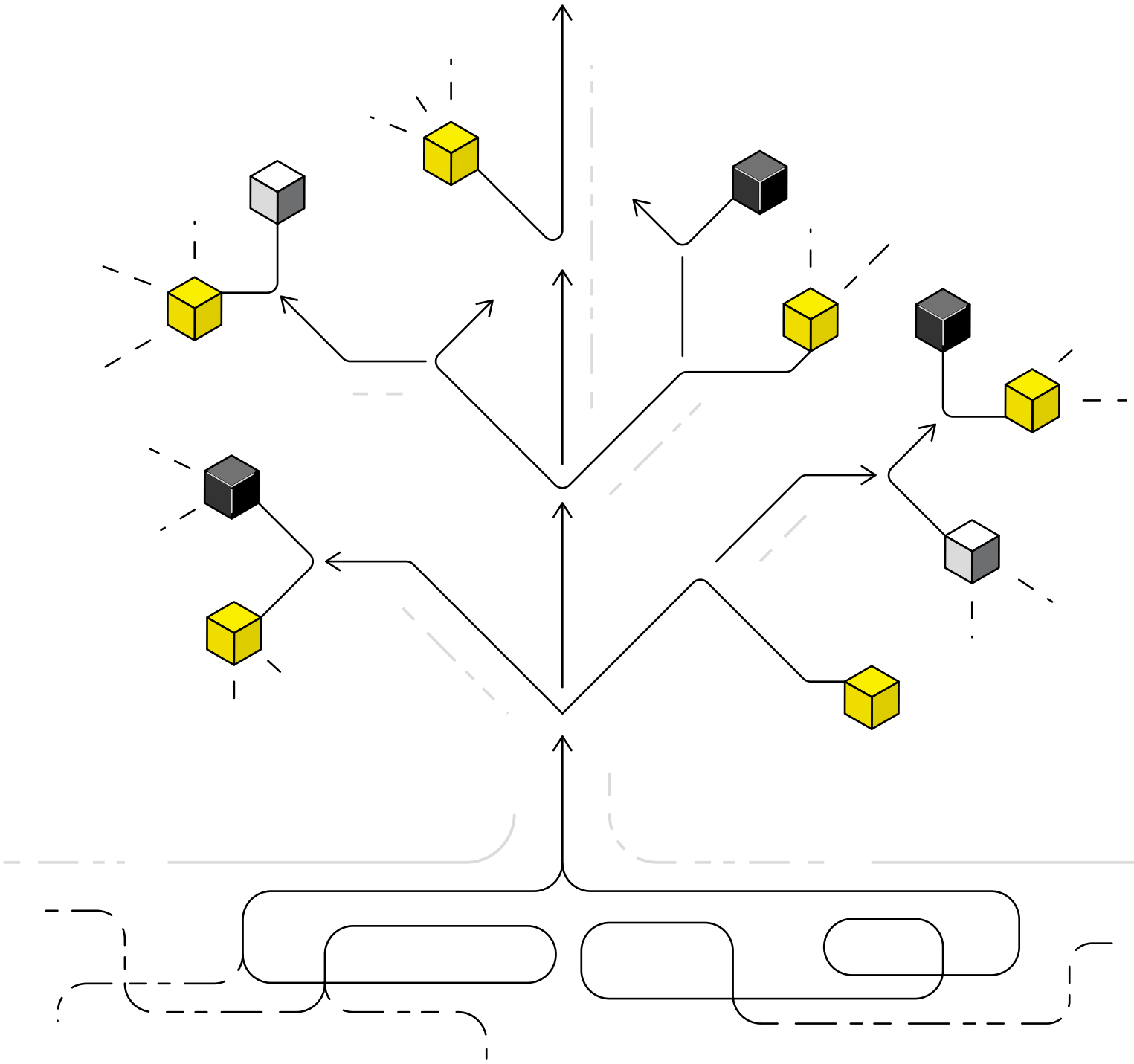
DIGITAL COMMONS AS PROVIDERS OF PUBLIC DIGITAL INFRASTRUCTURE



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1. SUMMARY

The concept of the Digital Commons encompasses diverse digital systems and solutions developed and maintained by groups rather than individuals or single entities. These groups coordinate through peer collaboration instead of pricing or subordination. Digital commons often start as small community projects but can scale into infrastructures, attracting large contributor bases and enabling global applications. Infrastructures, recognized for their economic and social functions, provide a generative input into various activities, though their overall impact remains challenging to measure.

The free market policies of the 1990s created a private and platform-driven digital environment. However, increasing demand for public digital infrastructures has led to new policy debates positioning the state as an "entrepreneurial state" promoting openness and "generative interoperability." These debates focus on the diverse public functions and derivative uses digital infrastructures should support. Foundations for digital services and transactions, critical internet stack components, public spaces, and shared production platforms are seen as vital generative inputs for economic and social well-being. Policymakers propose various forms of public ownership to ensure these infrastructures' public character and societal benefits, often incorporating Digital Commons.

This paper reviews existing literature, emphasizing on current global debates and typologies of public digital infrastructures. Through five case studies, the paper highlights approaches addressing infrastructure gaps and deepens the understanding of how Digital Commons can sustain and enhance various forms of public digital infrastructures.

The case studies demonstrate the nuanced approach to public digital infrastructures adopted by policymakers, leveraging the many Digital Commons and public ownership to maximize societal benefits and ensure inclusive, open, and interoperable ecosystems. The ZenDiS and scikit-learn cases illustrate ecosystem strategies aimed at strengthening open source software connecting information systems and devices. Decidim, created by the city of Barcelona, showcases partnerships providing alternative spaces for online public speech and debate. DHIS2, used by many governments for health information management, exemplifies collectively managed and produced digital infrastructures, facilitating resource and capacity mutualization. Finally, the European Open Science Cloud (EOSC) is a unique example of a pan-European attempt to build a shared infrastructure with a community of researchers, not only redefining the tools and processes used by researchers, but also developing an infrastructure embedded in the values and principles of Open Science. These case studies provide insights into the conditions necessary for Digital Commons to provide infrastructure, particularly regarding long-term funding, which communities struggle to secure. They also highlight the diverse relationships between public institutions and Digital Commons, impacting Digital Commons' governance.

2. DEFINITIONS

Digital Commons: Digital Commons are defined by three key features. First, they are based on a digital resource. A digital resource is understood here as one that can be broken down into bits or binary digits. The second characteristic is community – Digital Commons are predicated on distributed production and are managed collectively by a group rather than by a single individual or entity. Lastly, Digital Commons are defined by a governance system with established rules for access and sharing of the resource.

Digital Public Goods (DPGs): DPGs are digital goods that are technically and legally designed as non rivalrous and non exclusive digital resources. According to the UN Secretary General's Roadmap for Digital Cooperation, "digital public goods are open source software, open standards, open data, open AI systems, and open content collections that adhere to privacy and other applicable best practices, do no harm, and are of high relevance for attainment of the United Nations 2030 Sustainable Development Goals (SDGs)"[1].

Infrastructure: Infrastructures are facilities, systems or institutions that serve society-wide economic and social functions. Frischmann defines infrastructures as "shared means for many ends", as they provide the foundations for downstream activities and social benefits that exceed the private benefits of their production or use by individual entities[2].

Open Source Software (OSS): OSS is software published under a license that guarantees the freedom to use, study, change, and distribute the software and its source code to anyone and for any purpose. The Open Source Initiative (OSI) produced a list of 10 principles that licenses must follow in order to ensure that software can be considered open source: free redistribution, availability of source code, allowance for derived works, integrity of the author's source code, non-discrimination against persons or groups, non-discrimination against fields of endeavor, distribution of license, non-specificity to a product, no restrictions on other software, and technology-neutrality[3].

Public digital infrastructures: Public digital infrastructures are digital infrastructures designed to maximize public value by combining public attributes with public functions and various forms of public ownership[4]. In this publication, "Digital Public Infrastructure" (DPI) will refer to the model inspired by India's government-led digital identity, payment and data exchange systems. "Public Digital Infrastructure" (PDI) will refer to non-extractive alternatives to platforms and communication services essential to provide access to public spaces.

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[1] Digital Public Goods Alliance (DPGA), "Digital Public Goods Standard", September 21, 2020: https://digitalpublicgoods.net/standard/.

[2] Brett M. Frischmann, *Infrastructure: The Social Value of Shared Resources* (Oxford: Oxford University Press, 2013).

[3] Open Source Initiative, The Open Source Definition, February 16, 2024: https://opensource.org/osd.

[4] This definition is adapted from the work of David Eaves, Mariana Mazzucato and Beatriz Vasconcellos.

3. INTRODUCTION

Most of the early information and communications infrastructures were developed in the 20th century, a period that saw the emergence of the "modern infrastructure ideal," characterized by the provision of infrastructure directly by governments or through publicly regulated monopolies. Strong government involvement also characterized the early history of digital infrastructure. Economist Mariana Mazzucato calls this involvement the "entrepreneurial state."[5] Public sector contributions to foundational technologies and innovations such as microprocessors, the HTTP protocol, and GPS, as well as policies aimed at building the "information superhighways" on which our knowledge economies would be built, show how critical state involvement has been in the history of digital technologies.

In the late 1980s and 1990s, however, an important policy shift occurred that led to the **increasing deregulation and privatization of many infrastructures**. This movement was based on the neoliberal belief that public intervention should be limited to market failures – where private actors cannot make sufficient profit to provide goods and services. This neoliberal turn also affected digital infrastructures, initially the telecommunications sector responsible for providing access to the internet, but more importantly the development of digital services on top of these infrastructures in the beginning of the 21st century. The result has been a **digital landscape driven primarily by market forces**, fostering rapid wealth accumulation and the emergence of dominant digital platforms that exploit network effects, user lock-in strategies, and data extraction to extend their reach across all sectors of economies and societies. Platforms have gained extraordinary power and wealth by coordinating diverse and independent actors while extracting value from their interconnections.[6] This capability has enabled them to challenge traditional infrastructure. Their vertical integration strategy, coupled with recent technological advancements – particularly the development of centralized cloud computing architectures exemplified by hyperscalers and the rise of artificial intelligence (AI) – has further increased their infrastructural power. Companies like AWS, Microsoft Azure, and Google dominate cloud computing, creating bottlenecks in market segments and posing future risks of similar constraints in AI systems and applications.[7]

Today, global policies on digital technologies seem to be at a pivotal juncture. After years of a utilitarian, laissez-faire approach, and a reliance on market forces to dictate technological development, there is **a growing recognition of the need to shape digitalization in alignment with societal priorities**. As highlighted in the United Nations Secretary-General's Roadmap for Digital Cooperation: "Digital technology does not exist in a vacuum – it has enormous potential

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[5] Mariana Mazzucato, *The Entrepreneurial State* (London: Demos, 2011).

[6] Jean-Christophe Plantin, Carl Lagoze, Paul N. Edwards, and Christian Sandvig, "Infrastructure Studies Meet Platform Studies in the Age of Google and Facebook," *New Media & Society* (2016): https://journals.sagepub.com/doi/abs/10.1177/1461444816661553.

[7] Dieuwertje Luitse, "Platform power in AI: The evolution of cloud infrastructures in the political economy of artificial intelligence," *Internet Policy Review,* 13 (2) (2024): https://policyreview.info/articles/analysis/platform-power-ai-evolution-cloud-infrastructures.

for positive change, but can also reinforce and magnify existing fault lines and worsen economic and other inequalities. (…) The world is at a critical inflection point for technology governance."[8]

At the same time, recent research on infrastructure highlights a growing challenge to the traditional economic view that confines public intervention to addressing market failures. This shift is primarily driven by geopolitical changes, such as the rise of China, the emergence of new dependencies, and the increasing fragility of global value chains. However, this trend is not merely a return to economic interventionism. Many voices advocate for a more generative role for public policy,[9] focused on ensuring the quality and quantity of basic services, rather than focusing on areas where there is limited private supply of public goods.[10] This shift prompts a **reevaluation of the classical economic divide between private and public spheres and a redefinition of the "publicness" of infrastructures**. Indeed, arguments for the publicness of infrastructure are increasingly being examined critically by both academics and activists, asking what benefits infrastructure provides, who benefits from this infrastructure, what kinds of knowledge – expert or non-expert – define these benefits, and what technical tools are needed to achieve them.[11]

Over the past decade, there has been a significant adaptation in policies to address the new power dynamics created by dominant digital platforms. This shift recognizes the **collective responsibility in steering technological trajectories** and emphasizes the necessity of public interventions – not only through regulation but also through strategic investments aimed at reclaiming digital sovereignty. The European Union's evolving role in the digital sphere reflects this broader global resurgence of industrial policy and the reconceptualization of the state as a strategic actor.[12] Regulations such as the Digital Markets Act (DMA) and the Digital Services Act (DSA) have formed an initial answer in this respect. More proactive approaches in shaping technological development are illustrated by recent initiatives such as the "Next Generation Internet," supporting "open source decentralized digital solutions" aimed at supporting values such as "openness, inclusivity, transparency, privacy, cooperation, and protection of data."[13] While governments have historically invested heavily in the support of innovation and startup programs, or in the digitalization of small and medium enterprises (SMEs) and industries, increasingly, political focus is turning toward alternative forms for the governance of technology, moving beyond market-driven models. This shift is far from being specific to the EU and has given rise, globally, to a renewed interest in public digital infrastructures.

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[8] U.N. Secretary-General, "Report of the Secretary-General: Roadmap for Digital Cooperation," United Nations, June 2020, https://www.un.org/en/content/digital-cooperation-roadmap/.

[9] Luca Calafati, Julie Froud, Colin Haslam, Sukhdev Johal, and Karel Williams, "What is the foundational economy?" Foundational Economy, August 2023, https://foundationaleconomy.com/introduction/.

[10] Brett M. Frischmann, *Infrastructure: The Social Value of Shared Resources* (Oxford: Oxford University Press, 2013).

[11] Stephen J. Collier, James Christopher Mizes, and Antina von Schnitzler, "Preface: Public Infrastructures / Infrastructural Publics," Limn, https://limn.it/articles/preface-public-infrastructures-infrastructural-publics/.

[12] Mariana Mazzucato and Dani Rodrick, "Industrial Policy with Conditionalities: A Taxonomy and Sample Cases," UCL Institute for Innovation and Public Purpose, Working Paper Series: IIPP WP 2023-07, 2023.

[13] "Next Generation Internet initiative," European Commission, accessed March 27, 2023, https://digital-strategy.ec.europa.eu/en/policies/next-generation-internet-initiative.

Infrastructure policies are usually the result of a specific and political problematization of social relations that defines **a hierarchy between elements that are perceived as foundational because they provide a generative input into a wide range of activities**. This makes infrastructures recognized for their society-wide economic and social functions, even though their overall impact and spillover effects remain challenging to measure.[14] In this context, various political, cultural, and legal visions regarding the "publicness" of digital infrastructures are co-existing today, forming a diversity of alternative models to the private dominance of today's digital landscape. The Government of India has been a strong advocate of a specific vision of what "Digital Public Infrastructure" (DPI) should be, inspired by its own experience in developing a stack of interoperable technologies that facilitate essential functions for both public and private service delivery. In this context, public institutions control protocols and norms to ensure interoperability while public-private partnerships are established to deploy public services on top of these building blocks.[15] Other visions for "Public Digital Infrastructure" emphasize the public's responsibility in **developing and maintaining an ecosystem of open protocols and software components that rely on collective governance and non-extractive economic models.**[16]

Such visions for public digital infrastructures follow trends in the management of infrastructure challenging the traditional private/public dichotomy and call for the integration of various forms of collectivity into public infrastructure - ranging from government-owned infrastructures to community-based management of resources. Within this framework, public infrastructures should not only have public attributes and functions but also rely on public ownership, which can range from ensuring public control to public funding or even direct public provision. Commons – and particularly Digital Commons – are gaining prominence in this context, as they promote public participation through the involvement of citizens, civil society, and private entities in resource management.[17] The concept of the Digital Commons has been used to describe the **large diversity of digital systems and solutions that have been owned, developed, and maintained by a group rather than by a single individual or entity.** These groups differ from businesses or state institutions because they do not coordinate through pricing or subordination, but through collaboration among peers.[18] Digital Commons often began as small community projects but many have scaled to become society-wide infrastructures, attracting vast contributor bases and enabling global applications and uses. Early 21st-century examples like Wikipedia, the online encyclopedia, and Apache, an open source software that supports over 20%

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[14] Brian Larkin, "The Politics and Poetics of Infrastructure," *Annual Review of Anthropology* 42, no. 1 (October 21, 2013): 327–43, https://doi.org/10.1146/annurev-anthro-092412-155522.

[15] Vy Dang et al., "Synergising Digital Public Infrastructure and Digital Commons for Sustainable Development," Gateway House, 2024, https://www.gatewayhouse.in/wp-content/uploads/2024/03/Gateway-House-Publication_Synergising-Digital-Public-Infrastructure-and-Digital-Commons-for-Sustainable-Development.pdf.

[16] "Generative Interoperability," Open Future, accessed June 25, 2024, https://openfuture.eu/publication/generative-interoperability.

[17] Dimitris Dalakoglou, "Infrastructural Gap: Commons, State and Anthropology," *City* 20, no. 6 (November 2016): 822–31, https://doi.org/10.1080/13604813.2016.1241524.

[18] Yochai Benkler, *The Wealth of Networks: How Social Production Transforms Markets and Freedom* (New Haven:Yale University Press, 2006).

of the million busiest websites globally,[19] exemplify the profound impact of Digital Commons. Some authors have even described the current Internet Stack to be an "accidental megastructure" of Digital Commons.[20]

In this context, Digital Commons are gaining political attention for their potential to provide an answer to various social demands for digital infrastructure, such as the demand for alternatives to current surveillance-based platforms, for digital sovereignty and for the respect for digital rights, but also for a more competition-friendly digital environment that would improve the accessibility and quality of digital services. In this context, Digital Commons are perceived as "a key mechanism for providing public digital infrastructure."[21] The report "Towards a Sovereign Digital Infrastructure of Commons," adopted by 19 EU Member States during the Digital Assembly held in July 2022, does not only recognize the potential of Digital Commons to "support European digital sovereignty," but also emphasizes their potential as an alternative to the "enclosure strategies" of both "governments and major digital services providers." Such an approach, based on "collective intelligence and networking" or "multilateral governance" is presented as a form of "public-civic-private cooperation."[22] These mechanisms could be considered a potential answer to contemporary infrastructure critics, who reject centralized and technocratic public-private partnerships as a way to provide public infrastructures and present the **commons as a way to reclaim the governance over technical systems.**[23] Such criticisms have been particularly vivid in the context of digital infrastructures, where government-led initiatives can create risks for the respect of human rights.[24]

In addition, collaboration with Digital Commons is also an opportunity for public institutions that often lack internal capacities, funding, and expertise to provide better digital infrastructure and services. This corresponds to the literature on infrastructure studies that argues that commons emerge specifically in the context of an "infrastructural gap" or in "times of trouble," where public institutions are absent. This historical dichotomy between the commons and the state is present in the traditional literature on commons, which still largely considers their interaction to be antagonistic[25]. It also explains the limitations of Digital Commons as providers of public digital infrastructures. The fact that commons, as a resource management principle, are

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[19] "Apache HTTP Server," Wikimedia Foundation, accessed May 13, 2024, 09:36, https://en.wikipedia.org/wiki/Apache_HTTP_Server.

[20] Marco Berlinguer, "Digital Commons As New Infrastructure: A New Generation of Public Policy for Digital Transformation," *Umanistica Digitale* 5 (11) (2021): 5-25, https://doi.org/10.6092/issn.2532-8816/13695.

[21] P. Keller, "European Public Digital Infrastructure Fund White Paper," Open Future, 2022, https://openfuture.pubpub.org/pub/public-digital-infra-fund-whitepaper.

[22] "The report on the digital commons: an essential lever for European sovereignty," French Ministry for Europe and Foreign Affairs, press release, June 24, 2022, https://www.diplomatie.gouv.fr/fr/politique-etrangere-de-la-france/diplomatie-numerique/actualites-et-evenements/article/le-rapport-sur-les-communs-numeriques-un-levier-essentiel-pour-la-souverainete.

[23] Dimitris Dalakoglou, "Infrastructural Gap: Commons, State and Anthropology," *City* 20, no. 6 (November 2016): 822–31, https://doi.org/10.1080/13604813.2016.1241524.

[24] Reetika Khera, *Dissent on Aadhaar* (Orient BlackSwan, 2019).

[25] Pierre Dardot and Christian Laval, *Commun : Essai Sur La Révolution Au XXIe Siècle* (Paris: La Découverte, 2014).

a more participatory alternative to the private and technocratic nature of "Big Infra" projects,[26] means that they also appear to be better suited for infrastructures that mostly rely on ongoing human contributions and maintenance efforts, rather than on heavy capital investment. Recent research contributions on Digital Commons in particular, however, showed that depending on the political context, the state can play a constructive role in protecting and even supporting Digital Commons. Evidence from recent experimentations in public service provision show how co-production between self-governed citizen communities with hierarchical public administration can lead to the establishment of hybrid forms of institutions.[27]

[26] Big Infra projects are large-scale and technical infrastructure projects associated with high capital intensity and technocratic management, as opposed to the commons, associated with labor and maintenance, as well as community management. See for instance Dimitris Dalakoglou, "Infrastructural Gap: Commons, State and Anthropology," *City* 20, no. 6 (November 2016): 822–31, https://doi.org/10.1080/13604813.2016.1241524.

[27] Sébastien Shulz, "Moving from Coproduction to Commonization of Digital Public Goods and Services," *Public Administration Review* (February 15, 2024): https://doi.org/10.1111/puar.13795.

4. OVERVIEW AND OBJECTIVES

The purpose of this paper is twofold. First, it aims to provide an overview of the history of policies that have made Digital Commons potential providers of public digital infrastructures. Second, this paper aims to identify key policy issues that need to be considered for the provision of public digital infrastructures through Digital Commons.

The first section will critically examine conceptual visions of public digital infrastructures by reviewing recent economic and sociological infrastructure studies. It will discuss the extent to which commons have been presented as an alternative to capital-intensive and technocratically dominated "Big Infra" projects. It will then explore contemporary visions of the "publicness" of infrastructure, showing that there is a shift from state ownership to various forms of collective involvement in infrastructure, with a focus on maximizing the public value of infrastructure. Finally, these findings will be linked to current debates and discourses about public digital infrastructure. The mapping of these debates will be limited to the strictly digital spheres of public infrastructure, where Digital Commons are already providing alternative infrastructures or are part of public strategies to build and maintain them.

The second section will review existing literature on the interplay between Digital Commons and the state to identify emerging issues and challenges in supporting Digital Commons as providers of public digital infrastructures. Through case studies of novel forms of public support for infrastructure provision through Digital Commons, the paper seeks to highlight approaches that address infrastructure gaps and contribute to a deeper understanding of how Digital Commons can sustain and enhance public digital infrastructures.

This paper is written as an academic contribution to improve our understanding of the potential public role of Digital Commons. It is also part of various contemporary efforts to include support for Digital Commons in public policy, especially in the European Union. It should contribute to the current objective of the European Commission to define a new strategic agenda for Digital Commons through the NGI Commons project.[28] It should also contribute to the design of the "Digital Commons European Digital Infrastructure Consortium,"[29] which is currently being scoped as an initiative of France, the Netherlands, Germany, and Estonia. In recent months, strengthening Europe's digital infrastructure has become a key issue in discussions about the region's future and competitiveness. This topic features prominently in the European Commission's white paper on digital infrastructures, Mario Draghi's report on European competitiveness, and new debates surrounding digital independence. These discussions also connect with the global discourse on Digital Public Infrastructure (DPI).

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[28] Several authors of this paper are members of the NGI Commons consortium. More information on NGI Commons can be found on the following website: https://commons.ngi.eu/objectives/.

[29] The European Digital Infrastructure Consortium (EDIC) is a legal framework aiding Member States to set up and implement multi-country projects. More information on this instrument can be found on the website of the European Commission: https://digital-strategy.ec.europa.eu/en/policies/edic.

5. WHAT ARE PUBLIC DIGITAL INFRASTRUCTURES?

The contested notion of infrastructure

The word infrastructure was first used by French engineers working on public roads in the nineteenth century. It was used to describe "structures below," therefore implying **a vertical order between structures that can be considered foundations** (and are usually invisible) **and the layers above** that are supported by this "underlying plumbing." Today, the term infrastructure is usually associated with the process of development, for which infrastructures are considered to be a prerequisite. It has become a broad and dynamic term that is no longer reserved for the technical and physical artifacts underlying energy, railroad, and telecommunications systems, as it can include the social and intangible systems our societies rely on, from education systems to law or even languages.[30]

This contemporary understanding of the word can first be found in the economic development literature debates of the 1950s. According to William Rankin, it was after the Second World War that infrastructure became "a label for the technical-political systems required for growth and modernity."[31] This economic literature has sought to rationalize the use of the term. Such rationalization was necessary to justify and normalize investment policies across national borders in the context of both decolonization and the emergence of official development assistance programs. For this reason, **one of the key features of infrastructure is the provision of interoperability for the secure and stable circulation of people, goods, capital, or data, by setting norms and standards**. Railroad systems for instance need a standard track gauge, and languages need agreed upon grammatical rules to fulfill their purpose.

At the beginning of the twentieth century, infrastructure was still widely associated with the notion of "social overhead capital." It was considered a special kind of capital that is, in opposition with conventional capital, shared by several enterprises and can therefore not be attributed to a single productive activity.[32] In other words, **infrastructures generate social benefits that exceed the private benefits of the mere production or use of an infrastructure by single enterprises**. Indeed, infrastructures have so-called positive externalities (or spillover

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[30] Jean-Paul D. Addie, Michael R. Glass, and Jen Nelles, "Regionalizing the Infrastructure Turn: A Research Agenda," *Regional Studies, Regional Science* 7, no. 1 (January 1, 2020): 10–26, https://doi.org/10.1080/21681376.2019.1701543; Kathryn Furlong, "Geographies of Infrastructure 1: Economies," *Progress in Human Geography* 44, no. 3 (June 2020): 572–82, https://doi.org/10.1177/0309132519850913.

[31] William J Rankin, "Infrastructure and the International Governance of Economic Development, 1950–1965," *Internationalization of Infrastructures: Proceedings of the 12th Annual International Conference on the Economics of Infrastructures* (2009): https://history.yale.edu/sites/default/files/files/2009%20rankin%20-%20infrastructure%20and%20development.pdf.

[32] William J Rankin, "Infrastructure and the International Governance of Economic Development, 1950–1965."

effects) that can affect third parties or even social and economic development in general.[33] Such effects are difficult to measure because the causal links between infrastructure and its benefits are mostly indirect. Infrastructures do indeed provide a generative input to other economic activities, which can be very diverse. You do not use an electricity network for its own sake, but in order to do something else. And it is very difficult to capture and compare all the different uses of a road: using a road to transport commercial goods is very different from using it to go to hospital. Some attempts to classify different types of infrastructure have been based on the typology of derivative uses to which they provide input, for example distinguishing between infrastructure used to produce market goods, public goods, or non-market goods.[34] Nevertheless, fully understanding and modeling the impacts of infrastructure remains a challenge.

Attempts to normalize infrastructure have identified **two key economic features: a demand side characterized by "publicness" and a supply side characterized by "capitalness"** (or capital intensity). The demand side is characterized by publicness because infrastructures are usually considered as public goods. This means that they are non-rival and non-exclusive: many people should be able to use the infrastructure at the same time, and access to it is usually unrestricted or difficult to restrict. The supply side, on the other hand, is characterized by capitalness, as infrastructure tends to have very high fixed costs and relatively low operating costs.[35] For example, while the cost of installing and deploying a national telecommunications network is huge, the marginal cost of an additional user of the network is very low or even close to zero. This cost structure makes it difficult to set individual prices.

These two economic features have been used in the classical economic literature to explain why infrastructure can be considered a natural monopoly. Without the guarantee of a long-term economic rent, there is no incentive for self-interested actors to make the huge investments required to build the infrastructure in the first place, especially if individual access to the infrastructure or to the positive externalities infrastructure produces is difficult to restrict. This is seen as the origin of the challenge of providing public goods: collective action is needed to avoid free riding – where individuals benefit from the public good but have insufficient incentives to contribute to it.

From a classical perspective, this specific market failure justifies government intervention. Indeed, one of the three roles of the state identified by Adam Smith – alongside protecting its population from invaders or from itself – was "that of erecting and maintaining those public institutions and those public works, which, though they may be in the highest degree advantageous to a great society, are, however, of such a nature, that the profit could never repay

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[33] Brett M. Frischmann, *Infrastructure: The Social Value of Shared Resources* (Oxford: Oxford University Press, 2013).

[34] Brett M. Frischmann, "An Economic Theory of Infrastructure and Commons Management," *Minnesota Law Review* (2005): https://papers.ssrn.com/sol3/papers.cfm?abstract_id=588424.

[35] Frischmann, *Infrastructure*.

individuals, and which it therefore cannot be expected that any individual or small number of individuals should erect or maintain."[36]

The interpretation of this economic division between public and private has varied over time. It has contributed to the "modern infrastructure ideal" of the second half of the twentieth century, characterized by state monopolies and tight control over infrastructure. It also provided the basis for the neoliberal turn that eventually led to increasing competitive private or public-private provision of infrastructure based on "selective premium infrastructural configurations"[37] such as leasing deals to private companies or the commercialization of infrastructure services. From a legal perspective, the theory of essential facilities has provided the ground for a competitive provision of infrastructure. Essential facilities are indeed "an asset or infrastructure to which a third party needs access to offer its own product or service on a market" where "no reasonable alternatives are available and duplication of the facility is not feasible due to legal, economic or technical obstacles."[38]

In addition, opening up traditional monopolies to competition came with increasing financialization of infrastructure. According to Kathryn Furlong, the increasing financial engineering of debt-led infrastructure development transformed the unattractive high investment in public works into assets that could be marketed to private investors. As these assets can be sold on financial markets dependent on global debt dynamics, they can even create a "disconnect between the returns to infrastructure and those to investors." This trend, which enables the generation and extraction of wealth for an increasing number of infrastructure projects, has contributed – in combination with deregulation and public austerity measures – to their continued privatization, which in turn threatens universal and equal access to them.[39]

Contemporary financialization shows the limits of classical economic definitions of infrastructure based on publicness and capitalness. This is in line with the social science literature that rejects infrastructure as a neutral economic concept and emphasizes its normative and political nature, to the point of considering infrastructure as the "setting and stake of social struggle."[40] This makes infrastructure dependent on the specific socio-historical context in which it is embedded. It also means that **infrastructure emerges from a political negotiation of what are perceived as "the most basic elements of collective consumption** (and collective disposal) organizing social, economic and environmental lives which are lived, at least partly, in common."[41]

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[36] Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nation*s (Scotland, Kingdom of Great Britain: W. Strahan and T. Cadell, London, 1776).

[37] Addie, Glass, and Nelles, "Regionalizing the Infrastructure Turn."

[38] Inge Graef, "Essential facility," in D. Healey, W. Kovacic, P. Trevisán, & R. Whish (Eds.), *Global dictionary of competition law, Concurrences,* Article 12256 (2021): https://www.concurrences.com/en/dictionary/essential-facility.

[39] Furlong, "Geographies of Infrastructure 1."

[40] Addie, Glass, and Nelles, "Regionalizing the Infrastructure Turn."

[41] Fran Tonkiss, "Afterword: Economies of Infrastructure," *City* 19, no. 2–3 (May 4, 2015): 384–91, https://doi.org/10.1080/13604813.2015.1019232.

As Rankin shows, our economic understanding of infrastructure is still heavily influenced by the theory of staged growth and the post-war need of industrialized states to negotiate extraterritorial norms and material priorities for international trade and cooperation.[42] Such negotiations may formally take place at the level of governments, but they tend to "appear as complex points of intersection between state and speculative interests, and narratives of industrial restructuring."[43] They can emerge outside clearly coordinated public efforts, especially in the context of rapid technological change: "against the will of their creators – and also against the concepts of politicians – infrastructures seem to have a will of their own. They are not only pushed through from above but also demanded from below, conflicting interests influence their shape, and they are used and rearranged in reaction to actual needs."[44]

This reconfiguring nature of infrastructure has led to an increasingly abstract use of the notion, especially in the field of science and technology studies (STS). Infrastructure then becomes a specific set of relations – usually made of hybrid networks of humans and machines – that is dependent on a specific perspective. This perspective is **a problematization of various yet fundamental aspects of collective life** that allow for the trafficking of "goods, ideas, waste, power, people and finance."[45] As such, infrastructure constitutes a methodological tool that can be mobilized strategically to create new knowledge and achieve certain political goals.[46] This literature analyzes contestations of "the technical procedures of expert judgment in infrastructure planning and management," especially "through claims and counter-claims about the values produced by infrastructure, about the publics those values serve, about the kinds of expert or non-expert knowledge that are relevant for defining these values, and about the technical means required to realize them."[47] Such contestations come for instance from political movements that have historically opposed infrastructure projects, criticizing their negative impact on the environment or on inequalities and wealth extraction, but also the specific threats in case of accidents or disruptions. Such movements oppose "Big Infra" projects steered by government and corporate interests in the name of more distributed and resilient infrastructures, based on "auto-economies of people."[48]

This recognition of the possibility of multiple forms of infrastructure at different scales, combined with the contemporary awareness of planetary boundaries and the "infrastructural gaps" left by the state and the market, has contributed to the recognition of new forms of collective responsibility for both physical and social infrastructures, and "posits that people are

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[42] Rankin, "Infrastructure and the International Governance of Economic Development, 1950–1965."

[43] Tonkiss, "Afterword."

[44] Dirk van Laak, "Technological Infrastructure, Concepts and Consequences," *Icon*, vol. 10 (2004): 53–64, http://www.jstor.org/stable/23787127.

[45] Brian Larkin, "The Politics and Poetics of Infrastructure," *Annual Review of Anthropology* 42, no. 1 (October 21, 2013): 327–43, https://doi.org/10.1146/annurev-anthro-092412-155522.

[46] Pierre Mounier and Simon Dumas Primbault, "Sustaining Knowledge and Governing Its Infrastructure in the Digital Age: An Integrated View," Infoscience, EPFL, 2013. https://infoscience.epfl.ch/record/306657?v=pdf.

[47] "Limn Preface: Public Infrastructures / Infrastructural Publics."

[48] Tonkiss, "Afterword."

and should be the most integral part of infrastructure."[49] In this context, infrastructure is often associated with the concept of the commons, as a resource management principle built on active involvement by the public.[50] It has also led to the emergence of a multidisciplinary field of research dedicated to "the often hidden work done in repair, custodianship, stewardship, tending and caring for the things that matter" as the founders of the "Festival of Maintenance" put it.[51]

An important distinction made in this literature focuses on the opposition between large-scale "hard infrastructure" projects, which are capital intensive, and local "soft infrastructure," which rely on sometimes fragile social structures and various forms of community participation for their maintenance.[52] This distinction already seems to indicate that **commons represent a resource management principle better suited to the provision of infrastructure that is less capital intensive** and more dependent on the ongoing contribution and maintenance efforts of people. Digital Commons, however, seem to distinguish themselves from classical material commons, as they can rely on labor intensive supply and community governance, while managing large-scale and technical infrastructures. It is important to note that this is an archetypical distinction: the boundary between capital-intensive systems and a commons approach may not be so rigid. While commons-based management might be less applicable during the initial development of capital-intensive systems, it can still offer significant benefits in their planning, governance, and long-term maintenance.

	Type of infrastructure	**Economics (supply-side)**	**Governance**
"Big Infra"	Large-scale and technical	Capital intensive: high fixed and low operating costs	Technocratically managed
Commons	Local and social	Labor intensive: maintenance, custodianship, stewardship	Community participation

Table 1: Archetypical opposition between "Big Infra" and the commons.

This first section has reviewed infrastructure studies spanning various fields and disciplines. It has shown that the concept of infrastructure always suggests a hierarchy between foundational structures, often invisible, and the layers above them. This hierarchy reflects the political negotiation of society's basic elements of collective consumption and production. Frischmann defines infrastructures as "shared means for many ends,"[53] as they generate downstream economic activities and social benefits that exceed the private benefits of the mere production

[49] Bae-Gyoon Park et al., "Enabling Infrastructure: Seeing Infrastructure as the Urban Commons," *International Journal of Urban Sciences* (February 28, 2024): 1–13, https://doi.org/10.1080/12265934.2024.2321337.

[50] Dimitris Dalakoglou, "Infrastructural Gap: Commons, State and Anthropology," *City* 20, no. 6 (November 2016): 822–31, https://doi.org/10.1080/13604813.2016.1241524.

[51] "About Maintain", Maintain, accessed June 27, 2024, https://maintain.community/.

[52] Dimitris Dalakoglou, "Infrastructural Gap: Commons, State and Anthropology."

[53] Frischmann, Infrastructure.

or use of an infrastructure by single entities. Infrastructures also enable secure and stable circulation of people, goods, capital, and data by setting norms and standards. They are characterized by their fragility, requiring significant financial investment and human effort for deployment and maintenance. Economically, infrastructures have indeed a demand side marked by "publicness" and a supply side marked by "capitalness." Commons, as a resource management principle that has emerged as a more participatory alternative to the private and technocratic nature of "Big Infra" projects, appears to be better suited for infrastructures that rely more on ongoing human contributions and maintenance efforts than on heavy capital investment.

Competing definitions of the "public"

Infrastructure studies show that the economic perspective inherited from the development theory of the 1950s, which limited public intervention to market failures, is increasingly being challenged. A growing number of voices indeed call for a "distinctive role of public policy" that aims "not to boost private consumption by delivering economic growth but to ensure the quantity and quality of foundational services."[54] This trend raises the question of redefining the private/public dichotomy, the nature of publicness, and its ability to incorporate various forms of collectivity. The notion of commons is playing an increasing role in these debates. While social movements mobilize the concept to reject "deep structural categories embodied in the dualities of state/market, public/private, objective/subjective and universal/local,"[55] commons – and digital commons in particular – are *de facto* already playing a key role in the provision of some infrastructure, such as the "digital infrastructure stack,"[56] as we will see in the next section.

The progressive abandonment of the private/public dichotomy inherited from development theory implies, according to Frischmann, to not exclusively focus on the "supply-side issues" of infrastructure, especially the problem of "securing cost recovery and incentives to invest in the face of decreasing-cost phenomena." Instead, more attention needs to be given to the "tremendous societal demand for public infrastructures," which can not be solely understood through the willingness of private users to pay for them in a market setting, as such an approach totally evacuates the large and positive spillover effects infrastructure can have on society.[57] Reformulating the demand for infrastructure as a collective demand that can't be broken into aggregated private needs leads necessarily to a delimitation problem. In fact, if private actors are not the right unit to understand infrastructure demands, what is the right unit to represent collective interests? And what are the institutions able to represent such collective interests?

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[54] Luca Calafati, Julie Froud, Colin Haslam, Sukhdev Johal, and Karel Williams, "What is the foundational economy?", Foundational Economy, accessed August 2023, https://foundationaleconomy.com/introduction/.

[55] Heidi Sohn, Stavros Kousoulas, and Gerhard Bruyns, "Commoning as differentiated publicness," *Footprint* 9 (2015): 1-8, https://journals.open.tudelft.nl/footprint/article/view/895.

[56] Marco Berlinguer, "Digital Commons as New Infrastructure," *Umanistica Digitale* No. 11 (January 25, 2022): 5-25, https://doi.org/10.6092/ISSN.2532-8816/13695.

[57] Frischmann, *Infrastructure*.

PUBLIC ATTRIBUTES

A first key feature of public infrastructures that most authors agree with is that they should be publicly accessible. The economic literature considers that goods that "naturally" present this feature should be considered public goods, justifying the involvement of the state in their management. But public access could also be understood as a normative feature of non-excludability, stemming from the Roman tradition of res publicae, which opposes both private and public property. It means that certain goods should not be owned exclusively by anyone, including governments, which contradicts the state ownership often implied in economic literature. This brings the concept closer to the idea of the public domain: goods from which no one should be legally excluded.[58] One can nevertheless consider that public infrastructures should in any case have "public attributes" in the sense that they aim to provide universal and unrestricted access. In the context of digital infrastructures, such unrestricted access is usually enabled by open licenses. Open Source Software (OSS) for instance is software published under a license that guarantees the freedom to use, study, change, and distribute the software and its source code to anyone and for any purpose. The Open Source Initiative (OSI) produced a list of 10 principles that licenses must follow in order to ensure that software can be considered open source: free redistribution, availability of source code, allowance for derived works, integrity of the author's source code, non-discrimination against persons or groups, non-discrimination against fields of endeavor, distribution of license, non-specificity to a product, no restrictions on other software, and technology-neutrality[59].

PUBLIC FUNCTIONS

A second feature of public infrastructures is their participation in public goals. A first general understanding of this feature could be based on the opposition with private goals: infrastructure that would only serve one or a few entities' interest or profit could therefore not be considered as public. The public function of infrastructure is nevertheless a highly contested one, as **the notion of "public interest" covers different understandings depending on legal, historical, socio-cultural, and political contexts**. While the French understanding of public interest, for instance, historically referred to the interest of the State – as a body representing the nation as a whole – the notion of "common good" in the English context usually refers to a general interest of society that is not essentially the responsibility of the state.[60]

This is reflected in the European Union's definition of services of general interest, which acknowledges states' capacity to define what these services are but also recognizes that they can be provided by non-public organizations. The EU recognizes the following three categories of general interest: services of general economic interest, "which are basic services that are carried out in return for payment, such as postal services"; non-economic services that include police and judiciary systems; and social services of general interest, which "respond to the needs

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[58] Fabienne Orsi, "Biens publics, communs et État : quand la démocratie fait lien," https://hal.science/hal-01884973

[59] Open Source Initiative, "The Open Source Definition," Opensource.org, 2007, https://opensource.org/osd.

[60] G. Gallenga and C. Hervé, "Présentation : Services publics : l'État face au commun," *Anthropologie et Sociétés*, 43(2) (2019): 9–21, https://doi.org/10.7202/1067017ar.

of vulnerable citizens, and are based on the principles of solidarity and equal access," such as "social security schemes, employment services and social housing."[61] For David Eaves, Mariana Mazzucato, and Beatriz Vasconcellos, similarly, public functions of infrastructure can be characterized by public goals such as fostering community and social relationships, fostering economic activity, guaranteeing better quality of life or guaranteeing essential capabilities.

For these authors, however, the **public attributes and functions of infrastructure are not enough to ensure the maximization of the public value** of infrastructure, which needs to take into account "the processes surrounding value creation and maximization, and the political economy implications." For infrastructures to maximize public value, "proactive governments who set the direction for the required collective action"[62] are therefore required. This approach reflects a new trend in the management of infrastructure, which goes beyond the classical public/private dichotomy and implies that "government direction, centrally defined public purpose, and large-scale planning are combined – in still-emergent ways – with market mechanisms, private actors, and public input."[63]

PUBLIC OWNERSHIP

Similarly to Eaves et al., we will assess institutional arrangements to deliver infrastructure according to their capacity to maximize public value creation, accepting that the societies' views on what constitutes public value are diverse and can change over time. To be in accordance with the sociological critique that infrastructure too often rests on expert judgment only, we will not only assess if these arrangements can deliver **publicly accessible** infrastructure (public attributes) that is designed **for the public** (public functions), but also to what extent they can be delivered **of and by the public** (public ownership).

Public ownership extends the debate beyond the question of participatory governance models that provide a space for the public to be consulted, and includes questions regarding **the active participation of the public in the control, funding, and provision of infrastructure** as well. While it is unrealistic for every individual to participate in all aspects of every infrastructure, several authors have proposed **"commoning" as a form of "differentiated publicness."**[64] This concept promotes public participation through the involvement of civil society communities, either focused on specific territories or particular public issues. In this framework, public ownership extends beyond government ownership. Public provision of infrastructure could involve citizen participation or decentralized contributions from various entities, not solely relying on public servants. Public funding could encompass numerous small private donations. Public control might include various governance forms where citizens and civil society organizations have decision-making power, not only through their public representatives.

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[61] European Commission, "Services of General Interest," European Commission, 2023, https://commission.europa.eu/topics/single-market/services-general-interest_en.

[62] Eaves, Mazzucato, and Vasconcellos, "Digital Public Infrastructure and Public Value."

[63] Stephen J. Collier, James Christopher Mizes, and Antina von Schnitzler, "Preface: Public Infrastructures / Infrastructural Publics," Limn, https://limn.it/articles/preface-public-infrastructures-infrastructural-publics/.

[64] Sohn, Kousoulas, and Bruyns, "Commoning as differentiated publicness," 1-8.

Based on this view, Wikipedia could be considered a model of public infrastructure. Wikipedia has clearly public attributes and functions, as its content is shared through a Creative Commons license, ensuring non-exclusive use, and as it supports public goals, which are access to knowledge and education. Additionally, one could consider that it is produced by the public, in this case by a large number of volunteering citizens, funded by the public, as the Wikimedia foundation relies on millions of small donations, and governed by the public, as the non-profit foundation hosting Wikipedia has established open, participative, and democratic decision-making processes to rule its management.[65]

However, delegating power to citizens or communities raises fundamental questions about infrastructure management. Public institutions are not only expected to be democratic but also to adhere to specific rules and regulations. When public services are delegated to the private sector, this typically comes with **public service obligations** aimed at mitigating potential negative externalities, ensuring inclusion (both equal access and equitable distribution of value), and **providing effective transparency and accountability mechanisms**, such as audit systems and grievance redress mechanisms. Sector-specific obligations are usually added to these public service obligations.

According to Mazzucato, there are two more challenges in delegating public services and utilities. The first is ensuring "collective learning and building long-term capabilities and capacities" to counterbalance the strengthening of private expertise, which can create dependencies that negatively affect the public. Secondly, she argues that only states can ultimately ensure the overall "purpose and directionality" necessary for decisions impacting society as a whole.[66]

Public interest		**Public ownership**		
“For the public”		**“Of and by the public”**		
Public attributes	Public functions	Public control	Public funding	Public production
Infrastructure is publicly accessible.	Infrastructure participates in public goals.	Infrastructure is governed by the public.	Infrastructure is funded by the public.	Infrastructure is produced by the public.

Table 2: Defining Publicness: Attributes, Functions, and Ownership of Public Infrastructures, adapted from Davis Eaves et al.

[65] Dariusz Jemielniak, “Wikimedia movement governance: the limits of a-hierarchical organization,” *Journal of Organizational Change Management*, 29 (2016): 361-378, https://www.emerald.com/insight/content/doi/10.1108/JOCM-07-2013-0138/full/html

[66] David Eaves, Mariana Mazzucato, and Beatriz Vasconcellos, “Digital Public Infrastructure and Public Value,” UCL Institute for Innovation and Public Purpose, 2024, https://www.ucl.ac.uk/bartlett/public-purpose/publications/2024/mar/digital-public-infrastructure-and-public-value-what-public-about-dpi.

This section has shown that contemporary perspectives on infrastructure management mark a shift from traditional economic views that confined public intervention to addressing market failures. There is a growing emphasis on public policy's role in ensuring the quality and accessibility of foundational services. This shift challenges the traditional private/public dichotomy and calls for integrating various forms of collectivity into public infrastructure. Public infrastructures should therefore not only have public attributes and functions but also a form of public ownership, which can range from ensuring public controls to public funding or even direct public provision.

The concept of commons, particularly Digital Commons, is gaining prominence as it promotes public participation through the involvement of citizens, civil society, and private entities in resource management. However, this approach also raises questions about how to represent collective interests effectively and ensure the accountable and transparent management of infrastructures. In the following sections of this paper, we will investigate strategies to maximize public value creation in contemporary debates on public digital infrastructures We will examine how these strategies serve the public interest and how they involve the public in the ownership, funding, and control of digital infrastructures.

Policy debates on public digital infrastructures

This section provides an overview of four contemporary policy debates on public digital infrastructures, focusing on policy areas where Digital Commons already play a critical role or where public institutions are developing strategies that include Digital Commons as potential infrastructure providers. It will briefly review some of the history of digital infrastructures, showing how the free market policies of the 1990s have led to the current platform-driven digital environment.

In this context, Digital Commons are often perceived as an alternative that could participate in the development of **a digital landscape relying on collective governance and non-extractive economic models**. It is important to note that debates about Digital Commons as providers of public digital infrastructures tend to focus on infrastructures that are purely digital (made of bits), excluding the physical layers of infrastructure formed by network and computing infrastructures. Indeed, community networks and community hosting services are currently clearly limited to providing local, small-scale, and grassroots network alternatives, struggling to raise the necessary capital and to adapt to public service obligations and regulations designed for private "Big Infra" projects.[67] Digital Commons do, however, offer well-established alternatives to the immaterial layers of digital infrastructure from which most private platforms have emerged, notably because of the scalability of non-rival digital resources. This observation confirms the assumption made earlier that commons are appropriate providers of a public infrastructure when the supply of that infrastructure relies more on human contributions and maintenance efforts than on large capital investments.

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[67] Felix Tréguer, "Supporting Community Networks Through Law and Policy". Workshop on community networking infrastructure, June 2016, Barcelona, Spain: https://www.researchgate.net/publication/309032412_Supporting_Community_Networks_Through_Law_and_Policy.

FROM THE INFRASTRUCTURE IDEAL TO A PLATFORM-DRIVEN DIGITAL ENVIRONMENT

Telecommunication networks, and to some extent even the first computer technologies and the early internet, were born in the era of the "modern infrastructure ideal." Postal, telegraph, and telephone services were historically provided by publicly regulated monopolies or even directly by governments. In the 1960s, the concept of the "computing utility" initially envisaged shared computing power similar to these telecommunications services, ensuring accessibility and affordability for all. Analysts were imagining "giant computers whose central processing unit (CPU) time could be shared, in the same way that electric utility customers share huge power plants." The French Minitel system introduced in the 1980s was based on similar premises.[68]

Across the globe, governments played a significant role in developing foundational technologies, as exemplified by the early development of the internet sponsored by government agencies such as the US Department of Defense's Defense Advanced Research Projects Agency (DARPA) or the US National Science Foundation, who laid the groundwork for a shared network accessible to researchers and, eventually, the general public. Economist Mariana Mazzucato has described this **government involvement in innovation and technological change as the hallmark of an "entrepreneurial state,"** which she observes across a wide range of key technologies – from essential components such as the hard disk drive, microprocessors, memory chips, and LCD displays, to the development of GPS, the HTTP protocol, touchscreen technology, or even virtual assistants.[69]

The internet in particular, as an ubiquitous network of networks, based on the globally adopted TCP/IP protocols, has been considered as a key contemporary infrastructure, especially because of the many essential products and services that depend on it today. Its public governance model, based on multi-stakeholder participation, has led many researchers to consider it both an infrastructure and a global commons.[70] The actual provision of the internet was also largely funded by governments, who invested in the "information superhighways" to support the public uptake of a network originally mostly used by academics. However, with the advent of neoliberal policies, internet service provision became largely deregulated and fragmented into private companies. Today, most internet service providers are private companies, with a few countries offering state-sponsored access to connectivity in public spaces, and only a handful of community-owned networks managed as Digital Commons resisting.[71] While the physical networks managed by telecom operators are still considered infrastructure and regulated

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[68] Jean-Christophe Plantin et al., "Infrastructure Studies Meet Platform Studies in the Age of Google and Facebook," *New Media & Society* 20, no. 1 (January 2018): 293–310, https://doi.org/10.1177/1461444816661553.

[69] Mazzucato, *The Entrepreneurial State*.

[70] Frischmann, "An Economic Theory of Infrastructure and Commons Management."

[71] Félix Tréguer, "Alternative Internet Networks: History and Legacy of a "Crazy Idea". *IAMCR 2017*, July 2017, Cartagena, Colombia: https://shs.hal.science/halshs-01850948/document.

accordingly by policymakers, this model has consistently posed challenges to providing universal, affordable, and reliable access, especially in remote areas.[72]

The development of services on top of the network infrastructures was largely left to market powers, resulting in an unprecedentedly rapid accumulation of private wealth, with some of the most highly valued companies in history emerging in the digital economy. A large number of analyses have provided explanations for these processes, among which the **large network effects that have led to "winner-takes-it-all" situations, data extraction, or the technical possibility to lock-in users** within a product environment or an ecosystem of services. These strategies have been mobilized by contemporary platforms to become bottlenecks of the digital economy – or even essential facilities of the economy in general, notably through their "exclusive control over search engines, ecommerce platforms, and app-stores."[73] While platforms share many features with infrastructure, considering that they serve as a beneficial foundation for a variety of uses and have become truly unavoidable, they "leverage programmability and interconnection to achieve control, rather than relying on direct provision and expansion."[74]

This ability to coordinate heterogenous and independent actors while extracting value from these interconnections has allowed platforms to challenge existing traditional infrastructure, buying the submarine cables forming the internet backbone, competing with broadcast and media infrastructures, or combining cloud computing power and software components, merging them into business models presented as "infrastructure as a service."[75] The vertical integration strategy pursued by these platforms, combined with recent technological developments – in particular, the extensive development and rationalization of centralized cloud computing architectures – best exemplified by the systemic power of massive-scale data center providers (hyperscalers) and the development of artificial intelligence (AI), especially the global hype around generative AI models, has given these platforms additional infrastructural power. Concentrations in cloud computing by companies such as Amazon Web Services (AWS), Microsoft Azure, and Google are already creating a bottleneck for entire cloud computing market segments and threaten to create an additional one over AI systems and applications in the future.[76]

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[72] Christopher Ali, "The Politics of Good Enough: Rural Broadband and Policy Failure in the United States," *International Journal of Communication*, [S.l.], v. 14 (November 2020): 23, https://ijoc.org/index.php/ijoc/article/view/15203.

[73] Nikolas Guggenberger, "Essential Platforms," *SSRN Electronic Journal* (2020): https://doi.org/10.2139/ssrn.3703361.

[74] Jean-Christophe Plantin, Carl Lagoze, Paul N. Edwards, and Christian Sandvig, "Infrastructure Studies Meet Platform Studies in the Age of Google and Facebook," *New Media & Society* (2016): https://journals.sagepub.com/doi/abs/10.1177/1461444816661553.

[75] Kamila Benzina, "Cloud Infrastructure-as-a-Service as an Essential Facility: Market Structure, Competition, and the Need for Industry and Regulatory Solutions," *Berkeley Technology Law Journal* (2019): https://doi.org/10.15779/Z38QV3C43D.

[76] Dieuwertje Luitse, "Platform power in AI: The evolution of cloud infrastructures in the political economy of artificial intelligence," *Internet Policy Review* 13 (2) (2024): doi: 10.14763/2024.2.1768, https://policyreview.info/articles/analysis/platform-power-ai-evolution-cloud-infrastructures.

This increasing **private concentration of infrastructural power** has led to numerous policy debates on digital sovereignty and the need for renewed industrial policies, especially in Europe. But because of the amounts of capital necessary to compete with existing private infrastructures, European countries have still not found any public and coordinated answer to the current situation.[77] In the first half of the year 2024 alone, Microsoft announced that it would invest €4 billion in France[78] and €3.2 billion in Germany[79] to further develop its cloud and AI infrastructure.

RENEWED SOCIAL DEMANDS FOR PUBLIC DIGITAL INFRASTRUCTURES

The platform model has inspired many other organizations, especially in the context of the increasing rationalization and externalization of economic activity, leading to a degree of "platformization" of infrastructure.[80] The model has also inspired the public sector - where platform strategies are sometimes considered to be a new form of governmental action, which focuses on controlling key resources that create an enabling environment for private actors and civil society to provide public goods and services[81]. This vision can be found in the Indian model of "Digital Public Infrastructure" (DPI) that will be discussed in the next section. But the unprecedented power and wealth of private platforms has also led to counter-claims that see "Public Digital Infrastructure" as the very opposite of the platform model. From this perspective, Public Digital Infrastructure is redefined as "a shared set of rules and open protocols," where no single actor "owns a whole suite of tools and can unilaterally set the rules." The platform model indeed contrasts with the protocol-based and collectively-governed network of networks that characterizes the internet. The internet laid the ground for "a protocol-based economy"[82] producing "generative interoperability"[83] that, unlike platforms, allows for a variety of downstream uses without centrally controlling or extracting value from them. Public Digital Infrastructure in this sense therefore comes with a renewed role for the public, which requires

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[77] European Commission, "White Paper - How to master Europe's digital infrastructure needs?" (Communication), COM(2024) 81 final: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14168-White-Paper-How-to-master-Europes-digital-infrastructure-needs_en?_en=.

[78] "Microsoft announces the largest investment to date in France to accelerate the adoption of AI, skilling and innovation", Microsoft website, accessed May 13, 2024, https://news.microsoft.com/fr-fr/2024/05/13/microsoft-announces-the-largest-investment-to-date-in-france-to-accelerate-the-adoption-of-ai-skilling-and-innovation/.

[79] Georgia Butler, "Microsoft to invest €3.2bn in doubling AI infrastructure and cloud capacity in Germany," *Data Center Dynamics* (February 16, 2024): https://www.datacenterdynamics.com/en/news/microsoft-to-invest-32bn-in-doubling-ai-infrastructure-and-cloud-capacity-in-germany/.

[80] Plantin et al., "Infrastructure Studies Meet Platform Studies in the Age of Google and Facebook."

[81] Tim O'Reilly, "Government as a Platform," *Innovations: Technology, Governance, Globalization* 6, no. 1 (January 2011): 13–40, https://doi.org/10.1162/inov_a_00056.

[82] Katja Bego, "Towards Public Digital Infrastructure: A proposed Governance Model," Open Future, accessed December 2022, https://openfuture.eu/wp-content/uploads/2022/12/TowardsPublicDigitalInfrastructure_v0.2.pdf.

[83] "Generative Interoperability" Open Future, accessed June 25, 2024, https://openfuture.eu/publication/generative-interoperability.

addressing both a vast array of socio-economic development challenges and the current concentration of digital markets.[84] The European Union, for instance, has taken many measures to develop legal environments that contribute to an increased interoperability but also established strategies to be more present in international bodies where technical norms and standards are established.[85]

In the context of these trends, the rest of this section will examine current debates on public digital infrastructures. It will be limited to the infrastructures that are purely digital (made of bits), excluding physical layers on the one hand and immaterial and social layers on the other, while acknowledging the intertwined nature of these systems. As mentioned in the previous section, we will consider infrastructures as "shared means to many ends," resulting from the political negotiation of society's basic elements of collective consumption and production. The paper identified the following **four areas of policy debates where social demands** for public digital infrastructures **can be clearly identified**, and where Digital Commons can be part of strategies to maximize public value creation:

1. Controlling technical foundations for the uptake of public and private digital services,
2. Maintaining and securing the shared open foundations of the internet stack,
3. Providing non-extractive alternatives for access to Digital Public Spaces,
4. Supporting collectively-governed platform intermediaries in key economic sectors.

CONTROLLING TECHNICAL FOUNDATIONS FOR THE UPTAKE OF DIGITAL SERVICES

The discourse on Digital Public Infrastructure (DPI) has garnered significant global attention, particularly due to the pioneering efforts and advocacy of the Indian government. India has conceptualized DPI as **open and interoperable technologies that facilitate essential functions for both public and private service delivery**.[86] This concept is notably inspired by India's advancements in digital identity, e-commerce, and payment systems. India's DPI model, known as India Stack, comprises a set of open application programming interfaces (APIs) considered "government-owned, non-competing goods… made available at low costs."[87] This model aims to

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[84] Aarushi Gupta and Aman Nair, "Unpacking Digital Public Infrastructure: Navigating Conceptual Ambiguities," T20 Policy Brief, T20 India, July 2023, https://t20ind.org/research/unpacking-digital-public-infrastructure/.

[85] Clément Perarnaud, "Finding the path to a more open internet - a new European approach towards internet standards," Open Future, accessed February 2024, https://openfuture.eu/wp-content/uploads/2024/02/240320_Finding_the_path_to_a_more_open_internet.pdf.

[86] Vy Dang et al., "Synergising Digital Public Infrastructure and Digital Commons for Sustainable Development," Gateway House, accessed March 2024, https://www.gatewayhouse.in/wp-content/uploads/2024/03/Gateway-House-Publication_Synergising-Digital-Public-Infrastructure-and-Digital-Commons-for-Sustainable-Development.pdf.

[87] Aadya Gupta and Suyash Rai, "The Economic Case for Digital Public Infrastructure," Carnegie India, accessed February 29, 2024, ihttps://carnegieendowment.org/posts/2024/02/the-economic-case-for-digital-public-infrastructure?lang=en.

create an ecosystem of services through DPIs: public institutions offer and **control networks or gateways, on top of which independent but interoperable services can be developed** by individual entities. India's DPIs were mostly developed through public-private partnerships that closely associated with India's non-profit organization iSPIRIT, which represents the Indian software industry.[88]

A key example is Aadhaar, launched in 2010, which is the world's largest biometric ID system. Its open architecture enables various sectoral applications, making it a foundational system for accessing public and private services. As noted by Vy Dang et al., the India Stack has been lauded for fostering innovation in both the private and public sectors and for allowing the government to streamline key digital services. However, it has faced criticism regarding security and privacy risks associated with its centralized nature. Additionally, the public platformization strategy adopted as part of the India Stack development has been questioned because of its increased involvement of for-profit entities in welfare delivery, healthcare, and education. According to Eshani Vaidya, the fact that private entities play a significant role in building and managing digital services can lead to a lack of accountability and contribute to social exclusion, particularly for marginalized groups.[89] Some of these criticisms have led to the establishment of more robust regulatory frameworks around the adoption of DPI in India, and triggered international debates on the need to establish safeguards before deploying DPIs.[90]

The importance of DPI to address common governmental challenges and accelerate development is now endorsed by a range of actors that reach far beyond India. The Brazilian Central Bank (BCB) has for instance launched its own domestic public digital payment infrastructure called "Pix"[91]. Estonia's X-Road, an open source government data exchange system, is an example of a European DPI that is often mentioned internationally. The scalability and adaptability of these solutions has attracted significant interest from various stakeholders, including development organizations, consultancy firms, and digital vendors, eager to leverage these experiences to support the uptake of digital transactions and services. Organizations that have adopted India's DPI vision include the United Nations Development Programme (UNDP),

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[88] Dang et al., "Synergising Digital Public Infrastructure and Digital Commons for Sustainable Development."

[89] Eshani Vaidya, "What's public about India's digital public infrastructures?", Bot Populi, Talking Digital Justice, accessed September 2024, https://botpopuli.net/whats-public-about-indias-digital-public-infrastructures/

[90] "Leveraging DPI for Safe and Inclusive Societies", Interim Report, Office of the United Nations Secretary-General's Envoy on Technology (OSET), United Nations Development Programme (UNDP), accessed April 2024, https://www.dpi-safeguards.org/.

[91] Luca Belli, "Building Good Digital Sovereignty through Digital Public Infrastructures and Digital Commons in India and Brazil," https://cyberbrics.info/ (cyberBRICS, September 11, 2023), https://cyberbrics.info/building-good-digital-sovereignty-through-digital-public-infrastructures-and-digital-commons-in-india-and-brazil/.

the G20, foundations like the Bill & Melinda Gates Foundation and private sector giants like Huawei, Amazon Web Services (AWS) and Mastercard.[92]

The Universal DPI Safeguards Framework has adopted a broad description of DPI as "a set of shared digital systems that should be secure and interoperable, and can be built on open standards and specifications to deliver and provide equitable access to public and / or private services at societal scale and are governed by applicable legal frameworks and enabling rules to drive development, inclusion, innovation, trust, and competition and respect human rights and fundamental freedoms"[93]. This definition envisions a type of public digital infrastructure that emphasizes openness and interoperability (public attributes), but also adherence to key development goals and human rights (public functions). Generally, the openness of DPI means collaboration with non-governmental organizations and the management of certain tools as digital commons. However, there remains ambiguity regarding the "public" nature of DPI ownership and governance.

MAINTAINING AND SECURING THE SHARED OPEN FOUNDATIONS OF THE INTERNET STACK

Another important debate on digital infrastructure concerns more directly the development, maintenance, and security of the various collectively shared layers of the technological "stack"[94]. The boundaries of this stack are difficult to establish because of the growing interconnection and interoperability required among all information systems and devices. As put by Berlinguer, "it is not just physical infrastructure, such as cables, web servers, hardware or data centers, but also infrastructure made, for example, of software, protocols, data, standards, operating systems, and programming languages. (…) The increasingly pervasive and ubiquitous intermediation of digital networks and data flows (…) is contributing to potentially expanding and blurring the scope of the notion of infrastructure."[95]

The analogy of the stack has been recognized to account for the complexity and stratification of these systems, giving the possibility to introduce multiple perspectives while showing interdependencies and hierarchies.[96] Because many of the shared layers of the Internet Stack are based on open source software (OSS) and are governed collectively, they have often been

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[92] Jan Krewer, "Signs of progress: Digital Public Infrastructure is gaining traction", Open Future, accessed March 13, 2024, https://openfuture.eu/blog/signs-of-progress-digital-public-infrastructure-is-gaining-traction/.

[93] Office of the UN Secretary-General's Envoy on Technology (OSET) and United Nations Development Programme (UNDP), "The Universal Digital Public Infrastructure Safeguards Framework" (New York, NY 10017, USA: United Nations, September 2024): https://dpi-safeguards-framework.org/frameworkpdf%20page%208

[94] Benjamin H Bratton, *The Stack : On Software and Sovereignty* (Cambridge, Massachusetts: The Mit Press, 2016).

[95] Marco Berlinguer, "Digital Commons As New Infrastructure: A New Generation of Public Policy for Digital Transformation," *Umanistica Digitale* 5 (11)(2021): 5-25, https://doi.org/10.6092/issn.2532-8816/13695.

[96] T. Straube, "Stacked spaces: Mapping digital infrastructures," *Big Data & Society*, *3*(2)(2016): https://doi.org/10.1177/2053951716642456.

described analytically as digital commons,[97],[98] which together form an "accidental megastructure" without any unique and central form of coordination.

The growing political focus on various Internet Stack layers is mostly the result of a realization of the critical and global role of OSS, with 96% of codebases containing OSS[99] and "roughly 70-90% of any software stack" consisting of OSS.[100] In this context, the foundational role of OSS for a vast array of downstream activities has been widely documented. Frank Nagle estimates that without OSS, companies would face $8.8 trillion in software development costs.[101] A significant study commissioned by the European Commission also highlighted the economic value of OSS: the research revealed a cost-benefit ratio of 1:4 for OSS investments and demonstrated that OSS substantially contributes to the EU's GDP, with a 10% increase in OSS contributions potentially boosting the EU's GDP by 0.4% to 0.6% annually.[102]

Many open source tools are indeed crucial in driving scientific and technological progress, aiding breakthroughs in life sciences, physical sciences, and the digital economy: the open source tool NumFocus allowed, for instance, the production of the first image of a black hole.[103] Additionally, OSS can create shared industrial goods vital for sectors like the automobile industry[104] and support the growth of SMEs,[105] supporting the case for public investments into OSS as part of an "entrepreneurial state" strategy that would proactively support foundational innovations. Digital Commons are also increasingly mentioned in policy debates on alternative ecosystems

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[97] Chinmayi Sharma, "Tragedy of the Digital Commons," *101 North Carolina Law Review 1129* (2023): https://ssrn.com/abstract=4245266 or http://dx.doi.org/10.2139/ssrn.4245266.

[98] Atul Pokharel, "Maintaining the Digital Commons: A Comparison of Debian Linux and Irrigation Canals in Nepal," Watson Institute for International and Public Affairs Research Paper No. 2016-33 (June 28, 2016): https://ssrn.com/abstract=2802653 or http://dx.doi.org/10.2139/ssrn.2802653.

[99] Synopsys, "*2024 Open Source Security and Risk Analysis Report,*" Synopsys Software Integrity Group, 2024, https://www.synopsys.com/content/dam/synopsys/sig-assets/reports/rep-ossra-2024.pdf.

[100] Open SSF and Linux Foundation,"Whitepaper: The Open Source Software Security Mobilization Plan," The Linux Foundation, accessed May 2022, https://openssf.org/oss-security-mobilization-plan/.

[101] Manuel Hoffmann, Frank Nagle, and Yanuo Zhou, "The Value of Open Source Software," Harvard Business School Strategy Unit Working Paper No. 24-038, accessed January 1, 2024, https://ssrn.com/abstract=4693148 or http://dx.doi.org/10.2139/ssrn.4693148.

[102] K. Blind, M. Böhm, P. Grzegorzewska, A. Katz, S. Muto, S. Pätsch, and T. Schubert, "The impact of Open Source Software and Hardware on technological independence, competitiveness and innovation in the EU economy - Final study report". Brussels: European Union Publications Office, 2021. https://data.europa.eu/doi/10.2759/430161

[103] "Case Study: First Photograph of a Black Hole", NumFOCUS, accessed September 2024, https://numfocus.org/case-studies/first-photograph-black-hole.

[104] Johan Linåker and Astor Nummelin Carlberg, "Vision Paper: Open Source Software in the Automotive Industry," Eclipse Software Defined Vehicle (SDV) working group, accessed February 2024, https://newsroom.eclipse.org/news/announcements/vision-paper-open-source-software-automotive-industry.

[105] Open Forum Europe, "FOSS4SMEs Policy Recommendation Report," Erasmus+ Programme of the European Union, Brussels, Belgium, 2019, https://epale.ec.europa.eu/sites/default/files/o3-a3_final_policy_recommendation_report.pdf.

and value chains in the field of AI,[106] based on a mutualized access to critical resources such as data sets and governance models that ensure these resources are resilient to extraction or capture by private interests.[107]

But the interest in the OSS infrastructure behind the Internet Stack is also driven by several external factors: heightened scrutiny of value chains and global dependencies due to the COVID-19 pandemic, rising geopolitical tensions, technological competition, information warfare, and the militarization of digital infrastructures,[108] contributing to the popularity of proposals aimed at strengthening states' digital sovereignty. In this context, some vulnerabilities of OSS – such as the OpenSSL case – have generated political attention to a still widely underinvested political field.

In the 2016 report *Roads and Bridges: The Unseen Labor Behind Our Digital Infrastructure*, the risks of contemporary overreliance on underfunded infrastructure, largely supported by volunteers driven by reputation-building, obligation, or passion, has been established,[109] More and more attention is being paid to the maintenance required by digital technologies, which has historically been associated only with innovation. In the context of OSS, maintenance is essential to keep software up to date and compatible with new systems, to fix bugs, or to patch security vulnerabilities. The volunteers who perform these activities – which tend to become more complex and necessary over time – are increasingly overwhelmed and become potential targets for social engineering attacks, as in the case of the recent XZ Utils vulnerability.[110]

Many analysts see this as a prime example of the "tragedy of the digital commons."[111] where many benefit from a shared resource without contributing back to it in an appropriate way, such as by donating to an open source project's host, who is typically responsible for its maintenance. This also derives from the fact that foundational software (or “tech to build tech”) is often overlooked in comparison with beyond citizen-facing products and services. In response, several

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[106] Joana Varon, Sasha Costanza-Chock, and Timnit Gebru, “Fostering a Federated AI Commons ecosystem,” Coding rights, Policy brief submitted to the T20 Task Force 05, on “Inclusive digital transformation,” under the subtopic “Challenges, Opportunities, and Governance of Artificial Intelligence,” accessed June 2024, https://codingrights.org/docs/Federated_AI_Commons_ecosystem_T20Policybriefing.pdf.

[107] Zuzanna Warso and Alek Tarkowski, “Commons-based Data Set Governance for AI,” Open Future, accessed March 2024, https://openfuture.eu/publication/commons-based-data-set-governance-for-ai/.

[108] “Political Affairs Chief Spells Out Double-edged Nature of Digital Technologies, in Briefing to Security Council,” United Nations, press release, May 23, 2022, https://press.un.org/en/2022/sc14899.doc.htm.

[109] “Roads and Bridges: The Unseen Labor Behind Our Digital Infrastructure,” Ford Foundation, 2016, https://www.fordfoundation.org/work/learning/research-reports/roads-and-bridges-the-unseen-labor-behind-our-digital-infrastructure/.

[110] Nicholas Gates and Jan Krewer, “Responding to XZ utils: Can a digital commons approach reinforce OSS security?”, NGI Commons, April 24, 2024, https://commons.ngi.eu/2024/04/24/responding-to-xz-utils-can-a-digital-commons-approach-reinforce-oss-security/.

[111] Chinmayi Sharma, “Tragedy of the Digital Commons,” *101 North Carolina Law Review 1129* (2023): https://ssrn.com/abstract=4245266 or http://dx.doi.org/10.2139/ssrn.4245266.

calls – both from academia[112],[113] and from open source communities themselves[114] [115] – have been made to consider OSS as part of our public infrastructure, and therefore as a resource that should receive public funding.

In this context, the suggested role of public institutions to contribute to the overall resilience and security of some "critical infrastructure" components of the Internet Stack. This approach typically begins with the development of internal intelligence and understanding of critical systems and their dependencies on societies, economies, and public institutions to identify systemic digital risks.

A notable example is the "Free and Open Source Solutions for European Public Services" (FOSSEPS) pilot initiated by the European Parliament to map the common dependencies of European institutions on OSS.[116] Unlike the traditional tendency of states to focus inwardly on their largest national industrial players, this approach aims to create a more decentralized digital landscape by developing funds that can provide sustainable and long-lasting support for the OSS ecosystem.[117] The suggested strategies also involve opportunistic investments in targeted packages, by tracking dependencies and vulnerabilities, conducting risk assessments, and identifying needs from the grassroots level. This requires ongoing dialogue between OSS communities and dedicated public institutions, exemplified by the German Sovereign Tech Fund, an initiative launched in 2022.[118] These ideas are also reflected in the industry-inspired trend to establish Open Source Program Offices (OSPOs), in order to mainstream collaboration with OSS communities in public administrations.[119]

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[112] Stewart Scott, Sara Ann Brackett, Trey Herr, and Maia Hamin, "Avoiding the success trap: Toward policy for open-source software as infrastructure," Atlantic Council, report, accessed February 8, 2023, https://www.atlanticcouncil.org/uncategorized/open-source-software-as-infrastructure/.

[113] Tom Milton, Cailean Osborne, and Matt Pickering, "A UK Open-Source Fund to Support Software Innovation and Maintenance," UK Day One, April 17, 2024, https://ukdayone.org/briefings/a-uk-open-source-fund.

[114] Tobie Langel, "1 Billion Dollars for Open Source Maintainers," presentation at State of Open Con (February 2024): https://speaking.unlockopen.com/nBXJS5/1-billion-dollars-for-open-source-maintainers.

[115] Matthew Hodgson, "Open Source Infrastructure must be a publicly funded service," *Matrix* (blog), April 4, 2024, https://matrix.org/blog/2024/04/open-source-publicly-funded-service/.

[116] Deloitte Consulting and Inno3, "Identify (and find ways to help fix) critical open source software used by European Public Services," European Commission, June 2022, https://joinup.ec.europa.eu/sites/default/files/news/2022-08/FOSSEPS%20-%20Critical%20Software%20Study%20Report%202022.pdf.

[117] Scott, Brackett, Herr, and Hamin, "Avoiding the success trap: Toward policy for open source software as infrastructure."

[118] Sovereign Tech Fund, "Strengthening Digital Infrastructure and Open Source Ecosystems in the Public Interest," SPRIND GmbH, accessed June 2024, https://www.sovereigntechfund.de/.

[119] "OSPOs for Good: Building & Designing Cooperative Digital Infrastructure," OpenForum Europe, accessed June 21, 2023, https://openforumeurope.org/comprehensive-report-on-the-role-of-ospos-in-sustainable-digital-transformation/.

PROVIDING NON-EXTRACTIVE ALTERNATIVES FOR ACCESS TO DIGITAL PUBLIC SPACES

Another important debate on Public Digital Infrastructure has emerged in response to the private-led development of digital services in the 21st century, which has – as demonstrated above – resulted in the dominance of a few large companies over key infrastructures not only for the economy but for society as a whole. These debates focus on the risks to human and digital rights posed by the provision of key digital services – especially widely used – by monopolistic players whose business models are based on surveillance capitalism.[120] While some of these risks have been addressed by a new set of regulations that emerged in 2010 as a response, including the General Data Protection Regulation (GDPR), but also the Digital Markets Act (DMA) and the Digital Services Act (DSA) in the EU, this section will show that many authors still argue that public institutions should play a stronger role in creating non-private alternatives for online speech and debate, which includes many social media platforms, forming spaces for political and civic engagement, spaces of knowledge sharing and scientific production, or educational and cultural spheres.

The 2020 Waag report "Digital European Public Spaces," for example, argues that while physical public spaces are governed by a social contract that protects public values, digital spaces lack such basic agreements. Social media platforms are often perceived as digital public spaces due to their widespread accessibility and free use, but they still operate under private rules without democratic accountability. In fact, platforms enforce their own rules and use opaque algorithms to manage content, curating political discourse based on hidden rules and agendas.[121] Given that a digital world dominated by private corporations cannot effectively guarantee privacy, democratic debate, and human rights, there is a growing social demand for "digital services and platforms that exist outside the control of commercial entities that extract value from users of their platforms."

According to Paul Keller and Zuzanna Warso,[122] public institutions should therefore participate in the design of "fora for public and private exchanges, access to information, and tools for civic organization" that "adhere to democratic and collective forms of governance."[123] This underlying vision for digital public spaces has been adopted by several European stakeholders in a

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[120] Shoshana Zuboff, *The Age of Surveillance Capitalism* (Oxford, Oxford University Press: 2019).

[121] Sander van der Waal, Marleen Stikker, Max Kortlander, Quirine van Eeden, Tom Demeyer, and Stefano Bocconi, "Online European Public Spaces," Amsterdam: Waag, 2020. https://culturalfoundation.eu/wp-content/uploads/2021/05/Waag-Report-on-European-Digital-Public-Spaces.pdf.

[122] Zuzanna Warso is one of the two authors of this publication. Jan Krewer and Zuzanna Waros are both employed by the Open Future Foundation, co-founded by Paul Keller. The Open Future Foundation is a think tank that promotes the concept of Digital Public Space: http://openfuture.eu/about/

[123] Paul Keller and Zuzanna Warso "Digital Public Space Primer - Investing in public digital infrastructures to secure digital rights," Open Future, October 2023, https://openfuture.eu/wp-content/uploads/2023/10/231024DPS_primer.pdf.

manifesto calling for governments to take more responsibility in the maintenance of a "public stack" for a Shared Digital European Public Sphere (SDEPS).[124]

In his definition of digital public spheres inspired by Habermas, Christian Fuchs emphasizes the "democratic, non-capitalist and unideological character" of the public sphere in order to effectively facilitate critical public debate. In this context, the technical infrastructure providing access to such spheres should be "publicly owned and managed by independent, non-profit organizations."[125] This approach is similar to the research results and policy recommendations of Ethan Zuckermann's Initiative for Digital Public Infrastructure at the University of Massachusetts at Amherst.[126] For Zuckermann, governments should support new online media institutions, similar to their establishment of public service broadcasters such as the British Broadcasting Corporation (BBC) at the beginning of the 20th century. They should run interoperable, standards-based communication protocols, messaging applications, networking services or media platforms. Such new institutions should be "publicly spirited" but "diverse in funding," "plural in purpose," "participatory in governance," and "publicly auditable and reviewable."[127] Several proposals to reinvent pluralism in the digital age have adopted the idea that public institutions' role should be to allow citizens to exercise their rights by creating independent public spaces where citizens could individually and collectively decide about moderation rules, for instance by developing alternative forms of algorithmic recommendations.[128]

Many authors – from Zuckermann to Fuchs – consider Wikipedia and other Digital Commons to be good examples of the new type of public service media that governments should support. For Keller and Warso, Digital Commons are also "a key mechanism for the provision of a Public Digital Infrastructure," while recognizing the necessity of significant public intervention to enable non-profit alternatives to scale and compete effectively.[129] This raises the question of defining a new relationship between public institutions and Digital Commons. In addition to the historical European models for investing in media landscapes to ensure plurality, contemporary developments in knowledge infrastructures can offer interesting insights in this respect. In the context of the advent of Open Science, many public institutions have indeed financially supported the development of open infrastructures which are largely hosted by non-profit

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[124] Paul Keller, "Introducing SDEPS - Shared Digital European Public Sphere," Centrum Cyfrowe, Commons Network, and publicspace.online, accessed July 5, 2021, https://shared-digital.eu/introducing-sdeps-shared-digital-european-public-sphere/.

[125] C. Fuchs, "The Digital Commons and the Digital Public Sphere: How to Advance Digital Democracy Today," *Westminster Papers in Communication and Culture*, 16(1)(2021): 9–26, https://doi.org/10.16997/wpcc.917.

[126] Initiative for Digital Public Infrastructure at UMass Amherst, "Initiative for Digital Public Infrastructure," publicinfrastructure.org, 2021, accessed september 2024 https://publicinfrastructure.org/.

[127] Ethan Zuckerman, "The Case for Digital Public Infrastructure," Knight First Amendment Institute, January 17, 2020, https://knightcolumbia.org/content/the-case-for-digital-public-infrastructure [https://perma.cc/3NDZ-CCPK].

[128] Anne Alombert, "Assurer nos libertés à l'ère de l'intelligence artificielle," Conseil national du numérique, March 2024, https://cnnumerique.fr/assurer-nos-libertes-lere-de-lintelligence-artificielle.

[129] Keller and Warso, "Digital Public Space Primer - Investing in public digital infrastructures to secure digital rights."

organizations, with "strong and widespread commitment to community engagement."[130] For Mounier-Primbault, the example of knowledge infrastructures demonstrates that future infrastructures should not only rely on "supposed non-values (such as rationality, efficiency, emergency, short-term)," but also "embed values" to offer an alternative model to the extractivism of the platform mode and be part of a resilient and sustainable community ecosystem.[131]

SUPPORTING COLLECTIVELY-GOVERNED INTERMEDIARIES IN KEY ECONOMIC SECTORS

A final important area of policy debate on public digital infrastructures and alternative architectures to the private platform model is represented by debates inspired by the platform cooperative movement. Platform cooperatives are collectively owned and democratically governed, in contrast to venture capital-funded platforms. The term "platform cooperativism" was introduced by Trebor Scholz in his 2014 article, "Platform Cooperativism vs. the Sharing Economy."[132] The goal of his article was to shed light on the exploitation and manipulation of both workers and users by platforms, and to suggest that both groups could benefit from alternative models. The term is now largely associated with solutions to the abuses of the "gig economy," which involves an increasing reliance on temporary and part-time work performed by independent contractors and freelancers, but also significant transfers of wealth as commissions and fees are applied by these international platforms to sometimes very local transactions.

According to the EU, "over 28 million people in the EU work through one (or more) of these digital labor platforms. In 2025, that number is expected to reach 43 million people."[133] While various regulatory efforts have been made to mitigate some of the negative externalities and impacts of platform work, such as the Platform Work Directive, several actors, including the Platform Coop Consortium, are calling for more active support from public institutions for the development of collectively-owned platforms. Such policies are considered to offer opportunities to restructure current value chains for digital labor and to contribute to the development of local economies.[134]

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[130] Gail Steinhart and Lauren Collister, "Announcing the State of Open Infrastructure Report 2024," *Invest in Open Infrastructure* (blog), May 28, 2024, https://investinopen.org/blog/announcing-the-state-of-open-infrastructure-2024/.

[131] Mounier and Primbault, "Sustaining Knowledge and Governing Its Infrastructure in the Digital Age: An Integrated View."

[132] Trebor Scholz, "Platform Cooperativism vs. the Sharing Economy", Medium, December 2014, https://medium.com/@trebors/platform-cooperativism-vs-the-sharing-economy-2ea737f1b5ad#.575nndfdq.

[133] "COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT REPORT Accompanying the document Proposal for a Directive of the European Parliament and of the Council to improve the working conditions in platform work in the European Union", European Commission, December 10, 2021, https://op.europa.eu/en/publication-detail/-/publication/48491c8f-59bb-11ec-91ac-01aa75ed71a1.

[134] Alexandre Bigot-Verdier, "Plateformes coopératives: infrastructures territoriales de coopération," La Coop des Communs, accessed October 2020, https://coopdescommuns.org/fr/rapport-plateformes-cooperatives-infrastructures-territoriales-de-cooperation/.

Collectively-owned platforms include various alternatives that can range from platforms established and owned by public institutions to platforms managed by informal collectives. The report "Policies for Cooperative Ownership in the Digital Economy" by the Platform Cooperativism Consortium and the Berggruen Institute examines government policies affecting collectively-owned platforms in various regions. The report covers several supportive measures that have already been implemented, such as cooperative legislation reforms, tax benefits, public procurement incentives, business support services, and cross-border municipal cooperation.

While these policies have fostered a conducive environment for some platform cooperatives, and while examples of publicly-owned platforms for local transportation exist in certain cities, for instance in Brazil, the report acknowledges that no collectively-owned platform can yet compete with venture capital-funded platforms and their financial resources. The report therefore concludes that the public funding of cooperative platforms should be part of "national, regional, and municipal development strategies" that blend regulatory measures with funding that could also include "direct state ownership,"[135] an approach that is reminiscent of approaches advocating a form of industrial policy.

Learnings from contemporary debates on public digital infrastructures

In reviewing current policy debates on public digital infrastructures, several key issues have emerged. First, infrastructure policies result from a specific and political problematization of social relations that defines a hierarchy between elements that are perceived as foundational because they provide a generative input into a wide range of activities. This makes infrastructures recognized for their society-wide economic and social functions, even though their overall impact and spillover effects remain challenging to measure. Secondly, from a supply perspective, infrastructures can require substantial initial investments. Their inherent fragility and potential need for reconfiguration demand ongoing maintenance, which involves significant human and financial resources. The Commons, as a resource management principle that has emerged as a more participatory alternative to the private and technocratic nature of "Big Infra" projects, appears to be well suited for infrastructures that rely heavily on ongoing human contributions and maintenance efforts. This observation also applies to digital infrastructures, where the Digital Commons seem to participate in the development of a protocol-based digital landscape relying on collective governance and non-extractive economic models.

Infrastructures must ensure interoperability for the secure and stable circulation of people, goods, resources, capital, or information. They possess the capacity to set norms and standards, but also to include and exclude. For this reason, effective accountability mechanisms, such as audit systems and grievance redress mechanisms, are essential components for public infrastructures. The public nature of infrastructures is subject to different interpretations. Modern understandings do not limit this nature to government ownership and, instead, analyze

[135] Trebor Scholz, Morshed Mannan, Jonas Pentzien, and Hal Plotkin, "Policies for Cooperative Ownership in the Digital Economy," *Platform Cooperativism Consortium* (blog), Berggruen Institute, December 2021, https://platform.coop/blog/policies-for-cooperative-ownership-in-the-digital-economy/.

publicness as a spectrum or as a process that should maximize their public value. Hence, while public infrastructures should have public functions and attributes, the degree of public ownership or public involvement in the production, funding, and control of infrastructures can vary.

While the free market policies of the 1990s have led to the current platform-driven digital environment, the high social demand for public digital infrastructures has led to new policy debates that position the state as an "entrepreneurial state" that provides infrastructure that is built on the principles of openness – favoring a digital landscape based on "generative interoperability." Policy debates focus on the diverse public functions that digital infrastructures should support and the derivative uses they should enable. The political demands that current efforts to build public digital infrastructures are trying to answer include the need for technical foundations for public and private digital services, which are usually referred to as DPI, critical components of the open technological stack, communication services and platforms to access public spaces, and shared production platforms. All are seen as vital generative inputs necessary for contemporary economic and social well-being. There is a consensus on the public attributes of the technical objects forming public digital infrastructures, particularly their openness and non-exclusive nature, which qualifies most of them as digital public goods. However, various forms of public ownership have been proposed for these different spheres of public digital infrastructures, reflecting a nuanced approach to ensuring their public character. The criticism against the centralized architecture of certain models shows the importance of public ownership and governance. Technical attributes alone, such as interoperability, are indeed not sufficient to ensure the maximization of public benefits.

Digital Commons play an important role in the provision and management of many of the alternatives to the private platform model and can play a role in the public provision of digital infrastructure in all the fields currently discussed by policymakers. For DPI policies, the strategy usually involves public institutions controlling protocols and norms to ensure interoperability, supported by public-private partnerships. The participation of the development and maintenance of the Internet Stack relies on an ecosystem strategy, with a mix of private and public funds to back open source software (OSS) communities, with OSS projects managed as Digital Commons. In the realm of public spaces, public-commons partnerships seem to be key, with public funding supporting independent infrastructures managed as Digital Commons. For co-production platforms, the strategy deployed by policymakers blends policy instruments to restructure digital value chains, advocating for collective management of these platforms.

Category	Social demand (public function)	Systems and objects with public attributes	Public value maximization strategy	Public ownership (control, funding, production)
Digital Public Infrastructure (DPI)	Uptake of digital transactions and services to support growth and inclusion.	Open APIs, gateways, and software buildings blocks for identity, data exchange, or payment systems.	Platform strategy: public institutions control protocols and norms to ensure interoperability.	Public-private partnerships are established to deploy public services on top of these building blocks.
Internet Stack	Secure, reliable, and sovereign internet for industries, public institutions, and society at large.	Foundational open source software components and libraries, protocols, data, standards, operating systems, and programming languages ("tech to build tech").	Ecosystem strategy: development of private and public funds to support OSS communities as well as strategic investments in critical dependencies.	OSS projects are usually produced and managed as Digital Commons (see Berlinguer).
Public spaces	Access to healthy online spaces for civic and political engagement.	Interoperable, standards-based communication protocols and open networking services.	Public-commons partnerships: public funding that supports plural and independant infrastructures.	Infrastructures have independent governance models that ensure transparency and pluralism.
Co-production platforms	Collective control over digital inter-mediation of production and consumption.	Open data and open source components of intermediation platforms.	Common ownership: blending policy instruments to support the restructuring of digital value chains.	Platforms should be managed democratically, as opposed to venture capital-funded platforms.

Table 3: Overview of Strategies Behind Major Public Digital Infrastructure Discourses.

5. DIGITAL COMMONS AND THE STATE

Characteristics of Digital Commons

In Section 1, we have shown the role that Digital Commons already play in providing some of the fields of public digital infrastructures that are currently discussed by policymakers and that their value is increasingly recognized in this context. This section provides an overview of the different ways in which the relationship between Digital Commons, the state, including public administration has been conceptualized and theorized to date. In addition, we provide case studies to illustrate how the interplay has unfolded in different contexts, shedding light on the dynamics and implications for both Digital Commons and state actors. This analysis seeks to improve understanding of the relationship between the Digital Commons and the state, as the interaction between these entities becomes particularly important when Digital Commons serve as public digital infrastructures.

A substantial body of literature explores the concept of Digital Commons, and it is beyond the scope of this paper to offer a comprehensive review of the various stances adopted over the past few decades on this topic. For the purposes of this publication, Digital Commons are defined by three key features. First, they are based on a **digital resource**. A digital resource, understood here as one that can be broken down into bits or binary digits, is considered a non-rivalrous good—its value does not diminish, even when consumed by multiple users, though physical mediums may be required for access. Some authors even describe digital resources as anti-rival goods[136]. The second characteristic is **community** – Digital Commons are predicated on distributed production and are managed collectively by a group rather than by a single individual or entity. These communities coordinate not through pricing or subordination but through voluntary peer production. Lastly, Digital Commons are defined by a **governance** system with established rules for access and sharing of the resource. These rules are primarily designed to safeguard the resource's development and sustainability against exclusive uses and profit-making and can make a resource completely non-excludable – for instance, when open source licenses are employed. Moreover, the governance systems encourage deliberation and free participation by community members, ensuring their design promotes sustainable and inclusive use.[137]

The Digital Commons as the third way beyond the market and the state?

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[136] Steve Weber, *The Success of Open Source* (Cambridge, Mass. ; London: Harvard University Press, 2005).

[137] For an analysis of what distinguishes digital from traditional ("earthly" or "tangible") commons and what makes digital ("intellectual") commons special, see e.g., James Boyle, "The Second Enclosure Movement and the Construction of the Public Domain," SSRN Electronic Journal (2003): https://doi.org/10.2139/ssrn.470983. See also Mélanie Dulong De Rosnay and Felix Stalder, "Digital Commons," Internet Policy Review 9, no. 4 (December 17, 2020): https://doi.org/10.14763/2020.4.1530. "Unlike tangible commons (such as urban gardens, forests or meadows), the digital commons (such as free software or Wikipedia) are not affected by overuse or material exclusivity. However, their existence can still be threatened by undersupply, inadequate legal frameworks, pollution, lack of quality or findability."

Much of the classic literature on the Digital Commons examines its role within the modern market economy and its potential to influence and disrupt market structures by fostering peer-to-peer collaboration and decentralized production. Benkler's work has been instrumental in characterizing the role of information commons and decentralized collaboration for innovation, information production, and freedom in the networked economy and society.[138]

The (Digital) Commons was sometimes seen as offering **a radical possibility of a world beyond the market and the state**[139] and as a "third way of organizing society and the economy that differs from both market-based approaches with their orientation toward prices, and from bureaucratic forms of organization with their orientation toward hierarchies and commands;" a "socially progressive alternative to producing and sharing resources and to organizing collective action (...)."[140] In that sense, the Digital Commons was considered as having "post-capitalist potential."[141]

When the (Digital) Commons was conceptualized as a counterpoint to both the capitalist market and the "centralized-controlled state politics,"[142] the Digital Commons and the state were positioned as opposing forces. Even within this perspective of the Digital Commons-state relationship, the value and necessity of state support for individual Digital Commons – for example, in areas like open science – is recognized.

In his analysis of free and open source software (FOSS), Berlinger highlights the evolution of commons studies, emphasizing the shift from viewing commons as autonomous spheres separate from the market and the state to understanding them as entities that interact with markets.[143] He proposes three hybrid arrangements for understanding this interplay: semi-commons, shared infrastructure, and ecosystem creation.[144] While the transition to FOSS is well

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[138] Benkler introduced the notion of peer-to-peer production based on commons. He designated a new form of production, which relies neither on hierarchical control, nor on the market, and which allows the production of intangible goods with greater efficiency, as human capital has become the most determining factor of success in the context of an economy based on innovation. See: Yochai Benkler, *The Wealth of Networks: How Social Production Transforms Markets and Freedom* (New Haven, London: Yale University Press, 2006).

[139] David Bollier, Silke Helfrich, and Commons Strategies Group, eds. *The Wealth of the Commons: A World beyond Market and State* (Amherst: Levellers Press, 2012).

[140] Dulong De Rosnay and Stalder, "Digital Commons."

[141] Christian Fuchs, "The Digital Commons and the Digital Public Sphere: How to Advance Digital Democracy Today," *Westminster Papers in Communication and Culture* 16, no. 1 (March 22, 2021): https://www.westminsterpapers.org/article/id/917/.

[142] Dulong De Rosnay and Stalder, "Digital Commons."

[143] Marco Berlinguer, "Digital Commons as New Infrastructure," *Umanistica Digitale* No. 11 (January 25, 2022): 5-25, https://doi.org/10.6092/ISSN.2532-8816/13695.

[144] The semi-commons model allows for the parallel growth and coexistence of markets and commons, enabling open business models such as service sales, support, and freemium offerings. The core software remains a commons, while commercialization opportunities arise from the shared base. The shared infrastructure model explains why companies adopt FOSS, as it allows market participants to share and reduce the costs and risks associated with production components. The ecosystem creation model highlights the strategic use of FOSS to drive innovation and disrupt industries.

underway in the marketplace, public administration and policymakers are struggling to effectively engage with the model. Berlinger attributes this to two factors. First, neoliberal political orientations discourage public policy and the public sector from directing and guiding technological development. Second, the individualistic and libertarian ethos of early FOSS communities further complicated the role of government and public policy in these environments. These factors make it difficult to rethink and redefine the role of government in FOSS-driven public digital infrastructures.

This analysis points to the fact that the relationship between the Digital Commons and the state is porous, and that neither the category of Digital Commons nor the role of the state in relation to it is monolithic, but can vary significantly depending on the political, economic, and social context.

Operationalizing the relationship between Digital Commons and the state

As noted above, the discourse of commons is marked by a significant tension between the commons and the state. Many researchers and practitioners, particularly in digital communities that are more open to libertarian ideas, emphasized the decentralized and self-regulating nature of commons, and have been skeptical of public intervention. At the same time, other researchers have seen the rise of commons as an opportunity to rejuvenate or reclaim historic public services.

Traditionally, the relationship between the state and the many commons has been conceptualized as **a conflict between two distinct social systems – communal resource management (the commons) and state-driven processes** such as privatization and enclosure. In the case of commons, resources are managed collectively by a community, with rules and norms established by the community members themselves. On the other hand, the state, especially in its neoliberal form, often promotes individual ownership and market-based resource allocation. This has led to processes where common lands or resources are converted into private property. Such state-driven processes have historically resulted in significant social and economic changes, often at the expense of communal resource management.[145] The most evident and widely quoted instance of this tension was the enclosures and privatization of common lands during the agricultural revolution in Europe.

The antagonism and tension between commons and the state is not only historical but continues to manifest itself in contemporary contexts, including the digital realm. With the advent of the internet, new forms of commons have arisen, and the relationship between these Digital Commons and the state has continued to be a subject of theoretical inquiry. In the Digital Commons sphere, this relationship has a distinct aspect related to the origins of the internet,

[145] "Constructive Confrontation or Constructive Tension – the State and the Commons," *Green European Journal*, November 28, 2016: https://www.greeneuropeanjournal.eu/constructive-confrontation-or-constructive-tension-the-state-and-the-commons/.

which was initially propelled by government military funding. Despite this state-led initiative, the academic community played a significant role in the creation of the internet and enjoyed considerable freedom in its development.[146] Thus, the emergence of the internet points to a deeply rooted interplay between top-down and bottom-up efforts to build and sustain the Digital Commons.

In the introductory chapter of *The Wealth of Networks*, Benkler points to the "rise of individual and cooperative private action and the relative decrease in the dominance of market based and proprietary action." Then he goes on to ask, "Where in all this is the state?" Benkler notes that in both the United States and Europe the state has often supported market-based industrial incumbents at the expense of individuals in the emerging networked information economy. Benkler criticizes state interventions that cater to incumbents or attempt to optimize outdated modes of information and cultural production. However, he does not object to the state pursuing liberal projects and commitments and notes that his position is not rooted in a theoretical skepticism about the state. He suggests that the state could play constructive roles, such as funding neutral broadband networks and basic research, as well as regulating to prevent monopoly control over digital resources.

According to Benkler, the state's role is limited due to the trajectory of markets and the rise of individual and social action in the digitally networked information environment. He sees nonmarket individual and social action as the most important domain for advancing liberal commitments, given the economics of computation, communications, information, knowledge, and cultural production. Despite this, Benkler does not resist many of the roles traditionally played by the liberal state. He concludes that once the networked information economy stabilizes and the importance of voluntary private action outside of markets is understood, the state can adjust its policies to facilitate nonmarket action and use its outputs to support liberal commitments. In other words, for Benkler, **the state has historically disrupted and interfered with rather than supported the commons**, but there is potential for a more nurturing relationship. At the same time, this potential is limited by the economics of commons-based peer production.

The work of legal scholars such as Lawrence Lessig and James Boyle has emphasized the key role of state-adopted legal and institutional frameworks, particularly intellectual property law, in governing Digital Commons and ensuring equitable access. More recently, other scholars have also pointed to the need for legal frameworks to protect Digital Commons from enclosure or appropriation, given **the risk of public investment being captured to produce open resources that are then commoditized by large corporations**.[147]

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[146] See e.g., Justyna Hofmokl, "The Internet Commons: Towards an Eclectic Theoretical Framework," *International Journal of the Commons* 4, no. 1 (2010): 226–50, https://www.jstor.org/stable/26523021.

[147] Dulong De Rosnay and Stalder, "Digital Commons."

Scholarship has also looked at legislative interventions that go beyond guaranteeing access and protecting the commons from enclosure, but that can "act as leverage for commoners."[148] Based on the analysis of five specific pieces of legislation adopted in France between 2014 and 2016, Peugeot suggested a typology of the legal devices protecting or promoting the commons. She distinguished four functions that encompass the law's various capacities in relation to commons: the ability to facilitate, protect, institute, and contribute.

In this framework, facilitation involves the extension of traditional property rights structures, achieved through exceptions in copyright laws or the establishment of alternative management systems. Protection focuses on protecting commons from the threat of enclosure by legally recognizing their existence or prohibiting exploitative practices. These two functions correspond to the roles of legal regulation recognized above. Institution, on the other hand, goes further in that it involves more active promotion of cooperative and democratic governance frameworks. Finally, contribution supports commons either directly by providing open data or indirectly by adopting free software.

Similarly, in the context of FOSS, Berlinguer looked at different pro-FOSS policy areas that ranged from allowing the use of FOSS in public administration, requiring that public procurement give equal consideration to FOSS alternatives, and policies favoring FOSS solutions over proprietary ones, to attempts to make the use of FOSS mandatory in public administration. In the context of the creation and maintenance of scientific data commons, Contreras distinguished nine functional roles that state actors can play.[149] He proposed the following categories: creator, funder, convener, collaborator, endorser, curator, regulator, enforcer, and consumer, while recognizing that some of them are overlapping.

Some of the most recent studies by Sebastien Shulz on the relationship between the state and Digital Commons look into the "commonization of digital public goods and services."[150] This is a process of **blending ("hybridization") self-governed citizen communities with hierarchical public administration**. This field of inquiry is guided by three main questions. First, how can equal access rights and administrative protection of sensitive data coexist? Second, how can the horizontal logic of peer production be integrated into the hierarchical production of official databases and software by bureaucratic administrations? And third, how can hierarchical management of public goods and services be reconciled with citizen self-governance institutions? These three questions correspond to the features of Digital Commons: equal access, co-production, and self-governance. In the process of hybridization between Digital Commons and public administration, these features are operationalized through open data initiatives, citizen crowdsourcing, and co-governance.

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[148] Valerie Peugeot, "Facilitatrice, protectrice, instituante, contributrice : la loi et les communs," VECAM, accessed May 6, 2024, https://vecam.org/_old/Facilitatrice-protectrice-instituante-contributrice-la-loi-et-les.html.

[149] Jorge L. Contreras, "Leviathan in the Commons: Biomedical Data and the State," in *Governing Medical Knowledge Commons*, eds. Katherine Strandburg, Brett Frischmann, and Michael Madison (Cambridge, Cambridge University Press, 2017).

[150] Sébastien Shulz, "Moving from Coproduction to Commonization of Digital Public Goods and Services," *Public Administration Review* (February 15, 2024): https://doi.org/10.1111/puar.13795.

Shulz focuses on the power dynamics between citizens and administrators in co-governing digital public goods and services. Case studies analyzed by Shulz confirm there is a tension between the desire of citizen communities to self-organize and the hierarchical administrative procedures imposed by the state actors. Shulz identifies five factors that enhance and two that hinder citizen power in the co-governance of commonized digital public goods and services. Factors that enhance citizen power include

1. Support within the administration for the commonization,
2. Political context favorable to commons-like reforms,
3. Willingness to adapt the existing state-centric institutions,
4. Opening of working and organizational digital workspaces, and
5. The ability to modify or create new legal administrative rules so as to institutionalize citizen-centric co-governance.

The fact that only a small proportion of citizens are involved in shared governance and the tendency towards "state-ization" are, on the other hand, factors that limit the power of citizens in digital co-governance arrangements. While in this study, Shulz looks into commonized public goods – and this process is distinct from converting Digital Commons into public goods or public digital infrastructures – the factors identified by Shulz remain relevant in both scenarios.

Insights from the policy debates on Digital Commons and the state

Experts have emphasized the necessity for legal structures to safeguard Digital Commons from being enclosed or appropriated. More recent studies have also examined legislative measures that not only ensure access and shield Digital Commons from enclosure, but also serve as a catalyst for Digital Commons.

In his study of the commonization of public goods, Shulz identified factors that enhance citizen power in the co-governance of commonized digital public goods and services. These factors are also relevant for enabling Digital Commons to serve as providers of public digital infrastructures. Essentially, a political environment that is conducive to commons-based reforms is a prerequisite for allowing Digital Commons to fulfill the functions of infrastructures. Political will and supportive policies that cover the different capacities of the state in relation to Digital Commons (the ability to facilitate, protect, institute, and contribute) must drive the transition and ensure its sustainability. Moreover, when considering the assignment of the role of public digital infrastructures to the Digital Commons, **public and state institutions may need to adapt to include elements of community management and collective decision-making**. The ability to modify or create new administrative rules is critical for establishing the new arrangements and ensuring their legality and sustainability.

While the recognition of Digital Commons as providers of public digital infrastructures can bring some opportunities, it also has implications for their governance models. First, there's the risk of

"state-ization," which refers to the potential encroachment of state control or influence over Digital Commons. While increased state involvement could bring more resources and support, it could also undermine the autonomy and self-governance that are fundamental characteristics of Digital Commons. **Government-imposed regulations or standards could stifle a Digital Commons community**, changing the very nature and "spirit" of the commons. Second, serving as public digital infrastructures would bring additional obligations and requirements. Digital Commons would need to ensure a level of reliability, accessibility, and security expected of public infrastructure. This may require the implementation of more robust systems and protocols, which may require additional resources and expertise. In addition, increased public scrutiny and accountability would be inevitable given the public function that Digital Commons would serve.

Recognizing Digital Commons as providers of public digital infrastructures also requires a shift in policy. This shift must take into account the significance of the role that Digital Commons play and the different functions that the government can fulfill in relation to them. While the state's roles of facilitator, protector, institutor, and contributor already encompass a wide range of actions and responsibilities toward commons, the recognition of Digital Commons as providers of public digital infrastructures introduces additional complexities and new responsibilities, in particular in terms of the need to maintain and sustain the commons.

In this new context, Digital Commons may be subject to increased regulation and oversight. Policies would need to be developed to ensure that they meet certain standards of reliability, accessibility, and security. Policies would also need to be implemented to provide funding and resources to Digital Commons in recognition of their role in providing public infrastructure. These additional responsibilities could be interpreted as a new role for the state. In this role, the state assumes a more active and ongoing responsibility for ensuring the health, sustainability, and public utility of Digital Commons. This includes not only protecting and contributing to them, but also **actively managing and overseeing their operation in a way that serves the public interest**.

As far as implications for public policy are concerned, one finding from Berlinger's research on FOSS is also relevant.[151] Berlinger emphasizes the need for a new generation of public policy to navigate the new political economy, which includes combining different regimes of ownership, governance, and value creation, as well as managing a tripartite governance system that consists of governments, markets, and communities. Policymakers need to address the shortcomings of each governance system. To achieve this, they must design new governance methods that provide the essential elements of stability and standardization, while ensuring spaces for experimentation, innovation, and growth of new markets.

[151] Berlinguer, "Digital Commons as New Infrastructure."

6. CASE STUDIES

Methodology of the case studies

The case studies in this paper explore the interactions betweenDigital Commons and infrastructure. They focus on novel forms of public support for infrastructure provision through Digital Commons. The case studies cover initiatives that specifically address an infrastructure-related challenge, i.e., support for the sustainable provision and maintenance of a service, as opposed to one-off research and innovation funding. The case studies have been guided by the following research questions:

- Under what conditions can Digital Commons (community-governed digital resources) participate in the provision of infrastructure (systems that have society-wide economic or social functions)? What type of infrastructural services are provided by Digital Commons?
- What is the nature of the relationship between the public and the private/civic spheres when infrastructure is provided by Digital Commons (procurement, partnership, funding, etc.)? Are there specific frictions or challenges? What does it mean for state support methods and modalities in general? What learnings can be drawn from this example? How do they differ from previous public intervention in the field?
- What does support as infrastructure mean for Digital Commons and their governance? How do Digital Commons adapt to public service obligations, sectoral regulations or accountability and transparency requirements?

In each case study, the context and actors involved are described. The study then identifies the infrastructure challenges and explains how the infrastructure is provided and what the governance structure is. It outlines the support from public actors and evaluates its sustainability. Finally, it links the findings to the research questions and discusses their implications.

Decidim (Nil Homedes Busquets)

CONTEXT

Decidim is a free and open digital infrastructure for participatory democracy that is widely used around the world. More specifically, Decidim is a web environment (a framework) built with Ruby on Rails that allows anyone to create and configure a web platform to be used as a political network for democratic participation.[152] Decidim is currently used by more than 450 organizations in 30 different countries. Of these, 240 are cities and government organizations and 180 are social organizations. It has currently been implemented in various institutional contexts, including the city of Barcelona, the European Commission, the Government of

[152] X. E. Barandiaran, A. Calleja-López, A. Monterde, and C. Romero, *Decidim, a Technopolitical Network for Participatory Democracy: Philosophy, Practice and Autonomy of a Collective Platform in the Age of Digital Intelligence* (Switzerland: Springer Nature, 2024).

Catalonia, the cities of Helsinki (Finland) and New York (USA), the Brazilian Federal Government, and the French National Assembly, among hundreds of others.[153]

Launched by the Barcelona City Council, the Decidim Barcelona project started in 2016 with the need to coordinate the Municipal Action Plan, a participatory project for the strategic planning of the next four years of the city's projects. After being a success, two needs were raised. First, to have a more flexible software that allows the city to have more functionalities to coordinate different participatory mechanisms, such as: being able to handle multiple participatory processes, assemblies, initiatives, consultations, etc. And second, the fact that other cities approached the City Hall and asked to reuse the software. Following this initial process, and due to the project's open and collaborative nature, the code was completely rewritten a year later. The decision was made not to develop from scratch but to reuse the code of the Consul platform (Decidim initially started as a fork of it), so that the platform could be reused by any other city thanks to a more modular architecture. Taking advantage of this modular architecture, external organizations have extensively extended Decidim, with more than 100 modules currently being developed by them.[154]

Thus, Decidim was initially created in response to a very specific need of the Barcelona City Council, and this, together with the lack of similar projects that met all the technical and political requirements that the city council needed, are the reasons that led to the creation of Decidim. In Barcelona, it became the city's digital infrastructure for participation, and gradually its use spread around the world. Recently, Decidim was recognized by the Digital Public Goods Alliance (DPGA) as a digital public good.[155] In this way, Decidim has become a public digital infrastructure. This infrastructure consists primarily of the participation platform itself, but also includes documentation, design elements, community modules and data sets. All these elements serve to compose a participatory democratic system within any organization.[156]

GOVERNANCE MODEL AND COMMUNITY

The Decidim Association, created on February 16, 2019, in an extraordinary assembly[157] following a participatory process,[158] was conceived as the governance instrument of the Decidim community – that is, of the group of individuals and legal entities interested in the development, growth, and improvement of the democratic infrastructure of digital participation based on Decidim. The Barcelona City Council has transferred the management and maintenance of the

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[153] "Decidim in use - These cities, regions and organizations are already using Decidim," Decidim, accessed June 2024: https://decidim.org/usedby/.

[154] "Decidim Modules," Decidim, accessed June 2024: https://decidim.org/modules/.

[155] "Decidim is recognized as a Digital Public Good," Decidim, accessed July 2023: https://decidim.org/blog/2023-07-13-decidim-is-recognized-as-a-digital-public-good/.

[156] Barandiaran, Calleja-López, Monterde, and Romero, *Decidim, a Technopolitical Network for Participatory Democracy*.

[157] "Exceptional SOM: Constituent Assembly of the Decidim Association," Decidim, accessed June 2024: https://meta.decidim.org/processes/decidim-gov/f/959/meetings/1169.

[158] "Decidim.GOV: Democratic Governance for an open community," Decidim, accessed June 2024: https://meta.decidim.org/processes/decidim-gov.

source code to the Decidim Association through an agreement signed between the Barcelona City Council, Localret, and the Decidim Association. This public-commons collaboration is an example of how to design the governance of Digital Commons. It is a unique example in the world of how to implement free software as a public policy with a community governance model.

The Decidim community is called Metadecidim and is made up of individuals and organizations that use the software and want to contribute to its improvement. Any person, company, university, or public institution that has a relationship with the Decidim software is part of the community. In order to articulate the participation of all community members, the Metadecidim platform was established.[159] The Decidim project has always been developed in an open and collaborative way in all aspects. Anyone can participate in the process of democratically designing Decidim by simply accessing the "Propose new features"[160] participatory process in Metadecidim. Any member of the community can propose a new feature or suggest improvements to an existing one.

SUPPORT MODALITIES AND REVENUE MODEL

The Decidim project has several sources of funding and resource generation, which are made public in detail in Decidim's Sustainability Plan.[161] Today, the association is mainly funded by the Barcelona City Council and the Government of Catalonia, which make a transfer of resources to the association. These funds are invested in the dynamization of the community and the management of the contributions to the code.

In addition, every year, the Barcelona City Council invests in new developments and improvements through public tenders carried out by companies of the Decidim ecosystem. Some of these improvements are customizations for the Barcelona installation.[162] However, there is also a part of this investment that goes to new functionalities and improvements for the main repository of the Decidim software. Thus, the city of Barcelona has financed most of Decidim's development so far.

Furthermore, a new partnership policy was introduced in 2022 to create a path for companies providing Decidim services to contribute to the Digital Commons that underpin their business model.[163] This policy requires companies to contribute 3% of their turnover from Decidim services. This mechanism relies on trust, as the association cannot enforce payment.

CONCLUSION

There are always tensions between the public, the private, and the commons. In the case of Decidim, the association represents the guardians of the commons and the community. It is the

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[159] "Metadecidim," Decidim, accessed June 2024: https://meta.decidim.org/.

[160] "Propose new features," Decidim, accessed June 2024: https://meta.decidim.org/processes/roadmap/.

[161] "Sustainability Plan," Decidim, accessed June 2024: https://meta.decidim.org/rails/active_storage/blobs/redirect/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBa

[162] "Home page," decidim.barcelona, accessed June 2024: https://decidim.barcelona.

[163] "Partnership policy," Decidim, accessed June 2024: https://decidim.org/partnership-policy/.

guardian of the original values and principles of the project. The private sector is represented by the companies that provide Decidim services, and the public sphere of the project is made up of all the governments that use Decidim and can contribute to its funding and governance.

The Barcelona City Council, as the main public partner of Decidim, has been a key factor in the success of the project, not only through its financial support, but also through its clear political support for the governance model of Decidim as a Digital Commons, recognizing the association as a central actor in the public-common governance model. This partnership includes regular meetings to align visions and define the roadmap between the association and the council. The Government of Catalonia has also played a crucial role through funding and participation in governance. A key challenge for Decidim is to involve other global administrations in this governance model in order to establish Decidim as a universally shared commons and to diversify its funding. Relationships between Digital Commons and public institutions can also create tensions. For example, some of these tensions may arise from the current public procurement model, which, due to its rigidity, lacks the flexibility to adapt both to the unforeseen events typical of code development and to the needs of communities.

The diversification of Decidim's revenue model also relies on a greater involvement of the private sector in the maintenance and development of the software. Private sector involvement in Decidim presents a dichotomy: some companies exploit the commons for profit without contributing, while others engage constructively with the community – for example, by becoming official partners or donating 3% of their revenue to the association. This "tragedy of the commons" scenario calls for mechanisms to encourage reciprocal contributions from private entities. An interesting development in the context of the Digital Commons is the possibility of new forms of cooperation between private sector organizations, sometimes even competitors, who can pool their resources through Decidim and sometimes even jointly bid for tenders to provide new services to the public. Such collaborations show the potential for private sector contributions to increase the robustness of the commons.

The lack of bureaucracy is pointed out as one of the limitations that have hindered the large-scale expansion of the Digital Commons.[164] In that sense, a key challenge for Decidim's transition from a small community-based experiment at the local level to a global infrastructure for citizen participation is the need to further institutionalize some of the community's rules and processes, while maintaining the flexibility and openness of a bottom-up initiative. As the community expands, structured rules for participation and collaboration become increasingly necessary. Indeed, the growth of a Digital Commons, especially as partnerships with public and private institutions increase, requires the definition of stronger internal rules – for example, to adapt to public requirements related to grants or tenders, but also to protect against potential extractive and fraudulent use of the shared resource. This includes defining a policy against the misuse of their tool by governments that do not genuinely intend to promote citizen participation.

The case study of Decidim provides key insights into how Digital Commons can effectively contribute to infrastructure provision. As a model of public-commons governance, Decidim is

[164] C. Rendueles, *Comuntopía: Comunes, postcapitalismo y transición ecosocial*, (Madrid: Akal, 2024).

based on effective delegation to a community, represented by an association that ensures democratic participation, and the definition of rules to ensure the long-term sustainability of resource management. Several key lessons emerge from this case study. First, the long-term sustainability of a Digital Commons requires ongoing funding to maintain the infrastructure, not just funding for new features. Second, fostering strong community and participatory governance is critical, and such engagement requires resources for collective deliberation processes. Third, the administrative adoption of Digital Commons by public institutions is crucial for scaling such projects and demonstrating political commitment. For those involved in the Decidim journey, their model can be replicated in various digital policies and services, promoting new forms of governance that transcend the traditional public-private divide. Political conviction and a commitment to community building are essential to the realization of these new governance models, which could play a critical role in addressing contemporary challenges, including the climate crisis, by putting democratic participation at the forefront of public planning and infrastructure development.

German Center for Digital Sovereignty (Nicholas Gates)

CONTEXT

Open Source Programme Offices (OSPOs) create a strong enabling environment for supporting and deploying Digital Commons as part of public digital infrastructures. By channeling and coordinating open source community efforts, and in turn creating channels for getting more funding and support back into the community, OSPOs can function not only as resource centers, but can scale support to bodies across entire jurisdictions, provide coordination with government policies and regulations, and ensure local innovation and contributions flow back to support the entire open source ecosystem. It can be argued that OSPOs in government are an important policy tool for helping to support many solutions that can be understood as Digital Commons and which will ultimately become part of public digital infrastructures.

To better understand the potential of OSPOs for Digital Commons governance, this case study considers the case of Germany's *Zentrum Digitale Souveränität* (ZenDiS) ("Center for Digital Sovereignty" in English). ZenDiS is different from normal OSPOs in the way it goes beyond promotion of open source and policy-making, but also really focuses on actively working to bridge the gap between developer communities and government by helping to provide open source solutions for the public sector.

CHALLENGE

While many OSPOs have had a lot of success in supporting and nurturing open source ecosystems,[165] a challenge still remains in how you channel those efforts toward the specific needs of governments. OSPOs must still work within the confines of the strict legal requirements governments are subject to when procuring, implementing, and maintaining any software solution or solutions. This, in theory, creates more challenges for governments to support Digital Commons projects, where there is a presumption of more defined obligations around

[165] "The 2023 State of OSPOs and OSS Initiatives," The Linux Foundation, accessed 25 September 2024: https://www.linuxfoundation.org/research/ospo-2023.

contribution, support, and governance of something which, in most cases, operates legally outside of government.

One of the primary aspects of this challenge that ZenDiS has encountered in working with the community and participating in community governance of open source projects – many of which ought to be regarded as Digital Commons – is the lack of guardrails. Because governments are subject to implementing standards defined by legislation, or upholding rules and regulations mandated by their own government or the EU, they need to be very intentional about what projects they support and who can participate in them. This is done with an eye toward mitigating risk and upholding security, while still being able to participate in and leverage the benefits of Open Source.

Compliance is another issue. Most governments, including Germany, have strict requirements around which solutions you can use and what must be proven in order to adopt and maintain an IT project. While part of adopting open source in the public sector is changing some of these policies, either through rules or through legislation,[166] change must also happen through innovations in governance. Therefore, ZenDiS has been using its position in the open source ecosystem in Germany to try and figure out how to create more regulated spaces where it can still contribute to open source projects, but work with the community on its own terms. ZenDiS does this in order to make sure that its contributions to – and the contributions it receives from – those projects uphold relevant rules and requirements for public procurement and maintenance.

DESCRIPTION

The ecosystem ZenDiS stewards provides a level of coordination that helps to ensure that there is healthy, community-based governance of open source projects being supported by the national government and adopted by local public administrations.[167] Its office helps cement the role of key software and standards as Digital Commons while enabling a more active role for local and regional governments in the open source ecosystems present in their jurisdictions.[168]

Because of the aforementioned challenges – such as guardrails and compliance – ZenDiS has sought to strengthen community governance models of open source Digital Commons projects, in order to enable public sector contribution while also adapting them to government requirements (e.g., procurement and cybersecurity) and facilitating rules-based access. Even beyond what other OSPOs have done, ZenDiS has tried to build a thriving open source ecosystem and provide connections to public administrations. It also uses those relationships to explore new models of governance that mitigate risk while enabling governments to contribute to open source solutions as forms of Digital Commons.[169]

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[166] Lea Beiermann and Alexander Smoliantski, *Interview with ZenDis by Nicholas Gates*, 17 June 2024.

[167] "German government executes OSS-based vision of digital sovereignty," Joinup, accessed 25 September 2024: https://joinup.ec.europa.eu/collection/open-source-observatory-osor/news/centre-digital-sovereignty.

[168] Lea Beiermann and Alexander Smoliantski, Interview with ZenDis by Nicholas Gates, 17 June 2024.

[169] Lea Beiermann and Alexander Smoliantski, *Interview with ZenDis by Nicholas Gates*, 17 June 2024.

The most notable way ZenDiS does this is through the Open CoDE platform, a joint platform of the public administrations in Germany that enables the exchange of open source code and software. As stated on the Open CoDE website: "The central repository of open source code is intended to promote reuse and collaborative work on public administration software solutions between administration, industry and society."[170] We argue that ZenDiS, via the Open CoDE platform, provides policy infrastructure that is crucial for supporting and deploying Digital Commons as infrastructure.

Open CoDE is a platform built by ZenDiS using GitLab as the main component. The goal of Open CoDE was to help create some of the guardrails mentioned above, as well as facilitate rules-based contribution to, and collaboration on, open source projects with dependencies in the public sector.[171] At present, Open CoDE hosts more than 4,400 Users, 1,400 repositories, and 550 groups.[172] It was stipulated from the outset when Open CoDE was launched in 2022 that anyone can contribute through the platform, but a project can only be initiated by those who are part of the public sector or have a partnership with a public sector entity. This ensures that the code is available and transparent to all, but the platform will not serve as an alternative to existing repository solutions for non-public sector entities.[173]

While Open CoDE is not the only platform public administrations and municipalities use, it has become the dominant alternative. As a regulated and shared platform, it helps create a solution for managing the tightrope of balancing community contribution and governance with the needs of public sector adoption and maintenance. In the view of the ZenDiS team, it offers a reliable and necessary solution for facilitating the governance of many projects that can be considered Digital Commons in Germany. In particular, it has helped support the development of several other open source Digital Commons for the public sector, including openDesk – which can be regarded as a form of public digital infrastructure.[174]

openDesk is a project to create an open workspace collaboration suite for use by German public administrations.[175] With openDesk, the government is ostensibly trying to bundle many open source software solutions together. The code has been hosted on Open CoDE and is being developed in the open, with collaboration from members of the open source community.[176] Through Open CoDE, they are working to ensure that different companies can develop different components of openDesk and contribute to them, with the government playing a facilitating role in making sure they interoperate.[177]

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[170] "Open CoDE, Homepage" Open CoDE, accessed 25 September 2024: https://opencode.de/en.

[171] Lea Beiermann and Alexander Smoliantski, *Interview with ZenDis by Nicholas Gates*, 17 June 2024.

[172] "Open CoDE, Homepage" Open CoDE, accessed 25 September 2024: https://opencode.de/en.

[173] Lea Beiermann and Alexander Smoliantski, *Interview with ZenDis by Nicholas Gates*, 17 June 2024.

[174] "German Government launches openDesk Software Project," FOSSLIFE, accessed 25 September 2024: https://www.fosslife.org/german-government-launches-opendesk-software-project.

[175] Lea Beiermann and Alexander Smoliantski, *Interview with ZenDis by Nicholas Gates*, 17 June 2024.

[176] "Sovereign workspace openDesk: German Ministry of the Interior provides answers," Free Software Foundation Europe, accessed 25 September 2024: https://fsfe.org/news/2023/news-20230920-01.en.html.

[177] Lea Beiermann and Alexander Smoliantski, *Interview with ZenDis by Nicholas Gates*, 17 June 2024.

LOOKING FORWARD

Across all of its activities, ZenDiS has been working to track the development of Digital Commons projects, with many examples emerging of projects with shared contribution from a number of regions and municipalities. Developing and launching Open CoDE has given public sector entities in Germany a forward-looking way to help support access and sharing rules for projects being used by the public sector, while enabling them to contribute upstream and participate in their adoption downstream.

Despite these successes, ZenDiS faces some challenges in the road ahead as it seeks to support Digital Commons. One challenge is around the issue of capacity. While it is collaborating with open source communities, the need still exists to improve technical talent in the public sector and enable more dynamic and active relationships with open source communities, particularly as new solutions emerge and are adopted by the public sector. ZenDiS also needs to do more work to involve civil society and strengthen the collaboration models for working with businesses in more defined ways.

Another issue is that of public funding and investment. As a result, ZenDiS is actively identifying ways to act not just as a contributor but help the projects it supports to receive money, feedback, additional offers of support, etc. Moving forward, it wants to build a closer relationship with the Sovereign Tech Fund,[178] which funds a lot of critical open infrastructure in Germany and beyond. The goal of doing this is so that ZenDiS can play a more strategic role in supporting and investing in highly open Digital Commons being used at scale as part of digital infrastructure all across Germany.

CONCLUSION

In summary, Germany's ZenDiS has taken crucial steps to shape the rules and norms of various open source software packages as Digital Commons through its Open CoDE platform,[179] supporting the wide reach and impact of the public sector while also working with the communities that support the government. In ZenDiS' case, it also supports coordination between open source developers and government bodies – including the Sovereign Tech Fund.[180] This case study offers many lessons for how governments can facilitate participation in Digital Commons governance, even as they continually learn new lessons about how best to do so.

Despite some growing pains, the emerging evidence from ZenDiS suggests a strong case for how the public sector can practically help support open source software as Digital Commons and procure Digital Commons as infrastructure, as well as make a case for open alternatives to proprietary solutions. By working with policymakers, OSPOs like ZenDiS can play a key role in introducing Digital Commons as part of digital transformation strategy positions and blueprints

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[178] "Sovereign Tech Fund Homepage," Sovereign Tech Fund, accessed 25 September 2024: https://www.sovereigntechfund.de/.

[179] "Open CoDE, Homepage" Open CoDE, accessed 25 September 2024: https://opencode.de/en.

[180] "Open Source Observatory Policy Factsheet – Germany", Joinup, accessed 25 September 2024, https://joinup.ec.europa.eu/sites/default/files/inline-files/Factsheet%20Germany.pdf.

for digital government transformation. This gives the government another policy lever to help standardize new business models for procuring and maintaining Digital Commons as public digital infrastructure, helping to ensure the success of the model as a viable alternative to more restrictive commercial options.

DHIS2 Platform (Lea Gimpel)

Many thanks to Scott Russpatrick and Mike Frost for sharing their insights and research on DHIS2.

CONTEXT

DHIS2 is a free, web-based, open source platform designed for data collection, analysis, visualization, and sharing of aggregate and individual data. It is the leading health information management system, with implementations in over 80 low- and middle-income countries worldwide, covering 30% of the world's population. It is also recognized as a digital public good in the DPG registry.[181] It was initially developed for the health sector but has been deployed in several other sectors, including managing education, agriculture, and logistics projects.[182] The history of DHIS2 spans almost 25 years: The web-based product was launched in 2006 and marked a shift from the standalone software DHIS1, which was first deployed in two South African provinces in 1998.[183]

DHIS2 is a global software collaboration project managed by the University of Oslo's Health Information Systems Programme (HISP). The HISP Center at the university serves as the central hub for coordinating software development, capacity building, and sharing knowledge and innovation within a global network that includes academic institutions, ministries of health, non-governmental organizations (NGOs), and funding agencies.[184] [185] This international network comprises 17 in-country and regional hubs that offer continuous, direct support for implementation partners, usually Ministries of Health or NGOs.

CHALLENGE

In low- and middle-income countries, DHIS2 fills a gap due to a lack of commercial providers for health information management services. Especially for last-mile services, there is no market for commercial providers, making public solutions necessary to give people access to fundamental services and ensure their right to health as enshrined in several human rights instruments, such

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[181] "DHIS2 General Information," Digital Public Goods Alliance, accessed June 2024: https://app.digitalpublicgoods.net/a/11016.

[182] "DHIS2 in action," DHIS2, accessed June 2024: https://dhis2.org/in-action/.

[183] Jørn Braa and Sundeep Sahay, *Integrated Health Information Architecture: Power to the Users (*Matrix Publishers, January 2012), https://www.mn.uio.no/ifi/english/research/groups/is/research-library/integrated-health-information-architecture/prelims.pdf

[184] Jørn Braa, Eric Monteiro, and Sundeep Sahay, "Networks of Action: Sustainable Health Information Systems Across Developing Countries," *MIS Quarterly*, 28 (2004): 337-362, https://doi.org/10.5555/2017227.2017230.

[185] Jørn Braa, Ole Hanseth, Arthur Heywood, Woinshet Mohammed, and Vincent Shaw, "Developing Health Information Systems in Developing Countries: The Flexible Standards Strategy," *MIS Quarterly*, 31: 381-402, https://doi.org/10.2307/25148796.

as the Universal Declaration of Human Rights from 1948. Many low- and middle-income countries only have limited resources to develop, deploy, and maintain key software infrastructure. For this reason and because of their familiarity with DHIS2 as a software application deployed in some countries for decades, several countries have also started using DHIS2 in other domains (mentioned above). This development is aided by the HISP Network recognizing DHIS2's potential as an innovation platform to provide social options rather than an application strictly focused on one application area. In the academic literature, social options are considered open, commons-based, generic resources that support social value creation for various issues.[186] Accordingly, in recent years, DHIS2 has been developed into an information management infrastructure that can underpin essential public service delivery.

DESCRIPTION

The software development, capacity building, and sharing of knowledge and innovations in the global HISP network are managed by the HISP Center at the University of Oslo (in the platform literature, the HISP Center would take the role of a platform leader[187]). As an innovation platform providing social options, DHIS2 faces a collective action dilemma[188]: While broad participation of different stakeholders is essential in creating joint value for a community by enabling heterogeneous actors to contribute different assets to the collective interest, aligning diverging interests and activities requires orchestration and governance[189][190]. Researched dynamics in platform ecosystems unveiled that open governance and deferring decisions regarding platform resources to contributors enable co-creation, spill-over effects, and innovations[191]. However, governance structures that are too open can lead to a diversion of focus from the shared goals. Platform leaders – those who orchestrate contributions and steer the group toward a common goal – must simultaneously enable distributed autonomy and collective action[192].

That's also the role of the University of Oslo's HISP Center: It develops and evolves the governance mechanisms steering the global HISP network toward creating social value for and with the global network. HISP network hubs submit and vote on feature requests through an

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186 Brett M. Frischmann, *Infrastructure: The Social Value of Shared Resources* (Oxford: Oxford University Press, 2013).

187 Evans, David S., Andrei Hagiu, and Richard Schmalensee. 2006. "Invisible Engines." Invisible Engines, August. https://doi.org/10.7551/MITPRESS/3959.001.0001.

188 Cennamo, Carmelo, and Juan Santaló. 2019. "Generativity Tension and Value Creation in Platform Ecosystems." Organization Science 30 (3): 617–41. https://doi.org/10.1287/ORSC.2018.1270.

189 Dhanasai, Charles, and Arvind Parkhe. "Orchestrating Innovation Networks." *The Academy of Management Review* 31, no. 3 (2006): 659–69. http://www.jstor.org/stable/20159234.

190 Wareham, J., Fox, P. B., & Cano Giner, J. L. (2014). Technology ecosystem governance. Organization Science, 25(4), 1195–1215.

191 Reuver, Mark de, Carsten Sørensen, and Rahul C. Basole. 2018. "The Digital Platform: A Research Agenda." Journal of Information Technology (2): 124–35. https://doi.org/10.1057/S41265-016-0033-3.

192 Ghazawneh, Ahmad, and Ola Henfridsson. 2013. "Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model." *Information Systems Journal* 23 (2): 173–92. https://doi.org/10.1111/J.1365-2575.2012.00406.X.

open roadmap process where everyone in the national and regional DHIS2 network participates. One key advantage of this governance structure is that the HISP Center can act as a mediator for individual goals of national and regional hubs, making sure that the product is developed in a generic, building-block manner that benefits everyone and makes in-country adaptation easy. National and regional hubs are encouraged to develop and share back their own modules and custom applications through open APIs, a software development kit, an App Hub, and tutorials, thus capacitating local developers and providing a channel for decentralized innovation while also realizing local community benefits. One example is, for instance, the development and uptake of a COVID-19 tracker module, which was developed in Sri Lanka and subsequently implemented in more than 30 countries globally. All in all, the global community only contributes a fraction to the core product, but the HISP Center estimates that third-party contributors provide 15-20% of critical functionality in any implementation of DHIS2. Applications in the area of education and logistics are nearly exclusively dependent on third-party applications. This high rate of critical features developed outside of the core is also due to a strong community ethos, which is actively cultivated and results in the vast majority of users contributing back their generic innovations. The HISP Center aspires to increase the number of external contributions to the core by developing new contribution mechanisms.

Another benefit of this governance structure is its effect on trust-building. Since the University of Oslo maintains the product, DHIS2 is free of commercial interests and government meddling. This is a key component of the relationships the HISP Center built with numerous donors and supporters over the years.

SUPPORT MODALITIES

Several donors, including the Norwegian Agency for Development Cooperation (NORAD), the World Health Organization *(*WHO), the United Nations Children's Fund (UNICEF), or the U.S. President's Emergency Plan for AIDS Relief (PEPFAR), provide funding to DHIS2. DHIS2 is only reliant on donor and research funding, without any other underlying business model. While this has been a successful strategy over many years, challenges persist: Donors tend to fund innovations and implementations, often neglecting maintenance of the core. Such funding is usually "catalytic," with donors expecting to end their support at a certain point in time. However, infrastructure requires steady and reliable funding over many years without the perspective of meeting an "endpoint." Third-party applications funded by short-term, catalytic funding or developed by the community without external support specifically face sustainability challenges, and DHIS2 currently explores commercial models to maintain these innovations indefinitely.

DHIS2 also struggles with the common free-rider problem of commercial software providers extending and building on top of its product without contributing anything back. In some cases, this leads to competitors offering the same services, such as data warehousing, coupled with additional features, effectively diverting donor funding from DHIS2 to commercial providers. Lastly, many Western countries' shifting political landscape and economic struggles have put international development funding under more scrutiny. It has already led to reduced budgets for development assistance in many countries, including Norway, Germany, the UK, and the Netherlands.

CONCLUSION

The journey of DHIS2 is a testament to the power of commons-based governance to work toward collective interests and create social value locally and globally. Such models seem especially pertinent in contexts in which market failures prevail or commercial models fail to address community values and the public interest at large. The long history of DHIS2 shows the need to evolve governance structures over time to navigate the collective action dilemma and mitigate complexity in a rapidly changing technology landscape. In terms of relationship management with the HISP network and partners, capacity development and trust-building play an essential role. The emerging role of DHIS2 as a foundational infrastructure requires new funding vehicles and rethinking community governance mechanisms to address the free-rider problem, safeguarding the platform against commercial competitors and supporting non-commercial forms of value creation such as equitable healthcare for the many.

scikit-learn (Cailean Osborne)

This case study stems from a research paper on the funding model of scikit-learn.[193] It is based on 25 interviews with maintainers and public & private sponsors over 2 years (2022-2023).

CONTEXT

scikit-learn is a Python library that implements machine learning (ML) algorithms for classification, regression, and clustering, as well as related tools for data preprocessing, model fitting, model evaluation, and data visualizations. Initially called scikits.learn, the project was started by David Cournapeau as a Google Summer of Code project in 2007. After a dormant period, it was relaunched as scikit-learn in February 2010 by Fabian Pedregosa, Gaël Varoquaux, Alexandre Gramfort, and Vincent Michel, who were researchers at the French Institute for Research in Computer Science and Automation (Inria). Nowadays, it is one of the most impactful and popular projects in the ML/AI OSS landscape, described as "the Swiss army knife of ML" due to its widespread use in research and industry.[194] To date, the project has been maintained by core developers, mostly based at Inria, and a global community of volunteers.[195] Since its first public release in 2010, scikit-learn has been supported by the Inria Foundation[196] and a mixed funding model combining public research grants, corporate sponsorship, community donations,

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[193] Preprint version: Cailean Osborne, "Public-Private Funding Models in Open Source Software Development: A Case Study on Scikit-Learn," arXiv preprint, 2024, arXiv:2404.06484. Published version: Cailean Osborne, "Open Source Software Developers' Views on Public and Private Funding: A Case Study on *scikit-learn*". CSCW Companion '24, November 9–13, 2024, San Jose, Costa Rica.

[194] "The 2019 Inria French Academy of Sciences Dassault Systèmes Innovation Prize: scikit-learn, a success story for machine learning free software," Inria, accessed January 2020, https://www.inria.fr/en/2019-inria-french-academy-sciences-dassault-systemes-innovation-prize-scikit-learn-success-story.

[195] OSS Insight - scikit-learn/ scikit-learn, 2023, OSS Insight website, accessed March 16, 2023, https://ossinsight.io/analyze/scikit-learn/scikit-learn#overview.

[196] "La Fondation Inria," Inria, 2020, accessed June 26, 2024, https://www.inria.fr/en/la-fondation-inria.

and as of November 2021 a €32 million grant announced in France's artificial intelligence (AI) strategy.[197]

CHALLENGE

At the time of scikit-learn's creation, there was a lack of open source libraries for ML. This gap in the ML ecosystem posed significant challenges for researchers and engineers, who sought to implement and compare various ML algorithms without the burden of writing code from scratch or relying on scattered, inconsistent, and often poorly maintained implementations.[198] Nowadays, OSS[199] [200] and open models[201] are indispensable to ML/AI research and innovation,and scikit-learn is used by millions of researchers and engineers across the world for building predictive models for diverse applications, from research in bioinformatics and climate science to industry use cases such as fraud detection and stock price prediction. However, the maintainers explained that its sustainability and impact were not inevitable, and the project has faced a number of challenges, from the under-development of the scientific Python ecosystem in the early 2010s to pressures stemming from industry dominance in AI research and development.[202] As explained below, its community approach has been crucial in ensuring that scikit-learn remains a state-of-the-art digital public good for ML researchers and engineers that is available for free under its permissive BSD license and has remained independent of the strategic goals of a single vendor.

DESCRIPTION

scikit-learn is provided for free as a Python library, available for anyone to use, modify, and distribute under the permissive BSD license. The project is maintained and developed by a core team of developers, primarily based at Inria, and a global community of contributors who voluntarily dedicate their time and expertise to improve the library.[203] The community contains

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[197] "Stratégie National pour L'Intelligence Artificielle," Ministère de l'Économie, des Finances et de la Souveraineté industrielle et numérique (November 2021): https://www.economie.gouv.fr/strategie-nationale-intelligence-artificielle.

[198] Sören Sonnenburg, Mikio L. Braun, Soon Ong Cheng, Samy Bengio, Leon Bottou, Geoffrey Holmes, Yann LeCun, Klaus Robert Müller, Fernando Pereira, Carl Edward Rasmussen, Gunnar Rätsch, Bernhard Schölkopf, Alexander Smola, Pascal Vincent, Jason Weston, and Robert C. Williamson, "The Need for Open Source Software in Machine Learning," *Journal of Machine Learning Research*, 8 (October 2007): 2443–2466.

[199] Max Langenkamp and Daniel N. Yue, "How Open Source Machine Learning Software Shapes AI," In *Proceedings of the 2022 AAAI/ACM Conference on AI, Ethics, and Society, AIES '22* (New York, NY, USA: Association for Computing Machinery, July 2022), 385–395.

[200] Matt White, Ibrahim Haddad, Cailean Osborne, Xiaoyang, Liu, Ahmed Abdelmonsef, and Sachin Varghese, "The Model Openness Framework: Promoting Completeness and Openness for Reproducibility, Transparency and Usability in AI," *arXiv* (March 2024): https://arxiv.org/abs/2403.13784.

[201] Osborne, C., Ding, J. & Kirk, H.R. The AI community building the future? A quantitative analysis of development activity on Hugging Face Hub. Journal of Computational Social Science (2024). https://doi.org/10.1007/s42001-024-00300-8.

[202] Nur Ahmed, Muntasir Wahed, and Neil C. Thompson, "The growing influence of industry in AI research," *Science*, 379(6635) (March 2023): 884–886.

[203] OSS Insight - scikit-learn/ scikit-learn, 2023, OSS Insight website, accessed March 16, 2023, https://ossinsight.io/analyze/scikit-learn/scikit-learn#overview.

volunteers from across the world and companies.[204] The majority of contributions come from researchers and developers in the US, India, Germany, France, the UK, Canada, China, Japan, Switzerland, and the Netherlands. The maintainers lay great importance on this diversity and make efforts to cultivate the project's identity as the collective effort of a global community. For example, Julien Jerphanion, a maintainer, explained that, "The major part of the labor is based on benevolence of people working in their free time and not asking to get paid." This community-based model ensures that scikit-learn remains responsive to the needs of its diverse user base, which includes researchers, data scientists, and software developers, among others. The community-driven approach also aligns with open science principles, which emphasize transparency, collaboration, and knowledge sharing. According to Gaël Varoquaux, a co-founder, the project seeks to provide a public alternative to the tools offered by profit-oriented industry giants, and while the project is funded by public and private entities, decision-making about the project will and must always "come from the community."

SUPPORT MODALITIES

scikit-learn has benefitted from several sources of funding, including public research grants, commercial sponsorship, micro-donations, and a €32 million grant announced in France's AI strategy.[205] Each type of funding has presented unique advantages and challenges, and has funded different aspects of the project under different timelines. Since 2010, according to François Goupil, the community manager, Inria has provided around €1.5 million in support via staff salaries, public research grants, office space, computing resources, and event sponsorship. As Olivier Grisel, a maintainer, noted, "[Public funding] is not new with the AI strategy." The project also benefits from micro-donations from the community via NumFOCUS and student projects have been sponsored by the Google Summer of Code program. Adrin Jalali, a maintainer, explained that while "the major stuff is not funded through NumFOCUS," it has been useful in funding marketing, events, and so far, one internship for underrepresented groups.

In 2018, the scikit-learn consortium was established under the Inria Foundation to stabilize funding, to secure employment for maintainers, and to develop new features.[206] Companies join via annual memberships in three tiers: silver (€30,000), gold (€50,000), and platinum (€100,000). The Technical Committee elaborates a strategic technical roadmap for the project, including gathering feedback from the community, while the Advisory Committee advises on various topics, such as the consortium's membership and financial status. To date, it has included Dataiku, Microsoft, Nvidia, Intel, AXA, Boston Consulting Group, BNP Paribas Cardif, Hugging Face, Fujitsu, and Chanel. Other companies, such as Quansight Labs, have indirectly funded the project by sponsoring maintainers. Through their sponsorship, companies gain a voice in scikit-learn's development via the Technical Committee and Advisory Board. While the maintainers appreciate the industry use cases and needs that their consortium members share, some sponsors have sought to influence the project's development and direction in ways that conflicted with

[204] OSS Insight - scikit-learn/ scikit-learn, 2023, OSS Insight website, accessed March 16, 2023, https://ossinsight.io/analyze/scikit-learn/scikit-learn#overview.

[205] scikit learn. scikit-learn, 2023. https://scikit-learn.org/stable/about.html.

[206] Gaël Varoquaux, "A foundation for scikit-learn at Inria," *Gaël Varoquaux* (blog), September 2018, https://gael-varoquaux.info/programming/a-foundation-for-scikit-learn-at-inria.html.

project's norms. To manage these demands, the maintainers employ governance protocols that limit funders' influence and safeguard decision-making among maintainers and the community. For example, the Technical Committee cannot override decisions with rough consensus among maintainers. Jalali explained, "If there's two thirds majority in cast vote, for whatever vote we do, then the Technical Committee doesn't step in … because the power is given to the [maintainers] and that's by design." This example highlights the importance of governance protocols to safeguard the community interests whilst being funded by companies with private interests.

In November 2021, France's AI strategy, "La stratégie nationale pour l'intelligence artificielle," announced a €32 million grant for the duration of five years to support the development and maintenance of a data science commons, which includes but is not limited to scikit-learn and its satellite projects skrub, joblib, and fairlearn, as well as an open source platform for data science.. Through this funding, the French government aims to enhance French competitiveness in AI R&D, facilitate AI adoption throughout the economy, and support the digital sovereignty of France and Europe more widely. The maintainers expressed their gratitude for the government's financial support and recognition. Jalali emphasized the stability the funding brought to the project, allowing them to make long-term plans for recruitment and the technical roadmap. Goupil especially praised a requirement to acquire matching funds from both public and private sources throughout the EU: "I think it would be dangerous for us to be exclusively funded by the private sector or to be exclusively funded by the French government, because we have many good contributors who are not French." However, challenges emerged in aligning policy goals with the project's core strengths and community norms. For example, disagreements arose around expanding scikit-learn into deep learning, developing OSS tools without competing with domestic companies, and the slow pace of fund disbursement, which could be critical for more financially precarious OSS projects. Some consortium members raised concerns about the potential politicization of the project, with French policy goals like digital sovereignty probably not being well received by the global community. Despite these challenges, the maintainers remained committed to preserving the community ethos of scikit-learn and commended their constructive interactions with the government officials. In particular, the government's multi-stakeholder process involving experts from research and industry was useful for refining the grant, demonstrating the value of multi-stakeholder consultations for designing grants that balance policy goals with the expertise and needs of OSS developers.

CONCLUSION

This case study highlights the role of diversified funding, including public research grants, community micro-donations, and private sponsorship, in sustaining community-governed OSS projects like scikit-learn. It sheds light on the respective benefits and challenges of being funded by public institutions like the French government and private companies. On the one hand, commercial sponsors understand the importance of maintenance and expose the maintainers to industry use cases and challenges, but in some cases, commercial sponsors try to influence the project in ways that are perceived to be at odds with the community norms. On the other hand, the government is providing long-term support for the project in the public interest, but the slow pace of the French government and the initial neglect of funding maintenance were challenges that the maintainers had to address. The community-based governance of

scikit-learn has been critical to ensuring that the project remains focused on serving the needs of its users and contributors, rather than being driven by commercial or political interests. While it is still too early to evaluate the impact of the French government's €32 million grant, the political will of the French government to support scikit-learn and the Digital Commons for data science through such a substantial, long-term grant, as well as to adapt the funding package based on dialogue with the scikit-learn developer community, is commendable and should be noted as a potential blueprint for future funding interventions by other governments.

Overall, this case study contributes to the understanding of infrastructure provision through Digital Commons and the role of public actors in supporting these initiatives, providing insights into the design and implementation of a public-private OSS funding model, the governance mechanisms necessary to safeguard community interests, and the potential for such models to be replicated in other Digital Commons projects. The success of scikit-learn's funding and governance model serves as a template for other community-led OSS projects seeking long-term sustainability and focus on their users and contributors.

European Open Science Cloud (Roksana Wilk)

CONTEXT

The European Open Science Cloud (EOSC) aims to create a federated and open multi-disciplinary environment for European researchers, innovators, companies, and citizens to publish, find, and reuse data, tools, and services for research, innovation, and education. It promotes seamless access and FAIR (Findability, Accessibility, Interoperability, and Reusability) management of research data and digital objects. The genesis of EOSC can be traced back to the European Commission's 2015 communication, "A Digital Single Market Strategy for Europe,"[207] which laid the groundwork for integrating Europe's digital research infrastructure. The initiative gained momentum with the 2016 communication, "European Cloud Initiative – Building a competitive data and knowledge economy in Europe," where the European Commission proposed the creation of the European Open Science Cloud.[208] In 2017, the EOSC Declaration outlined guiding principles and invited stakeholders to endorse and commit to contributing to the EOSC's development.[209] The implementation phase officially began with the establishment of the EOSC Governance Board and Executive Board in 2018. The EOSC Strategic Implementation Plan[210] and

[207] European Commission, "A Digital Single Market Strategy for Europe" (Communication), COM(2015) 192 final: lex.europa.eu/legalcontent/EN/TXT/?uri=COM%3A2015%3A192%3AFIN.

[208] European Commission, "European Cloud Initiative - Building a competitive data and knowledge economy in Europe" (communication), (COM(2016) 178 final: https://eurlex.europa.eu/legal-content/EN/TXT/?qid=1555074889405&uri=CELEX:52016DC0178.

[209] EOSC, "EOSC Declaration (#1): The European Open Science Cloud – New research and innovation opportunities," Eosc-portal.eu, 2024, https://eosc-portal.eu/sites/default/files/eosc_declaration.pdf.

[210] European Commission: Directorate-General for Research and Innovation, Jones, S. and Abramatic, J., *European Open Science Cloud (EOSC) strategic implementation plan*, Jones, S.(editor) and Abramatic, J.(editor), Publications Office, 2019, https://data.europa.eu/doi/10.2777/202370

the EOSC Partnership under Horizon Europe[211] are crucial milestones, guiding the initiative from 2021 onwards.

As an initiative set up to facilitate a practical implementation of Open Science and support the overall scientific process in Europe and beyond, it gathers a significant number of important actors and stakeholders:

- The European Commission: As the driving force behind EOSC, the European Commission provides funding, policy guidelines, and coordination. Key roles are played by the Directorate-General for Research and Innovation (DG RTD) and the Directorate-General for Communications Networks, Content, and Technology (DG Connect).
- The EOSC Association: Established in 2020, the EOSC Association includes research-performing organizations, service providers, and industry representatives. It oversees the strategic implementation and operation of the EOSC ecosystem, ensuring alignment with the European research community's needs.
- National governments and funding agencies: National governments and funding bodies like the French National Research Agency (ANR) and the German Research Foundation (DFG) offer financial support and policy alignment. They facilitate infrastructure development at the national level.
- National Research and Education Networks (NRENs): Organizations like the European Grid Infrastructure (EGI) Federation, the EUDAT Collaborative Data Infrastructure (or EUDAT CDI) , OpenAIRE, the Gigabit European Academic Network (GÉANT) and their technology partners provide the connectivity backbone of EOSC, linking institutions across Europe and enabling data sharing and access to services.
- Research infrastructures: Institutions such as the European Organization for Nuclear Research (CERN), the European Bioinformatics Institute (EMBL-EBI), and the European Space Agency (ESA) contribute domain-specific expertise, large-scale datasets, and advanced research tools, ensuring EOSC aligns with scientific needs.
- Libraries and data repositories: Entities like the Association of European Research Libraries (LIBER) and university libraries advocate for Open Access and ensure data repositories comply with FAIR principles. They also support and train researchers to engage effectively with EOSC.
- Academic and research institutions: Universities and research institutions actively contribute data, develop tools, and adopt EOSC infrastructure to enhance research efficiency. They engage in pilot projects and community-building activities.

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[211] European Commission, "The EOSC Partnership Proposal Is Now Published," European Commission Website, June 11, 2020, https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/eosc-partnership-proposal-now-published-2020-06-11_en.

- Research communities and user groups: Scientific communities, including life sciences (ELIXIR), environmental sciences (ENVRIV, Copernicus), social sciences (CESSDA and many others), drive requirements and service development. Their feedback ensures EOSC remains relevant and valuable to users.

CHALLENGE

Recognized by the Council of the European Union as part of the European Research Area's 2022-2024 policy agenda,[212] the EOSC seeks to deepen open science practices and integrate with other sectoral data spaces in the European data strategy. Its deployment is expected to enhance research productivity, innovation, and trust in science.

The EOSC exhibits infrastructure characteristics notably by setting norms and standards for data circulation. The development of this infrastructure involves creating shared technological backbone infrastructure offering data, tools, and services for the scientists and science-facilitators, while addressing European Open Science policy aspects and the development of sustainable business models, and supporting the adoption of best practices. The objective is to facilitate the exchange of capacities, such as data storage and computing resources, across disciplines and countries, fostering a more integrated and efficient scientific community. By developing pilots that integrate services and infrastructures, EOSC supports interoperability across various scientific domains. Engaging a broad range of stakeholders, it builds trust and skills essential for adopting open scientific research practices. EOSC reduces fragmentation and improves interoperability between existing data infrastructures, enabling sharing and reuse of complex data across different domains and formats. This approach leverages existing resources to create a reliable open data environment, ensuring that data from publicly funded research is open and that incentives for sharing data are created.

DESCRIPTION

For the time being, community-based governance is adapted for the EOSC instead of classical state or private sector provision due to the need for a diverse and inclusive approach. Initially, the initiative was fragmented and led by different EU Commission departments, but it has since evolved into a more coordinated effort based on the tripartite governance structure. At the same time, entities building and leveraging the EOSC activity are transforming into the EOSC Node Federation. Technicalities and practical implementation details for that model are under development guided by the EOSC Association with the support and resources of other stakeholders constituting the EOSC initiative.

These multi-stakeholder models include various actors, from the European Commission to the research community. In both of them, the bottom-up approach ensures that initiatives are driven by those directly involved in implementation, aligning diverse national and sectoral goals. However, there is an ongoing discussion about whether some of the organizational and governmental topics like "possible money transfer mechanism and supported business models in

[212] Council of the European Union, "Future governance of the European Research Area (ERA)" (Council Conclusion), 14308/21, 26 November 2021: https://data.consilium.europa.eu/doc/document/ST-14308-2021-INIT/en/pdf.

EOSC Federation" should not be decided using the top-down approach with a considerable amount of community consultations and discussions.

SUPPORT MODALITIES

The implementation of the EOSC began in 2015 with efforts by the European Commission to align and coordinate with various stakeholders in the European research landscape. In its initial phase (2018-2020), the European Commission invested around €250 million through Horizon 2020 to prototype EOSC components and set up interim governance to prepare for post-2020 strategies. The current phase (2021-2030) is guided by a Strategic Research and Innovation Agenda (SRIA), developed with the EOSC community, and is focused on a stakeholder-driven approach.

The project-based funding of the EOSC requires researchers to form consortia to apply for specific calls. While this funding approach fosters innovation by promoting competitive grants and cross-disciplinary partnerships, it poses sustainability challenges, as the infrastructure development is tied to specific projects with limited timelines. However, stable activities are maintained through statutory funding from public institutions, with services like software and user support provided on a best-effort basis. Additional support comes from organizations like the European Organization for Nuclear Research (CERN) and the National Aeronautics and Space Administration (NASA), as well as national funds dedicated to digitalization and cybersecurity, which can align with EOSC objectives.

A co-investment of at least €1 billion from EU and non-EU partners is planned for the next seven years. Project officers from the European Commission collaborate with research communities to identify key areas for future funding, while the progress is overseen by the tripartite governance structure.

CONCLUSION

The relationship between public, private, and civic spheres within the EOSC is characterized by a dynamic interplay where different research communities, organized as consortia, collaborate to provide various components of the EOSC infrastructure. This collaboration is underpinned by public funding primarily through European Commission initiatives, such as Horizon 2020, alongside national government contributions. Policy instruments used in the case of the EOSC differ significantly from previous public interventions in the field. Instead of a top-down approach, the EOSC was designed to employ a bottom-up, community-based governance structure that prioritizes inclusivity and collaboration with research institutions.

However, the EOSC faces several challenges. The reliance on project-based funding introduces sustainability issues, as infrastructure development is often tied to specific, time-bound projects. This can lead to fragmentation and a lack of continuity in services and support. Additionally, the multi-stakeholder governance model, while inclusive, can lead to complexities in decision-making and coordination.

This case study reveals important insights for public support methods and modalities. It underscores the necessity of a mixed funding approach, combining competitive grants with

stable, long-term funding commitments to ensure sustainability. Moreover, it highlights the value of a stakeholder-driven governance model that integrates diverse perspectives and expertise, thereby enhancing the relevance of the infrastructure for the public. An increasingly decentralized approach is envisioned for the future of the EOSC, as the EOSC Federation will allow more flexibility in terms of financial mechanisms and business models within the EOSC.

7. CONCLUSION

The first part of this publication has shown that current public value maximization strategies for public digital infrastructures adopted by policymakers emphasize the role of the state as an "entrepreneurial state" that promotes a digital environment based on openness and generative interoperability. This approach prioritizes the creation of digital infrastructures that support multiple public functions and enable multiple derivative uses, recognizing the importance of openness and non-exclusivity. Policymakers propose various forms of public ownership to ensure the public character and societal benefits of these infrastructures, all of which include some Digital Commons as a mechanism for infrastructure provision.

The case studies analyzed in this paper confirm this nuanced and multifaceted approach to public digital infrastructures, using Digital Commons and various forms of public ownership to maximize societal benefits and ensure inclusive, open, and interoperable digital ecosystems. The case studies of ZenDiS and scikit-learn better illustrate the ecosystem strategy followed by public institutions aiming to strengthen the stack of OSS increasingly connecting information systems and devices. The case of Decidim, created by the city of Barcelona as a new type of commons-based institution, shows what kind of partnerships can be built to provide alternative spaces for online public speech and debate. DHIS2 – a software component used by many governments to develop their health information management systems – illustrates how digital infrastrcutures can be collectively managed and produced, allowing mutualization of resources and capacity. Finally, the European Open Science Cloud is a unique example of a pan-European attempt to build a shared infrastructure with a community of these researchers, not only redefining the tools and processes used by researchers, but also developing an infrastructure embedded in the values and principles of Open Science.

The case studies provide various insights into the necessary conditions for Digital Commons to provide infrastructure, especially in terms of long-term funding, which – as shown by the review of literature in this paper – communities struggle to provide. It also shows the diversity of relationships that can be built between public institutions and Digital Commons, with consequences on the governance of Digital Commons.

Necessary conditions

The case studies show that the potential of Digital Commons to contribute to the provision of public digital infrastructures hinges on several key conditions. Firstly, there must be a clear need that aligns with a public function, which implies that Digital Commons should contribute to achieving public goals. These goals could be related to, for example, a Sustainable Development Goal or the enjoyment of a fundamental right. Secondly, while the degree of formalization of the commons can vary, some level of it seems necessary and inevitable for a successful public–commons partnership. This formalization could take various forms. For instance, it could be achieved by setting up an association or by integrating the Digital Commons into a public research institution. This formal structure provides a framework for collaboration with the (other) public institutions. Thirdly, the long-term sustainability of Digital Commons is contingent on continuous funding. This funding is crucial not just for the development of new features, but

also for maintaining the existing infrastructure and facilitating collective deliberation processes. Finally, for Digital Commons to scale as public digital infrastructures, political will and favorable political climate are indispensable. Without the backing of the political establishment, Digital Commons may struggle to achieve the necessary scale and impact.

Nature of the relationship

When considering the relationship between public institutions and Digital Commons, it is crucial to recognize that public institutions are not a homogeneous category. Different institutions can assume different roles and perform different functions in relation to the commons. Nevertheless, the relationship between public institutions and Digital Commons in the context of infrastructure provision revolves primarily around governance and funding. In terms of governance, there are different setups. In some cases, governance is fully delegated to a community, as seen with Decidim, where state institutions play a minimal role in governance structures. Alternatively, there can be co-governance, such as with the European Open Science Cloud (EOSC), where tripartite governance involves strategic coordination among the European Commission, the EOSC Steering Board representing participating countries, and the EOSC Association representing the research community. In other instances, the public institution (e.g., a university) remains the central governance hub, as is the case, for example, with DHIS2. Funding and other forms of support are another critical aspect of the relationship between the public institutions and the commons. While donations and grants are popular, more public funding is typically available for innovation rather than maintenance of the commons. Public funding for digital infrastructure in the form of projects often poses sustainability challenges. Public tenders can be used for new developments and improvements of the commons, but these come with challenges in adapting to public procurement rules and the risk of preferential treatment or picking winners.

Consequences for Digital Commons

When Digital Commons receive support as infrastructure, it brings about significant implications for their governance and operation. One of the primary concerns, especially in Digital Commons projects initiated by the community, is the risk of "statization" and politicization. This fear stems from the potential for increased state control or political influence that could alter the original objectives or operations of the commons. When Digital Commons assume the role of public digital infrastructures, it impacts their relationships with both the state and market actors. This could manifest in various ways, such as dealing with private funding or navigating attempts by private actors to influence the project agenda. The transition to a public role may also introduce new requirements and expectations. These could pertain to transparency, governance, or technical requirements, necessitating adjustments in the commons' operations and strategies. Scaling up presents its own set of challenges. Governance, in particular, can become a collective action dilemma. While broad participation of different stakeholders is essential to create common value for a community, aligning divergent interests and activities requires careful orchestration and governance. Finally, there is the perennial challenge of "free riding" by other actors. This is a common issue for Digital Commons, where commercial software vendors may

extend and build on the product without contributing anything in return, leading to competition and potential dilution of the commons' value.

_ABOUT

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