaning occurring on the blockchain) may be a dauntingly technical concept highly linked to growth culture. An alternative path for countercultures could be to explore decentralized currencies that are off-chain (happening off the blockchain), and rather than delving into cryptocurrencies explore variations of community currencies, time banking and platforms for crowdsourcing.

Egalitarian economy denotes technological infrastructure impacting how countercultures can create and manage alternative value systems. In the observed technologies, this function was closely connected to governance, as the involved technologies served to decentralize economies to the local scale, thereby redefining the meaning of 'value' in the context.

Impacts

The CAPE functions were found to be associated with impacts on *i) Value ii) Autonomy iii) Collaboration iv) Trust,* and *v) Self-organization* (VACTS). Below, these impacts are discussed in relation to supporting operational areas for countercultures.

Value

A central dimension emerging in this review is how value is embodied in technology, here understood both as *value* in an economic sense and as *values* associated with post-growth. Technologies are discussed not as neutral artefacts; rather, they tend to stabilize particular power relations while marginalising others (Grunwald 2018; Kerschner et al. 2018; Likavčan and Scholz-Wäckerle 2018; March 2018; Pansera et al. 2019). Assumptions of technological neutrality hide ideological commitments embedded in the infrastructure. Garcia et al. (2018) argue that technological progress often increases operational complexity in systems shaping human life, with adverse consequences for social diversity, political differentiation, and economic equality. Closely related is the concern raised by Pazaitis et al. (2017) on how value generated through social sharing mechanisms is assessed and distributed. These critiques underscore the risk that an uncritical adoption of technologies may inadvertently reinforce growth-oriented values and associated patterns. Likavčan and Scholz-Wäckerle (2018) attribute this tendency to the dominance of neoliberal ideology, under which technologies are largely developed to prioritise profit and efficiency rather than broader social and ecological values. They propose *technology appropriation* as a means to repurpose technologies in line with alternative value systems.

An approach to consciously translate alternative values into technological design can be seen in Decentralised Autonomous Organisations (DAOs). In platforms such as Backfeed, community members contribute resources (e.g., code, designs, ideas, services) and the value of their contribution is determined through a participatory evaluation. Contributions positively evaluated by the community receive economic tokens and reputation rewards, aligning incentives with community-defined values (Pazaitis et al. 2017). In this way, common values are engrained in the operational logic of the infrastructure. However, the potential of such value-oriented systems requires critical thought rather than an unquestioned belief that all technological innovation inherently is associated with progress. Contemporary techno-utopian narratives can mirror neoliberal assumptions about growth and progress (Nabben 2023), reproducing dominant paradigms even under the guise of decentralisation (Mitra et al. 2023). Therefore, technological adoption should be accompanied by a critical evaluation of its effects.

This need for a critical approach is emphasised by scholars such as Kerschner et al. (2018), Vetter (2018) and Garcia et al. (2018). Kerschner et al. (2018) articulate criteria to assess whether technologies meaningfully support communal and ecological values, while Garcia et al. (2018) propose the approach of using methodological Luddism to critically examine and regulate technology in light of degrowth goals. Vetter's work on convivial technologies further illustrates how values such as adaptability, accessibility and relatedness can inform design practices (Vetter, 2018).

In summary, technologies involved with economic and administrative functions - such as decentralized currencies tied to contribution and governance - has capacity to translate the values of a community into its very operational system. However, it is essential to be aware of the values already ingrained in the used infrastructure as well as to critically evaluate the actual effect of the technology, recoupling it as means to specific ends.

Autonomy

Innovations that primarily relate to how countercultures can be empowered in their self-sufficiency are reflected in the selected papers under the theme of *autonomy* (see Table 5) due to its prevalence in the papers, and as a key concept in degrowth literature (Kerschner et al. 2018). Here, autonomy is understood following Nabben (2021), who draws on Glanville (2015) to define it as a property of a system or society that exceeds the sum of its individual parts and enables collective capacities otherwise unattainable (Nabben 2021, p. 10).

The literature generally discuss autonomy from both individual and collective perspectives. At the level of individual autonomy community members want to live and work in settings that fosters a culture of maintaining individuality while being part of a collective (Flisbäck and Carlén 2021) - an arrangement arguably favored by technological infrastructures since contemporary platforms allow individuals to simultaneously be part of a local, firmly geographically anchored place as well as a virtual global community (Kostakis and Bauwens 2014). Collective autonomy in the context is often framed as a search for a non-reliance on global systems - since these are deemed untrustworthy, unreliable and financially not sound (Jarvenpaa and Teigland 2017). This systemic mistrust, and the corresponding search for alternatives, is expressed through a variety of technologies. Smart contracts and blockchain technologies are seen as ways to compensate for existing failing institutions (Jarvenpaa and Teigland 2017; Nabben 2021; Pazaitis et al. 2017). Community currencies are used to decentralize economies (Seyfang and Longhurst 2013; Szemerédi and Tatay 2021), and open data and local production is used to bypass global production chains (Dulong de Rosnay and Le Crosnier 2012; Kostakis et al. 2018; Niaros et al. 2017; Potts et al. 2021).

Importantly, this pursuit of autonomy does not imply isolation. Kostakis et al. (2018) argues how the objective should be to ultimately develop global-oriented productive models, arguing that models such as DGML can allow for commons-oriented narratives to converge and '… support the creative communities who are building the world they want, within the confines of the political economy they aspire to transcend' (p.127). The emergence of technologies supporting global coordination mechanisms has here provided new means to share and collaborate effectively across groups according to alternative values. These innovations open for new knowledge dispersal, where local groups gain access to the knowledge of others - a glue for a naturally widely dispersed movement.

Exercising control over knowledge (collaborative commons), finance (egalitarian economy), and production systems (peer production) appears to support decentralization while maintaining the comforts, agency and connectedness associated with centralized systems. In this way, the technologies associated with autonomy may enable communities to pursue alternative visions decoupled from a paradigm that has historically concentrated power over production, finance, and knowledge.

Collaboration

Both internal and external collaboration appears essential to the existence of countercultures. Collaboration in addition underpins the premises of sharing economy and self-sufficiency, relying on a distribution regarding the creation, production and sharing of resources.

While communities of the 1970's were criticized for being isolationist (Flisbäck and Carlén 2021), communities present in the literature in contrast appear highly connected to both each other and the world at large. In relation to the key term of self-sufficiency, Skrzypczyński (2021) found the communities they investigated in relation to basic resource self-sufficiency did not wish to be 100% self-sufficient, but instead wished to focus on local, regional and national *collaborations*. The potential of such collaborations can be exemplified through Pazaitis et al. (2017), who visualizes the idea of Decentralized Cooperation (DC) as an ecosystem where interacting DCs are constitutive elements, supporting each other according to the extent at which they need each other's products or services, and not working in isolation but using their impact to engage more agents into their productive processes, share their vision and social mission.

Several technologies can be identified in the literature as supporting such connected collaboration, from internal coordination tools (such as digital institutions, decentralized currencies and digital governance supporting assisted administration) to platforms allowing for the sharing of best irrigation systems or blueprints on how to locally print functioning replacement limbs (related to collaborative commons and peer production) (Kostakis et al. 2018).

A stream of models where individuals allow for the temporary use of goods or services through collaborative platforms has emerged (Pazaitis et al. 2017). This can be contrasted with the market failure and underuse of resources because of technical, commercial and contractual barriers erected in the digital world, also called a tragedy of the anti-commons (Dulong de Rosnay and Le Crosnier 2012). A genuine sharing economy might in the context express itself by mutualizing and sharing infrastructures, both immaterial (digital commons, software, design) and material (makerspaces, machinery). Individuals and communities could '… globally cooperate on the design of the products, the design of the machinery to produce them and even on the collaborative processes through which both the previous aspects are made possible' (Kostakis et al. 2018, p. 1686).

Technologies allowing for better internal and external collaborations corresponding to post-growth relate to a transparent and egalitarian treatment of information and resources. Collaborative technologies can internally let countercultures support the agency of each individual, as well as allow for sharing of knowledge with other groups, creating networks of change.

Trust

A main reason why countercultures are established is the *lack* of trust in current systems (Flisbäck and Carlén 2021). In relation to this, an interesting dimension in the

literature is the track that a well-designed technology might be able to breed trust in the underlaying system.

Jarvenpaa and Teigland (2017) expresses this along the lines that people trust the platform, not necessarily the people who use it. Some technologies are argued to even replace the trust we now place in institutions. This is mirrored in Pazaitis et al. (2017) who discuss blockchain as a base for decentralized cooperation 'as long as people trust the underlying technological infrastructure' (p.110) and Hanisch et al. (2023) who, when defining their conceptual framework for digital governance, state that '… trust can be algorithmically enhanced by shifting from individual actors to a complete system' (p.1). As such, trust in the platforms is more important for users than trust in individuals. This can be seen in how online platforms digitalize trust, increasing revenue through automation of transactions - if you trust the transactional infrastructure, you trust it with your monetary transfers despite not knowing the individual receiving the transaction.

Trust has been called the currency of the sharing economy (Botsman 2012) and many platform providers in the sharing economy today have developed extensive systems designed to build interpersonal trust, institutional trust, and product trust (Jarvenpaa and Teigland 2017, p.2). Although primarily applied in growth contexts, automating trust relations towards degrowth goals would be an interesting topic to explore further. Especially since Kerschner et al. (2018) point out that the primary challenge of technology lies not in its inherent nature, but in its appropriation by the growth paradigm, begging the question of appropriation for other purposes (Likavčan and Scholz-Wäckerle 2018). For example, Szemerèdi and Tatay (2021) discusses how a community currency based on smart contracts might be able to 'increase the level of transparency, trust and reduce or even eliminate the costs of transactions when applied in the sharing economy' (p.45).

Trust is also inherent in the collaboration of knowledge, where it is common to share designs that are not patented, can be modified, improved upon or replicated by anyone and for any use (Dulong de Rosnay and Le Crosnier 2012; Kostakis et al. 2018). Jarvenpaa and Teigland (2017) lifts understanding the role of trust between users and emerging technologies as a future avenue of research. When Kostakis et al. (2018) discuss practices for degrowth they end by stating that none of them are an automatic result of technology alone, but of a socially formatted appropriation of technology by creative communities, and that none of these developments could have been achieved '… without the sharing of knowledge and physical infrastructures, for which the existence of socialized global infrastructures, like the Internet, are of paramount importance' (Kostakis et al. 2018, p. 1686).

The above discussions indicate that functional technological infrastructure aimed towards post-growth might, in effect, increase trust in this emerging paradigm. However, choosing which technologies to trust and ensuring their intended function is a crucial step, where the wrong choice may instead lead to mistrust.

Self-organization

Self-organization, the ability for a group to coordinate complex tasks without centralized control, is both a core ethos and a practical challenge for countercultures.

Unlike traditional companies, countercultural groups tend to self-organize (Isacson and Adelfio 2023) around a core of highly motivated individuals supported by ad hoc contributors (Pazaitis et al. 2017). One way to comprehend self-organization is through the concept of *stigmergy*. Pazaitis et al. (2017) describes stigmergy as the indirect coordination, seen in specific animal species like ants, termites, and birds, involves individual agents leaving traces in their environment to guide the actions of others. Attempting to scale self-organized groups often conflicts with the original social intentions of the community, which prioritizes cooperation and social relations among distributed network of peers, rather than adopting market-oriented, hierarchical structures (Pazaitis et al. 2017).

Technological innovations address these scaling challenges by enabling new capacities. Through the Information and Communications Technology (ICT) revolution, loosely affiliated individuals gain the ability to self-organize on a project-specific basis and contribute their productive capacity voluntarily (Pazaitis et al. 2017). While groupware and collaborative software have existed since at least the 1990s, with enthusiastic attempts to create tools for group collaboration (Cockburn and Jones 1995; Cheifet 1991, 1994), the functional landscape shifted significantly with the improvement of cloud services (Altamimi 2015). In 2009, the emergence of blockchain technology introduced governance systems that integrated components needed for new socio-economic systems - enabling avenues of previously unwieldy political systems, such as those inspired by and meritocracy principles (Pazaitis et al. 2017). One of the potential benefits in using such organizational structures such as DAO's is that people can both contribute to a platform and benefit from its success - since every participant is both a contributor and a shareholder (Pazaitis et al. 2017).

However, as touched upon in the Value discussion, these technologies are not ideologically neutral (Nabben 2021). critically discusses the evolution of DAO's from their questionable origins as a response to the atrocities in World War II and an 'engineering' approach to social and political challenges, via their early and arguably failed experiments through to the more human-technical balanced approach of today. This evolution represents an underlaying danger in using technological infrastructure, where the role of humans is downgraded. On one hand, DAO's provide a concrete and localized example of technology that show potential in regard to setting up new, decentralized institutions. On the other hand, they risk falling into a socio-economic engineering category, perpetuating the Californian 1990s techno elitist ideology in their imaginary of autonomy via techno and free market economics engineering approach to social challenges (Nabben 2021).

Regarding self-organization, it is of utmost importance to not rely on technology alone to resolve issues of power and influence (Pazaitis et al. 2017). Success depends on balancing the human-machine factor to ensure that technological innovations are aligned with post-growth values, and, importantly, remain tools of the community rather than imposing their own logic upon it.

Table 4 shows a synthesis of the discussion, summarizing how each function relates to specific clustered technologies and their potential operational impacts for countercultures.

Table 4 Synthesis: a tentative toolbox of post-growth technologies, including functions (CAPE) and impacts (VACTS))

Functions	Collaborative commons	Assisted administration	Peer production	Egalitarian economy
Technologies	Open data Digital resources Collaborative spaces Digital twins	Open data Digital resources Collaborative spaces Artificial Intelligence Digital governance Groupware	Open data Digital resources Collaborative spaces Collaborative production Local manufacturing	Digital institutions Decentralized currencies Collaborative spaces Collaborative production Digital governance Web3
Impact	Glocal collaboration, shared libraries of blueprints, ideas and alternative practices.	Support for coordination and decentralized governance, easing the burden of administration.	Self-production and autonomy from global production mechanisms.	Economic self-sufficiency, value, and trust mechanisms outside the growth model.

Limitations

This study is a scoping review and does not have as its purpose to catalogue all available network-enabled innovations. The aim is merely to sketch the outlines of which toolbox is available to countercultures working towards post-growth, denoted by the keywords of degrowth, self-sufficiency and sharing economy. It does not evaluate the technologies involved. To anchor technologies in the value base of a group it is important to tie their use to an evaluation in light of which end they are intended to support, a point frequently raised by post-growth associated scholars (Illich 1973; Garcia et al. 2018; Kerschner et al. 2018). As stated, technology is not neutral. Ultimately, what values the technologies encode will determine their effect.

Finally, the very nature of these technologies is that they change at the speed of the internet, meaning a focus on the details of specific technologies would be quickly obsolete. The approach of this study is therefore to not focus on specific technologies but on *conglomerations* of technologies. This intends to extend the relevance of this research, since even though individual technologies may quickly become obsolete, functions and impacts stay relevant for longer.

Conclusion

This scoping review identifies innovations associated with post-growth and outlines the specific functions they enable with respect to the operational dynamics of countercultures. By clustering innovations - such as digital twins, collaborative production

tools, groupware, and decentralized Web 3 architectures - it demonstrates how these technologies conglomerate into four main functionalities scaffolded by technological infrastructure: collaborative Commons, assisted Administration, peer Production and egalitarian Economy (CAPE). Collaborative commons allow for sharing and contributing towards developing post-growth in practice. Assisted administration makes it easier to organize around and implement ideas, reducing the administrative burden of implementation. Peer production takes non-physical data from global collaborative commons and translates it into local physical form, thereby bypassing central production chains and democratizing access to production. Finally, egalitarian economy denotes alternative financial mechanisms that underpin counterculture operations.

The review further discusses how these functions may impact the operational areas concerning Value, Autonomy, Collaboration, Trust and Self-organization (VACTS). Both economic and ideological value is seen to be able to translate into the foundational architecture of the underpinning technological infrastructure. Autonomy is supported through increased control over production, information and finance. Collaboration is facilitated through the spreading and collective improvement of knowledge and experience across communities. Trust is bolstered in the system if the supporting technological infrastructure aligns and works as intended. Finally, Self-organization is enabled through the use of technologies that help manage non-hierarchical structures.

Ultimately, this study identifies four compartments of a *tentative toolbox for countercultures*, containing technologies that enable alternative modes of operation regarding the management of commons, administration, production, and economy. We argue that the four identified functions (CAPE) and their impacts (VACTS) are structurally relevant for supporting the logistics of what Escobar (2018) calls the 'Pluriverse' - a multitude of collaborative and placed-based approaches engaging with 'making new worlds'. This toolbox indicates a set of technological infrastructure that supports both the interdependence of beings and functional autonomy - two paradoxical forces that often coexist on the internet. These tools let us imagine countercultures that transcend local marginalization, and - supported by carefully selected technological infrastructure – flourish into a movement of locally rooted yet globally connected laboratories of systemic change. The power lies in a modular approach, where the global movement acts as a network of small, autonomous, and locally adapted nodes empowered by connective digital structures.

Regarding how the toolbox is utilized in practice, we align with Garcia et al. (2018) on the necessity for employing methodological luddism. Under this approach, any use of technologies is bound to an assessment that evaluates them in light of a diverse set of values, enabling a reorganization of technological infrastructure in a proper fashion towards ends (Garcia et al. 2018). However, even with such an assessment, intending for a careful and responsibility led approach to the employ of technologies, growth imperatives may still be entrenched in the technology. In addition, considering public discourse concepts such as 'Technofeudalism' (Varoufakis 2023) and 'Enshittification' (Doctorow 2022), alongside how 'technological fix' and 'technology as progress' narratives still prevail, a view of technologies as categorical 'tools of the enemy' would be a highly understandable stance. Such potential rejec-

tion of technology by countercultures is an issue that falls outside the current scope and requires further understanding from within the situated context.

Finally, the tentative toolbox outlined in this study serves as a starting point for further empirical and participatory research. Although the identified potential of this infrastructure appears promising, the current analysis primarily synthesizes academic perspectives. Future research should therefore investigate how countercultural groups themselves perceive, appropriate, or reject these technologies, and how such tools are reconfigured through situated practice. Doing so bridges the gap between theoretical potential and lived experimentation, advancing our understanding of how convivial technological infrastructures can support contexts through which post-growth futures emerge.

Appendix

Table 5 Summary of the ten selected articles in relation to terms, technologies, functions and impacts

Source	Innovation terms	Technologies *1st order concepts*	Functions *2nd order themes*	Impacts Aggregate dimensions
Dulong de Rosnay and Le Crosnier (2012) **An Introduction to the Digital Commons: From Common-Pool Resources to Community Governance** https://shs.hal.science/halshs-00736920v1 *An introductory analysis of digital resources and commons-based peer production focused on the governance used by communities to produce resources which remain available for all to share and build upon.*	• Digital resources • Digital commons • Collaborative commons • Interoperability • Online communities • Commons-based peer production (CBPP) • Common-pool resources	• Open data • Digital resources • Collaborative Production • Collaborative spaces	• Collaborative commons • Peer Production	• Collaboration • Value • Autonomy
Kostakis et al. (2018) **The convergence of digital commons with local manufacturing from a degrowth perspective: Two illustrative cases** https://doi.org/10.1016/j.jclepro.2016.09.077 *Demonstrates the degrowth potential of designing locally and manufacturing globally using desktop and benchtop manufacturing technologies (peer production).*	• Design Global Manufacture Local (DGML) • Digital commons • Peer Production • Open Source • Open Hardware • Open Software • Open Design • 3d-printers • Laser cutters • Makerspaces	• Open data • Collaborative Production • Local manufacturing • Collaborative spaces	• Peer Production • Collaborative commons	• Collaboration • Autonomy

Table 5 (continued)

Source	Innovation terms	Technologies *1st order concepts*	Functions *2nd order themes*	Impacts Aggregate dimensions
Altamimi (2015) **More than Two Decades of Research on Groupware: A Systematic Lexical Analysis** https://doi.org/10.5281/zenodo0.1099342 *A lexical analysis of the literature on collaborative technologies/software, related to how groups can collaborate more effectively.*	• Groupware • Collaborative software • Collaborative technologies • Project management systems • Workflow management systems • Electronic calendaring • Collaborative document editors • Cloud services • Productivity/Collaboration tools	• Groupware • Digital governance	• Assisted Administration	• Collaboration • Autonomy • Self-organization
Hanisch et al. (2023) **Digital governance: A conceptual framework and research agenda** https://doi.org/10.1016/j.jbusres0.2023.113777 *Discusses how digital governance tools have led to the emergence of new collaborative dynamics compared to traditional behind-the-scenes governance.*	• Algorithmic management • Artificial intelligence • Blockchain • Corporate governance • Digital governance • Digital transformation • Interorganizational governance • Public forums	• Digital governance • Digital institutions • Artificial Intelligence	• Assisted Administration	• Value • Autonomy • Self-organization
Jarvenpaa and Teigland (2017) **Trust in Digital Environments: From the Sharing Economy to Decentralized Autonomous Organizations** https://doi.org/10.24251/HICSS0.2017.700 *Discusses traditional institutions and online platforms from the perspective of trust and the sharing economy. Discusses the replacement of failing institutions and the role of trust in this process.*	• Blockchain • Bitcoin • Smart Contracts • Decentralized Autonomous Organizations (DAO's)	• Web3 • Digital Institutions • Digital governance • Decentralized currencies	• Assisted Administration	• Trust • Autonomy • Self-organization • Value

Table 5 (continued)

Source	Innovation terms	Technologies *1st order concepts*	Functions *2nd order themes*	Impacts Aggregate dimensions
Pazaitis et al. (2017) **Blockchain and value systems in the sharing economy: The illustrative case of Backfeed** https://doi.org/10.1016/j.techfore0.2017.05.025 *Explores the potential of blockchain technology in enabling a new system of value that can better support the dynamics of social sharing*	• Collaborative platforms • Blockchain • Bitcoin • Backfeed • Decentralized Cooperation (DC)	• Web3 • Digital institutions • Digital governance • Decentralized currencies	• Assisted Administration • Egalitarian Economy	• Autonomy • Self-organization • Value
Szemerédi and Tatay (2021) **Sharing communities – Community currency in the sharing economy** https://doi.org/10.1556/204.2020.00027 *Outlines a prototype for peer-to-peer payments through smart contracts without blockchain technology based on the narrative that community currencies can promote genuine practices of sharing as opposed to a profit-oriented approach.*	• Community currencies • Smart contracts • Peer-to-peer payments • Virtual currency schemes • Cryptocurrencies • Ethereum • Timebanks	• Web3 • Digital institutions • Digital governance • Decentralized currencies	• Egalitarian Economy	• Value • Autonomy • Self-organization • Trust
Niaros et al. (2017) **Making (in) the smart city: The emergence of makerspaces** https://doi.org/10.1016/j.tele0.2017.05.004 *Discusses the role and potentially transformative effects of makerspaces in democratizing the means of production.*	• Peer Production • Makerspaces • Digital commons • Technology governance	• Digital resources • Local manufacturing • Collaborative spaces	• Peer Production • Collaborative commons	• Collaboration • Autonomy • Self-organization
Kukushkin et al. (2022) **Digital Twins: A Systematic Literature Review Based on Data Analysis and Topic Modelling** https://doi.org/10.3390/data7120173 *Explores the literature around how digital twins are currently being used, and tendencies for how they might be used in the future.*	• Digital Twins • Topic modelling • Machine learning	• Open Data • Digital resources • Digital twins • Artificial Intelligence	• Assisted Administration • Collaborative commons	• Autonomy • Collaboration

Table 5 (continued)

Source	Innovation terms	Technologies *1st order concepts*	Functions *2nd order themes*	Impacts Aggregate dimensions
Nabben (2021) **Imagining Human-Machine Futures: Blockchain-based 'Decentralized Autonomous Organizations'** https://doi.org/10.2139/ssrn0.3953623 *Critically evaluates the past, current and possible future of decentralized autonomous organizations in achieving individual and collective autonomy.*	• Decentralized Autonomous Organizations (DAO's) • Blockchain • Algorithmic governance • Artificial General Intelligence (AGI)	• Web3 • Digital institutions • Digital governance • Decentralized currencies • Artificial Intelligence	• Assisted Administration • Egalitarian Economy	• Autonomy • Self-organization • Collaboration

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Declarations

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Declaration of generative AI and AI-assisted technologies in the writing process During the preparation of this work the author(s) occasionally used ChatGPT and Google Gemini to improve language, readability and reference formatting. After using this service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Competing interest The authors declare that there are no conflicts of interest regarding the submission of this manuscript. This work is the result of original research conducted by the authors, has not been previously published, and is not under consideration for publication elsewhere. All authors have read and approved the final manuscript, affirming its integrity and originality, and have given their approval for its publication. The authors also confirm that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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