From Open Access to Collective Governance

Two Decades of Digital Commons Policies in the European Union

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NGI COMMONS

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About this Report

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Executive Summary

This report provides a comprehensive—though not exhaustive—overview of policies supporting Digital Commons over the past 20 years. While focusing on the European Union (EU) and its member states, it includes relevant examples from other regions and local levels. Based on desk research, it synthesizes findings from existing reports and mappings on Digital Commons. A key contribution of this report is its integration of different resources under the holistic framework of Digital Commons, while most sources have focused on individual subsets of Digital Commons, such as open source software or open data.

The concept of **Digital Commons encompasses a diverse range of systems and solutions that are collaboratively owned, developed, and maintained by communities** rather than single entities. These commons operate on principles of peer collaboration rather than hierarchical control or market pricing. Initially emerging from grassroots efforts, many Digital Commons—such as Wikipedia and Apache—have millions of daily users. Today, open source software (OSS) constitutes 76% of all software code, growing to **form the backbone of global digital infrastructures**. Studies have estimated that OSS contributes €65–€95 billion to the EU's GDP, comparable to the air and water transport sectors combined. Globally, OSS's market value is estimated at $8.8 trillion. Beyond software, Wikimedia Commons' images alone have been valued at $28.9 billion. These studies show the performance of Digital Commons as a mode of production. They have formed a stack of technologies that has become increasingly complex and intertwined, a stack on which everybody, from major tech companies, to governments, global industries and societies are dependent on.

At the start of the 21st century, **Europe adopted policies centered on open access, promoting the free circulation of knowledge, software and data**. Milestones like the 2003 Directive on Public Sector Information reuse and the European Commission's 2012 recommendation for open access to publicly funded research laid the groundwork for embedding openness into digital policy frameworks. Publicly funded resources, including outputs of research were increasingly made available proactively, based on "open by default" policies. Additionally, incentives for the circulation and reuse of data outside of the public sector were established, for instance for highly valuable datasets. These efforts emphasized the **economic benefits of making information and knowledge accessible** and aimed to support transparency and citizen empowerment. Additionally, the EU has become a pioneer in the adoption of OSS for the modernization of its administrations: 14 countries in the EU have adopted legally binding documents to support public sector adoption of OSS tools. Beyond regulatory measures, governments have created procurement guidelines, collaborated on catalogues of OSS solutions, created networks of practices, or more recently, established Open Source Programme Offices (OSPOs), facilitating the implementation of OSS solutions to **avoid vendor lock-ins and for increased transparency, interoperability, and cost-efficiency.**

Over the past decade, Digital Commons policies have **shifted focus from promoting openness to addressing governance and collective management of digital infrastructures**. This evolution reflects concerns over digital sovereignty, following the Snowden revelations, but also the rise of a few dominant platforms, and global tensions around digital value chains. Corporations have strategically used Digital Commons, as seen in Google's Android

and Chromium projects, to maintain control while benefiting from collaborative ecosystems. Similarly, Tesla's patent-sharing initiative set industry standards for electric vehicles to advance the companies' strategic goals. These examples highlight how Digital Commons can serve as **tools for innovation, for collaboration between competitors, but also as tools for setting rules and standards, for reshaping markets and gaining power.**

By the late 2010s, policies evolved to **not only support open resources but also to invest in the infrastructures and institutions that facilitate their sharing**. A growing focus on mutualized infrastructures for publishing and data sharing is exemplified by initiatives like Europeana, the European Open Science Cloud or the Nordic Institute for Interoperability Solutions. Interoperability has become a central strategy for both private and public sectors. Corporations leverage it to integrate internal systems and control external access via APIs, while publicly initiated projects such as Gaia-X promote openness, competition, and ecosystem development by embedding values like transparency, trust, and decentralization.

EU countries also began broadening their OSS policies to address goals beyond cost-efficiency and administrative modernization. This shift aligned the EU with regions like Asia, where countries such as South Korea and China had already **incorporated OSS into industrial strategies to strengthen local ICT industries and achieve technological independence**. In the EU, similar approaches have been adopted in key areas like chips, cloud computing, artificial intelligence (AI), and the automotive industry. For example, the EU has invested **€270 million in high-performance processors based on RISC-V, an open source architecture for chip designs**, or supported the development of open source middleware for cloud computing as part of the **Important Project of Common European Interest (IPCEI) on Cloud Infrastructure and Services**.

Digital Commons are further instrumental in advancing **"Digital Public Infrastructure" (DPI)**, which underpins systems for data exchange, identity, and payments. Public investments in open APIs can drive digital transformation while ensuring public oversight of critical ecosystems. European initiatives such as the **EU Digital Identity Wallet** have been announced to rely on open and interoperable building blocks. Beyond infrastructure, Digital Commons play a pivotal role in international cooperation, particularly in achieving the Sustainable Development Goals (SDGs). Initiatives like the **Digital Public Goods Alliance** deploy Digital Commons in software, data, and AI to provide cost-effective solutions for technology transfer.

Digital Commons are also increasingly seen as a means to "de-privatize" infrastructures and create public digital spaces that form alternatives to purely profit-driven systems. The **EU's 2022 report, "Towards a Sovereign Digital Infrastructure of Commons"**, endorsed by 19 member states, underscores the importance of Digital Commons in securing European digital sovereignty. It advocates for governance frameworks that prioritize "public-civic-private cooperation" over private and technocratic management, emphasizing **collective governance, resilience, respect for digital rights, and interoperability**. Policies in this context prioritize collaboration over competition, blending public and civic engagement to foster a more inclusive and sustainable digital ecosystem. Efforts such as the **Next Generation Internet (NGI) initiative** and the German **Sovereign Tech Agency** reflect this approach, supporting both new and existing infrastructures critical to global digital ecosystems.

Finally, the report highlights that Europe's support for open internet principles and global shared resources has faced challenges from cybersecurity threats and global geopolitical clashes. Initiatives like Gaia-X show the EU's struggle to **balance openness with local ecosystem support**, while the **politicization of international standards and support for open source foundations** underscores tensions between international collaboration and national interests. Emerging governance models demonstrate the potential of public-commons collaborations to be tailored to match the political sensitivity of sovereignty and security concerns. These range from community-led projects to co-governance structures and neutral public maintainers.

Effective governance and institutional frameworks are essential to maintain and scale Digital Commons. Several challenges and gaps were identified in current policy frameworks, including **fragmented funding**, a **lack of long-term support**, and **insufficient public sector capacities**. The report concludes with recommendations to integrate Digital Commons more broadly into European policies, emphasizing the need for strategic alignment with societal goals such as sustainability and digital sovereignty:

- **Mainstreaming Digital Commons into European policies:** Embedding the culture and practices of Digital Commons across member states and aligning them with existing policy frameworks and indicators.
- **Investing in technologies and the institutions that sustain them:** Supporting both the technological foundations and the governance structures necessary for the long-term sustainability of Digital Commons.
- **Scaling impact by increasing financial support and pooling resources:** Addressing fragmentation through resource integration and fostering collaboration across member states and stakeholders.
- **Mobilizing Digital Commons to achieve the green transition:** Strategically aligning Digital Commons with environmental policies to foster innovation in sustainable technologies and systems.

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Introduction: From Open Access to Collective Governance

Digital Commons have played a central role in the history of technological developments in Europe–and beyond. In 1989, **Tim Berners-Lee, a researcher at the European Organization for Nuclear Research (CERN), invented the World Wide Web**. Originally designed as a tool to facilitate knowledge sharing among scientists, the Web was conceived as an open system that would be freely accessible to all. Its principles of universality and decentralization became cornerstones of the web as a digital common[1]. In 1991, **Linus Torvalds, a student at the University of Helsinki in Finland, began developing the Linux kernel**. What started as a personal project soon became the foundation of one of the most significant open source software (OSS) initiatives. Linux has since become a critical component of global digital infrastructure, underpinning operating systems, servers, smartphones, and countless other devices[2]. The **2005 launch of Arduino in Italy** marked another milestone in the evolution of Digital Commons. Developed as a tool for students at the Interaction Design Institute Ivrea, Arduino democratized access to hardware by providing an open platform for creating interactive electronic projects. Since then, Arduino has empowered millions of makers, educators, and innovators worldwide[3]. More recently, in 2016, **Eugen Rochko, a student at Friedrich Schiller University in Germany, released the first version of Mastodon**, a decentralized social media platform. Mastodon emerged as a response to concerns over centralized control and surveillance on major social platforms by providing an open source and federated alternative[4].

These examples illustrate how **European initiatives have continually shaped the global digital landscape by not only contributing to foundational innovations but also by promoting a vision of technology rooted in collaboration and openness**. This ethos was fundamental to the development of Digital Commons globally, and its roots can be traced back to the scientific origins of most of the **fields where Digital Commons have grown, from educational and cultural resources to science, designs, software, and datasets**.

The Scientific Ethos and Freedom of Information

A clear example of the scientific roots of Digital Commons can be observed in the field of software development. Initially, programming was not envisioned as a commercial enterprise but as a collective effort to advance computer science. In this context, an ethic emerged that emphasized **collaboration and the unrestricted sharing of information**, characterized by a playful and enthusiastic approach to programming. This ethos became a defining feature of open source software (OSS), where collective contributions are essential for driving

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[1] Tim Berners-Lee, "The Original Proposal of the WWW, HTMLized," W3.org, 1989, https://www.w3.org/History/1989/proposal.html.

[2] Wikipedia Contributors, "Linux Kernel," Wikipedia (Wikimedia Foundation, June 29, 2019), https://en.wikipedia.org/wiki/Linux_kernel.

[3] Arduino, "What Is Arduino?," Arduino.cc, February 5, 2018, https://www.arduino.cc/en/guide/introduction.

[4] Will Knight, "The Man behind Mastodon Built It for This Moment," Wired, November 14, 2022, https://www.wired.com/story/the-man-behind-mastodon-eugen-rochko-built-it-for-this-moment/.

innovation and solving complex problems[5]. This ethic aligns closely with the ideals of science, as formalized by American sociologist Robert Merton. Rather than seeking exclusive property rights over their discoveries, scientists are supposed to be driven by recognition and esteem, viewing the shared ownership of knowledge as vital to scientific progress[6]. Ideally, these principles should foster **a scientific culture that treats informational goods as commons—resources to be collaboratively managed and produced rather than privatized**. Similarly, the foundational principles of open source software or open data are designed to ensure that technologies remain accessible, shareable, and open to continuous improvement[7].

The **internet's widespread adoption in the early 2000s made global knowledge sharing a practical reality**, enabling collaboration on an unprecedented scale. Wikipedia, launched in 2001, exemplifies this shift. As of 2023, Wikipedia was indeed edited at a rate of over 2 edits every second, made by a global network of several millions of editors over the years[8]. Since its creation, it has grown to become the world's largest openly accessible knowledge repository, governed under the umbrella of the nonprofit Wikimedia Foundation[9]. As a result, new political movements emerged, centered on the belief that **informational goods—such as data, knowledge and software—should circulate freely**. These movements' ideals are best illustrated by the famous aphorism "information wants to be free", attributed to Stewart Brand. It states that informational goods are, by nature, supposed to be shared publicly. Communication technologies are seen as enabling horizontal networks for knowledge sharing, **breaking the artificial centralized power structures of industrial society**, which relied on opaque information retention by experts within organizational boundaries. Information freedom is viewed as an essential part of a counterculture not only for innovation but for societal justice, self-determination and equality[10]. This movement drew parallels between the nature of these informational goods and the physical goods that were shared and managed collectively. Similarly to the resistance by communities against the "enclosure" of collectively managed lands as the result of their privatization in the context of industrialization processes, the **Digital Commons movement emerged as a response to new "enclosures" on immaterial goods**[11], resisting the barriers that would limit the free exchange of information[12]. The Open Access movement, formalized with the Budapest Open Access Initiative (BOAI) in 2002, exemplifies this resistance to the "enclosure" of knowledge. Open

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[5] Pekka Himanen, The Hacker Ethic and the Spirit of the Information Age (London: Vintage, 2001, 2001).

[6] Robert K Merton, The Sociology of Science: Theoretical and Empirical Investigations (1942; repr., Chicago: University of Chicago Press, 1973).

[7] Simon Chignard, "A Brief History of Open Data," www.paristechreview.com (ParisTech Review, March 29, 2013), https://www.paristechreview.com/2013/03/29/brief-history-open-data/.

[8] Wikipedia Contributors, "Wikipedia:Statistics," Wikipedia (Wikimedia Foundation, July 24, 2019), https://en.wikipedia.org/wiki/Wikipedia:Statistics.

[9] Leonhard Dobusch and Jakob Kapeller, "Open Strategy-Making with Crowds and Communities: Comparing Wikimedia and Creative Commons," Long Range Planning 51, no. 4 (August 2018): 561–79, https://doi.org/10.1016/j.lrp.2017.08.005.

[10] Benjamin Loveluck, Benjamin Loveluck, Réseaux, Libertés et Contrôle. Une Généalogie Politique d'Internet (Paris: Armand Colin, 2015).

[11] Lessig, Lawrence. 2004. Free Culture: How Big Media Uses Technology and the Law to Lock down Culture and Control Creativity. New York: Penguin Press.

[12] Boyle, James. 2003. 'The Second Enclosure Movement and the Construction of the Public Domain'. SSRN Electronic Journal 66: 33–74. http://dx.doi.org/10.2139/ssrn.470983

access to scientific publications indeed was designed to challenge a model where academic publishers were profiting from publicly funded research while restricting access to scientific findings behind paywalls, and while researchers, who produce and review the content, receive little compensation[13].

Building on the growing popularity of these ideas, governments gradually adopted **policies supporting open access to software, data, content, and hardware, recognizing the societal and economic benefits of removing barriers to knowledge circulation**. In Europe, key legislative milestones supported this shift, embedding open access into policy frameworks. The 2003 Directive on the re-use of public sector information (and the later amended versions), marked a significant step by mandating that data produced by public sector bodies be made available for reuse. Later, the European Union showed its commitment to Open Access by mandating that all scientific publications funded under Horizon Europe programs should be made freely available. Many European governments began to endorse OSS in public administration, established data transparency initiatives, and supported open science policies. Through these efforts, open access gradually became a part of digital policy frameworks, with public institutions slowly embracing the associated values of transparency and decentralized collaboration.

Digital Commons as Social Technologies

The progressive inclusion of Digital Commons in policy frameworks demonstrates that Digital Commons are, above all, the **outcomes of political struggles and deliberate institutional designs.** The **design of the GNU General Public License by Richard Stallman was a consequence of the appearance of proprietary software**. It was rooted in a political vision of technology, carrying values and ideals that sought to redefine relationships between individuals, technology, and the collective good. Similarly, **Creative Commons licenses were born to ensure collective user rights, and in opposition to restrictive intellectual property policies**, such as the 1998 Copyright Term Extension Act (the "Mickey Mouse Protection Act") in the United States, which extended intellectual property rights. These policies were often accompanied by measures protecting the implementation of digital rights management or access control technologies to fight against online piracy[14]. Such examples demonstrate that, contrary to the notion of immaterial goods as inherently public goods, legal frameworks and technical measures can be implemented to restrict their circulation.

These policy debates **challenged the idea that digital resources are inherently common or public goods**. Unlike the traditional economic assumptions behind the concept of public goods, research on Digital Commons focuses on the **importance of collective rule-setting and institutional arrangements[15]**. Under this analytical framework, a resource becomes "common" not merely because of its inherent characteristics but through shared governance

[13] Peter Suber, Knowledge Unbound (MIT Press, 2016).

[14] Dulong de Rosnay, Mélanie, and Felix Stalder. 2020. "Digital commons". Internet Policy Review 9 (4). DOI: 10.14763/2020.4.1530. https://policyreview.info/concepts/digital-commons.

[15] Charlotte Hess, "Mapping the New Commons," SSRN Electronic Journal, 2008, https://doi.org/10.2139/ssrn.1356835.

mechanisms that ensure equitable access and sustainable use[16]. Open standards are good examples of Digital Commons as more than merely open resources. While they are defined by their accessibility—enabling anyone to use, implement, or modify them—**their true value lies in participatory governance**. Open standards are indeed not just technical specifications but institutional frameworks. Organizations like the Internet Engineering Task Force (IETF) and the World Wide Web Consortium (W3C) embody this principle, operating on principles such as openness, consensus, and public accountability. These principles ensure that the standards they create serve the common good rather than specific corporate interests[17]. This approach to Digital Commons builds on the work of the economist Elinor Ostrom, whose research demonstrated that groups of individuals can self-organize effectively to govern and sustain commons without reliance on markets or state-imposed regulations. Her governance-centric view of commons **shifted focus from the intrinsic nature of the resources themselves to the social and institutional arrangements that define how they are accessed, managed, and maintained**[18].

The Rise of Commons-based Peer Production

Digital Commons, especially OSS, have become indispensable to contemporary economies and societies, acting as critical infrastructures that enable innovation and economic development. Far from being a niche practice for scientists or activists, OSS underpins much of the technology that powers our modern world. According to the 2023 Open Source Security & Risk Analysis (OSSRA) report, **96% of commercial code incorporates OSS, and 76% of all code is open source**[19]. Platforms like GitHub, which hosts over 100 million developers globally, demonstrate the scale of the OSS community and its integration into the operations of all major tech companies[20].

Efforts to quantify the economic impact of Digital Commons reveal their significant contributions. A European Union study estimates that **OSS adds between €65–€95 billion to the EU's gross domestic product (GDP)**—an economic value comparable to the combined contributions of the air and water transport sectors. Furthermore, it predicts that a 10% increase in OSS contributions within the EU could generate an additional €100 billion, or 0.4%–0.6% GDP growth[21]. On a global scale, research led by Frank Nagle at Harvard estimates OSS's demand-side value—representing the market's willingness to pay for it—at

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[16] Paul N. Edwards, "'A Vast Machine': Standards as Social Technology," Science 304, no. 5672 (May 7, 2004): 827–28, https://doi.org/10.1126/science.1099290.

[17] ISOC, "Policy Brief: Open Internet Standards," Internet Society, October 30, 2015, https://www.internetsociety.org/policybriefs/openstandards/.

[18] Elinor Ostrom, Governing the Commons (Cambridge University Press, 1990), https://doi.org/10.1017/cbo9780511807763.

[19] Synopsys, "2023 Open Source Security and Risk Analysis Report (OSSRA)" (Sunnyvale, CA: Synopsys, Inc., February 2023).

[20] Thomas Dohmke, "100 Million Developers and Counting," The GitHub Blog, January 25, 2023, https://github.blog/news-insights/company-news/100-million-developers-and-counting/.

[21] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

$8.8 trillion, and its supply-side value—reflecting the labor costs of its development—at $4.15 billion[22]. Beyond software, Digital Commons like the ones hosted by the Wikimedia Foundation have also shown significant economic worth; one study estimated consumer benefits from Wikipedia in the hundreds of billions of dollars[23], while another valued Wikimedia Commons' images alone at $28.9 billion[24].

These numbers highlight the **immense value of managing software as commons**. Frank Nagle's research, for instance, indicates that firms would need to spend 3.5 times more on software than they currently do if OSS were unavailable[25]. Technological legacies and modern technology ecosystems have become so complex that **their maintenance and development by single competing entities under proprietary conditions seem not only economically irrational but also impractical**.

The economic success of Digital Commons has been studied and theorized in greater depth largely since the 2000s. Yochai Benkler specifically mentioned the concept in his famous work on "The Wealth of Networks". Benkler's concept of "commons-based peer production"[26] indeed argued that because digital technologies enable collaboration and knowledge-sharing on an unprecedented scale, **open modes of production would necessarily outcompete traditional, proprietary systems in generating both social and economic value**. This perspective solidified the view that free and open access to digital resources is not only compatible with innovation but actively promotes it by reducing transaction costs: "A world in which all agents can act effectively on all resources will be substantially more productive in creating information goods than a world in which firms divide the universe of agents into bounded sets"[27]. Benkler's work on commons-based peer production resonates with the concepts of open innovation developed by Chesbrough[28], user-driven innovation developed by von Hippel[29], co-creation developed by Zwass[30] or crowdsourcing developed by Olson and

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[22] Manuel Hoffmann, Frank Nagle, and Yanuo Zhou, "The Value of Open Source Software," Harvard Business School Working Paper, no. 24-038 (January 2024), https://doi.org/10.2139/ssrn.4693148.

[23] Jonathan Band and Jonathan Gerafi, "Wikipedia's Economic Value," SSRN Electronic Journal, 2013, https://doi.org/10.2139/ssrn.2338563.

[24] Kenneth L Erickson, Felix Rodriguez Perez, and Jesus Rodriguez Perez, "What Is the Commons Worth? Estimating the Value of Wikimedia Imagery by Observing Downstream Use.," in Proceedings of the 14th International Symposium on Open Collaboration (OpenSym '18: The 14th International Symposium on Open Collaboration, ACM (Association for Computing Machinery), 2018), https://doi.org/10.1145/3233391.3233533.

[25] Manuel Hoffmann, Frank Nagle, and Yanuo Zhou, "The Value of Open Source Software," Harvard Business School Working Paper, no. 24-038 (January 2024), https://doi.org/10.2139/ssrn.4693148.

[26] Benkler, Yochai. 2006. The Wealth of Networks: How Social Production Transforms Markets and Freedom. New Haven [Conn.]: Yale University Press. https://www.benkler.org/Benkler_Wealth_Of_Networks.pdf

[27] Benkler, Yochai. "Coase's Penguin, or, Linux and the Nature of the Firm." The Yale Law Journal 112, no. 3 (2002): 369–446. New Haven: The Yale Law Journal Company: https://www.yalelawjournal.org/article/coases-penguin-or-linux-and-the-nature-of-the-firm

[28] Henry Chesbrough, Open Innovation : Researching a New Paradigm (Oxford: Oxford Univ. Press, 2006).

[29] Eric von Hippel, "Democratizing Innovation: The Evolving Phenomenon of User Innovation," Journal for Betriebswirtschaft 55, no. 1 (2005): 63–78, https://doi.org/10.1007/s11301-004-0002-8.

[30] Vladimir Zwass, "Co-Creation: Toward a Taxonomy and an Integrated Research Perspective," International Journal of Electronic Commerce 15, no. 1 (October 2010): 11–48, https://doi.org/10.2753/jec1086-4415150101.

Rosacker[31] that emerged in the same decade. The literature around these concepts studies how collaborative and decentralised modes of production drive technological innovation.

The Paradox of Open

The work of Yochai Benkler analyzed Digital Commons as **an alternative mode of production, based on voluntary peer collaboration, and therefore intrinsically different from production within organizations or within markets**, which are using subordination and price signals to coordinate their activities. During the past 20 years, however, Digital Commons have become increasingly integrated in both markets and firms. The majority of tech companies have learned to use it in parallel to internal modes of production or market mechanisms, for instance to **crowdsource innovation[32]**. Tech companies also use Digital Commons to collaborate on software components with competitors, **co-producing shared infrastructures[33], or large-scale "industrial public goods"[34]**, which have been compared to the logics behind patent pools[35]. They also strategically mobilize Digital Commons to **establish control by setting standards, building the infrastructures their commercial activities rely on, and creating ecosystems that can reshape markets**. For instance, Google leverages open technologies like Android and Chromium to reinforce its dominance. Although Android's core is Open Source, Google maintains control over key proprietary elements, such as the Play Store. Similarly, Chromium, the foundation of Google Chrome, allows Google to influence browser development and web standards[36]. Tesla's release of over 300 patents in 2014 illustrates another approach to using Digital Commons. By freely offering these patents to the automotive industry, Tesla facilitated the development of electrified vehicles, not primarily for co-innovation but to set industry standards and build an ecosystem that aligns with its strategic goals[37]. These examples demonstrate how Digital Commons can be utilized **not only as collaborative tools but also as mechanisms for industrial strategies and as sources of power**.

These practices illustrate the fact that the openness promoted by early internet utopias as well as the open modes of production described by Benkler do not automatically lead to

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[31] David L. Olson and Kirsten Rosacker, "Crowdsourcing and Open Source Software Participation," Service Business 7, no. 4 (November 27, 2012): 499–511, https://doi.org/10.1007/s11628-012-0176-4.

[32] Rebecca Ackermann, "The Future of Open Source Is Still Very Much in Flux," MIT Technology Review, August 17, 2023, https://www.technologyreview.com/2023/08/17/1077498/future-open-source/.

[33] Marco Berlinguer, "The Value of Sharing. How Commons Have Become Part of Informational Capitalism and What We Can Learn from It. The Case of FOSS," Rassegna Italiana Di Sociologia, no. 2 (January 1, 2018): 263–88, https://doi.org/10.1423/90580.

[34] Mathieu O'Neil et al., "Co-Producing Industrial Public Goods on GitHub: Selective Firm Cooperation, Volunteer-Employee Labour and Participation Inequality," New Media & Society, April 27, 2022, 146144482210904, https://doi.org/10.1177/14614448221090474

[35] Thierry Rayna and Ludmila Striukova, "Large-Scale Open Innovation: Open Source vs. Patent Pools," International Journal of Technology Management 52, no. 3 & 4 (2010), https://ssrn.com/abstract=1712289.

[36] Malcolm Bain, "Google Chrome and Android: Legal Aspects of Open Source Software," in Google and the Law Empirical Approaches to Legal Aspects of Knowledge-Economy Business Models, ed. Aurelio Lopez-Tarruella, vol. 22 (The Hague: T.M.C. Asser Press, 2012), 259–86, https://doi.org/10.1007/978-90-6704-846-0_9.

[37] James Bessen, "History Backs up Tesla's Patent Sharing," Harvard Business Review, June 13, 2014, https://hbr.org/2014/06/history-backs-up-teslas-patent-sharing.

more horizontal societies and a distributed digital economy. Openness alone does not address the complex power dynamics within today's heavily intermediated information economy. This has been coined as the **"Paradox of Open"**: **openness can both disrupt and reinforce power dynamics**[38]. The concentration of power and wealth in the hands of few dominant privately-hold platforms has indeed reshaped debates on openness, as these players were able to develop closed sharing models. While openness still facilitates broad access and collaboration, it can also strengthen these platforms, which leverage open resources while retaining market dominance[39]. This reality reflects the naivety of some early open internet utopias, which prioritized the technical abundance of data and content while overlooking cognitive and social realities. Economists of immaterial public goods for instance failed to consider the constraints of the attention economy, a cornerstone of the platform model, or the essential processes of learning and appropriation that underpin effective knowledge sharing[40]. Through network effects, data extraction, and vertical integration, platforms have gained significant influence, creating chokepoints in the digital ecosystem and raising concerns about dependencies, especially in emerging technologies like AI[41].

While openness still facilitates broad access and collaboration, it can also strengthen these platforms, which leverage open resources while retaining market dominance. Reflecting this, policy attention has moved beyond removing "enclosures" on information and knowledge, focusing increasingly on **governance models that maximise public benefit and ensure responsible management of digital resources**[42]. By 2014, discussions around platform governance had broadened to include alternative models, exemplified by the emergence of the term **"platform cooperativism."** This concept proposed cooperative ownership structures as a counterweight to the dominance of centralized platforms, highlighting the need for economic and governance alternatives in the digital economy[43].

This trend is visible across major Digital Commons fields. For open data, the policy conversation has advanced from a simple open-versus-closed debate to the development of governance models that support stakeholders' control over data usage. Emerging licensing frameworks reflect these perspectives, allowing **local autonomy in data management** to ensure that open data serves community interests[44]. While open access has improved knowledge availability, it has not fundamentally altered power dynamics, particularly in

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[38] Keller, Paul, and Alek Tarkowski. The paradox of the open. Open Future, accessed February 2024: https://paradox.openfuture.eu/.

[39] David Bollier, "The Shift from Open Platforms to Digital Commons," Bollier.org, 2016, https://www.bollier.org/blog/shift-open-platforms-digital-commons.

[40] Dominique Boullier, "Sociologie Du Numérique," HAL (Le Centre Pour La Communication Scientifique Directe) "Collection U," no. 2e éd. (August 14, 2019), https://doi.org/10.3917/arco.boull.2019.01.

[41] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

[42] Sébastien Broca, "Communs et Capitalisme Numérique : Histoire d'Un Antagonisme et de Quelques Affinités Électives," Terminal, no. 130 (June 1, 2021), https://doi.org/10.4000/terminal.7595.

[43] Trebor Scholz and Nathan Schneider, Ours to Hack and to Own : The Rise of Platform Cooperativism, a New Vision for the Future of Work and a Fairer Internet (New York: Or Books, 2017).

[44] Benhamou, Yaniv and Dulong de Rosnay, Melanie, Open Data Commons Licences (ODCL): Licensing Personal and Non Personal Data Supporting the Commons and Privacy (December 12, 2023). Available at SSRN: https://ssrn.com/abstract=4662511 or http://dx.doi.org/10.2139/ssrn.4662511

academic publishing. New policies are therefore also promoting **collectively managed infrastructures for open science**, such as the European Open Science Cloud (EOSC)[45]. Additionally, there is growing concern about how knowledge commons, such as academic research and cultural content, are being monetized in the context of machine learning and generative AI, which often **extract value from open resources without fair returns** to original creators or the public domain[46].

Growing Concerns Over Digital Sovereignty

Today, the global digital policy landscape seems to be at a crossroads. As illustrated by the UN Secretary-General's Roadmap for Digital Cooperation, there is an **acknowledgment that technological trajectories can no longer be left entirely to private forces**, as digital systems can exacerbate inequalities or disrupt existing societal structures if left unchecked[47]. This awareness has prompted a reassessment of public intervention strategies. Increasingly, governments consider themselves not just regulators but strategic investors, seeking to reclaim digital sovereignty and steer technological development in line with public priorities[48].

The term "digital sovereignty" is contested and subject to different interpretations, encompassing diverse dimensions such as cybersecurity, economic resilience, and geopolitical autonomy[49]. In Europe, its prominence has grown significantly in response to events such as the **Snowden revelations on mass surveillance**, the dominance of a few private firms in the European digital landscape, the weaponization of digital technologies and infrastructure in recent conflicts, commercial disputes over emerging technologies like 5G, and the vulnerabilities in value chains exposed during the COVID-19 pandemic[50]. **Digital technologies challenge foundational principles of sovereignty, such as territoriality and authority**, as the internet transcends national boundaries. The concept extends to control over software, hardware, data, and networks, whose value chains are global and interdependent. Digital technologies are particularly susceptible to vulnerabilities such as backdoors in operating systems, software, third-party services, and hardware, which can lead to unauthorized access and jeopardize national security, trade secrets or individual's rights[51].

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[45] 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.

[46] Tarkowski, Alek, and Zuzanna Warso. "Commons-based Data Set Governance for AI." Open Future, March 21, 2024. Open Future Foundation. https://openfuture.pubpub.org/pub/principles-for-commons-based-data-set-governance-for-ai.

[47] 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/.

[48] Rikap, Cecilia, and Bengt-Åke Lundvall. The Digital Innovation Race: Conceptualising the Emerging New World Order. Cham: Springer International Publishing, 2021. https://doi.org/10.1007/978-3-030-89443-6

[49] Samuele Fratini et al., "Digital Sovereignty: A Descriptive Analysis and a Critical Evaluation of Existing Models," Digital Society 3, no. 3 (November 14, 2024), https://doi.org/10.1007/s44206-024-00146-7.

[50] European Institute of Innovation and Technology (EIT), "European Digital Infrastructure and Data Sovereignty" (Brussels, Belgium: EIT Digital, September 24, 2021), https://eit.europa.eu/library/european-digital-infrastructure-and-data-sovereignty.

[51] Gaël Duval, "From Sovereign Operating Systems to the Sovereign Digital Chain," in Reflections on Programming Systems Historical and Philosophical Aspects, ed. Giuseppe Primiero and Liesbeth De Mol (Switzerland: Springer Cham, 2018), 261–71, https://doi.org/10.1007/978-3-319-97226-8_9.

In this context, Digital Commons have been **increasingly considered by policy makers as part of the solution**[52]. The **Berlin Declaration** (2020) reinforced this agenda by promoting digital sovereignty based on **common standards, modular architectures, and open source technologies** to facilitate cross-border solutions[53]. The four freedoms of OSS, for instance, allow users to check software for vulnerabilities and to avoid vendor-lock, therefore providing them with **greater control and autonomy over technologies**.

An important dimension of digital sovereignty is the **capacity to set or influence rules governing digital communications and services**. This capacity is no longer limited only to the ability to enforce domestic regulations but to actively participate in the development of global technical standards, which are increasingly developed outside of traditional standardization bodies and where Digital Commons play an increasing role[54]. Some conceptions of digital sovereignty focus on the **ability to have control over critical infrastructures**, which requires massive investments in local innovation ecosystems and industries to reduce reliance on foreign technologies. Although the EU has been a leader in promoting open source adoption in public administrations, **countries in Asia have leveraged Digital Commons much earlier in the context of industrial strategies**, as seen in South Korea's or China's investments in their domestic open source ecosystem[55]. The example of India's industrial strategy has become famous for its focus on "Digital Public Infrastructure" (DPI), which are **generative foundations for public and private digital services and transactions**. DPI has allowed the Indian government to centrally manage a set of open application programming interfaces (APIs), which have been used by both the public and the private sectors to accelerate digital transactions and develop new services[56].

Finally, Digital Commons have been described as a **means to empower individuals, communities and organizations**, enabling them to reclaim control over the tools and systems that shape their digital lives. Such policies are part of a broader movement that aim to support an internet for the people by de-privatizing some infrastructures[57] and creating digital public spaces instead[58]. Public infrastructures, under this model, embody public

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[52] Johan Linåker and Sachiko Muto, "Software Reuse through Open Source Software in the Public Sector - a Qualitative Survey on Policy and Practice," DIVA Portal (RISE Research Institutes of Sweden AB, 2024), https://www.diva-portal.org/smash/get/diva2:1848137/FULLTEXT01.pdf.

[53] European Commission, "Berlin Declaration on Digital Society and Value-Based Digital Government" digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, 2020), https://digital-strategy.ec.europa.eu/en/news/berlin-declaration-digital-society-and-value-based-digital-government

[54] Marco Berlinguer, "Digital Commons as New Infrastructure," Umanistica Digitale, no. 11 (2021), https://doi.org/10.6092/issn.2532-8816/13695.

[55] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

[56] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

[57] Ben Tarnoff, Internet for the People (New York: Verso Books, 2022).

[58] 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.

values and collective ownership, supporting transparency, inclusivity, and citizen empowerment. The **Next Generation Internet (NGI) initiative by the European Union** supported more than 1000 grassroots projects across various internet layers, from hardware to applications, with over €140 million in funding. A 2024 impact study highlights its contributions to promoting interoperability, open standards, and the development of alternatives to dominant proprietary technologies[59].

Recognizing this potential, the **2022 report "Towards a Sovereign Digital Infrastructure of Commons"**, endorsed by 19 member states, highlights the role of Digital Commons in securing European digital autonomy. The report advocates for governance frameworks that emphasize "public-civic-private cooperation" over purely technocratic or private partnerships, supporting collective management of **digital systems that promote resilience, respect for digital rights, and prioritize interoperability and decentralization[60]**.

Structure and Methodology of the Report

How have EU governments adapted to these events and trends, and how were Digital Commons integrated into their policies? The objective of this mapping report is to **provide a comprehensive—though not exhaustive—overview of policies supporting Digital Commons over approximately the past 20 years**. While the focus is on policies from the European Union and its member states, some highly relevant examples from other regions or from the local level have also been included.

The mapping report is structured around a distinction between policies that have focused on promoting access to open digital resources (Section 1) and policies that promote the collective management of digital infrastructures (Section 2).

This distinction correlates with a chronological shift, as **most early European policy interventions focused on promoting Digital Commons by supporting open access to digital resources** and fostering innovation through Open Source Software adoption in the public sector (1.1), open access to knowledge, for publicly-funded research, but also cultural heritage and educational resources (1.2), Open Data, especially for public sector information (1.3), and Open Source Hardware (1.4), to a lesser extent.

More recently, policy attention has shifted towards **collective management of critical digital resources** to counter the dominance of large platforms and support digital sovereignty. In this context, the report will review policies that pursue the establishment of interoperability rules and standards (2.1), policies that support the pooling of resources in the context of industrial strategies and economic development (2.2), and policies that mobilize Digital Commons to empower individuals, communities and organizations (2.3).

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[59] Clémentine Valayer, "Benchmarking the Impact of the next Generation Internet Initiative," Publications Office of the EU (Directorate-General for Communications Networks, Content and Technology, 2024), https://op.europa.eu/en/publication-detail/-/publication/257ae66f-23c7-11ef-a195-01aa75ed71a1/language-en

[60] Report of the European Working Team on Digital Commons, "Towards a Sovereign Digital Infrastructure of Commons," Diplomatie.gouv (Ministère de l'Europe et des Affaires étrangères , June 2022), https://www.diplomatie.gouv.fr/IMG/pdf/report_of_the_european_working_team_on_digital_commons_digital_assembly_june_2022_wnetherlands_cle843dbf.pdf.

This report is intended to support the NGI Commons project's effort to **establish a strategic agenda for investments in Digital Commons for digital sovereignty**. Additionally, it aims to contribute to reflections around the design and establishment of a "Digital Commons European Digital Infrastructure Consortium," an initiative spearheaded by Estonia, France, Germany, and the Netherlands[61]. Strengthening Europe's digital infrastructure has recently emerged as a central issue in discussions about the region's competitiveness and future, as highlighted in the European Commission's white paper on digital infrastructures[62], and Mario Draghi's report on European competitiveness[63]. These discussions also tie into the broader global dialogue on Digital Public Infrastructure (DPI)[64].

This report is primarily based on desk research, synthesising findings from secondary sources, including existing reports and mappings on Digital Commons and related areas. This information was complemented by primary sources directly from government websites on relevant policy initiatives. A key contribution of this report is its **integration of different resources under the holistic framework of Digital Commons**, while most institutional reports have traditionally focused on individual subsets of Digital Commons, such as Open Source Software or Open Data.

The report does not provide an in-depth analysis of policy impact assessment, nor does it include reflections on policies that may have had a negative impact on the development of Digital Commons. The focus of the following sections is to provide an overview of past policies and experiences in the EU and to highlight some of the key policy trends. Finally, it should be noted that community networks or shared local telecommunications infrastructure are deliberately excluded from the scope of Digital Commons analyzed in this report. This is partly because their material nature, as opposed to the intangible or at least hybrid nature of digital goods, poses different challenges and policy issues. Secondly, because the recent netcommons project, also funded by the EU, has already produced significant resources on the subject[65].

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[61] Nathy Ercol, "European Collaboration for Digital Commons," Digital Government (Ministry of the Interior and Kingdom Relations (BZK), July 18, 2024), https://www.nldigitalgovernment.nl/news/european-collaboration-for-digital-commons/.

[62] 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=.

[63] Mario Draghi, "The Future of European Competitiveness – a Competitiveness Strategy for Europe," European Commision (Directorate-General for Communication, September 9, 2024), https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en#paragraph_47059.

[64] 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-gainingtraction/.

[65] Melanie Dulong et al., "Telecommunications Reclaimed: A Hands-on Guide to Networking Communities," Hal.science, 2019, https://shs.hal.science/halshs-02414439.

Timeline

Setting the Scene

1983

Launch of the GNU Project by Richard Stallman

1986

Establishment of the Internet Engineering Task Force (IETF)

1989

Invention of the World Wide Web by Tim-Berners-Lee

1991

Linus Torvalds starts to work on the Linux kernel

1995

Launch of the Apache HTTP Server ("httpd")

1998

Netscape open sources its web browser (later Mozilla Firefox)

2001

First edit on Wikipedia

First FABLab at the Massachusetts Institute of Technology (MIT)

Founding of Creative Commons

2002

Release of Budapest Open Access Initiative

2003

Berlin Declaration on Open Access to Knowledge

United Nations World Summit on the Information Society (WSIS)

First Directive on the re-use of public sector information (PSI)

2004

Launch of OpenStreetMap

2005

Draft of the Open Definition by the Open Knowledge Foundation

Launch of Arduino in Italy

Git Creation by Linus Torvalds

2006

First Pirate Party established in Sweden

Publication of the Wealth of Networks by Yochai Benkler

2007

Sebastopol Meeting on Open Government Data

First smartphone release

2008

Launch of Android Open Source Project

Cape Town Open Education Declaration

2010

EU opens investigation into Google's search practices

First European Interoperability Framework (EIF)

2011

Arab Spring

Launch of the Open Government Partnership (OGP)

CERN publishes its Open Source Hardware license

2012

EU publishes recommendations on Open Access

Launch of the OpenStack Foundation

2013

G8 Open Data Charter

Edward Snowden global surveillance disclosures

China launches a domestic alternative to GitHub

2014

Brazilian Civil Rights Framework for the Internet (Marco Civil)

First appearance of the term "platform cooperativism"

Right to Be Forgotten Ruling by Court of Justice of the EU

Horizon 2020 makes open access mandatory for publications

Tesla releases over 300 patents for electric vehicles

Discovery of Heartbleed vulnerability

Launch of the Core Infrastructure Initiative (later OpenSSF)

2015

Launch of the European Open Science Cloud initiative

Launch of the EU Free and Open Source Software Auditing program

2016

IANA stewardship transition

Adoption of the General Data Protection Regulation (GDPR)

First release of Mastodon

Launch of Hugging Face

2017

Launch of the Nordic Institute for Interoperability Solutions (NIIS)

2018

Acquisition of GitHub by Microsoft for 7,5 billion dollars

Cambridge Analytica Scandal

Launch of the Next Generation Internet (NGI) initiative

China publishes its Standards 2035 program

2019

Launch of the Digital Public Goods Alliance (DPGA)

Huawei files lawsuit against the US

2020

First case of Covid-19 in Europe

Berlin Declaration on Digital Society

Establishment of the Gaia-X Association

Establishment of the OpenAtom Foundation in China

2021

Discovery of the Log4j vulnerability

2022

Adoption of the Digital Services Act and Digital Markets Act

European Declaration on Digital Rights and Principles

Report ,"Towards a Sovereign Digital Infrastructure of Commons"

Adoption of Chips and Science Act (USA)

Adoption of the Data Governance Act

2023

Adoption of the European Chips Act

Publication of the Digital Euro proposal

Launch of the EU Digital Identity Wallet pilots

2024

Adoption of the Cyber Resilience Act

Adoption of the Interoperable Europe Act (IEA)

First Global Digital Public Infrastructure Summit in Cairo

Definitions

Data Commons: "Data Commons are communities that collectively and sustainably govern data and their relationships". This definition by Van Maanen et al. "emphasises the relationships and interdependencies between groups, the data that are in some way related to the group, and the various types of activities involved" which "implies that sustainability relates not only to the data but also to the community involved in their governance"[66].

Digital Commons: Digital Commons are digital resources which are defined by distributed and communal production, ownership and governance. The governance includes access and sharing rules to ensure the development and sustainability of the resource and the community against exclusive use, exclusive profit or value extraction. Digital Commons are based on a collectively defined framework within which they can be produced and maintained[67].

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)"[68].

Digital Public Infrastructure (DPI): The notion of Digital Public Infrastructure (DPI) generally refers to interoperable data exchange, identity and payment systems that form generative foundations for public and private digital services and transactions[69]. The Universal DPI Safeguards Framework led by the United Nations Secretary-General's Envoy on Technology (OSET) and the United Nations Development Programme (UNDP) defines 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"[70]

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[66] Gijs van Maanen, Charlotte Ducuing, and Tommaso Fia, "Data Commons," Internet Policy Review 13, no. 2 (April 4, 2024), https://doi.org/10.14763/2024.2.1748.

[67] This definition has been established by the NGI Commons project in the context of their feedback to the Member States working on the establishment of a Digital Commons European Digital Infrastructure Consortium (EDIC).

[68] Digital Public Goods Alliance (DPGA), "Digital Public Goods Standard," Digital Public Goods Alliance - Promoting digital public goods to create a more equitable world, September 21, 2020, https://digitalpublicgoods.net/standard/.

[69] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

[70] 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.

Digital Sovereignty: Digital sovereignty will be understood in this report as the "self-determined use of digital technologies and systems by individuals, industry, and governments", as defined by the German Sovereign Tech Agency[71].

Interoperability: The interoperability of systems and products describes their ability to work together with other systems or products. In the context of information technology, interoperability pertains to the ability of systems to exchange information effectively[72].

Open Access: Open Access refers to the unrestricted online access to peer-reviewed research to guarantee users' rights to freely read, download, copy, and distribute scholarly articles[73].

Open Education Resources (OERs): According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), OERs are "learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others"[74].

Open GLAM: The movement for Open GLAM (Galleries, Libraries, Archives, and Museums) is "a community of digital commons advocates and projects working to digitise public domain works of our cultural heritage without unnecessary legal, economic, or technical restrictions to their access and reuse by the public"[75].

Open Source Hardware (OSH): Open Hardware, or Open Source Hardware (OSH), refers to physical objects whose designs are openly shared and licensed to enable free use, modification, and distribution. OSH promotes collaboration and innovation by making technical specifications and design information publicly accessible, as emphasized by the Open Source Hardware Association (OSHWA)[76].

Open Source Software (OSS): OSS is software published under a licence 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 licences 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

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71 Sovereign Tech Agency, "Mission | What Is Digital Sovereignty?," Sovereign Tech Agency, accessed December 8, 2024, https://www.sovereign.tech/mission#what-is-digital-sovereignty.

72 Peter Wegner, "Interoperability," ACM Computing Surveys 28, no. 1 (March 1996): 285–87, https://doi.org/10.1145/234313.234424.

73 Budapest Open Access Initiative, "Read the Declaration," www.budapestopenaccessinitiative.org, 2002, https://www.budapestopenaccessinitiative.org/read/.

74 UNESCO. "Open Educational Resources," www.unesco.org, accessed December 6, 2024, https://www.unesco.org/en/open-educational-resources.

75 Dulong de Rosnay, Mélanie, and Felix Stalder. 2020. "Digital commons". Internet Policy Review 9 (4). DOI: 10.14763/2020.4.1530. https://policyreview.info/concepts/digital-commons

76 Open Source Hardware Association (OSHA), "Definition (English)," OSHA, accessed November 26, 2024, https://www.oshwa.org/definition/.

against fields of endeavour, distribution of licence, non-specificity to a product, no restrictions on other software, and technology-neutrality[77].

Open Standards: Open standards are standards that are "publicly available and developed via processes that are transparent and open to broad participation"[78].

Open Content: An open work can be freely used, modified, and shared by anyone for any purpose. An open work must therefore be in the public domain or under an open licence, accessible online at minimal cost, in a machine-readable and modifiable form, and provided in an open, restriction-free format compatible with open source software[79].

Platform Cooperatives: Platform Cooperatives are collectively owned and democratically governed, in contrast to venture capital-funded platforms. Collectively owned platforms include various democratic alternatives that can range from platforms established and owned by public institutions to platforms managed by informal collectives[80].

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[77] Open Source Initiative, The Open Source Definition (created on July 7, 2006, last modified on February 16, 2024): https://opensource.org/osd

[78] ISOC, "Policy Brief: Open Internet Standards," Internet Society, October 30, 2015, https://www.internetsociety.org/policybriefs/openstandards/.

[79] Open Knowledge Foundation, "Open Definition 2.1 - Defining Open in Open Data, Open Content and Open Knowledge," opendefinition.org (Open Knowledge Foundation), accessed November 6, 2024, http://opendefinition.org/od/2.1/en/.

[80] Trebor Scholz and Nathan Schneider, Ours to Hack and to Own : The Rise of Platform Cooperativism, a New Vision for the Future of Work and a Fairer Internet (New York: Or Books, 2017).

SECTION 1: Policies Promoting Access To Open Resources

1.1 Policies Promoting the Adoption of Open Source Software (OSS) in the Public Sector

Section 1.1 reviews policies that have promoted the adoption of open source software (OSS) by public sector administrations in the EU and in its member states. Early EU policies focused on the modernization of public sector organizations, but recent initiatives have expanded to address transparency, digital sovereignty, and interoperability. Policies that mobilize OSS of interoperability, industrial strategies, and digital sovereignty will be explored in more depth in the second part of this report. Policies to support OSS adoption include national regulatory measures, procurement guidelines, and OSS catalogs to reduce costs and reliance on proprietary software while enabling transparency and collaboration. The institutionalization of OSS through Open Source Programme Offices (OSPOs) has been critical, providing technical and strategic support to public administrations at national, local, and international levels.

1.1.1 Definitions

OSS is defined as the software published under a license that ensures the **freedom to use, study, modify, and distribute the software and its source code for any purpose**[81]. The roots of OSS and the principles that underpin it emerged during the 1950s and 60s in academic and research settings. Knowledge sharing and open collaboration were essential for software development practices. In this environment, software was indeed viewed as a collaborative tool for advancing computer science rather than a commercial product. In other words, informational goods were seen as commons, managed and produced collaboratively. From this scientific ethos emerged a “Hacker Ethic”, a playful and enthusiastic approach to collaborative software development.[82] This ethic deeply influenced early programmers and the culture of information sharing that would come to define open source software.

By the 1980s, the growing proprietary control of private firms over software triggered a political and legal response. Richard Stallman, a prominent advocate for software freedom, launched the Free Software Foundation (FSF) and the GNU Project to develop software that could be freely used and shared. Stallman argued that the four freedoms mentioned above were essential for user autonomy and for ensuring that technology served the public interest. This era saw the establishment of the first OSS licenses, such as the GNU General Public License (GPL), which required that any modified versions of the software remain free and openly accessible, thereby embedding these freedoms into a legal framework[83].

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[81] Open Source Initiative, The Open Source Definition (created on July 7, 2006, last modified on February 16, 2024): https://opensource.org/osd

[82] Pekka Himanen, The Hacker Ethic and the Spirit of the Information Age (London: Vintage, 2001, 2001).

[83] Benjamin Broca, Utopie Du Logiciel Libre. Du Bricolage Informatique À La Réinvention Sociale. (Neuvy-en-Champagne: Le Passager Clandestin, 2013), 288 pages.

The 1990s saw an **increasing recognition of OSS as a viable model for large-scale, knowledge-intensive projects**, proving that informational resources could be managed as commons rather than as proprietary commodities. OSS began to power critical elements of the Internet, including early web servers like the European Organization for Nuclear Research (CERN) httpd (1990), Apache (1995), and later nginx (2004), contributing significantly to the growth and rapid innovation of the World Wide Web[84]. The practical success of these open source projects demonstrated that complex, long-term projects could be managed collaboratively and sustainably, challenging market-based models of software production.

In 1998, the Open Source Initiative (OSI) was founded to standardize and advocate for open source practices. While the Free Software Foundation OSI established ten guiding principles that define OSS licenses, building on the four freedoms developed by the FSF: free redistribution, availability of source code, allowance for derived works, integrity of the author's code, non-discrimination against persons or groups, non-discrimination against fields of endeavor, license distribution, product neutrality, no restrictions on other software, and technology neutrality.[85] Since then, OSS has transformed from a scientific and political movement into a dominant paradigm in software development. Today, OSS is embedded in nearly every domain, from web servers and mobile applications to complex data analytics and AI systems. Some **96% of commercial code contains open source and 76% of code in general is open source**, according to the 2023 OSSRA report[86].

The collaborative and adaptable nature of OSS has encouraged widespread adoption, reshaped industries and enabling rapid technological progress. As OSS adoption grew, policies emerged to support its integration primarily in the public sector, particularly in Europe, where **open source is associated with cost reductions, transparency, avoiding vendor lock-in, sovereignty, and security**. This review examines the policies that have promoted OSS across European countries.

1.1.2 Overview of policy trends

The European Union study "The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy" provides a comprehensive overview of the evolution of OSS policies in Europe up to 2021, highlighting both chronological and regional differences. The study suggests that the **first wave of OSS policies that started in the early 2000s focused primarily on public sector adoption**. The data set on "Government Open Source Software Policies" published in 2022 by the Center for Strategic and International Studies, which is the most exhaustive global resource on OSS policies, confirms this focus: the dataset shows that **out of 669 policies listed, almost half of them (330 policies) related to public procurement**[87]. Early policies promoting OSS were

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[84] Dulong de Rosnay, Mélanie, and Felix Stalder. 2020. "Digital commons". Internet Policy Review 9 (4). DOI: 10.14763/2020.4.1530. https://policyreview.info/concepts/digital-commons.

[85] Open Source Initiative, The Open Source Definition (created on July 7, 2006, last modified on February 16, 2024): https://opensource.org/osd

[86] Synopsys, "2023 Open Source Security and Risk Analysis Report (OSSRA)" (Sunnyvale, CA: Synopsys, Inc., February 2023).

[87] Eugenia Lostri, Georgia Wood, and Meghan Jain, "Government Open Source Software Policies," Csis.org (Center for Strategic and International Studies, 2022), https://www.csis.org/programs/strategic-technologies-program/resources/government-open-source-software-policies.

indeed largely motivated by cost savings and centered around public procurement mandates favoring OSS over proprietary options. Initially, they addressed economic and legal barriers to OSS use, aiming to reduce dependency on proprietary software. OSS, indeed, is considered to allow for mutualized development and maintenance costs, lower license fees, and larger competition in tenders.

Over time, technical cooperation and support structures, such as communities of practices, local networks for knowledge-sharing or later Open Source Programme Offices (OSPOs), were gradually introduced to assist in effectively implementing OSS within public institutions[88]. The 2020 report on the "Status of Open Source Software Policies in Europe" indeed has found that **26 out of 28 European countries** (the study includes both EU member states and the United Kingdom) **have "put in place legal and political initiatives referring to OSS"**[89] (see Figure 1).

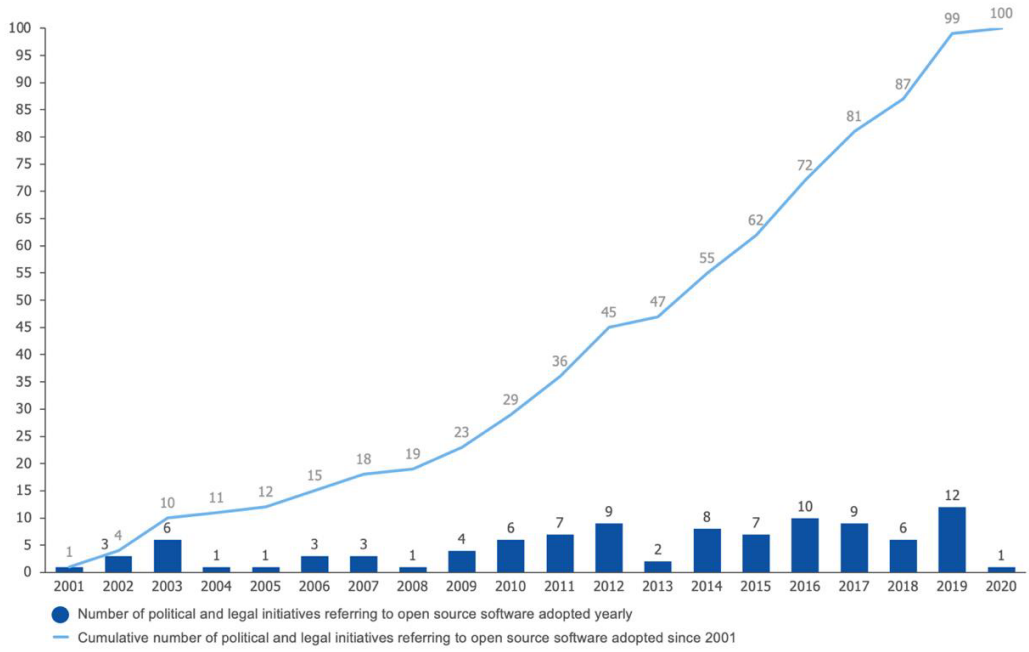

Figure 1: Adoption timeline of political and legal initiatives addressing open source software in 28 European countries (Source: Vivien Deveny, Debora Di Giacomo, and Clare O'Donohoe, "Status of the open source software policies in Europe")

At the end of the 2010 decade, European countries began expanding their OSS policies to include broader objectives beyond cost efficiency and the modernization of public

[88] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

[89] Vivien Devenyi, Debora Di Giacomo, and Clare O'Donohoe, "Status of Open Source Software Policies in Europe," Interoperable Europe Initiative (Brussels: European Commission, 2020), https://interoperable-europe.ec.europa.eu/sites/default/files/inline-files/OSOR_Status%20of%20OSS%20Policies%20in%20Europe_2020_0.pdf.

administrations, to include **new objectives such as transparency, interoperability and digital sovereignty**. These objectives were included in internal policies first.

Transparency is supported by OSS as it allows better **control of the operations of public services, audit data management, or understand algorithm-based decisions and interface definitions**. OSS is also considered a key tool to advance the digital sovereignty of public sector organizations. OSS has been considered more secure than proprietary solutions as it allows users to access and adapt a software's code. Beyond this possibility, it can reduce vendor lock-ins and is considered to enable "technical decisions based on national, regional, and local laws, norms, and values"[90].

Policies, especially in Europe, are increasingly combining open source with the development of **interoperability between administrations, between public and private services, and for cross-border exchanges**. The **2020 Berlin Declaration** for instance recognizes the value of **common standards, modular architectures, and open source technologies** to facilitate cross-border solutions[91]. The Open Source Observatory and Repository (OSOR), a platform that supports and encourages the adoption of OSS, shows this historic linkage: first funded under the Interoperability Solutions for Public Administrations Programme (ISA Programme), it is now under the auspices of the Interoperable Europe portal. These policies will be discussed in section 2.1.4 on EU policies promoting interoperability and data sharing.

A final trend is the adoption of external policies to promote OSS beyond the public sector, in order to support domestic innovation and software ecosystems. This shift aligned Europe more closely with regions like Asia, where countries started to embed OSS in industrial strategies, using it to **strengthen local ICT industries and achieve technological independence**[92]. This trend is confirmed by a more recent study by the European Commission from February 2024 on "Progress and trends in the national open source policies and legal frameworks"[93]. This new wave of measures, including for instance the Next Generation Internet (NGI) initiative, will be mentioned in the second section of this report on policies promoting the collective management of digital infrastructures.

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[90] Johan Linåker and Sachiko Muto, "Software Reuse through Open Source Software in the Public Sector - a Qualitative Survey on Policy and Practice," DIVA Portal (RISE Research Institutes of Sweden AB, 2024), https://www.diva-portal.org/smash/get/diva2:1848137/FULLTEXT01.pdf.

[91] European Commission, "Berlin Declaration on Digital Society and Value-Based Digital Government" digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, 2020), https://digital-strategy.ec.europa.eu/en/news/berlin-declaration-digital-society-and-value-based-digital-government

[92] 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

[93] Axel Thévenet et al., "Progress and Trends in the National Open Source Policies and Legal Frameworks," Interoperable Europe Initiative (Brussels: European Commission, February 2024), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/new-publication-progress-and-trends-oss-policies.

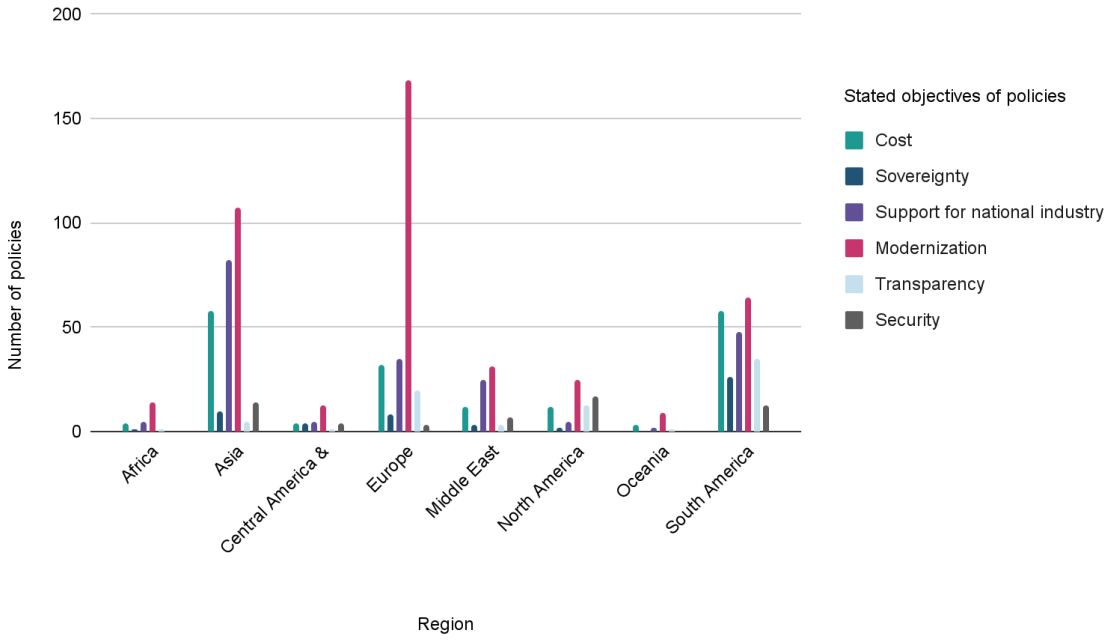

Figure 2: Stated Objectives of OSS policies according to region (Source: Eugenia Lostri, Georgia Wood, and Meghan Jain, "Government open source software policies," CSIS.ORG)

1.1.3 Regulatory measures mandating the use of OSS in public administrations

Regulatory frameworks in the EU and its member states have played an early role in supporting the adoption of OSS in public administrations. These frameworks primarily aim to provide legal clarity and set mandates for considering or prioritising OSS in government operations, often as part of broader **modernization policies that promote digitization of administrative functions and public services.** The motivations behind these policies are multifaceted, encompassing economic objectives (such as cost savings), technical advantages (including improved interoperability, security, and customizability), and normative goals (such as enhancing transparency in governance)[94]. Most often, these frameworks take the form of decree-level public procurement policies that favour OSS over proprietary software. In some cases, they go further by establishing open norms and standards across the public sector or committing to ensure that software developed by public administrations remains open and accessible to the public. The latter policies are connected to transparency concerns and open data policies. They establish obligations for governments to disclose public information, including the source code of the software they develop and use[95].

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[94] 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

[95] Axel Thévenet et al., "Progress and Trends in the National Open Source Policies and Legal Frameworks," Interoperable Europe Initiative (Brussels: European Commission, February 2024), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/new-publication-progress-and-trends-oss-policies.

While almost all European countries have launched political initiatives that promote the use of OSS in the public sector, **14 countries have adopted "legally binding documents, which include parliamentary resolutions, laws, directives, and decrees"**, according to the 2020 report on the "Status of Open Source Software Policies in Europe" (see Figure 2).

Figure 3: List of legal initiatives referring to open source software in Europe (Source: Vivienn Devenyi, Debora Di Giacomo, and Clare O'Donohoe, "Status of open source software policies in Europe")

One famous example of a mandatory public requirement for OSS adoption is the Ayrault Circular of 2012, which mandates that French public administrations prioritise OSS in procurement, requiring a thorough review of OSS alternatives when acquiring or updating software. The policy also encourages public institutions to reinvest 5-10% of savings achieved through OSS software into new OSS development and maintenance. According to Frank Nagle, this circular has impacted France's tech landscape, "creating a social value of $20 million per year", contributing to an increase of productivity, competitiveness, as well as the number of IT startups and employees[96].

However, while many of the regulations mandating the use of open source software in the public sector were widely supported by public institutions, civil society and the open source community, they have had only a limited impact on the actual uptake of open source, according to several reports that point to the ineffective implementation of these regulatory

[96] Nagle, Frank, Government Technology Policy, Social Value, and National Competitiveness (March 3, 2019). Harvard Business School Strategy Unit Working Paper No. 19-103, http://dx.doi.org/10.2139/ssrn.3355486

measures[97]. The **absence of designated bodies to oversee and enforce implementation**, coupled with shifting political priorities, led to inconsistent adoption of Open Source. For example, the aforementioned 2021 EU Study on the impact of Open Source mentions the example of Bulgaria, where a national law requiring public administrations to prioritise open source software in procurement was introduced in 2016. The law includes fines in the case of non-compliance. Despite this strict mandate, the law did not lead to the anticipated surge in Open Source usage, highlighting the challenges of implementing ambitious open source policies without sufficient support structures. The report identifies similar issues in Greece and Italy, where the Greek eGovernance Law and the Italian Code of Digital Administration faced obstacles due to the absence of adequate training, guidance, and organisational support[98].

1.1.4 Capacity building and communities of practice for OSS adoption

Policymakers have since recognized that successful open source policies require new organizational approaches and collaborative frameworks that engage diverse stakeholders across the ecosystem to ensure coherent and long-term implementation.

The European Union has implemented several initiatives to support member states in adopting open source technologies. The Open Source Observatory (OSOR), initially launched in 2013 as part of the ISA program, serves as a central repository for news on open source projects and public sector implementations, providing a platform for knowledge exchange and resource sharing among member states[99]. Additionally, the European Commission introduced the European Public Licence (EUPL) in 2017, a legally robust open source licence in 22 European languages and compatible with various legal frameworks[100]. Since 2020, the "Joinup Licensing Assistant tool" offers member states additional guidance on license selection, facilitating compliance and promoting the legal use of OSS in government operations[101].

Some countries have developed **procurement guidelines to support public sector adoption** of OSS, ensuring that government agencies can effectively and legally acquire and implement open source solutions. The "Agenzia per l'Italia Digitale" (AgID) for instance

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[97] Axel Thévenet et al., "Progress and Trends in the National Open Source Policies and Legal Frameworks," Interoperable Europe Initiative (Brussels: European Commission, February 2024), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/new-publication-progress-and-trends-oss-policies.

[98] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

[99] European Commission, "Open Source Observatory (OSOR)," Interoperable Europe Portal (European Commission), accessed November 4, 2024, https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor.

[100] European Commission: Directorate-General for Digital Services and Schmitz, P., European Union Public Licence (EUPL) – Guidelines July 2021, Publications Office, 2021, https://data.europa.eu/doi/10.2799/77160

[101] European Commission, "Joinup Licencing Assistant - Find and Compare Software Licences," Interoperable Europe Portal (European Commission, 2017), https://interoperable-europe.ec.europa.eu/collection/eupl/solution/joinup-licensing-assistant/jla-find-and-compare-software-licenses.

published “Guidelines on the acquisition and reuse of software for public administrations” in 2019[102]. In the absence of government initiatives, industry stakeholders or associations sometimes publish such support resources themselves, as in the case of the German Open Source Business Association (OSBA), which developed guidelines for procurement officers intending to buy OSS in 2018[103].

To enhance the discoverability and adoption of OSS, several countries have implemented **catalogues of software solutions** developed or used by public sector organisations. In Spain, the Technology Transfer Centre (TTC) manages a legally mandated national repository that requires public sector entities to publish acquired applications for reuse by other organisations, though it includes both open source and proprietary software[104]. The TTC is also connected with several regional repositories, such as those of Andalusia, Catalonia, and Extremadura, and links to the EU’s Joinup platform. In 2018, Spain partnered with the Inter-American Development Bank (IADB) to establish a federated network, facilitating cross-border sharing of digital solutions[105]. France’s code.gouv.fr, in contrast, exclusively focuses on OSS used or developed within the public sector. It is managed by the Free Software Unit inside the Interministerial Digital Directorate (DINUM). In Sweden, offentligkod.se serves as a widely recognized, albeit informal, catalogue of OSS in public sector use. Initiated by the Network Open Source and Data (NOSAD) network, this catalogue is populated by voluntary contributions from both public sector entities and service vendors, supporting an accessible database of OSS options for public sector needs[106].

In addition, **networks and communities of practice** facilitate knowledge exchange and learning among public administration professionals. For example, the "Blue Hats" movement in France brings together open source advocates within the government, creating a support system that is particularly beneficial for smaller administrations with limited OSS resources. These networks are crucial for fostering an OSS-friendly culture and ensuring the continuity of open source initiatives across various administrative levels[107]. The NOSAD network in Sweden illustrates another model for public servants to connect and exchange insights with one another and engage with the broader open source ecosystem. It supports this

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[102] Agency for Digital Italy, & Digital Transformation Team, “Guidelines on the acquisition and reuse of software for public administrations”. Docs Italia, 2019: . https://docs.italia.it/italia/developers-italia/gl-acquisition-and-reuse-software-for-padocs/en/stabile/index.html

[103] Till Jaeger, “Handreichung Zur Nutzung Der EVB-IT Beim Einsatz von Open Source Software,” OSB Alliance (Berlin: Open Source Business Alliance e.V., 2018), https://osb-alliance.de/publikationen/veroeffentlichungen/handreichungen-zur-nutzung-der-evb-it-beim-einsatz-von-open-source-software.

[104] Portal de Administración Electrónica, “¿Qué Es El Centro de Transferencia de Tecnología - CTT?,” Portal de Administración Electrónica (Ministerio para la Transformación Digital y de la Función Pública - Secretaría General de Administración Digital), accessed November 5, 2024, https://administracionelectronica.gob.es/pae_Home/pae_SolucionesCTT/pae_CTT_-__Que_es_.html.

[105] European Commission. EGovernment in Spain December 2018, 65. Brussels: European Commission, 2018. https://joinup.ec.europa.eu/sites/default/files/inlinefiles/eGovernment_in_Spain_December_2018_v2.00.pdf

[106] Johan Linåker, “Report: Software Reuse through Open Source Software in the Public Sector,” Virtual Home of Johan Linåker, April 25, 2024, https://www.linaker.se/blog/report-software-reuse-through-open-source-software-in-public-sector/.

[107] Gijs HILLENIUS, “Les Blue Hats - France Builds a Government Community for Open Source,” Interoperable Europe Portal (European Commission, December 14, 2018), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/les-blue-hats

interaction through regular meetings, dedicated communication channels, and an online repository of resources, all aimed at fostering OSS and open data reuse and collaboration[108].

Local governments have independently developed open source policies tailored to local needs over nearly two decades. In Germany, federal states such as Schleswig-Holstein have transitioned a range of digital public sector solutions to Open Source, benefiting from a governance model that allows local experimentation. Municipalities have leveraged OSS for specific public services, such as local transport, environmental monitoring, and public space management, finding that similar challenges across regions can be addressed through shared solutions. The city of Sundsvall in Sweden, which is recognized as Sweden's "Digitalisation City" is one example[109].

Associations have supported these efforts, enabling smaller municipalities to pool resources, conduct studies, and adopt open source solutions collectively. Examples of such associations can be found in Denmark with OS2, Germany with Vitako, in France with Adullact, in Belgium with iMio, in the Czech Republic with Open Cities or in Slovakia with Slovensko.Digital. This collaborative approach facilitates the sharing and reuse of open source solutions across municipalities, providing ready-to-deploy packages for smaller administrations[110].

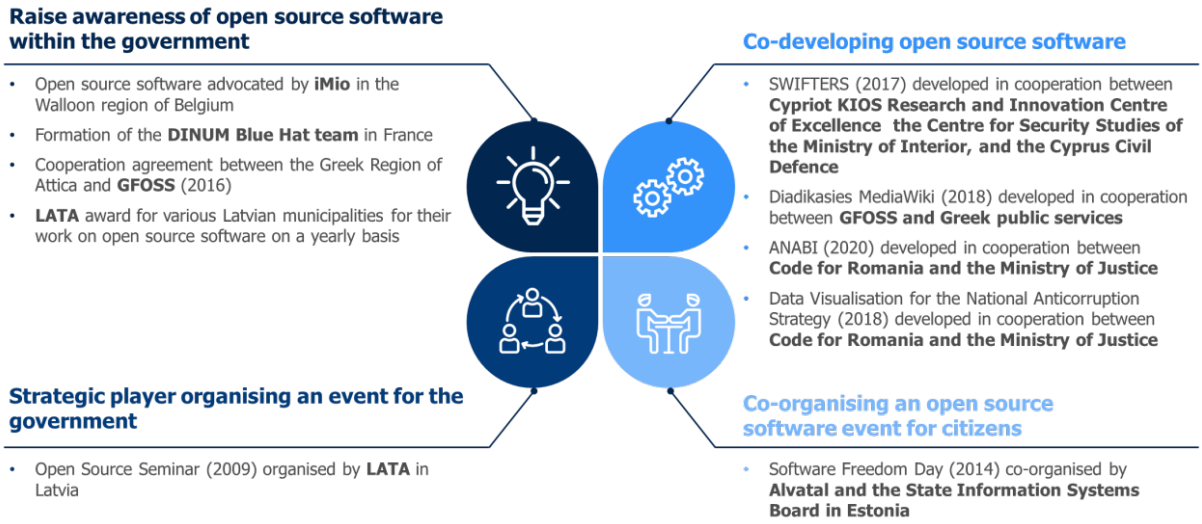

Figure 4: Instances of collaboration between governmental actors and strategic players (Source: Vivienn Devenyi, Debora Di Giacomo, and Clare O'Donohoe, "Status of open source software policies in Europe")

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[108] Johan Linåker, "Report: Software Reuse through Open Source Software in the Public Sector," Virtual Home of Johan Linåker, April 25, 2024, https://www.linaker.se/blog/report-software-reuse-through-open-source-software-in-public-sector/.

[109] Axel Thévenet et al., "Progress and Trends in the National Open Source Policies and Legal Frameworks," Interoperable Europe Initiative (Brussels: European Commission, February 2024), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/new-publication-progress-and-trends-oss-policies.

[110] Axel Thévenet et al., "Progress and Trends in the National Open Source Policies and Legal Frameworks," Interoperable Europe Initiative (Brussels: European Commission, February 2024), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/new-publication-progress-and-trends-oss-policies.

1.1.5 Institutionalization through Open Source Programme Offices (OSPOs)

Over the past decade, the institutionalization of open source policies within public administrations has evolved significantly, moving from informal networks of advocates to structured competence centers, later termed Open Source Programme Offices (OSPOs). Initially driven by "bureaucratic entrepreneurs" within organizations,[111] the **progressive establishment of formal knowledge centers** has allowed public institutions to reclaim technical expertise and establish strategic oversight in IT after years of externalization strategies.

OSPOs provide **centralized support for Open Source adoption, offering both technical guidance and policy direction**. The concept stems from the private sector, where OSPOs have become standard for managing the engagement with open source communities. According to the OSPO Five-Stage Maturity Model developed by the TODO Group, one can distinguish the following levels of maturity for such competence centers: compliance and education (stage 1), ecosystem participation (stage 2), hosting and community development (stage 3), strategic partnering (stage 4) and foundation leadership (stage 5)[112]. The maturity level can be applied to evolutions in public-sector engagement with Open Source, which has moved from early activities focusing on license compliance or mitigating legal risks to the promotion of Open Source and encouraging developers to contribute to OSS, up to stronger involvement in the community governance of OSS projects.

The report "Public Sector Open Source Program Offices - Archetypes for how to Grow (Common) Institutional Capabilities" based on the research work of Johan Linåker, provides a structured analysis of Open Source Program Offices (OSPOs) in the public sector across various European countries. The report identifies **several archetypes for structuring public sector OSPOs**, including:

- **National Government OSPOs** are typically hosted within central government departments to foster OSS across all public sectors. The report mentions examples in France, Italy, Germany, and Luxembourg, which promote OSS by setting guidelines, creating platforms for OSS discoverability, and supporting public sector compliance with open source policies.

- **Institution-centric OSPOs** are hosted within specific institutions to support internal capacity building for OSS use and management. The European Commission's OSPO, situated in DIGIT, and the Dutch Tax and Customs Administration are examples that focus on enhancing internal OSS expertise and fostering interoperability and collaboration between internal and external stakeholders.

- **Local Government OSPOs** support city-level open source initiatives aimed at achieving local policy goals. The OSPOs in Bratislava and Ventspils facilitate open

[111] Shulz, Sébastien. Transformer l'État par les communs numériques : Sociologie d'un mouvement réformateur entre droit, technologie et politique (1990-2020). PhD diss., Université Gustave Eiffel, 2021.

[112] TO DO Group, "OSPO Landscape - OSPO Five-Stage Maturity Model," OSPO Landscape (Linux Foundation, 2021), https://landscape.todogroup.org/guide#ospo-five-stage-maturity-model.

source solutions for digital transformation in municipal services, often with a strong emphasis on community engagement and practical, locally tailored applications.

- **Association-based OSPOs** serve as neutral platforms allowing municipalities to collaboratively develop and share OSS solutions. Notable examples include OS2 in Denmark, the Dutch Association of Municipalities, and the Open Cities network in the Czech Republic. These associations allow public sector organizations to pool resources, fostering broader OSS adoption across municipalities.

- **Academic OSPOs** are based within research institutions to support the development and dissemination of open source research outputs. Trinity College Dublin and LERO in Ireland are used in the report to illustrate this model, with activities centered around training researchers in open source practices and facilitating knowledge-sharing across academic and public domains.

- **Civil-society OSPOs** are independent organizations supporting public sector OSS capabilities without direct governmental affiliation. Code for Romania, a civic tech nonprofit, assists in developing open source public services across domains such as education and healthcare, working with both civil society and government to enhance OSS-driven public service delivery.

The report highlights the role of OSPOs as change agents, advocating cross-border and cross-sector collaboration to achieve policy goals such as digital sovereignty, interoperability, and innovation, reinforcing OSS as an essential tool for contemporary digital governance. As exemplified by the WHO's newly established OSPO, open source offices in the public sector increasingly adopt a broader mandate, encompassing not only software guidance but also the promotion of Digital Public Goods and fostering collaborative networks to enhance organizational transparency and resilience[113], as highlighted during the 2nd edition of the "OSPOs for Good" conference at the United Nations[114]. The movement to establish OSPOs is indeed increasingly becoming international: while the European Commission's OSPO network promotes open source adoption in public institutions across member states, the UNDP/ITU Open Source Ecosystem Enablement Initiative, supported by the EU, also extends this approach internationally[115].

1.2 Policies Promoting Open Access to Knowledge

The advent of personal computing and the internet created new practical possibilities for knowledge sharing, leading to a wider politicization of the free knowledge ideals rooted in scientific and software communities. This shift spurred debates on expanding intellectual property rights, the emergence of alternative licensing systems like Creative Commons, and global collaborative projects such as Wikimedia. Policies began to take shape in areas like

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[113] Astor Nummelin Carlberg, "WHO Builds an OSPO," Interoperable Europe Portal (European Commission, March 18, 2022), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/who-builds-ospo.

[114] Office of the Secretary-General's Envoy on Technology, "OSPOs for Good 2024," United Nations, 2024, https://www.un.org/techenvoy/content/ospos-good-2024.

[115] ITU, "Open Source Ecosystem Enabler," International Telecommunications Union, 2024, https://www.itu.int/en/ITU-D/ICT-Applications/Pages/Initiatives/OSEEPSI/home.aspx.

Open Science, Open Culture, and Open Education. Similarly to the field of OSS, section 1.2. shows that early EU policies in the field of open knowledge focused on public sector adoption, for instance, through the implementation of “open by default” principles for public sector documents or of mandates requiring openness for publicly funded research. Limitations in funding and institutional capacities, as well as the rise of new private intermediaries monetizing knowledge sharing led to a new interest in public infrastructures for data sharing, which will be discussed in section 2.1.5. Open Glam and Open Education Resources (OERs) efforts remain fragmented and heavily reliant on individual institutions, with limited cohesive strategies.

1.2.1 Definitions

The movement for open knowledge, sometimes also referred to as the free culture movement, refers to various resources and communities, which have similar principles but also operate in distinct fields, with close ties to both the OSS and the open data movement. Just like the OSS movement, the movement for open knowledge has its roots in scientific culture, and the **ideals of horizontal collaboration and free access to information**, already mentioned in the introduction of this report. The movement grew significantly and turned into a political movement mostly during the 1990s and the early 2000s, catalyzed by the **rise of computer science, the internet, and growing resistance to expanding intellectual property rights**. It also inspired itself by the experiences of OSS and the effectiveness of licenses in protecting collective user rights. Several open knowledge communities emerged as a result.

The first of these movements is the movement for Open Access. When capitalized, **Open Access refers to the movement for unrestricted online access to peer-reviewed research to guarantee users' rights to freely read, download, copy, and distribute scholarly articles**[116]. The Open Access movement, formalized with the Budapest Open Access Initiative (BOAI) in 2002, is an example of a form of resistance against the "enclosure" of knowledge, in a context where the internet was making knowledge sharing much easier and cheaper. The Open Access movement in this context wanted to challenge a model where academic publishers were profiting from publicly funded research while restricting access to scientific findings behind paywalls, and while researchers, who produce and review the content, receive little compensation[117].

The second movement is the movement for free culture, born out of the observation that copyright laws were growing increasingly restrictive, inhibiting cultural and scientific progress. Drawing direct inspiration from OSS licences, it resulted in the **creation of Creative Commons (CC) in 2002**, by Lawrence Lessig and Aaron Swartz. Creative Commons introduced a flexible licensing system, allowing creators to grant other permissions to use, remix, or share their work[118]. Licences that were developed with the aim of spreading derived productions by making sharing in similar conditions mandatory, like the CC-BY-SA licence, are often referred to as "copyleft" licence. The movement’s ideals were perhaps best

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[116] Budapest Open Access Initiative, “Read the Declaration,” www.budapestopenaccessinitiative.org, 2002, https://www.budapestopenaccessinitiative.org/read/.

[117] Peter Suber, Knowledge Unbound (MIT Press, 2016).

[118] Duncan Geere, “The History of Creative Commons,” Wired (Condé Nast, December 13, 2011), https://www.wired.com/story/history-of-creative-commons/.

exemplified by **Wikipedia, launched in 2001**, which embodies collaborative, global knowledge sharing. Wikipedia, along with its sister projects, stands today as the world's largest knowledge repository shared openly as a commons. Managed by the Wikimedia Foundation, which acts as a trusted institutional steward, Wikipedia relies on the voluntary contributions of a global network of editors, administrators, and community organisers. This community has established norms, codes of conduct, and guidelines that govern both content creation and the relationship between the Wikimedia Foundation and its contributors, fostering a robust and resilient model of open collaboration[119].

The free culture movement also resulted in debates on intellectual property rights, the so-called **"Copyright Wars,"** a term that encapsulated debates over copyright enforcement, digital rights, and public access. A famous example is the Copyright Term Extension Act, also known as the "Mickey Mouse Protection Act"[120]. This act was part of several other following legislative efforts aimed to expand copyright enforcement online, sparking widespread concern that they would limit internet freedom and access to information. These conflicts were initially triggered by legal responses to online piracy, leading to an increase in surveillance practices aimed at monitoring and curbing file-sharing activities[121]. Beyond piracy, however, the Copyright Wars soon expanded to broader issues, such as defining the scope of copyright and balancing it with **the preservation of the public domain[122]**. This tension raised fundamental questions about the accessibility of cultural and knowledge resources and the role of intellectual property in digital societies. A prominent actor in these debates was the Pirate Party, a political movement born in 2006 in Sweden as a direct result of these legal battles[123].

In the 2000s, free culture principles expanded into various knowledge and media projects, exemplified by initiatives like the Public Library of Science and Indymedia. Forums dedicated to free culture and knowledge access were established, and political movements were created to promote open access to knowledge[124]. As free knowledge principles spread, **new policy fields emerged to address open sharing in various domains**. The Open Knowledge Foundation, founded by Rufus Pollock in 2004 soon included groups and chapters in various regions and started to host projects on open data, for instance. Open Access movements

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[119] Leonhard Dobusch and Jakob Kapeller, "Open Strategy-Making with Crowds and Communities: Comparing Wikimedia and Creative Commons," Long Range Planning 51, no. 4 (August 2018): 561–79, https://doi.org/10.1016/j.lrp.2017.08.005.

[120] Lawrence Lessig, Free Culture : How Big Media Uses Technology and the Law to Lock down Culture and Control Creativity (New York: Penguin Press, 2004).

[121] Baldwin, Peter. The Copyright Wars: Three Centuries of Trans-Atlantic Battle. Princeton: Princeton University Press, 2014. https://doi.org/10.1515/9781400851911

[122] Melanie Dulong de Rosnay and Juan Carlos De Martin, The Digital Public Domain: Foundations for an Open Culture, Open Book Publishers, Digital Humanities Series vol. 2 (Open Book Publishers, 2012), https://doi.org/10.11647/obp.0019.

[123] Fredriksson, Martin. "Piracy & Social Change: The Pirate Party and the Politics of Communication." International Journal of Communication 9 (March 2015): 16. https://ijoc.org/index.php/ijoc/article/view/3742/1339.

[124] Morell, Mayo. "An Introductory Historical Contextualization of Online Creation Communities for the Building of Digital Commons: The Emergence of a Free Culture Movement." CEUR Workshop Proceedings 739 (2011): https://www.researchgate.net/publication/221273099_An_introductory_historical_contextualization_of_online_creation_communities_for_the_building_of_digital_commons_The_emergence_of_a_free_culture_movement

started progressively to organize around **principles for Open Science**, moving beyond access to scientific publications to include research outcomes such as data, but also addressing research practices. The movement also spread to culture and education, with communities establishing themselves around **Open GLAM (Galleries, Libraries, Archives, and Museums)**, promoting unrestricted access to digital cultural heritage as work of arts are increasingly digitised, or around **Open Education Resources (OERs)**, to make educational materials freely available for adaptation and use[125].

1.2.2 Overview of policy trends

Despite extensive debates on intellectual property rights, **no significant reforms were implemented to fundamentally alter copyright laws**. However, some adjustments were introduced, such as Article 14 of the 2019 Copyright in the Digital Single Market (CDSM) Directive, which safeguards the public domain status of works of visual art when digitized. This provision aims to ensure continued public access to cultural heritage[126].

Again, early interventions primarily focused on **public sector adoption of openness principles**. These policies encompass a wide range of commitments, from **international frameworks to national legislation, funder policies and mandates of local organizations**. These policies typically support "open by default" principles, especially in the public sector, where they aim to make publicly funded content accessible and reusable. Such policies are commonly applied to public research and works held by cultural institutions but can also encourage the society-wide adoption of open licenses, promoting a broader culture of shared resources and knowledge. The United Nations Educational, Scientific and Cultural Organization (UNESCO) is an example of an international organization that has promoted open access for its own publications by mandating the use of CC licenses but has also contributed to the promotion of principles for open science and international collaboration on Open Education Resources at large[127].

The movement for Open Data (see section 1.3) played an important role in the context of the EU. T**he 2013 PSI Directive was indeed a key step in the EU's push to make public sector information more accessible**. This directive provided a framework to standardize access and reuse of public data across member states. In 2014, the European Commission followed up with "Guidelines on recommended standard licenses, datasets and charging for the re-use of documents," encouraging public administrations to adopt open licenses, such as Creative

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[125] Tarkowski, Alek, Paul Keller, Zuzanna Warso, Krzysztof Goliński, and Jakub Koźniewski. "Fields of Open: Mapping the Open Movement." Open Future, July 6, 2023. Open Future Foundation. https://openfuture.pubpub.org/pub/fields-of-open.

[126] Séverine Dusollier, "The 2019 Directive on Copyright in the Digital Single Market: Some Progress, a Few Bad Choices, and an Overall Failed Ambition," Common Market Law Review 57, no. Issue 4 (August 1, 2020): 979–1030, https://doi.org/10.54648/cola2020714.

[127] Fengchun Miao, Sanjaya Mishra, and Rory McGreal, "Open Educational Resources: Policy, Costs, Transformation," https://unesdoc.unesco.org (United Nations Educational, Scientific and Cultural Organization (UNESCO) and Commonwealth of Learning, 2016), https://doi.org/10.54675/TGVE8846.

Commons (CC), to make access to public documents easier[128]. Early adopters of CC licenses included Austria, Estonia, and Denmark, helping to promote openness and consistent practices for public sector data across Europe[129].

The EU also progressively established **frameworks to support open access to knowledge and research**, beginning with recommendations and advancing to more comprehensive mandates. In 2012, the European Commission published the "Recommendation on access to, and the preservation of, scientific information, encouraging member states to adopt Open Access policies for all publicly funded research", including research data. This laid the groundwork for more binding initiatives, such as the 2014 Horizon 2020 program, the EU's 8th Framework Programme for Research and Innovation. Horizon 2020 made Open Access a mandatory requirement for all program-funded publications, making it a global best practice for Open Access funder policies[130].

A more recent trend is the **public support for mutualized infrastructures for knowledge sharing**, such as Europeana[131] and the European Open Science Cloud[132], which aim to enhance the accessibility of cultural and scientific resources while addressing challenges in the political economy of Open Access. A first challenge remains the limited technical and financial resources of public institutions tasked with digitization efforts. Additionally, the rise of private platform intermediaries led to closed models of knowledge sharing, leading to loss of control over user data, sharing rules and wealth transfers. The resulting interest of public institutions in the collective ownership of data infrastructures, for pooling resources, but also for the definition of standards and protocols ruling data sharing will be explored in section 2.1. Additionally, some policies focusing on Open Access tend to overlook the social and cognitive realities of learning and culture, which can't be limited to a technical process of content sharing. This limitation might explain the contrasting picture of policies in the field of Open Glam (section 1.2.4) and Open Education (1.2.5).

Finally, **the rise of artificial intelligence (AI) has introduced new dimensions to open access debates**, including concerns about fair remuneration for creative labor and the public financial burden of digitizing collections used to train private AI models[133]. But these

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[128] Hans Graux, "Licence Compatibility in Europe: A Winding Road to Creative Commons," Data.europa.eu - the Official Portal for European Data (Luxembourg: Publications Office of the European Union, 2023), https://data.europa.eu/sites/default/files/course/Licence%20compatibility%20in%20Europe%20a%20winding%20road%20to%20Creative%20Commons_EN.pdf.

[129] Creative Commons, "CC Factsheet - Creative Commons," wiki.creativecommons.org, 2017, https://wiki.creativecommons.org/wiki/CC_Factsheet.

[130] Jonathan P. Tennant et al., "The Academic, Economic and Societal Impacts of Open Access: An Evidence-Based Review," F1000Research 5 (September 21, 2016): 632, https://doi.org/10.12688/f1000research.8460.3.

[131] Europeana, "We Transform the World with Culture - Europeana Strategy 2015-2020," Europeana Pro, 2014, https://pro.europeana.eu/files/Europeana_Professional/Publications/Europeana%20Strategy%202020.pdf.

[132] 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.

[133] Warso, Zuzanna, Paul Keller, and Alek Tarkowski. "Exploring the Intersection of Openness and AI: Questions for Consideration and Collaborative Dialogue." Open Future, April 7, 2023. Open Future Foundation. https://openfuture.pubpub.org/pub/questions-on-ai-ml-and-openness.

challenges have also prompted new public investments the field, such as the European ALT-EDIC initiative, which consolidates European multilingual and multimodal language data to support the development of large language models[134].

1.2.3 Policies to support Open Access to research results and science

The Open Access movement originated within the scientific community, driven by researchers seeking greater access to scholarly publications. This demand was largely a response to **high subscription costs and the influence of commercial publishers, coupled with new digital and internet-based distribution options**. Researchers recognized the potential of these technologies to democratize access to scientific knowledge and reduce reliance on commercial entities[135]. A major early milestone was the **Budapest Open Access Initiative (BOAI)**, launched in 2002 after a conference by the Open Society Institute. The BOAI defined OA as unrestricted online access to peer-reviewed research and advocated for users' rights to freely read, download, copy, and distribute scholarly articles. This initiative laid the groundwork for OA as a global standard and was reinforced in 2012 with recommendations to make OA the default mode for disseminating research[136]. Another foundational moment was the **Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities** in 2003. Led by the Max Planck Society, this declaration urged researchers, institutions, and policymakers to ensure free access to scholarly works as a way to enhance global scientific collaboration and innovation. The Berlin Declaration broadened OA's impact, encouraging similar policies and initiatives across Europe and internationally[137]. Since the early 2000s, three main economic models have emerged to support OA, treating scientific output as part of a shared commons. The **green model** allows authors to make their articles or pre-prints available in institutional repositories, often with publisher permission. The **gold model** provides immediate public access to articles, sometimes with author processing charges. Finally, the **diamond or platinum models** involve institutional or library funding for OA journals, ensuring free access without charges to authors[138].

OA principles were progressively embedded in public policies, which mandated that **publicly funded research be deposited in open repositories**. Globally, the decade of 2010 marks an increase in policies mandating Open Access, as shown by the Registry of Open Access Repository Mandates and Policies (ROARMAP) (see Figure 5). A key example is the 2008 policy by the U.S. National Institutes of Health (NIH), which required that NIH-funded

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[134] European Commission, "ALT-EDIC," European Language Data Space (Directorate-General for Communications Networks, Content and Technology, 2023), https://language-data-space.ec.europa.eu/related-initiatives/alt-edic_en.

[135] Peter Suber, Knowledge Unbound (MIT Press, 2016).

[136] Budapest Open Access Initiative, "Read the Declaration," www.budapestopenaccessinitiative.org, 2002, https://www.budapestopenaccessinitiative.org/read/.

[137] Max-Planck-Gesellschaft, "Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities," Openaccess.mpg.de (Max-Planck-Gesellschaft, 2003), https://openaccess.mpg.de/Berlin-Declaration.

[138] Normand, Stephanie. 2018. "Is Diamond Open Access the Future of Open Access?". The IJournal: Student Journal of the Faculty of Information 3 (2). Toronto, Canada. https://theijournal.ca/index.php/ijournal/article/view/29482.

research be available through PubMed Central. The European Commission followed in 2014, introducing OA mandates within the Horizon 2020 framework[139].

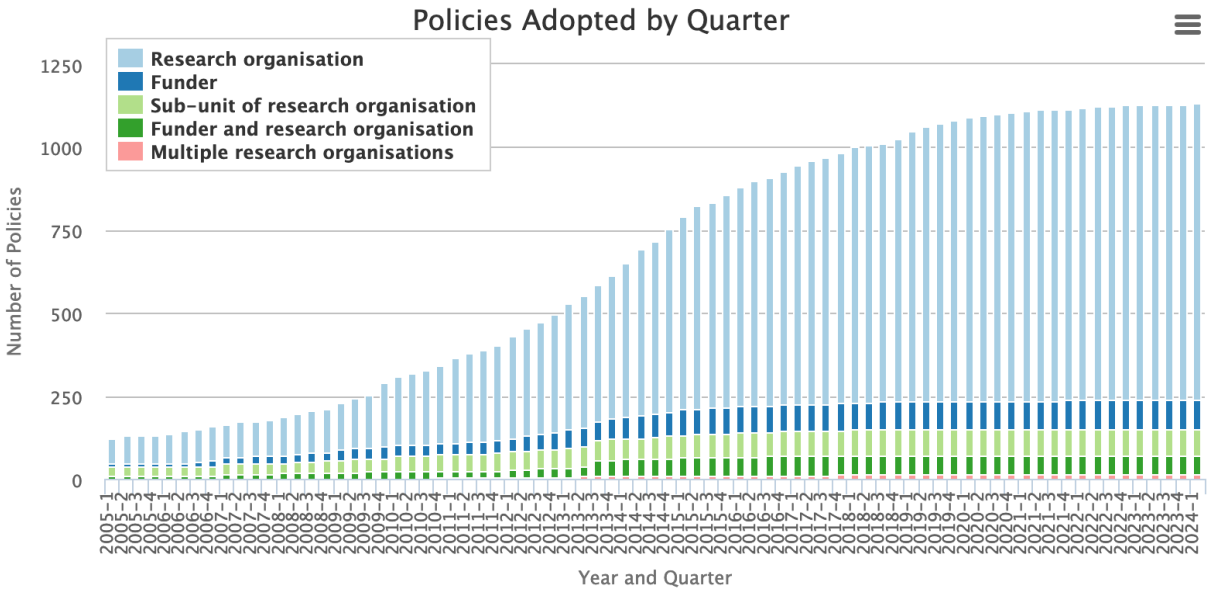

Figure 5: Global growth of Open Access mandates adopted by Universities, research institutions, and research funders by year (Source: Registry of Open Access repository mandates and policies)

Horizon 2020 has since become a global best practice for Open Access funder policies. Its replication varies, however, by member state, reflecting differences in national research funding capacities (see Figure 6). Some countries have adopted different or parallel approaches to funding mandates: Germany and France have for instance established **laws allowing researchers to deposit their accepted manuscripts in institutional repositories after an embargo period**, regardless of prior copyright transfer agreements with publishers[140].

[139] Jonathan P. Tennant et al., "The Academic, Economic and Societal Impacts of Open Access: An Evidence-Based Review," F1000Research 5 (September 21, 2016): 632, https://doi.org/10.12688/f1000research.8460.3.

[140] Jean-Claude Burgelman et al., "Open Science, Open Data, and Open Scholarship: European Policies to Make Science Fit for the Twenty-First Century," Frontiers in Big Data 2 (December 10, 2019), https://doi.org/10.3389/fdata.2019.00043.

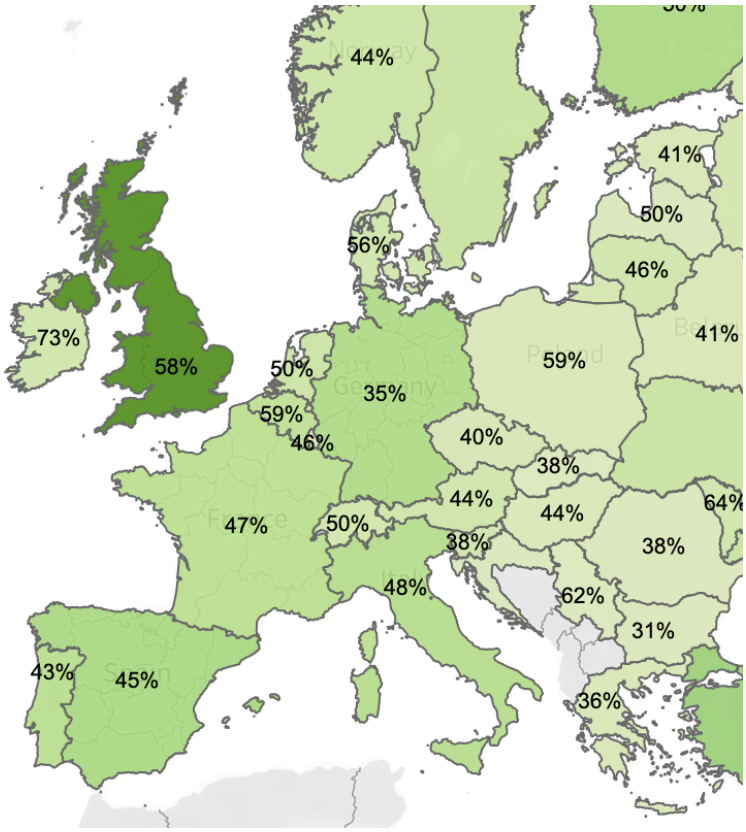

Figure 6: Average alignment to the Horizon 2020 Open Access policy based on 2024 data held in ROARMAP (Source: Registry of Open Access repository mandates and policies)

Despite studies widely acknowledging the positive impact of Open Access on knowledge availability[141], some critiques highlight **challenges related to the political economy of publishing**, particularly regarding reliance on high-profile journals controlled by a few commercial publishers. Key concerns include that institutions with limited funding, especially in the Global South, may face barriers due to high article processing charges, potentially exacerbating inequalities. Additionally, OA models risk influencing editorial decisions based on an author's affiliation or ability to pay and may prioritize publishing volume over quality[142].

As a result, public policies have progressively **expanded from OA to scientific publications to the objective of supporting Open Science (OS)**, embracing a broader vision focused on accessibility to scientific research results and data. UNESCO defines Open Science as an initiative to make scientific knowledge widely accessible across all sectors of society, bridging gaps between science and society for greater inclusivity and global impact[143]. In addition to open access, OS emphasizes ethics, research integrity, and citizen participation,

[141] Jonathan P. Tennant et al., "The Academic, Economic and Societal Impacts of Open Access: An Evidence-Based Review," F1000Research 5 (September 21, 2016): 632, https://doi.org/10.12688/f1000research.8460.3.

[142] Editorial: Open Access: No Closed Matter; In This Issue; In This Issue – Reviews, European Journal of International Law, Volume 34, Issue 3, August 2023, Pages 545–554, https://doi.org/10.1093/ejil/chad046

[143] UNESCO, "UNESCO Recommendation on Open Science," 2021, https://doi.org/10.54677/mnmh8546.

fostering a culture of transparency and reproducibility within scientific practices[144]. In 2016, the Council of the European Union further recommended the expansion of Open Access policies, signaling a shift toward a broader Open Science agenda that prioritizes open research data alongside open access to publications[145].

According to the "Report on Existing Policies and Guidelines" by the Responsible Open Science in Europe (ROSiE) project in 2022, Open Science has gained significant support and momentum in Europe, with **most countries already implementing national OS policies** and others actively developing them (see Figure 7). The study shows that this growth is recent and has been strongly influenced by EU-level initiatives, statements, and policies, which have catalyzed national efforts. The EU's role appears to be instrumental, enhancing the likelihood of OS adoption across member states. However, national and regional differences—stemming from unique research environments, legal frameworks, and strategic priorities—mean that OS policies must be tailored to each context. Overall, OS has expanded rapidly across Europe's research landscape, involving actors from the EU to national, institutional, and citizen levels. The relevance of OS has been further underscored by the COVID-19 pandemic, which highlighted the benefits of open research practices[146].

[144] Alejandra Manco, "A Landscape of Open Science Policies Research," SAGE Open 12, no. 4 (October 2022): 215824402211403, https://doi.org/10.1177/21582440221140358.

[145] Kelsey Wiens and Alek Tarkowski, "Global Open Policy Report," Creative Commons (Creative Commons, 2016), https://creativecommons.org/wp-content/uploads/2016/12/StateofOpenPolicyFullReport_FINAL-1-1-1-1.pdf.

[146] Mathieu Rochambeau and Teodora Konach, "Report on Existing Policies and Guidelines" Responsible Open Science in Europe (ROSiE), 2022, https://rosie-project.eu/deliverables/.

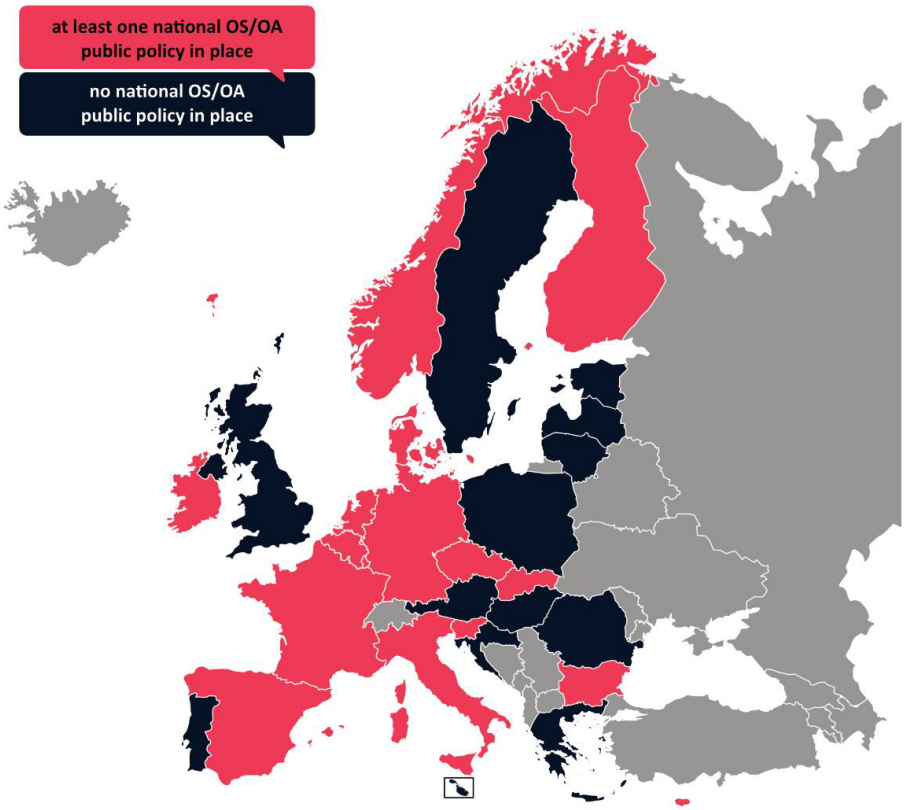

Figure 7: Countries in Europe with national Open Science and Open Access policies (Source: Mathieu Rochambeau and Teodora Konach, "Report on existing policies and guidelines")

As mentioned earlier, recent trends in Open Science policies focus on embedding core principles like the **FAIR data standards**—Findable, Accessible, Interoperable, and Reusable—to improve data sharing across EU-funded research. Beyond Open Access, policies increasingly promote incorporating open science into everyday research, with an emphasis on **Research Ethics (RE)**, **Research Integrity (RI)**, and **Citizen Science**[147].

[147] Mathieu Rochambeau and Teodora Konach, "Report on Existing Policies and Guidelines" Responsible Open Science in Europe (ROSiE), 2022, https://rosie-project.eu/deliverables/.

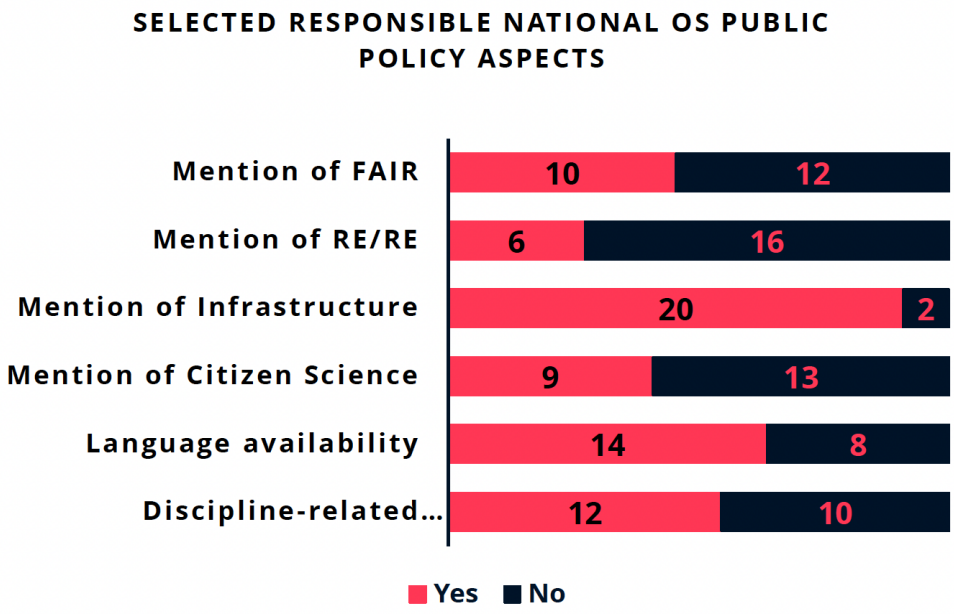

Figure 8: Public policy aspects mentioned in Open Science and Open Access policies in Europe (Source: Mathie Rochambeau and Teodora Konach, "Report on existing policies and guidelines")

Achieving these goals requires not only legal frameworks but also dedicated funding, coherent policies, and robust governance models[148]. The **European Open Science Cloud (EOSC)** plays a central role as a digital infrastructure that supports this movement (see section 2.1.5 on data-sharing infrastructures).

1.2.4 Policies promoting the dissemination of cultural heritage materials by Galleries, Libraries, Archives and Museums (GLAM)

Open access to culture is a key pillar of the open knowledge movement, reflected in the vibrant online practices of creation, remixing, and sharing culture. While the EU and its member states all have cultural policies, there are only limited proactive and coordinated efforts to promote open access to cultural heritage. In practice, open heritage initiatives often rely on individual institutions[149]. Some libraries and museums use terms of use to retain rights over digitized reproductions of public domain works, while others release content under fully unrestricted public domain terms[150].

The movement for **Open GLAM (Galleries, Libraries, Archives, and Museums)** has roots in the free culture movement, which advocates for making art, history, and knowledge freely accessible. The term Open GLAM is used to represent "a community of Digital Commons

[148] Jean-Claude Burgelman et al., "Open Science, Open Data, and Open Scholarship: European Policies to Make Science Fit for the Twenty-First Century," Frontiers in Big Data 2 (December 10, 2019), https://doi.org/10.3389/fdata.2019.00043.

[149] Kelsey Wiens and Alek Tarkowski, "Global Open Policy Report," Creative Commons (Creative Commons, 2016), https://creativecommons.org/wp-content/uploads/2016/12/StateofOpenPolicyFullReport_FINAL-1-1-1-1.pdf.

[150] Dulong de Rosnay, M. (2011). Access to digital collections of public domain works: Enclosure of the commons managed by libraries and museums". Proceedings of the 13th Biennial Conference of the International Association for the Study of the Commons (IASC). https://halshs.archives-ouvertes.fr/halshs-00671628

advocates and projects working to digitise public domain works of our cultural heritage without unnecessary legal, economic, or technical restrictions to their access and reuse by the public"[151]. While the public domain is distinct from the concept of Digital Commons and defines creative works no longer covered by copyright, either due to expiration, explicit waiver, or inapplicability[152], it has become a significant resource for commoning practices[153].

This movement sought first to **counter restrictive copyright laws and practices that have limited public access to cultural heritage** and are considered to be "enclosures of the commons"[154]. A significant debate within Open GLAM indeed concerns the protection of the public domain against "copyfraud"—the practice of inadvertently or intentionally applying restrictive licences to digital reproductions (or "digital surrogates") of public domain works[155]. The absence of ambitious public policies to proactively protect the public domain and the lack of European harmonization are considered to limit public enjoyment and creative reuse of cultural works. In addition, restrictive cultural heritage laws in several EU countries still limit access to public domain works by imposing fees and authorization requirements[156].

While several international organisations, including the UNESCO or the International Federation of Library Associations and Institutions have called for unrestricted public access to collections for education, social inclusion, and cultural preservation[157], and while the economic value of the public domain has been established[158]Open **Access to collections remains mostly at the discretion of European member states and often of individual establishments**. In 2011, the European Commission issued "Recommendations on the digitisation and online accessibility of cultural material", emphasizing the need to preserve the public domain status in digitized materials and to ensure open metadata. A key aspect of this debate in Europe took place in 2013 during the revision of the Directive on the Re-use of Public Sector Information (PSI), which allowed libraries, museums, and archives to decline requests to access heritage materials or charge fees, limiting full openness. The current version of the directive, the Open Data Directive (ODD) of 2019, still limits the application of

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151 Dulong de Rosnay, Mélanie, and Felix Stalder. 2020. "Digital commons". Internet Policy Review 9 (4). DOI: 10.14763/2020.4.1530. https://policyreview.info/concepts/digital-commons.

152 Séverine Dussolier, "Scoping Study on Copyright and Related Rights and the Public Domain". Geneva: World Intellectual Property Organization, 2010: https://www.wipo.int/publications/en/details.jsp?id=4143&plang=EN

153 Vasilis Avdikos et al., "Rethinking GLAMs as Commons: A Conceptual Framework," Open Research Europe 3 (July 9, 2024): 157–57, https://doi.org/10.12688/openreseurope.16473.2.

154 Melanie Dulong, "Access to Digital Collections of Public Domain Works: Enclosure of the Commons Managed by Libraries and Museums," Hal.science, January 10, 2011, 11, https://shs.hal.science/halshs-00671628.

155 Jason Mazzone, Copyfraud and Other Abuses of Intellectual Property Law (Stanford University Press, 2011).

156 Communia Association, "The Right to Use Public Domain Heritage," COMMUNIA, June 2024, https://communia-association.org/wp-content/uploads/2024/06/Polic—Findable, Accessible, Interoperable, and Reusable—y-Paper-20-on-the-right-to-use-Public-Domain-heritage.pdf.

157 IFLA-UNESCO, " Public Library Manifesto ," International Federation of Library Associations and Institutions, The Hague: 2022, https://www.ifla.org/public-library-manifesto/.

158 Kristofer Erickson et al., "Copyright and the Value of the Public Domain: An Empirical Assessment," March 18, 2015, https://ssrn.com/abstract=2571220.

open access to documents held by cultural heritage institutions[159]. Article 14 of the 2019 Copyright in the Digital Single Market (CDSM) Directive, should, however, safeguard the public domain status of works of visual art when digitized[160].

Economic sustainability and legal uncertainties remain a persistent challenge for GLAM institutions seeking to digitize and share collections. Many struggle to **balance the costs of digitization with the need to maintain Open Access[161]**. In the case of European Libraries working with Google on the digitization of their collections this has resulted in them ignoring explicit limits on the duration of exclusive access arrangements introduced in the 2019 ODD[162]. The Europeana platform, funded by the European Union, offers support to cultural establishments and provides a shared infrastructure that aggregates and standardizes digital cultural content from more than 2,500 institutions. Europeana's framework indeed requires metadata to be shared openly under the CC0 Public Domain Dedication, ensuring accessible data across the platform while reducing costs for smaller institutions. Europeana has set an important precedent, highlighting how shared infrastructure can support sustainable and accessible digital commons[163].

Positive examples of Open GLAM initiatives in Europe include the Rijksmuseum's open collections, where high-quality reproductions of public domain works are made freely available, and the British Library's digitization projects, which prioritise open access. These efforts underscore the value of Open GLAM, demonstrating that when institutions adopt policies for Open Access, they enhance cultural heritage accessibility and support economic and societal benefits[164]. Several European establishments have adopted similar policies, which contributed to the dynamism of the field in Europe.

1.2.5 Policies supporting the adoption of Open Education principles

The **landscape for Open Education Resources (OERs) in Europe presents a contrasting picture**. Although the EU has expressed ambitions for an open, diverse, and inclusive educational environment and has made strides in fostering an open science culture through

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[159] Communia Association, "The Right to Use Public Domain Heritage," COMMUNIA, June 2024, https://communia-association.org/wp-content/uploads/2024/06/Policy-Paper-20-on-the-right-to-use-Public-Domain-heritage.pdf.

[160] Séverine Dusollier, "The 2019 Directive on Copyright in the Digital Single Market: Some Progress, a Few Bad Choices, and an Overall Failed Ambition," Common Market Law Review 57, no. Issue 4 (August 1, 2020): 979–1030, https://doi.org/10.54648/cola2020714.

[161] Yaniv Benhamou and Justine Ferland, "Digitization of GLAM Collections and Copyright: Policy Paper," GRUR International 71, no. 5 (April 15, 2022): 403–21, https://doi.org/10.1093/grurint/ikac024.

[162] Arilee Arends, Annette de Bont, and Myrthe Rosenberg, "Demonopolizing the European Public Domain," Open Future, 2024, https://openfuture.eu/publication/demonopolizing-the-european-public-domain/.

[163] Europeana, "We Transform the World with Culture - Europeana Strategy 2015-2020," Europeana Pro, 2014, https://pro.europeana.eu/files/Europeana_Professional/Publications/Europeana%20Strategy%202020.pdf.

[164] Dougals McCarthy and Andrea Wallace, "Open GLAM Survey," Douglasmccarthy.com, May 2024, https://douglasmccarthy.com/projects/open-glam-survey/.

EU-funded research initiatives, the adoption of OERs in Europe remains fragmented and lacks cohesion[165].

Open Education policies are policies that aim to "widen access and participation to everyone by removing barriers and **making learning accessible, abundant, and** customizable for all." It usually builds on free, adaptable resources known as **Open Education Resources (OER)** or Open Education Content (OEC), available under open licenses like Creative Commons. Sometimes, it also includes Open Education Practices (OEP), which refer to learning methodologies based on the use and co-creation of open resources. Open Education policies aim to **reduce costs while making education more accessible and inclusive**[166]. Examples range from large university initiatives such as Open Massive Online Open Courses (MOOCs), to shared learning materials edited by teachers up to small online tutorials. The movement in the early 2000s with MIT's OpenCourseWare and gained international momentum through the support of international organizations such as the UNESCO and OECD, but also the support of private foundations like the William and Flora Hewlett Foundation[167].

OER has since gained global recognition, notably through the **2008 Cape Town Open Education Declaration**, which advocates for open access to resources and technologies, emphasizing educational equity, particularly in the Global South. Originating from a 2007 conference in Cape Town organized by the Shuttleworth Foundation and the Open Society Institute, the declaration encourages the adoption of open resources, technologies, and teaching practices in education. Released on January 22, 2008, it has since been endorsed by over 2,400 individuals and 250 organizations, including the Wikimedia Foundation[168].

According to OER defenders, however, current educational systems haven't kept pace yet with the opportunities offered by modern technologies. While the Internet offers unprecedented access to information and global learning, **traditional publishing limits the distribution and affordability of educational resources while creating dependencies and important costs in the public educational sector**. Additionally, reliance on commercial providers can increase the exposure of users, including minors, to surveillance through digital tools.[169] The Danish Data Protection Agency for instance ruled that there is insufficient legal basis for using Google Workspace as an educational tool in Danish schools due to

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[165] Priora, Giulia and Carloni, Giovanna, Open Educational Resources through the European Lens: Pedagogical Opportunities and Copyright Constraints (January 31, 2023). Forthcoming in Journal of Intellectual Property, Information Technology and Electronic Commerce Law (JIPITEC) 2023, Available at SSRN: https://ssrn.com/abstract=4343475 or http://dx.doi.org/10.2139/ssrn.4343475

[166] SPARC, "Open Education," SPARC, 2015, https://sparcopen.org/open-education/.

[167] Susan D'Antoni, "Open Educational Resources: Reviewing Initiatives and Issues," Open Learning: The Journal of Open, Distance and E-Learning 24, no. 1 (February 2009): 3–10, https://doi.org/10.1080/02680510802625443.

[168] "The Cape Town Open Education Declaration,", accessed November 12, 2024, https://www.capetowndeclaration.org/.

[169] SPARC, "SPARC Landscape Analysis and Roadmap for Action," SPARC (Washington, DC: Scholarly Publishing and Academic Resources Coalition (SPARC), September 2021), https://sparcopen.org/wp-content/uploads/2021/10/2021-Landscape-Analysis-101421.pdf.

concerns about data privacy. This decision arose from a 2019 case where a parent raised concerns over student data protection[170].

In Europe, the Council of Europe acknowledged OER in 2008 as a tool to address digital exclusion and enhance equity. However, **EU efforts have been limited due to education being primarily a national responsibility**. Key European communications such as "Rethinking Education" in 2012 (2012) and "Opening up Education" in 2013 encourage OER adoption but lack enforceable mechanisms. Programs like Erasmus+ promote open licensing but face challenges due to weak standards and the absence of centralized repositories[171]. The European Commission has nonetheless been providing tools to support stakeholders in the development of their own open educational strategies, for instance via the OpenEdu Framework or the Digital Competences Frameworks. The EU has funded some Open Education projects through Horizon Europe[172].

A report by the European Commission's Joint Research Centre provides a comprehensive analysis of open education policies across 28 EU member states[173]. The findings reveal that while **most member states have implemented initiatives related to open education**, significant progress is still required. Notably, the concept of Open Education is interpreted broadly, often extending beyond Open Education Resources (OER) and open content, reflecting diverse approaches and understandings across member states.

The report categorizes open education policies into four key types:

1. **Creation and Use of OER**: Policies that focus on enabling the creation, accessibility, and sharing of OER. Examples include the Netherlands' "Wikiwijs" platform, launched in 2008, which supports teachers in creating and sharing OER, and Norway's "Nasjonal Digital Læringsarena" (NDLA), established in 2006, which provides OER for secondary education funded by 18 regional districts.

2. **Comprehensive Strategic Education Policies**: These embed OER within broader national education strategies. For instance, Germany's 2022 national OER strategy integrates OER into its digital agenda, aiming to foster educational innovation and collaboration.

3. **General ICT Policies with OER Components**: Policies that incorporate OER as part of broader ICT and digital education strategies. Examples include the Netherlands' Acceleration Plan (2018), which involves university-level commitments to OER, and

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[170] Claas Thöle, "Insufficient Legal Basis to Use Google Workspace as an Educational Tool in Schools" International Network of Privacy Law Professionals, 2024, https://inplp.com/latest-news/article/insufficient-legal-basis-to-use-google-workspace-as-an-educational-tool-in-schools/.

[171] Kelsey Wiens and Alek Tarkowski, "Global Open Policy Report," Creative Commons (Creative Commons, 2016), https://creativecommons.org/wp-content/uploads/2016/12/StateofOpenPolicyFullReport_FINAL-1-1-1-1.pdf.

[172] Santos Andreia et al., "Policy Approaches to Open Education - Case Studies from 28 EU Member States (OpenEdu Policies)," RePEc: Research Papers in Economics, January 1, 2017, https://doi.org/10.2760/283135.

[173] Santos Andreia et al., "Policy Approaches to Open Education - Case Studies from 28 EU Member States (OpenEdu Policies)," RePEc: Research Papers in Economics, January 1, 2017, https://doi.org/10.2760/283135

Cyprus' Digital Strategy (2012), which promotes digital education through the provision of free educational content for schools.

4. **Open Government Policies with OER**: These align OER initiatives with open government strategies. For example, Greece's 2019 Open Government Partnership (OGP) Action Plan supports the development of a publicly accessible digital library of OER.

The report identifies barriers to OER adoption, such as **low digital literacy, limited institutional support**, and **insufficient policy alignment between national and EU-level efforts**. It underscores the need for coordinated strategies to overcome these challenges and recommends enhanced alignment between member states and the European Union to foster the widespread adoption of open education[174]. These conclusions are aligned with the findings of a 2023 study by the UNESCO on global OER policy, which shows the increasing role of governments in OER policy, but highlights that challenges continue to exist at various levels, such as lack of funding and cultural resistance. The study also mentions the positive impact of OER during the COVID-19 pandemic, as many tools allowed governments to face the crisis with accessible learning resources[175].

1.3 Policies Promoting Open Data

Section 1.3 reviews open data policies. The Open Data movement emerged in the mid-2000s as part of a convergence between OSS principles, demands for government transparency and accountability, and new capacities and economic interests for data analysis. The movement inspired governments to shift from request-based systems to access public information to proactive publication under open licenses. Beyond public sector data, more recent discussions have introduced the concept of "Data Commons," enabling stakeholders to pool and govern shared data collaboratively. This evolution reflects a stronger policy interest in data intermediaries and infrastructures but also a move away from binary open-closed frameworks toward nuanced governance models.

1.3.1 Definitions

The open data movement has shared roots with both the open knowledge and open source movements, all grounded in a scientific ethos that champions information sharing and collaboration. This movement is intertwined with the idea that **informational goods are naturally suited to be managed as commons**. The open data movement indeed began to take shape in scientific communities that viewed knowledge as a "common good" that should be accessible to all. Robert Merton, a key early figure in this movement, emphasized already in the 1940s that nothing should limit the circulation of scientific research[176].

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[174] Santos Andreia et al., "Policy Approaches to Open Education - Case Studies from 28 EU Member States (OpenEdu Policies)," RePEc: Research Papers in Economics, January 1, 2017, https://doi.org/10.2760/283135.

[175] Ben Janssen, Robert Schuwer, and Dominic Orr, "Key Policy Issues in Open Educational Resources. Background Paper Prepared for the 2023 Global Education Monitoring Report: Technology in Education." (Paris: UNESCO Digital LIbrary, 2023), https://doi.org/10.54676/PLDD8708.

[176] Simon Chignard, "A Brief History of Open Data," www.paristechreview.com (ParisTech Review, March 29, 2013), https://www.paristechreview.com/2013/03/29/brief-history-open-data/.

The momentum for open data expanded further in the 1990s, when the first mentions of the term can be found in official documents. It is the result of a convergence between the scientific ethos, new technological possibilities offered by the expansion of the Web, and historic public demands for government transparency and accountability in liberal democracies. The 2007 Sebastopol meeting, organized by open movement advocates like Tim O'Reilly and Lawrence Lessig, is largely considered a key moment that solidified open data's place within government discourse by proposing **eight principles for open data inspired by the values of OSS**. This meeting indeed participated in the emergence of a political movement that encouraged governments to make public data accessible to all citizens: "Information becomes more valuable as it is shared, less valuable as it is hoarded. Open data promotes increased civil discourse, improved public welfare, and more efficient use of public resources… By embracing the eight principles, governments of the world can become more effective, transparent, and relevant to our lives"[177].

The Sebastopol meeting also contributed to the emergence of a new form of activism, wherein tech-savvy citizens and organizations such as Code for America used open data to foster civic engagement and solve local governance issues. Andrew Schrock describes this as "**data activism**," which leverages data transparency to support community initiatives[178]. Several initiatives inspired by the model of citizen science emerged, allowing individuals, journalists, or civil society organizations to develop, maintain, and share their own datasets. A prime example is the OSS Ushahidi simplifies the mobilization of user-generated data to create new geographic information[179].

The historical shift introduced by the open data movement redefined the traditional approach to public information access established by the Freedom of Information Acts. Previous regulatory frameworks were primarily designed to regulate and grant access to government-held data upon request, but open data initiatives transformed this paradigm. Instead of requiring individuals to request access, open data principles advocate for proactive publication, **making public information readily available online by default**[180]. These new legal frameworks were inspired by the Open Definition developed by the Open Knowledge Foundation in 2005, which states that **open work can be freely used, modified, and shared by anyone for any purpose.** An open work must therefore be in the public domain or under an open licence, accessible online at minimal cost, in a machine-readable and modifiable form, and provided in an open, restriction-free format compatible with open source software[181].

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[177] Badiee, Shaida, Jamison Crowell, Lorenz Noe, Amelia Pittman, Caleb Rudow, and Eric Swanson. "Open Data for Official Statistics: History, Principles, and Implementation." Statistical Journal of the IAOS 37, no. 1 (2021): 139–159. https://doi.org/10.3233/SJI-200761.

[178] Andrew R Schrock, "Civic Hacking as Data Activism and Advocacy: A History from Publicity to Open Government Data," New Media & Society 18, no. 4 (February 16, 2016): 581–99, https://doi.org/10.1177/1461444816629469.

[179] Ushahidi, "About Ushahidi," Ushahidi, 2014, https://www-admin.ushahidi.com/about.

[180] Simon Chignard, "A Brief History of Open Data," www.paristechreview.com (ParisTech Review, March 29, 2013), https://www.paristechreview.com/2013/03/29/brief-history-open-data/.

[181] Open Knowledge Foundation, "Open Definition 2.1 - Defining Open in Open Data, Open Content and Open Knowledge," opendefinition.org (Open Knowledge Foundation), accessed November 6, 2024, http://opendefinition.org/od/2.1/en/.

More recent debates on data governance have expanded open data's scope beyond public sector information, introducing diverse institutional, legal, and technical arrangements to incentivize the circulation of data to maximize value creation[182]. As a result, discussions on various degrees of openness of datasets have emerged, which popularized the **concept of "Data Commons,"** enabling multiple stakeholders to pool data while creating tailored governance models that define access and sharing rights according to their own terms[183]. Some actors from the open data movement have even called for a new wave of open data policies in this context, with a stronger focus on various governance mechanisms, replacing the binary choice between open and closed data[184].

1.3.2 Overview of policy trends

Early examples of open data policies include the adoption of principles for the open exchange of geophysical and environmental statistical data both in the United States and in Europe[185]. The **Public Sector Information (PSI) Directive**, adopted by the European Union in 2003, marked a pioneering effort to **establish a unified framework for the reuse of public sector information across Europe**. Although the initial version of the directive did not explicitly reference "open data," it laid the groundwork for future open data policies within the EU, founded on principles of transparency and fair competition[186]. The U.S. government's adoption of open data under President Obama in 2009 marked a significant institutionalization of the ideals of the open data movement, quickly followed by many other countries.

Several international frameworks were established to further standardize these principles into technical and legal requirements and to support dialogue and collaboration between governments on these principles, such as Open Government Partnership (OGP), launched in 2011[187] and the G8 Open Data Charter of 2013[188], followed by the endorsement and support of open data initiatives by international organizations like the OECD or the World Bank. As a result, numerous governments have established comprehensive legal frameworks and

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[182] OECD (2019), Enhancing Access to and Sharing of Data: Reconciling Risks and Benefits for Data Re-use across Societies, OECD Publishing, Paris, https://doi.org/10.1787/276aaca8-en.

[183] Benhamou, Yaniv and Dulong de Rosnay, Melanie, Open Data Commons Licenses (ODCL): Licensing Personal and Non Personal Data Supporting the Commons and Privacy (December 12, 2023). Available at SSRN: https://ssrn.com/abstract=4662511 or http://dx.doi.org/10.2139/ssrn.4662511

[184] Young, Andrew, Andrew J. Zahuranec, and Stefaan Verhulst. "The Third Wave of Open Data." The GovLab, 2020. https://blog.thegovlab.org/the-third-wave-of-open-data.

[185] Badiee, Shaida, Jamison Crowell, Lorenz Noe, Amelia Pittman, Caleb Rudow, and Eric Swanson. "Open Data for Official Statistics: History, Principles, and Implementation." Statistical Journal of the IAOS 37, no. 1 (2021): 139–159. https://doi.org/10.3233/SJI-200761.

[186] Rufus Pollock and Danny Lämmerhirt, "European Union," in The State of Open Data - Histories and Horizons, ed. Tim Davies et al. (Cape Town: African Minds, 2019), http://library.oapen.org/handle/20.500.12657/24884.

[187] Open Government Partnership, "About," opengovpartnership.org (Open Government Partnership), accessed November 6, 2024, https://www.opengovpartnership.org/about/.

[188] Cabinet Office, "G8 Open Data Charter and Technical Annex," GOV.UK, October 20, 2016, https://www.gov.uk/government/publications/open-data-charter/g8-open-data-charter-and-technical-annex.

national data portals to streamline access to public information[189]. Most of the benefits associated with these measures were "**transparency and accountability of the government, participation and self-empowerment to the citizens, economic growth and also stimulation of innovation** through re-use of data"[190].

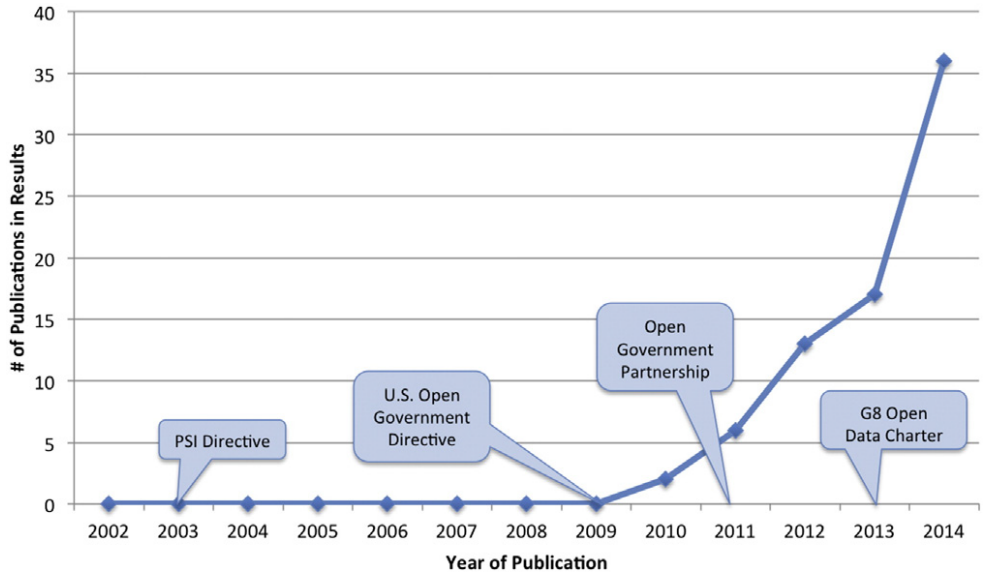

Figure 9: Increase of open government data literature by year (Source: Judie Attard, Fabrizio Orlandi, Simon Scerri, and Sören Aurer. "A systematic review of open government data initiatives")

In Europe, the 2013 revision of the **PSI Directive**, replaced in 2019 by the Open Data Directive, contributed to putting European countries at the forefront of the open data movement, which is evidenced by international ranking such as the Open Data Barometer or the Open Knowledge Foundation's Global Open Data Index. The Directive indeed created a **mandatory and harmonized framework for access to public sector data**, but also progressively expanded the scope of open data policies to cover content held by museums, libraries, and archives, and later to relevant data in the utility and transport sectors[191].

The last Open Data Barometer report from 2018, however, highlighted **mixed progress among the world's leading governments of the open data movement**. While 30 governments have committed to frameworks like the Open Data Charter or the G20 Anti-Corruption Open Data Principles, their actual performance varies. The report underscores that only a small percentage of datasets are fully open, with fewer than 20% of datasets meeting open data standards. To advance, the report recommends that governments continue adopting "open

[189] Attard, Judie, Fabrizio Orlandi, Simon Scerri, and Sören Auer. "A Systematic Review of Open Government Data Initiatives." Government Information Quarterly 32 (2015). https://doi.org/10.1016/j.giq.2015.07.006.

[190] Nugroho, Rininta, Anneke Zuiderwijk, Marijn Janssen, and W. Martin de Jong. "A Comparison of National Open Data Policies: Lessons Learned." Transforming Government: People, Process and Policy 9 (2015): 286–308. https://doi.org/10.1108/TG-03-2014-0008.

[191] Rufus Pollock and Danny Lämmerhirt, "European Union," in The State of Open Data - Histories and Horizons, ed. Tim Davies et al. (Cape Town: African Minds, 2019), http://library.oapen.org/handle/20.500.12657/24884.

by default" policies, invest more substantially in open data infrastructure, and actively engage with civil society to ensure that open data policies are purposeful and impactful[192].

GOVERNMENTS AND GROUPS	TOTAL SCORE (out of 100)	TOTAL SCORE CHANGE (since 1st Ed.)	READINESS (out of 100)	IMPLEMENTATION (out of 100)	IMPACT (out of 100)	G20 MEMBER	CHARTER ADOPTER
Canada	76	18	86	87	55	✓	✓
UK	76	-4	83	89	57	✓	✓
Australia	75	17	79	84	62	✓	✓
France	72	17	84	77	55	✓	✓
South Korea	72	25	82	67	67	✓	✓
Mexico	69	33	79	67	62	✓	✓
Japan	68	24	78	68	58	✓	✗
New Zealand	68	5	79	72	52	✗	✓
USA	64	-11	79	76	37	✓	✗
Germany	58	2	76	72	27	✓	✗
Uruguay	56	23	71	70	28	✗	✓
Colombia	52	25	69	60	28	✗	✓
Russia	51	10	62	59	32	✓	✗
Brazil	50	15	63	56	30	✓	✗
Italy	50	8	61	61	27	✓	✓
India	48	16	64	49	32	✓	✗
Argentina	47	14	66	56	20	✓	✓
Ukraine	47	25	60	52	28	✗	✓
Philippines	42	19	54	42	30	✗	✓
Chile	40	2	54	55	12	✗	✓
Indonesia	37	17	49	45	17	✓	✗
South Africa	36	14	50	37	22	✓	✗
Paraguay	34	15	41	45	15	✗	✓
China	31	15	44	38	10	✓	✗
Costa Rica	31	1	48	43	3	✗	✓
Turkey	31	5	33	53	7	✓	✗
Panama	30	10	47	42	0	✗	✓
Guatemala	26	2	36	37	5	✗	✓
Saudi Arabia	25	12	40	32	3	✓	✗
Sierra Leone	22	11	33	23	10	✗	✓

Figure 10: Open data barometer scores for Open Data Charter adopters and G20 members (minus EU) - Champions, contenders, and stragglers groups on green, yellow, or red background, respectively (Source: World Wide Web Foundation. Open data barometer–Leaders Edition)

In parallel, policies have increasingly started to incorporate **incentives for the circulation and reuse of data outside of the public sector.** At the European level, the 2019 EU Open Data Directive mandates that the European Commission identify a set of datasets with “high commercial or societal potential” to be made freely accessible. These datasets must be available in machine-readable formats, accessible through APIs, and, where applicable, downloadable in bulk. Recognized for their significant commercial or societal value, these datasets cover areas such as geospatial data, Earth observation, meteorology, corporate ownership, mobility, and publicly funded research. Nationally, France's 2016 Law for a Digital Republic requires that certain private sector data be made accessible using open standards, creating a category of "public interest datasets."[193]

[192] World Wide Web Foundation. Open Data Barometer - Leaders Edition. Washington, DC: World Wide Web Foundation, 2018: https://opendatabarometer.org/leadersedition/report/

[193] World Bank. World Development Report 2021: Data for Better Lives. Washington, DC: World Bank, 2021. https://doi.org/10.1596/978-1-4648-1600-0.

Most of the policy frameworks developed in this context, however, rely on non-coercive measures aimed at creating a trusted environment and incentives for data sharing. These approaches foster data-sharing environments through standardized data formats, licensing templates, and mechanisms for voluntary data exchanges under FRAND (Fair, Reasonable, and Non-Discriminatory) terms[194]. This trend also resulted in the establishment of new types of partnerships between private entities, but also between public and private entities or communities. The concept of "Data Commons" has emerged as a significant trend in data governance, allowing diverse stakeholders to co-manage pooled data resources with governance structures tailored to specific needs[195]. These trends are reflected in Europe by the adoption of the **Data Governance Act in 2020 and the establishment of "Common European Data Spaces**," which aim to make more data available within fair, secure, and trusted frameworks[196].

This vision is illustrated by the adoption of frameworks grounded in data sovereignty principles, allowing communities to **control access and usage rights beyond traditional open-data models**. This approach reflects a departure from simple open-access ideals toward more nuanced, community-oriented data governance that prioritizes local trust and benefit. One objective of these approaches is to define alternative licensing terms for Data Commons, which do not rely solely on the Open Definition but are able to incorporate "restrictions outside of certain boundaries (e.g., authorized users and uses), in order to protect the commons and certain values." Examples of such frameworks include the Digital Data Commons Privacy Pledge designed as part of the **"DEcentralised Citizens Owned Data Ecosystem" (DECODE) initiative**, a European project aimed at creating tools that balance individual control over personal data and data sharing. The Privacy Pledge includes a set of standardized commitments to respect privacy, data deletion rights, and limitations of purpose, among others. This project was supported by the European Commission to create a framework that entities can reuse to empower data subjects to share data while protecting their rights[197]. Another example of such nuanced approaches to Data Commons is the CARE principles. CARE stands for collective benefit, authority to control, responsibility, and ethics. These principles were developed by the Global Indigenous Data Alliance. They aim to work alongside the FAIR principles (Findable, Accessible, Interoperable, and Reusable), which prioritize data reusability, to provide greater control over the use of Indigenous data and Indigenous knowledge[198].

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[194] OECD. Enhancing Access to and Sharing of Data: Reconciling Risks and Benefits for Data Re-use across Societies. Paris: OECD Publishing, 2019. https://doi.org/10.1787/276aaca8-en.

[195] Jan J. Zygmuntowski, Laura Zoboli, and Paul F. Nemitz, "Embedding European Values in Data Governance: A Case for Public Data Commons," Internet Policy Review 10, no. 3 (September 30, 2021), https://doi.org/10.14763/2021.3.1572.

[196] European Commission, "Data Governance Act Explained | Shaping Europe's Digital Future," digital-strategy.ec.europa.eu (European Commission), accessed November 6, 2024, https://digital-strategy.ec.europa.eu/en/policies/data-governance-act-explained.

[197] Eleonora Bassi et al., "Licensing of Digital Commons Including Personal Data," DECODE, August 5, 2019, https://decodeproject.eu/publications/licensing-digital-commons-including-personal-data-update.html.

[198] Tarkowski, Alek, and Zuzanna Warso. "Commons-based Data Set Governance for AI." Open Future, March 21, 2024. Open Future Foundation. https://openfuture.pubpub.org/pub/principles-for-commons-based-data-set-governance-for-ai.

1.3.3 Policies mandating Open Access to public sector data

The roots of open data policies lie in early Freedom of Information laws, designed to provide citizens with access to government-held information. Sweden's 1766 “Freedom of the Press Act” can be considered to be the oldest example of laws improving government transparency and accountability by allowing the public to request specific documents[199]. However, these frameworks typically required citizens to initiate requests. The 2000s saw a shift towards **"open by default" policies**, requiring non-sensitive datasets to be made available proactively.

European governments, influenced by the EU’s 2003 Public Sector Information (PSI) Directive and its successors, have enacted legislation mandating that public sector data be accessible and reusable. All **European countries introduced national open data portals to** centralize access to public information on topics ranging from the environment to transport, made accessible in machine-readable formats[200]. Additionally, various local governments, including cities, created their own portals, although using diverging data standards and publication modalities. The European Data Portal combines national, regional, and thematic open data portals, as well as the EU's own Open Data Portal, providing a single point of access for data published by public administrations at various levels[201].

Despite significant progress, the implementation of open data policies faces several persistent challenges. According to an OECD report, the effective implementation of open data policies faces multifaceted **challenges across policy, technical, organizational, cultural, legal, and financial dimensions**. From a policy perspective, the lack of a unified strategy and sustainable economic models impedes consistent application across public sectors. Technically, the absence of standardized data formats limits interoperability, often due to siloed management practices within the government. Organizationally, many countries report inadequate training, with limited capacity-building efforts to equip civil servants with the necessary skills. Culturally, low awareness among public servants hinders adoption, as they are often unprepared to act as data stewards rather than mere data publishers. Legally, data protection laws create uncertainty, underscoring the need for frameworks that balance openness with privacy. Financially, high costs for data maintenance and a lack of stable funding models present significant barriers, suggesting a need for automation and clear incentives to support long-term data accessibility[202].

The Open Data Maturity (ODM) assessment is currently the main evaluation tool to track the advancement of European countries in enhancing the accessibility and reuse of public sector information. It examines open data maturity across four key dimensions: the development level of national open data policies, the range of features and datasets provided on national

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[199] World Bank. World Development Report 2021: Data for Better Lives. Washington, DC: World Bank, 2021. https://doi.org/10.1596/978-1-4648-1600-0.

[200] Page, Martin, Emir Hajduk, Eline N. Lincklaen Arriëns, Gianfranco Cecconi, and Suzan Brinkhuis. 2023 Open Data Maturity Report. Prepared as part of data.europa.eu. Luxembourg: Publications Office of the European Union, 2023: https://data.europa.eu/sites/default/files/odm2023_report.pdf

[201] European Commission, “Open Data Portals | Shaping Europe’s Digital Future,” digital-strategy.ec.europa.eu (European Commission), accessed November 6, 2024, https://digital-strategy.ec.europa.eu/en/policies/open-data-portals.

[202] OECD. Open Government Data Report: Enhancing Policy Maturity for Sustainable Impact. OECD Digital Government Studies. Paris: OECD Publishing, 2018. https://doi.org/10.1787/9789264305847-en.

data portals, the quality of metadata available on these portals, and efforts to monitor the reuse and impact of open data initiatives. It shows that the most mature countries in the EU are currently France, Poland and Estonia[203].

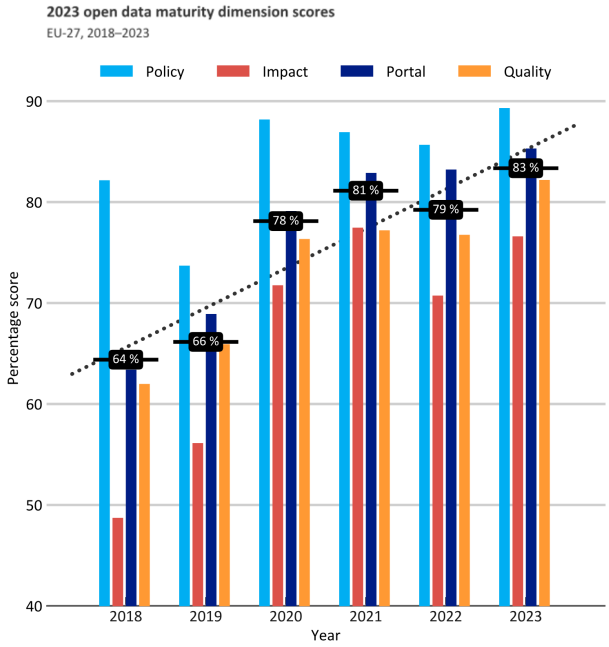

Figure 11: Average ODM scores in the EU-27 by dimension, 2018–2023 (Source: Page Martin, Emir Hajduk, Eline N. Lincklaen Arriëns, Gianfranco Cecconi, and Suzan Brinkhuis, “2023 Open Data Maturity Report”)

The impact assessment for the review of the Open Data Directive highlighted several ways in which **open data generates value for both society and the economy.** The direct economic value of public sector information was estimated at several billion euros by several studies[204]. Additionally, many social advantages are expected from these policies, such as reduced energy consumption or reduced transport travel time. According to a 2019 report by the OECD that reviewed several studies on the impact of open data policies, “data access and sharing is estimated to generate social and economic benefits worth between 0.1% and 1.5% of gross domestic product (GDP) in the case of public-sector data”[205].

The open data movement at large, while achieving some progress, also faces criticism. Governments have been accused to profess support for open data yet selectively withhold information, undermining public trust. Additionally, some reviews of open data policies argue that the movement has often overstated its promises of transparency, economic growth, and

[203] Page, Martin, Emir Hajduk, Eline N. Lincklaen Arriëns, Gianfranco Cecconi, and Suzan Brinkhuis. 2023 Open Data Maturity Report. Prepared as part of data.europa.eu. Luxembourg: Publications Office of the European Union, 2023: https://data.europa.eu/sites/default/files/odm2023_report.pdf

[204] Page, Martin, Emir Hajduk, Eline N. Lincklaen Arriëns, Gianfranco Cecconi, and Suzan Brinkhuis. 2023 Open Data Maturity Report. Prepared as part of data.europa.eu. Luxembourg: Publications Office of the European Union, 2023: https://data.europa.eu/sites/default/files/odm2023_report.pdf

[205] OECD. Enhancing Access to and Sharing of Data: Reconciling Risks and Benefits for Data Re-use across Societies. Paris: OECD Publishing, 2019. https://doi.org/10.1787/276aaca8-en.

innovation, with measurable impacts remaining elusive[206]. Indeed, fewer than half of EU member states have conducted formal assessments to evaluate open data's impact across domains such as government, society, environment, and the economy[207]. This **lack of comprehensive evaluation** limits understanding of open data's true benefits.

A significant critique lies in the movement's economic focus, which emphasizes innovation yet often **reinforces existing power structures rather than democratizing access or fostering equity.** However, a shift is emerging toward a more inclusive vision of data governance, with frameworks supporting democratic innovation. Initiatives at local, national, and regional levels highlight the dynamic relationship between citizens and public administration in Europe[208]. Such movements often build on the concept of Digital Commons in this context (see section 2.3.6). Nonetheless, the current business-driven architecture of the digitalization of the public sector, aimed mainly at enhancing the experience of citizens as customers, may also inadvertently reduce opportunities for meaningful empowerment and democratic engagement with government services[209].

1.3.4 Regulations and incentives for the circulation of privately held data

Recent data governance policies in the EU mark a shift in data regulation beyond individual rights-based approaches or purely economic frameworks. These policies **recognize data as a collective resource** with societal benefits maximized when data is shared under secure, structured conditions[210]. Unlike traditional privacy regulations that primarily emphasize protecting individual rights, contemporary policies emphasize collective benefits and public interest, asserting that data's value is unlocked only when it circulates within a trusted environment[211]. The goals of these policies can range from improving public services by making essential data accessible for evidence-based decision-making to stimulating innovation, such as advancing AI development[212].

The EU's *Open Data Directive* and France's *Law for a Digital Republic* for instance mandate the sharing of specific **"high value" datasets, or "data of public interest"**, particularly in areas

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[206] Samuel Goëta, Les Données de La Démocratie - Open Data, Pouvoirs et Contre-Pouvoirs, Collection Société numérique (Caen: C&F Editions, 2024).

[207] Page, Martin, Emir Hajduk, Eline N. Lincklaen Arriëns, Gianfranco Cecconi, and Suzan Brinkhuis. 2023 Open Data Maturity Report. Prepared as part of data.europa.eu. Luxembourg: Publications Office of the European Union, 2023: https://data.europa.eu/sites/default/files/odm2023_report.pdf

[208] Emiliana De Blasio and Donatella Selva, "Why Choose Open Government? Motivations for the Adoption of Open Government Policies in Four European Countries," Policy & Internet 8, no. 3 (July 19, 2016): 225–47, https://doi.org/10.1002/poi3.118.

[209] Patrice A. Dutil et al., "Rethinking Government-Public Relationships in a Digital World," Journal of Information Technology & Politics 4, no. 1 (April 2008): 77–90, https://doi.org/10.1300/j516v04n01_06.

[210] Mills, Stuart. "Who Owns the Future? Data Trusts, Data Commons, and the Future of Data Ownership." September 24, 2019. Available at SSRN: https://ssrn.com/abstract=3437936 or http://dx.doi.org/10.2139/ssrn.3437936.

[211] OECD. Enhancing Access to and Sharing of Data: Reconciling Risks and Benefits for Data Re-use across Societies. Paris: OECD Publishing, 2019. https://doi.org/10.1787/276aaca8-en.

[212] Jason Potts et al., "Profiting from Data Commons: Theory, Evidence, and Strategy Implications," Strategy Science 9, no. 1 (September 15, 2023), https://doi.org/10.1287/stsc.2021.0080.

such as transportation, environment, and health[213]. Other mandatory approaches include **portability obligations**: data portability obligations for personal data were already established by GDPR's Article 20. Complementing the DGA, the Data Act focuses on fair data access within the digital economy. It allows public bodies to access private sector data in emergency scenarios and promotes data portability and interoperability across cloud providers, specifically for IoT-generated data. The Act grants consumers and businesses rights to access and share data from connected devices, enabling users to select service providers, with the objective of increasing competition in economic sectors, such as repair and maintenance[214]. Such provisions align with the support for Open Source Hardware and networks of local production (see section 1.4).

One prominent approach involves incentivizing **voluntary data sharing**. These approaches foster data-sharing environments through standardized data formats, licensing templates, standard contractual agreements, and mechanisms for voluntary data exchanges under FRAND terms. Voluntary frameworks can also include mechanisms like data pools and sandboxes, where companies can share sensitive information securely and with adequate privacy safeguards[215]. Data-sharing practices in this context are often overseen by **data stewards, the institutional hosts of tailored legal arrangements**[216]. The **Data Governance Act (DGA)**, launched by the EU, extends this strategy by establishing regulations for data intermediaries—trusted entities that facilitate data sharing among private and public sectors while ensuring data security and neutrality. This Act encourages a model of **"data altruism,"** in which individuals and organizations voluntarily share data for societal benefits, particularly in areas like healthcare and environmental protection. The DGA also established the European Data Innovation Board, which promotes best practices in interoperability and data protection[217].

Policies are indeed increasingly focused on establishing **trusted intermediaries, such as data cooperatives and data trusts**, which act as neutral entities to facilitate data sharing between private entities, individuals, and public institutions[218]. In this context, governments try to create frameworks where data is managed under commons-based principles, allowing various stakeholders to access and utilise it under shared governance principles. These regulatory efforts also aim to address the monopolistic dynamics of the digital landscape by encouraging data portability, interoperability, and access to essential data.

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[213] World Bank. World Development Report 2021: Data for Better Lives. Washington, DC: World Bank, 2021. https://doi.org/10.1596/978-1-4648-1600-0.

[214] European Commission, "Data Act | Shaping Europe's Digital Future," digital-strategy.ec.europa.eu (European Commission, October 10, 2024), https://digital-strategy.ec.europa.eu/en/policies/data-act.

[215] World Bank. World Development Report 2021: Data for Better Lives. Washington, DC: World Bank, 2021. https://doi.org/10.1596/978-1-4648-1600-0.

[216] Hardinges, Jack, Peter Wells, Alex Blandford, Jeni Tennison, and Anna Scott. "Data Trusts: Lessons from Three Pilots." Open Data Institute, 2019. Accessed November 7, 2024. https://theodi.org/article/odi-data-trusts-report.

[217] European Commission, "Data Governance Act Explained | Shaping Europe's Digital Future," digital-strategy.ec.europa.eu (European Commission), accessed November 6, 2024, https://digital-strategy.ec.europa.eu/en/policies/data-governance-act-explained.

[218] Micheli, Marina, Eimear Farrell, Bruno Carballa Smichowski, Monica Posada Sanchez, Serena Signorelli, and Michele Vespe. Mapping the Landscape of Data Intermediaries. Luxembourg: Publications Office of the European Union, 2023. https://doi.org/10.2760/261724.

In this context, the European Commission introduced the **"Common European Data Spaces"** initiative, advocating for a sector-specific, community-driven approach to data governance that acknowledges the distinct requirements across various domains. By providing funding from the Digital Europe work program, the European Commission is facilitating the rollout of 14 Common European Data Spaces in critical sectors, including mobility, agriculture, energy, and healthcare. These data spaces are designed around a decentralized model with adaptable governance structures, incorporating standardized technical and operational protocols while allowing for sectoral customization. The European Data Innovation Board, which is being gradually established, plays a supportive role in overseeing the implementation and interoperability of these spaces[219].

1.4 Policies Promoting Open Source Hardware

The section 1.4 presents initiatives on Open Source Hardware (OSH). While there are no EU or member state policies that explicitly promote OSH, indirect support exists in areas such as standardization, open standards, and infrastructure funding around OSH ecosystems. Historically, OSH has grown through collaborative environments like fab labs and maker spaces, established within research and education institutions and later extending to the maker movement, with a focus on sustainable local manufacturing. Applications of OSH span diverse fields, including 3D printing, IoT, and AI hardware design. It, therefore, has spurred interest in the context of policies supporting innovation and industrial strategies. EU's support for RISC-V–an OSH project in the field of microchips–will be discussed in section 2.2.3.

1.4.1 Definitions

Open Hardware, or Open Source Hardware (OSH), refers to **physical objects whose designs are openly shared and licensed to enable free use, modification, and distribution**. OSH promotes collaboration and innovation by making technical specifications and design information publicly accessible, as emphasized by the Open Source Hardware Association (OSHWA)[220]. A famous European example of an OSH project is **Arduino, a platform that provides more than 100 easy-to-use hardware products, such as microprocessors and controller kits, which can be programmed through its simple development environment**. Originally created in 2005 for teaching purposes in Italy, Arduino is widely used by hobbyists and professionals to develop projects like robots, sensors, and motion detectors, enabling affordable and customizable tools for prototyping[221]. While many OSH projects have emerged in the field of electronics and microcontrollers, the field has expanded to various areas, from musical instruments to jewellery or medical devices[222].

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[219] European Commission, "Commission Staff Working Document on Common European Data Spaces," Https://Digital-Strategy.ec.europa.eu (Brussels: European Commission, January 24, 2024), https://digital-strategy.ec.europa.eu/en/library/second-staff-working-document-data-spaces.

[220] Open Source Hardware Association (OSHA), "Definition (English)," OSHA, accessed November 26, 2024, https://www.oshwa.org/definition/.

[221] Arduino, "What Is Arduino?," Arduino.cc, February 5, 2018, https://www.arduino.cc/en/guide/introduction.

[222] OSHWA, "The State of Open Source Hardware 2021," State of Open Source Hardware 2021 (Open Source Hardware Association (OSHWA), 2021), https://stateofoshw.oshwa.org/.

The OSH movement has various origins. Similarly to the Open Source Software (OSS) movement, it originated in **scientific and research practices**. The Homebrew Computer Club for instance was a group of researchers in Menlo Park, California, who played a key role in personal computer developments and inspired many later innovations in Silicon Valley[223]. OSH gained momentum as technology sharing became accessible and economically feasible with the rise of the internet and falling production costs. The concept of OSH traces back to 1997, when Bruce Perens introduced the Open Hardware Certification Program. In 1999, the Open Design Foundation formalized the notion of "open design" with the intent to apply open source principles to machine design[224].

In the 2000 decade, various collaborative environments - such as **FabLabs, hackerspaces or makerspaces** - equipped with digital fabrication tools like 3D printers and laser cutters were established and supported this trend. The first official FabLab was created in 2001 at the Massachusetts Institute of Technology (MIT) as a collaboration between the Grassroots Invention Group and the Center for Bits and Atoms, funded by a grant from the National Science Foundation[225]. Many of these spaces were originally established within research institutions, with public support for the buying of equipment. They combined this new equipment with the spirit of OSS. An example of this convergence is the RepRap project, a project to develop low-cost 3D printers[226].

Fablabs later became key drivers of the **maker and "Do-It-Yourself" (DIY) movements**, which were made famous by authors like Chris Anderson[227], Mark Hatch[228] and Dale Dougherty[229]. These movements emphasize on mobilizing local manufacturing and repair to empower individuals and communities to create and maintain tools that are tailored to their needs[230]. The Open Source Ecology network for instance is a collaborative network of farmers and engineers focused on creating designs for essential industrial machines needed to **establish**

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223 Michel Lallement, L'âge du Faire: Hacking, Travail, Anarchie (Paris: Éditions Du Seuil, 2015).

224 Open Source Hardware Association (OSHA), "Brief History of Open Source Hardware Organizations and Definitions – OSHWA," Oshwa.org, August 14, 2013, https://www.oshwa.org/research/brief-history-of-open-source-hardware-organizations-and-definitions/.

225 François Bottollier-Depois et al., "État Des Lieux et Typologie Des Ateliers de Fabrication Numérique - Rapport Final à La Direction Générale Des Entreprises," ENSSIB (Paris: Fondation internet nouvelle génération (FING) , April 2014), https://www.enssib.fr/bibliotheque-numerique/documents/64797-etat-des-lieux-et-typologie-des-ateliers-de-fabrication-numerique-rapport-final.pdf.

226 Michael Petch, "Interview: Dr. Adrian Bowyer on the 10th Anniversary of RepRap," 3D Printing Industry, May 29, 2018, https://3dprintingindustry.com/news/interview-dr-adrian-bowyer-10th-anniversary-reprap-133841/.

227 Chris Anderson, Makers : The New Industrial Revolution (New York: Crown Business, 2014).

228 Mark Hatch, The Maker Movement Manifesto : Rules for Innovation in the New World of Crafters, Hackers, and Tinkerers (New York: Mcgraw Hill, 2013).

229 Dale Dougherty, Free to Make: How the Maker Movement Is Changing Our Schools, Our Jobs, and Our Minds (Berkeley, California: North Atlantic Books, 2016).

230 Vasilis Kostakis et al., "The Convergence of Digital Commons with Local Manufacturing from a Degrowth Perspective: Two Illustrative Cases," Journal of Cleaner Production 197, no. Part 2 (October 2018): 1684–93, https://doi.org/10.1016/j.jclepro.2016.09.077.

small, sustainable, and resilient communities[231]. During the COVID-19 pandemic, OSH-enabled medical devices offered low-cost solutions to address urgent needs[232].

In Europe, the movement has been considered a **driver of innovation, democratization of technology, and empowerment, fostering creativity, education, and entrepreneurship**. According to a 2017 study, over 800 collaborative production spaces were established in Europe (see Figure 12). The various thematic focuses of these spaces include digital fabrication, programming, electronics, design, art, education, biohacking, entrepreneurship, and environmental initiatives. The report also describes the movement's history and evolution, linking it to advancements in technology but also to various social and cultural movements[233].

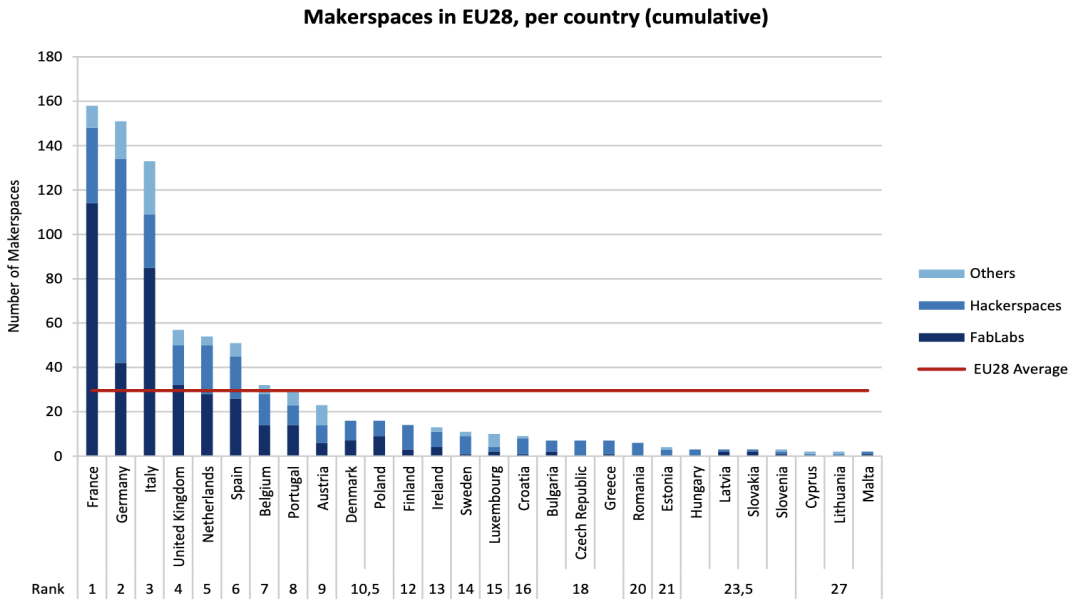

Figure 12: Total number of Makerspaces in EU28, listed by country and typology, 2017

1.4.2 Overview of policy trends

The research conducted for **this report could not identify any policy of the European Union or of its member states directly targeting or promoting OSH**, confirming observations made in earlier policy reports. As other reports note, however, one can find indirect support measures in areas that affect the development of OSH, "such as intellectual property rights, standardization policy, open standards implementation rules, as well as potential direct support for infrastructure, including fab labs and maker spaces." One recent example of such a policy is the "Directive on common rules promoting the repair of goods" adopted in 2024,

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231 Manuel Moritz et al., "Value Creation in Open-Source Hardware Communities: Case Study of Open Source Ecology," 2016 Portland International Conference on Management of Engineering and Technology (PICMET), September 1, 2016, https://doi.org/10.1109/picmet.2016.7806517.

232 Astor Nummelin Carlberg, "UNDP: Open Source Hardware Important in Global COVID-19 Response," Interoperable Europe Portal, November 10, 2022, https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/undp-open-source-hardware-important-global-covid-19-response.

233 Paulo Valente de Jesus Rosa et al., "Overview of the Maker Movement in the European Union," JRC Publications Repository (Luxembourg: Publications Office of the European Union, January 1, 2017), https://doi.org/10.2760/227356.

which aims primarily at promoting eco-design, responsible consumption, and the circular economy. While the directive does not include provisions to make repair-related information and tools publicly available, member states will have to implement measures "to promote repair, such as repair vouchers and funds, conducting information campaigns, offering repair courses or supporting community-led repair spaces."[234]

Most OSH initiatives are driven either by **individual research institutions**, such as CERN, which played a key role in advancing OSH licensing and its development in science. These initiatives focus on education, research and development, and sometimes entrepreneurship. Other OSH initiatives are supported by **regional or city-level policies**, which aim to support decentralized, low-cost, and sustainable fabrication.

These individual initiatives have created **networks to organize and promote OSH activities at the international level**, such as the Open Source Hardware Association (OSHWA), created in 2012. Since 2016, the Gathering for Open Science Hardware (GOSH) has brought together practitioners and advocates of the openness of scientific instruments, such as laboratory equipment, computing devices, reagents, field sensors, or satellites. UNESCO has included Open Hardware for Science in its Science Toolkit, designed to support the implementation of Open Science policies[235]. Some international organizations have provided funding and technical assistance to OSH solutions in the context of humanitarian and development programs, like the UNICEF Innovation Fund or the International Federation of Red Cross and Red Crescent Societies (IFRC) Solferino Academy[236].

While there are no public policies aimed at regulating OSH, key milestones to formalize practices included the establishment of the Open Source Hardware Definition in 2011 and the CERN Open Hardware License[237]. These frameworks provided legal and ethical foundations for the community, encouraging consistency on licensing and intellectual property matters, but also on documentation formats. An analysis on the dissemination practices of more than 100 OSH projects in 2017 found that **a wide range of practices in sharing documentation, from comprehensive sets to minimal disclosure,** can be observed in the field. Two main strategies in OSH development are identified in this article: fostering community-based collaborative development and enabling the diffusion of innovations developed in private settings. The article introduces an OSH lifecycle framework to describe these approaches

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[234] European Parliament, "Right to Repair: Making Repair Easier and More Appealing to Consumers" www.europarl.europa.eu (European Parliament, April 23, 2024), https://www.europarl.europa.eu/news/en/press-room/20240419IPR20590/right-to-repair-making-repair-easier-and-more-appealing-to-consumers.

[235] UNESCO, "Supporting Open Hardware for Open Science," UNESCO Digital Library, 2023, https://doi.org/10.54677/LUMO4515.

[236] Julieta Arancio, "Open Hardware: A Key for Accelerating Science and Technology towards the U.N. Sustainable Development Goals," ResearchGate (Gathering for Open Science Hardware (GOSH), September 2021), https://www.researchgate.net/publication/355203476_Open_Hardware_A_key_for_accelerating_science_and_technology_towards_the_UN_Sustainable_Development_Goals.

[237] Open Source Hardware Association (OSHA), "Brief History of Open Source Hardware Organizations and Definitions – OSHWA," Oshwa.org, August 14, 2013, https://www.oshwa.org/research/brief-history-of-open-source-hardware-organizations-and-definitions/.

(see figure 13)[238]. A more recent trend is the extension of standards for processes allowing "users to exercise their open permissions and to keep them findable and open in the digital infrastructure."[239]

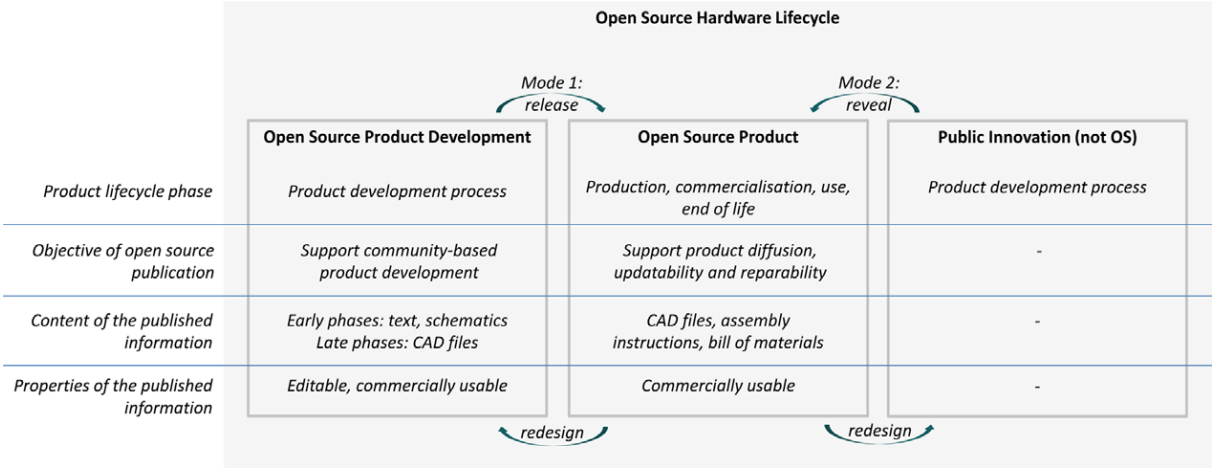

Figure 13: Open Source Hardware Lifecycle (Source: Jeremy Bonvoisin et al., 2017)

Applications of OSH principles can be found in 3D printing, robotics, sensor networks, and IoT, among many other areas. OSH also facilitates the design of integrated circuits and computer systems, which is crucial for tasks like deep learning. Global tech companies, such as Google, Facebook, and NVIDIA, have shared elements of their AI hardware designs, while projects like GreenWaves Technologies' ultra-low-power processors and Antmicro's edge AI solutions exemplify OSH's potential in advancing AI[240]. For these reasons, several countries such as China, but also the European Union, have **supported OSH technologies for chip development, notably through the RISC-V project, as part of their industrial strategies in the field**. Some OSH projects have also received funding through the European Union Next Generation Internet (NGI) initiative. These policies will be mentioned in section 2.

1.4.3 Policies supporting Open Source Hardware in research and education

OSH is increasingly considered to be an important dimension of Open Science because of its potential to **democratize access to scientific tools, reduce costs, and enhance research reproducibility**[241]. Grassroots movements like the Global Open Science Hardware (GOSH) network have been important in promoting OSH adoption. Their strategies focus on legitimizing OSH as part of Open Science strategies, establishing documentation standards,

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[238] Jérémy Bonvoisin et al., "What Is the 'Source' of Open Source Hardware?," Journal of Open Hardware 1, no. 1 (September 5, 2017), https://doi.org/10.5334/joh.7.

[239] Jérémy Bonvoisin et al., "Standardisation of Practices in Open Source Hardware," Journal of Open Hardware 4, no. 1 (2020), https://doi.org/10.5334/joh.22.

[240] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

[241] UNESCO, "Supporting Open Hardware for Open Science," UNESCO Digital Library, 2023, https://doi.org/10.54677/LUMO4515.

and embedding it in university programs to professionalize and incentivize its use. OSH designs are now found across various scientific disciplines, such as neuroscience, environmental monitoring, and microscopy. Platforms like the OpenFlexure Project provide open designs for tools like 3D-printed microscopes, which are used globally for applications ranging from malaria detection to soil analysis[242].

Research on the impact of OSH has found that by making scientific hardware accessible and modifiable, OSH can reduce the overall costs of research[243] and, therefore, represents an opportunity in research settings with limited access to funding. But OSH has been established as "a powerful strategy to access appropriate research technology in both low-resource and high-resource biology laboratories," as it facilitates access to "equipment by reducing dependence on import logistics," participates in "direct knowledge transfer," and allows to adapt instruments to specific needs and easily repair them[244].

OSH receives limited institutional support compared to mandatory publication of scientific data and articles. This lack of prioritization results in poor standardization and a reliance on voluntary contributions from researchers and communities. Universities often lack structured policies to support OSH, and researchers face difficulties in gaining recognition for their contributions to hardware development. The absence of procurement incentives and institutional metrics further hinders OSH integration. Mandatory adoption of OSH in public institutions could contribute to the creation of shared research infrastructures and the dissemination of Open Science good practices[245].

CERN has played a pioneering role in advancing Open Source Hardware (OSH) by **developing licensing frameworks**, **hosting global hardware designs through the Open Hardware Repository**, and creating tools for simulation and design. Its Open Source Programme Office (OSPO) supports internal and external stakeholders by providing training, guidance, and infrastructure to facilitate OSH adoption. CERN emphasizes collaboration with industry and research communities to maximize societal impact and ensure the accessibility and sustainability of OSH technologies[246]. CERN's OSH strategy originated from its need to enhance peer review and improve hardware quality while ensuring maximum freedom for users to reuse and adapt its research outputs. This approach also aimed to reduce duplication of efforts and address specific concerns, such as tracing the impact of CERN's

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[242] Julieta Arancio and Shannon Dosemagen, "Bringing Open Source to the Global Lab Bench," Issues in Science and Technology 38, no. no. 2 (2022): 18–20, https://issues.org/open-source-science-hardware-gosh-arancio-dosemagen/.

[243] Joshua M. Pearce, "Cut Costs with Open-Source Hardware," Nature 505, no. 7485 (January 29, 2014): 618–18, https://doi.org/10.1038/505618d.

[244] Tobias Wenzel, "Open Hardware: From DIY Trend to Global Transformation in Access to Laboratory Equipment," PLoS Biol 21, no. 1 (January 17, 2023): e3001931–31, https://doi.org/10.1371/journal.pbio.3001931.

[245] Javier Serrano, "Why Public Institutions Should Release More Open Hardware | Medium," Medium, June 2020, https://medium.com/@j.serrano/oshw-in-public-institutions-7726d2ea92a8.

[246] CERN, "Open Hardware | OpenScience at CERN," Openscience.cern (European Organization for Nuclear Research (CERN), 2024), https://openscience.cern/hardware.

research, particularly through its collection of hardware modules for particle accelerator controls and data acquisition[247].

Another example of a European leader in advancing OSH is TU Delft, which has implemented a policy to support the creation of open source, reproducible hardware projects. Originating as a grassroots effort, it is now supported by the university's Open Science program, which helps researchers navigate licensing, documentation, and best practices. The launch of the **Open Hardware Academy**, a structured program teaching project management, prototyping, and community building, has further institutionalized these efforts[248].

Beyond research and development, OSH is also strongly associated with education. Various studies have argued that makerspaces and OSH **enable learning through co-creation and experimentation processes, but also the establishment of communities of practices**[249]. In Europe, maker spaces are increasingly integrated into education, from early childhood to higher education and lifelong learning. They are thought to support interdisciplinary learning, problem-solving, informal social interactions, and peer mentoring. Makerspaces are also considered to help individuals stay engaged with societal and technological changes, offer pathways to formal education, and provide opportunities for skill validation and employment. Their slow inclusion in curricula could promote equity and competence-based education while aligning with European Key Competences for Lifelong Learning[250].

1.4.4 Policies promoting distributed manufacturing for local sustainable development

The development of OSH is closely tied to the rise of collaborative production environments, such as FabLabs, makerspaces, and hackerspaces. These spaces facilitate the **convergence of global Digital Commons with local production resources, embodying the "design global, manufacture local" model**[251]. This approach decentralizes production, promotes sustainability, and challenges mass production paradigms, drawing inspiration from movements like William Morris's Arts and Crafts[252]. Platforms such as WikiHow, Energypedia, Appropedia, and the Low-tech Lab for instance, contribute to this ecosystem by providing

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[247] Open Source Hardware Association (OSHA), "Brief History of Open Source Hardware Organizations and Definitions – OSHWA," Oshwa.org, August 14, 2013, https://www.oshwa.org/research/brief-history-of-open-source-hardware-organizations-and-definitions/.

[248] TU Delft, "The Rise of Open Hardware at TU Delft," tudelft.nl (Delft University of Technology (TU Delft)), accessed November 27, 2024, https://www.tudelft.nl/en/open-science/articles-tu-delft/the-rise-of-open-hardware-at-tu-delft.

[249] Steven Weiner, Micah Lande, and Shawn S Jordan, "What Have We 'Learned' from Maker Education Research? A Learning Sciences-Base Review of ASEE Literature on the Maker Movement," Papers on Engineering Education Repository (American Society for Engineering Education), September 10, 2020, https://doi.org/10.18260/1-2--31235.

[250] Riina Vuorikari, Anusca Ferrari, and Yves Punie, "Makerspaces for Education and Training: Exploring Future Implications for Europe," JRC Publications Repository (Luxembourg: Publications Office of the European Union, October 11, 2019), Publications Office of the European Union.

[251] Vasilis Kostakis et al., "The Convergence of Digital Commons with Local Manufacturing from a Degrowth Perspective: Two Illustrative Cases," Journal of Cleaner Production 197, no. Part 2 (October 2018): 1684–93, https://doi.org/10.1016/j.jclepro.2016.09.077.

[252] Fiona Maccarthy, Anarchy & Beauty : William Morris and His Legacy, 1860-1960 (New Haven: Yale University Press, 2014).

access to various resources, tutorials, and designs, enabling individuals and communities to build and repair things locally.

Several studies have been conducted on the diversity of models and social dynamics behind collaborative production environments. The studies analyze how these spaces combine work, leisure, and community engagement[253]. They also emphasize their role in fostering education and technological literacy, while driving innovation and interdisciplinary collaboration[254]. Other studies have looked more specifically in their role in driving sustainable practices, resource efficiency, and appropriate technology development. They show that practices around OSH can be integrated in both grassroots low-tech solutions and industrial innovations[255].

Support for these environments has primarily come from local initiatives, particularly in cities, which recognize their potential in urban planning, circular economies, and territorial cooperation. For instance, the Fab Cities network, established in 2011, connects local initiatives that leverage global knowledge exchange, data sharing, and distributed manufacturing to transition from linear to circular economies, fostering self-sufficient urban areas and reducing ecological footprints[256].

These local initiatives and their strengthening through international networks have been **supported by European programmes for research and innovation through Horizon Europe funds, but also for territorial cooperation through the European Structural and Investment funds**. Some past and current examples include: the DOIT project (2017-2020)[257], Fablabia (2019-2020)[258], REFLOW (2019-2022)[259], DIY4U (2019-2023)[260], Pop-Machina (2019-2023)[261], or mAKE (2022-2025)[262]. Studies evaluating the impact of European-funded projects emphasize the importance of local collaborative production environments in promoting

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253 Camille Bosqué, "Enquête Au Cœur Des FabLabs, Hackerspaces, Makerspaces," Techniques & culture (OpenEdition, 2015), https://journals.openedition.org/tc/7579?lang=en.

254 Paulo Valente de Jesus Rosa et al., "Overview of the Maker Movement in the European Union," JRC Publications Repository (Luxembourg: Publications Office of the European Union, January 1, 2017), https://doi.org/10.2760/227356.

255 ADEME, "Démarches 'Low Tech,'" La Librairie ADEME, March 2022, https://librairie.ademe.fr/consommer-autrement/5421-demarches-low-tech.html.

256 Tomas Diez Ladera, "Fab City White Paper - Locally Productive, Globally Connected Self-Sufficient Cities," Fab City, February 2016, https://fab.city/wp-content/uploads/2023/03/Fab-City_Whitepaper.pdf.

257 European Commission, "Entrepreneurial Skills for Young Social Innovators in an Open Digital World. A European Initiative," CORDIS - EU research results, September 4, 2022, https://cordis.europa.eu/project/id/770063.

258 European Commission, "FabLab as Entrepreneurship Supporting Tool for Innovation Agencies," CORDIS - EU research results, August 18, 2022, https://cordis.europa.eu/project/id/853530.

259 European Commission, "ConstRuctive MEtabolic Processes for MateriaL FlOWs in Urban and Peri-Urban Environments across Europe," CORDIS - EU research results, December 11, 2023, https://cordis.europa.eu/project/id/820937.

260 European Commission, "Open Innovation Digital Platform and Fablabs for Collaborative Design and Production of Personalised/Customised FMCG," CORDIS - EU research results, October 28, 2024, https://cordis.europa.eu/project/id/870148.

261 European Commission, "Collaborative Production for the Circular Economy; a Community Approach," CORDIS - EU research results, July 29, 2024, https://cordis.europa.eu/project/id/821479.

262 European Commission, "African European Maker Innovation Ecosystem," CORDIS - EU research results, February 1, 2022, https://doi.org/10.3030/101016858.

sustainability, innovation, and community engagement. These initiatives are shown to advance circular economy practices, improve resource efficiency, and address diverse urban challenges[263]. However, challenges remain, including inconsistent funding due to the competitive nature of grant-based European programs and the uneven implementation of openness and community participation practices in these programs[264].

1.5 Intermediary Summary: Policies Supporting Open Access

The first part of this report examined policies promoting Digital Commons across various domains, including OSS, open knowledge, open data, and OSH. These policies were all rooted in the belief in the power of openness to support research and innovation, but also to support collaboration and transparency. Most of these policies were focused on the adoption of open principles by the public sector.

Section 1.1 reviewed policies that have promoted the adoption of open source software (OSS) by public sector administrations in the EU and in its member states. Early EU policies focused on the modernization of public sector organizations, but recent initiatives have expanded to address transparency, digital sovereignty, and interoperability. Policies that mobilize OSS of interoperability, industrial strategies, and digital sovereignty will be explored in more depth in the second part of this report. Policies to support OSS adoption include national regulatory measures, procurement guidelines, and OSS catalogs to reduce costs and reliance on proprietary software while enabling transparency and collaboration. The institutionalization of OSS through Open Source Programme Offices (OSPOs) has been critical, providing technical and strategic support to public administrations at national, local, and international levels.

The advent of personal computing and the internet created new practical possibilities for knowledge sharing, leading to a wider politicization of the free knowledge ideals rooted in scientific and software communities. This shift spurred debates on expanding intellectual property rights, the emergence of alternative licensing systems like Creative Commons, and global collaborative projects such as Wikimedia. Policies began to take shape in areas like open science, open culture, and open education. Similarly to the field of OSS, section 1.2. showed that early EU policies in the field of open knowledge focused on public sector adoption, for instance through the implementation of "open by default" principles for public sector documents or of mandates requiring openness for publicly funded research. Limitations in funding and institutional capacities, as well as the rise of new private intermediaries monetizing knowledge sharing led to a new interest in public infrastructures for data sharing, which will be discussed in section 2.1.5. Open Glam and Open Education Resources (OERs) efforts remain fragmented and heavily reliant on individual institutions, with limited cohesive strategies.

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[263] Elisabeth Unterfrauner et al., "The Environmental Value and Impact of the Maker Movement—Insights from a Cross-Case Analysis of European Maker Initiatives," Business Strategy and the Environment 28, no. 8 (May 26, 2019): 1518–33, https://doi.org/10.1002/bse.2328.

[264] Lisa Monaco and Carlos Herce, "Impact of Maker Movement on the Urban Resilience Development: Assessment Methodology and Analysis of EU Research and Innovation Projects," Sustainability 15, no. 17 (August 25, 2023): 12856–56, https://doi.org/10.3390/su151712856.

Section 1.3 reviewed open data policies. The Open Data movement emerged in the mid-2000s as part of a convergence between OSS principles, demands for government transparency and accountability, and new capacities and economic interests for data analysis. The movement inspired governments to shift from request-based systems to access public information to proactive publication under open licences. Beyond public sector data, more recent discussions have introduced the concept of "Data Commons," enabling stakeholders to pool and govern shared data collaboratively. This evolution reflects a stronger policy interest in data intermediaries and infrastructures, but also a move away from binary open-closed frameworks toward nuanced governance models.

Section 1.4 presented initiatives on Open Source Hardware (OSH). While there are no EU or member state policies that explicitly promote OSH, indirect support exists in areas such as standardization, open standards, and infrastructure funding around OSH ecosystems. Historically, OSH has grown through collaborative environments such as fab labs and makerspaces, established within research and educational institutions, and later extending to the maker movement, with a focus on sustainable local manufacturing. The applications of OSH span diverse fields, including 3D printing, IoT, and AI hardware design. It therefore has spurred interest in the context of policies supporting innovation and industrial strategies. EU's support for RISC-V–an OSH project in the field of microchips–will be discussed in section 2.2.3.

Trends inside the different “fields of the open” analyzed in the first part of this report have already signaled a shift towards policies supporting the collective management of critical digital resources to counter the dominance of large platforms and support digital sovereignty. Digital sovereignty can be interpreted as the capacity to set or influence rules governing digital communications and services, as the ability to have control over critical infrastructure, without relying over on foreign technologies, but also as the ability of individuals, communities and organizations, to have a self-determined use of the tools and systems that shape their digital lives. In this context, the report will review policies that pursue the establishment of interoperability rules and standards (2.1), policies that support the pooling of resources in the context of industrial strategies for economic development (2.2), and policies that distribute ownership of critical digital resources, by mobilizing Digital Commons to empower individuals, communities and organizations (2.3).

SECTION 2: Policies Promoting the Collective Management of Digital Infrastructures

2.1 Policies Promoting Interoperability and Open Standards

Section 2.1 reviews policies that mobilize Digital Commons, especially open standards, to increase their capacity to define, set, or influence rules governing digital communications and services. The political economy of the internet is increasingly shaped by concerns about dominant platforms and digital sovereignty, leading to the politicization of critical infrastructure and positioning interoperability and open standards as key areas of focus. Governments, particularly in Europe, have increased their involvement in standard-setting, as exemplified by the EU's 2022 Standardisation Strategy. In parallel, the EU has begun to establish internal initiatives, such as the Interoperable Europe Act (IEA), to harmonize public sector services across its member states. Regulatory frameworks such as the Digital Markets Act (DMA) also mandate third-party interoperability for gatekeeper platforms. Inspired by successful initiatives such as Europeana, the Nordic Institute for Interoperability Solutions (NIIS), and the European Open Science Cloud (EOSC), the EU aims to support Common European Data Spaces with data sharing rules co-defined by participating stakeholders.

2.1.1 Definitions

The establishment of collective governance mechanisms for the management of the key technical components of our modern information and communications infrastructures has been essential for the uptake of the internet and the development of networks, applications and services able to communicate with each other globally.

The internet often referred to as a network of networks, owes its success to its initial **collaborative development and the establishment of an open governance model**. The internet's logical layer was indeed shaped by "Network Working Groups," informal collectives of researchers who operated on consensus and meritocracy, using open "Requests for Comments" documents to refine protocols[265]. These researchers developed the TCP/IP (Transmission Control Protocol and Internet Protocol), which they designed to ensure "end-to-end" communication, preventing internet providers from differentiating or discriminating among data packets carried by their networks. This "end-to-end" design made the **open interconnection** of an unlimited number of networks possible: it enabled the network to achieve global scale by ensuring **seamless communication across diverse infrastructures without centralized control at this logical layer**. The technical standards behind the Internet protocol suite are still maintained collaboratively today by the **Internet Engineering Task Force (IETF)**. For these reasons, the internet is not only recognized as a major contemporary infrastructure, but as a prime example of a digital common[266]. Similarly, the World Wide Web (or the web), accessible through the internet, was developed by computer scientist Tim

[265] Dominique Boullier, "Sociologie Du Numérique," HAL (Le Centre Pour La Communication Scientifique Directe) "Collection U," no. 2e éd. (August 14, 2019), https://doi.org/10.3917/arco.boull.2019.01.

[266] 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.

Berners-Lee at CERN with the objective of creating a collectively managed infrastructure: a "universal linked information system" - where resources are identified and located based on "uniform resource locators" (URLs)[267]. The web allows documents and other media content to be shared via web servers and accessed in a user-friendly manner via browsers, according to the rules established by the Hypertext Transfer Protocol (HTTP). The establishment of the the **World Wide Web Consortium (W3C)** in 1994 was aimed at creating **a structure for communities to jointly coordinate web standards**[268].

The capacity of various organizations–including governments, businesses, research communities and civil society–to agree on shared standards has been essential to build **interoperable systems and products, which means that they are able to work together with other systems or products[269].** In the context of information technology, interoperability pertains to the ability of systems to exchange information effectively. As digital systems grow more intricate and interconnected, ensuring interoperability among their components has become a critical challenge for large-scale infrastructures[270].

Standards are generally understood as **rules, models, or measures established by authority, tradition, or consensus**. Depending on how they were established, standards may be classified as *de facto*, *de jure*, or developed by recognized standardization organizations. *De facto* standards in competitive markets in the ICT sector have often turned into a battleground, where dominant players try to secure control by establishing a standard[271]. Such standards are usually referred to as closed standards, managed unilaterally by a single supplier, therefore creating risks and dependencies for other parties relying on them. In contrast, the bodies managing key protocols of the internet, and more generally the OSS movement, are developing **open standards, which are "publicly available and developed via processes that are transparent and open to broad participation"[272]**. While most definitions of open standards agree on requirements regarding the need for a process open to equal participation by all stakeholders, as well as the possibility of public assessment and use, some argue for the fact that to be open a standard should be available on a royalty-free basis, "free from legal or technical clauses that limit its utilisation by any party"[273,] while

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[267] Tim Berners-Lee, "The Original Proposal of the WWW, HTMLized," W3.org, 1989, https://www.w3.org/History/1989/proposal.html.

[268] World Wide Web Consortium, "History," W3C, 2024, https://www.w3.org/about/history/.

[269] Peter Wegner, "Interoperability," ACM Computing Surveys 28, no. 1 (March 1996): 285–87, https://doi.org/10.1145/234313.234424.

[270] Reza Rezaei, Thiam Kian Chiew, and Sai Peck Lee, "An Interoperability Model for Ultra Large Scale Systems," Advances in Engineering Software 67 (January 2014): 22–46, https://doi.org/10.1016/j.advengsoft.2013.07.003.

[271] Marco Berlinguer, "The Matrix: Is There a European Way to Cloud Computing?," Transform!Europe, May 5, 2024, https://transform-network.net/publication/the-matrix-is-there-a-european-way-to-cloud-computing/.

[272] ISOC, "Policy Brief: Open Internet Standards," Internet Society, October 30, 2015, https://www.internetsociety.org/policybriefs/openstandards/.

[273] European Committee for Interoperable Systems, "Geneva Declaration on Standards and the Future of the Internet," ECIS (European Committee for Interoperable Systems, 2008), http://www.ecis.eu/news/documents/OpenForumEuropeDeclaration.pdf.

some other definitions consider standards to be open when they are available through FRAND licensing frameworks, for instance[274].

Standards facilitate economies of scale and reduce transaction costs. Open standards, however, go beyond enabling universal information exchange; they are also recognized for fostering a level playing field among competitors and stakeholders. Because of their governance model, they are considered as **a form of social technology or institutional framework, rather than merely a technical concept**, justifying their classification as a sub-component of Digital Commons[275]. Open standards are integral to the **success of the internet and contribute to its generative nature**—the ability to "produce unanticipated change through unfiltered contributions from broad and varied audiences"[276]. For these reasons, governments have increasingly incorporated interoperability and the promotion of open standards into their digital policy agendas.

2.1.2 Overview of policy trends

The political economy of the internet has undergone significant transformation since its emergence in the second half of the 20th century, marked by the platformization and centralization of the digital landscape[277]. At the turn of the 20th century, neoliberal policies have not only transformed the telecommunications sector through waves of privatization but also paved the way for the market-driven development of digital services on top of these infrastructures. This shift enabled **dominant platforms to exploit network effects, lock-in strategies, and data extraction to consolidate their power[278]**. Companies like Amazon, Microsoft, and Alphabet have leveraged vertical integration and centralized cloud architectures to dominate critical market segments, including AI. These trends have heightened concerns about bottlenecks in infrastructure and the risk of concentrated control over emerging technologies[279].

In response to these developments, but also as a result of the Snowden disclosures, the discourse surrounding internet governance has shifted, particularly with the **increasing assertion of state sovereignty in digital spaces**[280]. The concept of digital sovereignty, while interpreted differently across regions, reflects a broader effort to counterbalance the dominance of Big Tech and the most influential states like the U.S. and China. The European

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[274] Xiaoping Wu, "Interplay between Patents and Standards in the Information and Communication Technology (ICT) Sector and Its Relevance to the Implementation of the WTO Agreements" (World Trade Organization (WTO), 2017), https://www.wto.org/english/res_e/reser_e/ersd201708_e.pdf.

[275] Marco Berlinguer, "Digital Commons as New Infrastructure," Umanistica Digitale, no. 11 (2021), https://doi.org/10.6092/issn.2532-8816/13695.

[276] Jonathan Zittrain, The Future of the Internet (Penguin UK, 2009).

[277] 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.

[278] Thomas Poell, David Nieborg, and José van Dijck, "Platformisation," Internet Policy Review 8, no. 4 (November 29, 2019): 1–13, https://doi.org/10.14763/2019.4.1425.

[279] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

[280] Broeders, Dennis. The public core of the internet: An international agenda for internet governance. Amsterdam University Press, 2016.

Union, for example, has taken decisive steps to curb the power of large platforms through various regulations and tries to assert its influence in global internet standard-setting[281]. Standards, essential for enabling interoperability between the countless autonomous systems comprising the internet, have become **a critical arena for geopolitical and economic contestation**, raising concerns over the future of the open internet, the growing power of monopolistic companies but also state surveillance capacities and civil liberties[282].

A second important trend is the **progressive expansion of the field of interoperability**, evolving from a technical concept limited to foundational layers of the internet to a central issue in broader discussions on internet governance and platform regulation. Historically, interoperability facilitated universal information exchange at the protocol and infrastructural levels. However, its scope now extends to higher levels of the internet stack, particularly platforms and services. Over the past two decades, the EU has encountered significant challenges in **promoting interoperability across public administrations and within its member states**. The aim has been to enhance communication, streamline coordination, simplify processes, reduce costs, and establish a unified market for public administration services[283]. To address the complexity of this endeavor, the EU has categorized interoperability into four distinct types: syntactical, technical, semantic, and organizational[284].

Interoperability has also become a focal point in antitrust discussions, particularly as **a mechanism to address monopolistic practices and consumer lock-in strategies in digital markets**. In the telecommunications sector, interoperability has long been a regulatory requirement, enabling seamless communication across providers and allowing users to switch services without technical barriers. **Regulations have been essential drivers of interoperability** in the ICT sector in the past[285]. The US government's pressure on AT&T during the post-war period for instance forced the company to grant non-exclusive licenses for all Bell System patents, which became key foundations for the semiconductor industry. The US government also prevented the company from entering the computer industry, therefore preventing it from marketing Unix - the operating system that later became the foundation of OSS developments[286]. The European Union has introduced several regulations and initiatives to address the monopolistic dominance of Big Tech, focusing on interoperability and data-sharing requirements. The European Union's Digital Markets Act

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281 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.

282 Laura DeNardis and Francesca Musiani, "Governance by Infrastructure: Introduction," in The Turn to Infrastructure in Internet Governance, ed. Francesca Musiani et al. (New York, NY: Palgrave, 2016), https://doi.org/10.2139/ssrn.2730689.

283 Andrea Renda, Nadina Iacob, and Alexandra Campmas, "Study Supporting the Evaluation of the Implementation of the EIF," Publications Office of the EU (European Commission, Directorate-General for Digital Services, 2021), https://op.europa.eu/en/publication-detail/-/publication/29d694d4-4696-11ec-89db-01aa75ed71a1/language-en.

284 European Commission, "New European Interoperability Framework," Interoperable Europe Portal, 2017, https://ec.europa.eu/isa2/sites/default/files/eif_brochure_final.pdf.

285 Giovanna Massarotto, "Driving Innovation with Antitrust," ProMarket, April 10, 2024, https://www.promarket.org/2024/04/10/driving-innovation-with-antitrust/.

286 Cory Doctorow, "Unix and Adversarial Interoperability: The 'One Weird Antitrust Trick' That Defined Computing," Electronic Frontier Foundation, May 7, 2020, https://www.eff.org/deeplinks/2020/05/unix-and-adversarial-interoperability-one-weird-antitrust-trick-defined-computing.

(DMA) reflects this perspective by proposing mandatory interoperability for "gatekeeper" platforms, including app stores and secondary services. Likewise, the GDPR's data portability provisions aim to strengthen user control and facilitate competition in the digital ecosystem[287].

Private entities have historically utilized interoperability to their advantage: internally, they achieve seamless technological integration within their systems, while externally, they employ proprietary and selectively modifiable interoperability to maintain control and regulate third-party access to their platforms, usually through the management of APIs[288]. Similarly, in the public sector, there is an emerging trend of leveraging interoperability strategically not only to promote openness and competition but also to **generate new ecosystems and markets**[289]. Governments are increasingly investing in and participating in the governance of data-sharing infrastructures through **tripartite governance models that involve public institutions, private markets, and communities**[290]. Initiatives such as Gaia-X aim to establish standards for secure and trustworthy environments while fostering decentralized ecosystems of cloud service providers. Likewise, the European Open Science Cloud (EOSC) integrates public interest principles, such as open science, into these infrastructures, embedding societal values within the governance of digital ecosystems.

2.1.3 Policies supporting institutions working on open internet standards

This section examines European policies designed to support institutions working on open internet standards. It begins by exploring the evolution of multi-stakeholder governance in internet standard-setting and the growing influence of sovereignty concerns, which have prompted reforms in both international and European standardization frameworks. The section focuses on the EU's role in fostering open standards through its participation in global standard-setting bodies like the IETF and W3C, the development of regional initiatives to address geopolitical and economic challenges, and key legislative, research, and diplomatic strategies underpinning its approach.

As the question of legitimacy and representativeness of internet governance bodies became more prominent in the early 2000s, the concept of multistakeholder governance progressively gained traction. The 2003 United Nations World Summit on the Information Society (WSIS), which resulted in the Tunis Agenda for the Information Society in 2005, was critical in this regard. It defined **multi-stakeholderism in the context of internet governance** as “the development and application by governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures and

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[287] Alek Tarkowski et al., “Generative Interoperability: Building Public and Civic Spaces Online,” Open Future (NGI Forward, March 2022), https://openfuture.eu/wp-content/uploads/2022/03/InteroperabilityReport.pdf.

[288] Chinmayi Sharma, “Concentrated Digital Markets, Restrictive APIs, and the Fight for Internet Interoperability,” University of Memphis Law Review 50, no. 2 (2019), https://doi.org/10.2139/ssrn.3400980.

[289] Alek Tarkowski et al., “Generative Interoperability: Building Public and Civic Spaces Online,” Open Future (NGI Forward, March 2022), https://openfuture.eu/wp-content/uploads/2022/03/InteroperabilityReport.pdf.

[290] Marco Berlinguer, “The Matrix: Is There a European Way to Cloud Computing?,” Transform!Europe, May 5, 2024, https://transform-network.net/publication/the-matrix-is-there-a-european-way-to-cloud-computing/.

programs that shape the evolution and use of the Internet"[291]. This trend led to the creation of the United Nations Internet Governance Forum (IGF), but also the Global Knowledge Partnership or the NETMundial initiative. These initiatives advocated for **consensus-based decision-making and stronger inclusion in internet governance** initiatives, especially of civil society organizations or user communities[292]. Most of the open standards related to internet governance are managed in international organizations such as the IETF and the W3C, but also the Internet Architecture Board (IAB) or the Institute of Electrical and Electronics Engineers (IEEE), which are based on self-organizing technical communities. These organizations develop **open participatory processes, based on "transparency, due process and cooperation"**, according to a 2012 Joint Statement of Affirmation[293].

The multi-stakeholder governance model for the internet has, however, faced criticisms due to a lack of clear definitions and implementation inconsistencies. Some authors have argued that the façade of multistakeholderism often masks domination by traditional powers like the U.S., Europe, and China[294]. While calls for multi-stakeholder governance have driven some progress, such as the **stewardship transition of the Internet Corporation for Assigned Names and Numbers (ICANN)** managing the Domain Name System (DNS), trust in this model has been undermined by geopolitical tensions and revelations, such as Edward Snowden's disclosures of US surveillance practices. These issues have catalyzed a shift toward "digital sovereignty," focusing on national and regional control over digital infrastructures and governance mechanisms[295]. In recent years, governments have increasingly sought to reclaim their influence in standard-setting processes. China's ambitious approach to shaping standards in emerging technologies, outlined in its "China Standards 2035 program" released in 2018, has been a significant catalyst for shifting dynamics in the USA's and EU's engagement with China. This strategy has further heightened awareness and concern over the geopolitical implications of standard-setting in critical technological domains[296].

Sovereignty concerns have influenced European standardization by driving reforms to the governance of key European Standardization Organizations (ESOs), including the European Telecommunications Standards Institute (ETSI), the European Committee for Standardization (CEN), and the European Committee for Electrotechnical Standardization (CENELEC). A recent **amendment to Regulation 1025/2012 on European standardization** now requires that, to be eligible for standardization requests from the European Commission, ESOs must

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[291] International Telecommunications Union (ITU), "Tunis Agenda for the Information Society," ITU (WSIS, 2005), https://www.itu.int/net/wsis/docs2/tunis/off/6rev1.html.

[292] Alison Harcourt, George Christou, and Seamus Simpson, "Global Standard-Setting in Internet Governance," in Global Standard Setting in Internet Governance (Online ISBN: 9780191877001: Oxford University Press, 2020), 1–14, https://doi.org/10.1093/oso/9780198841524.003.0001.

[293] OpenStand, "About Open Stand and the Modern Paradigm for Standards," July 19, 2018, https://open-stand.org/about-us/.

[294] Jack Goldsmith and Tim Wu, Who Controls the Internet? (New York, NY: Oxford University Press, 2006).

[295] Broeders, Dennis. The public core of the internet: An international agenda for internet governance. Amsterdam University Press, 2016.

[296] John Seaman, "China and the New Geopolitics of Technical Standardization," Notes de L'Ifri (Paris: Institut français des relations internationales (Ifri), January 2020), https://www.ifri.org/sites/default/files/migrated_files/documents/atoms/files/seaman_china_standardization_2020.pdf.

ensure that **national standardization bodies from European countries retain decision-making authority** at every stage of standard development. This reform is intended to strengthen the influence of European actors within ESOs[297]. For Marco Berlinguer, however, strategies to influence internet standards increasingly need to incorporate **innovative forms of collaborations between public, private and community players**. Major technology companies have leveraged open standards and open source to influence specific software layers, establishing de facto standards that create ecosystems centered around their platforms and capitalize on competitive advantages in related markets. Conversely, some **communities and businesses have collaborated to establish shared standards, resulting in the emergence of a new type of standards-setting organization**. For Berlinguer, the Linux Foundation, which has become a leading force in managing industry-wide collaborative projects within the global technology sector, is a prime example of this trend. At the same time, modern standards development organizations (SDOs) such as the W3C and IETF, which focus on web technologies, have increasingly incorporated open source methodologies into their intellectual property frameworks and open standards procedures[298].

The EU has recognized standards as a vital tool for advancing its technological and industrial objectives. Since 2016, it has worked on developing a comprehensive standards strategy to enhance internal consistency while also seeking to shape international competition in emerging technologies[299]. Through legislative measures, research and innovation initiatives, and global partnerships, the EU has actively promoted open internet principles, striving to **balance its pursuit of digital sovereignty with a dedication to multi-stakeholderism and the adoption of open standards**. Clement Perarnaud, a researcher specializing in European policy initiatives on open internet standards, shows the tensions between these two objectives. He highlights the EU's active role in international standard-setting bodies such as the IETF and W3C, but his research also reveals that, through certain regulatory measures (discussed in the next section), the EU has sought to create new *de jure* standards that influence *de facto* standards typically developed by open internet standard-setting bodies. According to Perarnaud, the **EU's 2022 standardization strategy** represents a move toward the regionalization of technological standardization, with potential implications for internet infrastructures. He identifies the **DNS4EU Initiative**, part of the 2020 EU Cybersecurity Strategy for the Digital Decade, as a significant effort to establish secure and interoperable digital infrastructure. While this initiative aims to reduce reliance on non-European providers and uphold interoperability, it also opens avenues for state actors to intervene more directly in internet architecture[300].

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297 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.

298 Marco Berlinguer, "Digital Commons as New Infrastructure," Umanistica Digitale, no. 11 (2021), https://doi.org/10.6092/issn.2532-8816/13695.

299 European Commission, "ICT and Standardisation | Shaping Europe's Digital Future," digital-strategy.ec.europa.eu, October 23, 2024, https://digital-strategy.ec.europa.eu/en/policies/ict-and-standardisation.

300 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.

The EU has also engaged in diplomatic initiatives such as the **Declaration for the Future of the Internet,** reaffirming its commitment to an open, secure, and interoperable internet. Collaborative efforts like the **EU-US Trade and Technology Council (TTC)** and the **Global Gateway Initiative** reflect the EU's emphasis on multilateral partnerships. The TTC fosters dialogue on technology governance between Europe and the US, while the Global Gateway Initiative focuses on deploying specific internet standards through investments in digital infrastructure in developing countries. Additionally, Perarnaud highlights the EU's diplomatic activities within the International Telecommunication Union (ITU), aimed at countering China's growing influence through strategic influence campaigns. The EU has further supported interoperable technologies and open source solutions aligned with open internet principles through initiatives like Horizon Europe. For instance, projects under **StandICT.eu seek to bolster European representation in global standard-setting bodies**, addressing governance imbalances and enhancing technical expertise. Moreover, the EU has implemented mechanisms to monitor the deployment of standards, ensuring adherence to open principles and reinforcing accountability in advancing an open and equitable internet[301].

2.1.4 European Union policies promoting interoperability and data sharing

This section examines European policies designed to promote interoperability, open standards, and data sharing. It begins with a review of internal policies that focus on enhancing interoperability within public administrations and between European member states. These policies aim to streamline public services, improve cross-border collaboration, and foster innovation in public sector operations. The section then explores external policies that target interoperability and data sharing in the private sector. These measures address issues such as monopolistic practices, data portability, and fair access to markets.

The European Union has made significant efforts to promote interoperability among public administrations, emphasizing the development of cross-border digital solutions and open source technologies. These efforts began with the **IDABC program** in 2004, followed by the **ISA program** (2010-2015) and its successor **ISA² program** (2016-2020). The ISA program established a framework for EU member states to collaborate on efficient cross-border digital public services, on a budget of €160 million supporting over 40 actions in areas such as trusted information exchange and interoperability architecture. ISA² extended these objectives, focusing on interoperable solutions for public administrations, businesses, and citizens with a budget of €131 million, covering areas like telecommunications, big data, and e-procurement[302].

A cornerstone of the EU's strategy is the **European Interoperability Framework (EIF)**, initially launched in 2010 and updated in 2017. The EIF provides 47 recommendations for improving

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[301] 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.

[302] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

interoperability governance, aligning with EU policies like the eIDAS Regulation. It emphasizes the use of OSS to reduce costs and enhance reusability, advocating for a level playing field for OSS across member states through National Interoperability Frameworks[303]. The **Tallinn Declaration on eGovernment** (2017) further strengthened commitments to interoperability. Ministers from 32 European countries **highlighted the role of open standards and open source technologies in supporting critical infrastructure and empowering public administrations** to innovate and develop advanced eGovernment solutions[304]. The **Berlin Declaration** (2020) reinforced this agenda by promoting digital sovereignty, calling for **common standards, modular architectures, and open source technologies** to facilitate cross-border solutions[305].

The non-binding nature of the European Interoperability Framework (EIF), coupled with the complexity and costs associated with achieving syntactic, technical, semantic, and organizational interoperability, has led to mixed outcomes, as highlighted in evaluations[306]. These challenges prompted calls for stronger measures, resulting in the introduction of the **Interoperable Europe Act (IEA)** in 2024. The IEA **mandates interoperability assessments** to evaluate the impact of IT system choices on pan-European interoperability. However, the Act also needed to align with the principles of subsidiarity and proportionality and had to ensure that national and local administrations are not overburdened by new IT system standards and requirements. A key feature of the IEA is its multi-level governance framework, led by the **"Interoperable Europe Board",** which oversees implementation[307]. The Act also emphasizes data sharing and collaboration, supporting the establishment of a **Common European Public Sector Data Space**, aimed at fostering interoperability and innovation across public administrations[308].

The European Union has introduced several regulations and initiatives to address the monopolistic dominance of Big Tech, focusing on interoperability and data sharing

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303 Andrea Renda, Nadina Iacob, and Alexandra Campmas, "Study Supporting the Evaluation of the Implementation of the EIF," Publications Office of the EU (European Commission, Directorate-General for Digital Services, 2021), https://op.europa.eu/en/publication-detail/-/publication/29d694d4-4696-11ec-89db-01aa75ed71a1/language-en.

304 European Commission, "Ministerial Declaration on EGovernment - the Tallinn Declaration," digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, 2017), https://digital-strategy.ec.europa.eu/en/news/ministerial-declaration-egovernment-tallinn-declaration.

305 European Commission, "Berlin Declaration on Digital Society and Value-Based Digital Government" digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, 2020), https://digital-strategy.ec.europa.eu/en/news/berlin-declaration-digital-society-and-value-based-digital-government.

306 Andrea Renda, Nadina Iacob, and Alexandra Campmas, "Study Supporting the Evaluation of the Implementation of the EIF," Publications Office of the EU (European Commission, Directorate-General for Digital Services, 2021), https://op.europa.eu/en/publication-detail/-/publication/29d694d4-4696-11ec-89db-01aa75ed71a1/language-en.

307 Council of the EU, "Interoperable Europe Act: Council Adopts New Law for More Efficient Digital Public Services across the EU," General Secretariat of the Council of the European Union, April 2024, https://www.consilium.europa.eu/en/press/press-releases/2024/03/04/interoperable-europe-act-council-adopts-new-law-for-more-efficient-digital-public-services-across-the-eu/.

308 European Commission, "The Interoperable Europe Act: Implications and Impact on EU's Digital Future," data.europa.eu (Publications Office of the European Union, April 15, 2024), https://data.europa.eu/en/news-events/news/interoperable-europe-act-implications-and-impact-eus-digital-future.

requirements. For instance, these rules mandate interoperability between widely used messaging services like Meta's Messenger and WhatsApp. The **Digital Markets Act (DMA)**, aims to safeguard users' rights and create fairer competition among businesses, acknowledging the critical role of digital platforms in providing essential services. The DMA targets "gatekeepers"—large platforms with significant market influence that act as bottlenecks for key digital services and applies to eight core platform services, including search engines, social networks, communications platforms, and cloud services. It establishes obligations for gatekeepers, such as **enabling third-party interoperability with their services**, **providing business users access to the data they generate**, allowing independent verification of advertising, and permitting businesses to promote and sell products outside the gatekeeper's ecosystem. Prohibited practices include blocking users from uninstalling pre-installed software and favoring the gatekeeper's own products in rankings[309].

Several policy initiatives of the European Union have been established to support data sharing, beyond the opening of public sector information initiated by the PSI directive. The **EU's Open Data Directive** for instance **mandates the sharing of specific "high-value datasets"** particularly in areas such as transport, environment, and health[310]. Other mandatory approaches include **portability obligations**: data portability obligations for personal data were already established by **GDPR's Article 20[311]**. The **Data Governance Act (DGA)** aims to increase data availability by clarifying users' ownership of data generated through products and services. A key innovation of the DGA is the creation of **European data spaces** in strategic sectors, such as health, public administration, energy, and manufacturing, to develop federated "sovereign data ecosystems" supported by shared cloud, AI, and data infrastructures (see next section). The DGA also seeks to regulate **data intermediaries** as trusted facilitators of data sharing and markets. Additionally, it promotes **data altruism** by encouraging voluntary data sharing and trust in data governance[312].

The **Data Act** complements the DGA by addressing underutilization of data through new user rights for accessing and sharing data from connected devices, with specific provisions for the Internet of Things (IoT) and cloud services. The Data Act aims to enable users to select service providers, with the objective of increasing competition in economic sectors, such as repair and maintenance. It includes rules to facilitate data portability, reduce switching costs for cloud providers, and introduce **binding obligations for Infrastructure-as-a-Service (IaaS)**

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309 European Commission, "The Digital Markets Act: Ensuring Fair and Open Digital Markets," commission.europa.eu (Directorate-General for Communication, 2022), https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en.

310 European Commission, "Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on Open Data and the Re-Use of Public Sector Information," eur-lex.europa.eu (Official Journal of the European Union, 2019), http://data.europa.eu/eli/dir/2019/1024/oj.

311 European Commission, "Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC (General Data Protection Regulation)," eur-lex.europa.eu (Official Journal of the European Union, 2016), http://data.europa.eu/eli/reg/2016/679/2016-05-04.

312 European Commission, "Data Governance Act Explained | Shaping Europe's Digital Future," digital-strategy.ec.europa.eu (European Commission), accessed November 6, 2024, https://digital-strategy.ec.europa.eu/en/policies/data-governance-act-explained.

providers to enable portability of raw data and applications. The Act also aims to prevent contractual abuses through model clauses and supports public sector access to private sector data for public interest purposes in emergency scenarios[313].

2.1.5 Public investments in data sharing infrastructure

This section examines the increasing emphasis on investment in data sharing infrastructure across various sectors. This trend reflects a shift in policy from simply advocating for open access to resources toward developing infrastructures and the institutions that govern them. Notable examples of this shift include **Europeana**, which enhances access to cultural heritage, and the **European Open Science Cloud**, which advances data-sharing in science and knowledge domains. Such an approach aligns with a strategic understanding of power relations and the political economy of digital infrastructures. By leveraging infrastructure, interoperability, and standards, governments can **embed public interest values into these systems and build ecosystems that serve societal needs**. Such data infrastructures are increasingly considered to be a fundamental component of addressing societal and ecological challenges[314].

The European Commission has started to support **Common European Data Spaces** as part of the Data Governance Act and through funding from the Digital Europe program. The act encourages a model of "data altruism", in which individuals and organizations voluntarily share data for societal benefit and establishes regulations for data intermediaries—trusted entities that facilitate data sharing among private and public sectors while ensuring data security and neutrality[315]. The European Commission is currently facilitating the rollout of 14 Common European Data Spaces in critical sectors, including mobility, agriculture, energy, and healthcare. These data spaces are designed around a **decentralized model with adaptable governance structures**, incorporating standardized technical and operational protocols while allowing for sectoral customization. The European Data Innovation Board, which is being gradually established, plays a supporting role in overseeing the implementation of these spaces and in defining interoperability standards[316]. The **"Simpl"** project was initiated in 2023 to provide "**an open source, smart and secure middleware platform that supports data access and interoperability** among European data spaces". Simpl is a prototype that aims to connect data spaces with a technical tool to share data based on self-determination and sovereignty, confidentiality, transparency, security, and fair competition[317].

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[313] European Commission, "Data Act Explained" digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, 2024), https://digital-strategy.ec.europa.eu/en/factpages/data-act-explained.

[314] Laura Létourneau, "Plaidoyer Pour Les Grandes Oubliées - Les Infrastructures Publiques de Partage de Données" (Digital New Deal, Terra Nova, September 11, 2024), https://www.thedigitalnewdeal.org/en/plaidoyer-pour-les-grandes-oubliees-les-infrastructures-publiques-de-partage-de-donnees/.

[315] European Commission, "Data Governance Act Explained | Shaping Europe's Digital Future," digital-strategy.ec.europa.eu (European Commission), accessed November 6, 2024, https://digital-strategy.ec.europa.eu/en/policies/data-governance-act-explained.

[316] European Commission, "Commission Staff Working Document on Common European Data Spaces," Https://Digital-Strategy.ec.europa.eu (Brussels: European Commission, January 24, 2024), https://digital-strategy.ec.europa.eu/en/library/second-staff-working-document-data-spaces.

[317] European Commission, "Simpl: Cloud-To-Edge Federations Empowering EU Data Spaces," Shaping Europe's digital future (Directorate-General for Communications Networks, Content and Technology, 2024), https://digital-strategy.ec.europa.eu/en/policies/simpl.

Several European initiatives demonstrate how leveraging infrastructure, governance, and interoperability rules can effectively achieve public goals. **Europeana**, launched by the European Commission in 2008, can be considered as an early prototype for Common European Data Spaces. It provides access to over 58 million digitized cultural heritage records from over 3600 cultural heritage institutions and organizations, based mostly on public domain works made available by these organisations as part of Open GLAM policy. It is currently funded under the Connecting Europe Facility[318]. The success story of Europeana highlights the value of operating data spaces as commons, based on decentralized stewardship, inclusive governance and with a focus on public benefits as opposed to particular interests[319].

Other notable examples include the **Nordic Institute for Interoperability Solutions (NIIS)**, a cross-border initiative established in 2017 by Estonia and Finland, later joined by Island. Operating as both a collaboration platform and an IT development body, NIIS promotes practical governance and operating models for and cooperation and innovation among its members[320]. NIIS operates as a non-profit association funded entirely by public contributions from its member countries. NIIS serves as the central coordinator for **X-Road, a decentralized data-exchange layer that ensures secure and standardized data transfer between organizations**. It operates as an open source solution under the MIT license, allowing free access for individuals and organizations globally. Initially developed in Estonia two decades ago, X-Road has grown into a widely adopted international solution, with deployments in over 20 countries. A key feature of X-Road is federation, enabling interoperability between ecosystems in different countries. NIIS serves as the central coordinator for X-Road, managing software development, documentation, and collaboration among members and the global community[321].

Similarly, the **European Open Science Cloud (EOSC)**, initiated in 2015, aims to foster open science through a federated infrastructure for research services. With €250 million invested in its initial phase, EOSC is steered by tripartite governance involving the European Commission, participating countries, and the research community, ensuring alignment with public interest goals[322]. This multi-stakeholder framework includes contributions from diverse research organizations such as CERN. The EOSC is primarily funded by EU project-based grants requiring consortium applications, with additional support from national and public funds directed towards digitization and cybersecurity initiatives. The EOSC is designed

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[318] European Commission, "Europeana | Shaping Europe's Digital Future," digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, 2024), https://digital-strategy.ec.europa.eu/en/policies/europeana.

[319] Paul Keller, "Five Things I Know about Data Spaces," Open Future, 2021, https://openfuture.eu/blog/five-things-i-know-about-data-spaces/.

[320] Report of the European Working Team on Digital Commons, "Towards a Sovereign Digital Infrastructure of Commons," Diplomatie.gouv (Ministère de l'Europe et des Affaires étrangères , June 2022), https://www.diplomatie.gouv.fr/IMG/pdf/report_of_the_european_working_team_on_digital_commons_digital_assembly_june_2022_wnetherlands_cle843dbf.pdf.

[321] Giulia Guadagnoli, "Open Source in International Cooperation - a Conversation with Petteri Kivimäki on X-Road.," Interoperable Europe Portal, August 9, 2021, https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/open-source-international-cooperation.

[322] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

as a federated, multi-disciplinary platform enabling European researchers, innovators, companies, and citizens to publish, discover, and reuse data, tools, and services across research, innovation, and education[323].

On a national level, **Finland** provides examples of data sharing ecosystems in logistics. Projects such as Fintraffic's traffic data ecosystem and the Ministry of Transport and Communications' digitization strategy enhance data flows and logistics efficiency. These efforts are coordinated through open associations like CaaS Nordic ry, emphasizing collaboration among companies and authorities[324].

2.2 Policies Mobilizing Digital Commons for Industrial Strategies and Economic Development

Policies increasingly recognize Digital Commons, particularly OSS, as critical components of modern infrastructure and industrial strategies. Section 2.2 reviews policies that mobilize this mode of production to stimulate and steer economic development. Successful examples include South Korea and China, which have supported domestic industries by investing in OSS. The EU is adopting similar strategies in areas like semiconductor design, cloud computing, artificial intelligence, and sustainable mobility, with initiatives such as RISC-V and Gaia-X. Private companies leverage Digital Commons to crowdsource innovation, set industry standards, and consolidate control. Similarly, governments focus on the interoperability and scalability of Digital Public Infrastructure (DPI) and Digital Public Goods (DPGs), collaborating with external stakeholders while maintaining control over norms and standards.

2.2.1 Definitions

Digital Commons, especially OSS, have become indispensable to contemporary economies and societies, acting as **critical infrastructures that enable innovation and economic development**. Far from being a niche practice, OSS underpins much of the technology that powers our modern world. According to the 2023 OSSRA report, **96% of commercial code incorporates OSS, and 76% of all code is open source**[325]. Platforms like GitHub, which hosts over 100 million developers globally, demonstrate the scale of the OSS community and its integration into the operations of all major tech companies[326].

Efforts to quantify the economic impact of Digital Commons reveal their significant contributions. A European Union study estimates that **OSS adds between €65–€95 billion to**

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[323] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

[324] Report of the European Working Team on Digital Commons, "Towards a Sovereign Digital Infrastructure of Commons," Diplomatie.gouv (Ministère de l'Europe et des Affaires étrangères , June 2022), https://www.diplomatie.gouv.fr/IMG/pdf/report_of_the_european_working_team_on_digital_commons_digital_assembly_june_2022_wnetherlands_cle843dbf.pdf.

[325] Synopsys, "2023 Open Source Security and Risk Analysis Report (OSSRA)" (Sunnyvale, CA: Synopsys, Inc., February 2023).

[326] Thomas Dohmke, "100 Million Developers and Counting," The GitHub Blog, January 25, 2023, https://github.blog/news-insights/company-news/100-million-developers-and-counting/.

the EU's GDP—an economic value comparable to the combined contributions of the air and water transport sectors. Furthermore, it predicts that a 10% increase in OSS contributions within the EU could generate an additional €100 billion, or 0.4%–0.6% GDP growth[327]. On a global scale, research led by Frank Nagle at Harvard estimates OSS's demand-side value—representing the market's willingness to pay for it—at $8.8 trillion, and its supply-side value—reflecting the labor costs of its development—at $4.15 billion[328]. Beyond software, Digital Commons like Wikimedia have also shown significant economic worth; one study estimated consumer benefits in the hundreds of billions of dollars[329], while another valued Wikimedia Commons' images alone at $28.9 billion[330]. These numbers highlight the **immense value of managing technological foundations as commons**. Frank Nagle's research for instance indicates that firms would need to spend 3.5 times more on software than they currently do if OSS were unavailable[331]. Technological legacies and modern technology ecosystems have become so complex that their maintenance and development by single competing entities under proprietary conditions would not only be economically irrational but also impractical.

The inherent value of Digital Commons, however, remains challenging to measure. This challenge can be traced to the characteristics many of them share with **public goods, marked by non-rivalry and non-excludability.** As defined by economist Paul Samuelson in 1954, public goods are those that can be consumed by one person without reducing their availability to others and are difficult or costly to exclude others from accessing[332]. Public goods create positive externalities, their benefits extend to those who do not directly contribute to the creation or maintenance of the goods, often leading to significant societal benefits difficult to measure. This nature also aligns with the historical **notion of infrastructure or "social overhead capital,"** a term used in the early 20th century to describe shared resources that provide benefits beyond individual enterprises, or so-called **"spillover effects"[333]**. Just as electricity grids or transportation networks serve as **generative inputs for diverse activities**, Digital Commons like OSS create foundational layers for countless

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327 Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

328 Manuel Hoffmann, Frank Nagle, and Yanuo Zhou, "The Value of Open Source Software," Harvard Business School Working Paper, no. 24-038 (January 2024), https://doi.org/10.2139/ssrn.4693148.

329 Jonathan Band and Jonathan Gerafi, "Wikipedia's Economic Value," SSRN Electronic Journal, 2013, https://doi.org/10.2139/ssrn.2338563.

330 Kenneth L Erickson, Felix Rodriguez Perez, and Jesus Rodriguez Perez, "What Is the Commons Worth? Estimating the Value of Wikimedia Imagery by Observing Downstream Use.," in Proceedings of the 14th International Symposium on Open Collaboration (OpenSym '18: The 14th International Symposium on Open Collaboration, ACM (Association for Computing Machinery), 2018), https://doi.org/10.1145/3233391.3233533.

331 Manuel Hoffmann, Frank Nagle, and Yanuo Zhou, "The Value of Open Source Software," Harvard Business School Working Paper, no. 24-038 (January 2024), https://doi.org/10.2139/ssrn.4693148.

332 Paul A Samuelson, "The Pure Theory of Public Expenditure," The Review of Economics and Statistics 36, no. 4 (1954): 387–89, https://doi.org/10.2307/1925895.

333 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.

applications. **Infrastructures are "shared means to many ends"**: their uses are wide-ranging and often difficult to quantify—just as a road may facilitate the transportation of goods or provide access to health care[334]. This diversity also makes the true economic value of Digital Commons challenging to capture in numerical terms.

Finally, Digital Commons should be analyzed as an alternative mode of production, building on the work of Yochai Benkler. While this mode of production, based on voluntary peer collaboration, is intrinsically different from production within organizations or within markets, which are using subordination and price signals to coordinate their activities[335], most tech companies have learned to use it in parallel to internal modes of production or market mechanisms. Tech companies are indeed using **open source to crowdsource innovation**. Such a model can **outperform proprietary approaches**: a leaked Google document from May 2023 highlighted how open source contributors have significantly advanced large language model development, achieving levels of testing, integration, and expansion that private efforts alone could not match[336]. Tech companies also use Digital Commons to **collaborate on software components with competitors, co-producing large-scale "industrial public goods"**[337] that have been compared to the logic behind patent pools[338].

Big tech companies strategically mobilize Digital Commons to **establish control by setting standards, building the infrastructures their commercial activities rely on, and creating ecosystems that can reshape markets**. For instance, Google leverages open technologies like Android and Chromium to reinforce its dominance. Although Android's core is open source, Google maintains control over key proprietary elements, such as the Play Store. Similarly, Chromium, the foundation of Google Chrome, allows Google to influence browser development and web standards[339]. Tesla's release of over 300 patents in 2014 illustrates another approach to using Digital Commons. By freely offering these patents to the automotive industry, Tesla facilitated the development of electrified vehicles, not primarily for co-innovation but to set industry standards and build an ecosystem that aligns with its strategic goals[340]. These examples demonstrate how Digital Commons are utilized not only as collaborative tools but also as **mechanisms for industrial strategies and sources of power.**

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

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

[336] Rebecca Ackermann, "The Future of Open Source Is Still Very Much in Flux," MIT Technology Review, August 17, 2023, https://www.technologyreview.com/2023/08/17/1077498/future-open-source/.

[337] Mathieu O'Neil et al., "Co-Producing Industrial Public Goods on GitHub: Selective Firm Cooperation, Volunteer-Employee Labour and Participation Inequality," New Media & Society, April 27, 2022, 146144482210904, https://doi.org/10.1177/14614448221090474

[338] Thierry Rayna and Ludmila Striukova, "Large-Scale Open Innovation: Open Source vs. Patent Pools," International Journal of Technology Management 52, no. 3 & 4 (2010), https://ssrn.com/abstract=1712289.

[339] Malcolm Bain, "Google Chrome and Android: Legal Aspects of Open Source Software," in Google and the Law Empirical Approaches to Legal Aspects of Knowledge-Economy Business Models, ed. Aurelio Lopez-Tarruella, vol. 22 (The Hague: T.M.C. Asser Press, 2012), 259–86, https://doi.org/10.1007/978-90-6704-846-0_9.

[340] James Bessen, "History Backs up Tesla's Patent Sharing," Harvard Business Review, June 13, 2014, https://hbr.org/2014/06/history-backs-up-teslas-patent-sharing.

2.2.2 Overview of policy trends

The strategic mobilization of Digital Commons is now well-established in the private sector, where openness and interoperability are used to drive innovation and market control. Internally, firms achieve seamless technological integration within their systems, while externally, they selectively enable interoperability—typically through APIs—to regulate third-party access, maintain platform dominance, and shape markets. Additionally, businesses leverage commons-based peer production to crowdsource innovation, collaborate on shared industrial goods, and strategically expand or disrupt markets. Similarly, in the public sector, Digital Commons are increasingly being used not only to **promote openness and competition but also to catalyze the creation of new ecosystems and markets**.

Over the past decade, Europe has broadened its OSS policies, moving beyond goals like cost efficiency and public sector modernization to include priorities like transparency, innovation, and digital sovereignty. This shift mirrors earlier trends in regions such as Asia, where Digital Commons are integrated into industrial strategies to strengthen local ICT industries and enhance technological independence. According to a 2024 European Commission study, this evolution is reflected in national policies that now encompass models involving public institutions, private markets, and Digital Commons[341]. This shift parallels what some have called a resurgence of industrial policy, defined as "deliberate attempts to shape sectors of the economy to meet public aims", in response to geopolitical shifts and the fragility of global value chains[342].

This section will review three different trends. The first is that Digital Commons are **increasingly embedded in industrial policies as tools for technological and economic catch-up**. Digital Commons play a critical role in these efforts by supporting research and innovation, building technological foundations, and enhancing skills in domestic industries. In Europe, such strategies are visible in initiatives focused on chips, cloud computing, and AI, where open and collaborative approaches are seen as essential to maintain competitiveness and independence.

Second, governments are increasingly leveraging Digital Commons to establish and manage key infrastructures that underpin digital transformation. The global push for **"Digital Public Infrastructure" (DPI)** emphasizes that systems for data exchange, digital identity, and payment are fundamental to modernizing economies. Public investment in these foundational infrastructures enables the development of open APIs that can be used by both public and private actors to create digital services. These initiatives aim not only to

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[341] Axel Thévenet et al., "Progress and Trends in the National Open Source Policies and Legal Frameworks," Interoperable Europe Initiative (Brussels: European Commission, February 2024), https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/new-publication-progress-and-trends-oss-policies.

[342] Amy Kapczynski and Joel Michaels, "Administering a Democratic Industrial Policy," Harvard Law & Policy Review, Forthcoming Yale Law School, Public Law Research Paper Yale Law & Economics Research Paper (Available at ssrn.com, January 30, 2024), https://ssrn.com/abstract=4711216.

accelerate digital transformation but also to ensure public oversight and control over critical digital ecosystems[343].

Finally, Digital Commons are also playing an increasing role in international cooperation efforts aimed to achieve the SDGs. Multi-stakeholder alliances, such as the UN-endorsed **Digital Public Goods Alliance**, extend the role of international collaboration from establishing norms and standards to **supporting the deployment of Digital Commons for software, data or AI models**[344]. Such alliances rely on the idea that Digital Commons can represent opportunities for renewed forms of global collaboration, as they represent "the least expensive and most effective solutions for technology and knowledge transfer to developing nations"[345]. At the same time, international cooperation policies are also part of strategies to support domestic solutions to become part of international standards, allowing to excerpt influence and export technical services.

2.2.3 National investments in strategic resources for domestic industries

This section examines the role of Digital Commons in industrial policies aimed at fostering technological and economic catch-up. Given the longer experience of countries like China and South Korea in integrating Digital Commons into their strategies, the analysis begins with a review of their policies. The section will then provide examples from recent European industrial policies targeting critical sectors such as semiconductors, cloud computing and AI, as well as the mobility industry.

2.2.3.1 Examples of industrial policies leveraging Digital Commons in Asia

China has integrated OSS into its industrial policies as **a strategic tool to enhance domestic innovation and reduce reliance on foreign technologies**. This approach has been explicitly outlined in the country's last two Five-Year Plans (2016 and 2021), which direct government agencies to actively promote OSS communities. The Ministry of Industry and Information Technology (MIIT) plays a central role, providing financial support for initiatives such as Gitee, a domestic OSS platform designed to complement global counterparts like GitHub. Since its creation in 2013, Gitee has become a key component of China's OSS ecosystem, reporting over 12 million users. These efforts are complemented by restrictions on global OSS contributions and prioritization of domestically beneficial features, often documented primarily in Chinese, to strengthen local firms and shield the country from geopolitical risks[346].

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[343] 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-publicinfrastructure/.

[344] Digital Public Goods Alliance (DPGA), "Governance - Digital Public Goods Alliance," Digital Public Goods Alliance - Promoting digital public goods to create a more equitable world, November 25, 2021, https://www.digitalpublicgoods.net/governance.

[345] Jamil Alkhatib, Mohab Anis, and Hamid Noori, "Open Source: The next Big Thing in Technology Transfer to Developing Nations," in IAMOT 2008 Proceedings (International Association for Management of Technology, 2008), https://www.researchgate.net/publication/251735575_OPEN_SOURCE_THE_NEXT_BIG_THING_IN_TECHNOLOGY_TRANSFER_TO_DEVELOPING_NATIONS.

[346] Jeff Gortmaker, "Open Source Software Policy in Industry Equilibrium," Jeff Gortmaker, November 13, 2024, https://jeffgortmaker.com/files/Open_Source_Software_Policy_in_Industry_Equilibrium.pdf.

China has **integrated open source in its education and training strategies** early on. In 2005, the Chinese government facilitated the establishment of the Leadership of Open Source University Promotion Alliance (LUPA), initially comprising 70 member universities. This initiative has since expanded, leading to over 300 universities and schools offering courses on open source technologies. That same year, the Guangdong Linux Centre, in collaboration with 27 universities, launched the Guangdong Leadership of Open Source University Promotion Alliance. Government-led initiatives, such as the Red Flag Linux project, also sought to **replace proprietary systems** like Microsoft Windows, reflecting the dual objectives of fostering local innovation and achieving technological independence. As part of this strategy, it became mandatory for new computers to include an operating system, with a preference for software developed in China being actively promoted. However, like many other government-initiated Linux distributions, Red Flag Linux was eventually discontinued, despite being mandated for use in all government agencies by 2010[347].

More recently, Chinese companies, including Huawei with its HarmonyOS, a closed operating system based on the Android Open Source Project (AOSP), have adopted **OSS strategies to counter U.S. export controls**. The OpenAtom Foundation, established jointly in 2020 by several Chinese tech companies like Alibaba, Baidu, Huawei aims to position China as a leader in the global open source ecosystem[348]. China has also recognized the strategic **importance of Open Source Hardware (OSH), particularly in the semiconductor sector.** Anticipating potential restrictions on access to chips, the Chinese government established the "China RISC-V Alliance", which seeks to promote the development and adoption of the RISC-V open source architecture as an alternative to Western-controlled closed standards like x86 and ARM. As a result, Chinese firms have started to produce special-purpose chips based on the RISC-V architecture[349]. Programs like "One Student One Chip" foster local skills and mobilize open source principles to reduce the costs of chip design[350].

South Korea has also strategically mobilized **open source technologies across the public sector, education, international collaboration, and industry to support technological independence and innovation**. Early efforts included guidelines for OSS adoption in public procurement and public administration, even with financial incentives for migration to open operating systems, though these initiatives achieved limited success. In education, centers of excellence, such as the Linux Hub Centre at Seoul National University, have advanced open source skills and knowledge. Internationally, South Korea has collaborated on open source initiatives, including a multi-million dollar agreement with Japan and China in the early 2000s

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[347] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

[348] Wikipedia Contributors, "OpenAtom Foundation," Wikipedia (Wikimedia Foundation, July 19, 2024), https://en.wikipedia.org/wiki/OpenAtom_Foundation.

[349] Rebecca Arcesati and Caroline Meinhardt, "China Bets on Open-Source Technologies to Boost Domestic Innovation" merics.org (Mercator Institute for China Studies (MERICS), May 19, 2021), https://merics.org/en/report/china-bets-open-source-technologies-boost-domestic-innovation.

[350] Kezia Leung, "RISC-V Expanding in China," Riscv.org (RISC-V International, August 14, 2023), https://riscv.org/blog/2023/08/risc-v-expanding-in-china/.

to develop Linux-based products for the Asian market and a partnership with Brazil's National Information Technology Institute (ITI) to exchange OSS expertise. In the industrial sector, initiatives like the Open Source Software Competence Plaza (OSSCP), with a $12 million annual budget, provide comprehensive support for businesses adopting OSS. Additionally, the Korea Copyright Commission allocates $3 million annually to promote OSS license compliance and governance. Currently, South Korea's national strategy focuses on **building a secure technology stack aligned with Fourth Industrial Revolution standards while minimizing reliance on foreign-controlled components**. This includes addressing potential security risks in open source systems through studies initiated by the Ministry of Interior and Safety[351].

2.2.3.2 European policies to promote open source hardware technologies in the semiconductor industry

The semiconductor industry lies at the intersection of digital sovereignty, supply chain security, and economic competitiveness. Chips, as critical components of modern digital infrastructure, are pivotal to technological independence, particularly in fields like AI and high-performance computing. These concerns have spurred initiatives like the European Chips Act[352].

Open source hardware represents a major advantage in this context. As noted in the staff working document accompanying the European Chips Act: "open source tools are essential for introducing new companies and more developers into the field"[353]. Additionally, open source allows for greater transparency and verification of designs, mitigating risks related to hidden vulnerabilities[354]. **Europe already benefits from expertise in open source Electronic Design Automation (EDA) tools**, as many prominent initiatives in the field, such as "Coriolis, Edalize, FuseSoC, GHDL, Klayout, Litex, NextPNR", are "created and developed primarily by Europeans". The open source processor design community saw significant growth in 2015, fueled by opportunities from the RISC-V open standard. Since then, many designs have been adopted in research and commercial products. RISC-V's open source nature allows Europe to reduce dependency on foreign proprietary architectures such as ARM and x86[355].

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[351] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

[352] Shawn Donnelly, "Semiconductor and ICT Industrial Policy in the US and EU: Geopolitical Threat Responses," Politics and Governance 11, no. 4 (November 8, 2023), https://doi.org/10.17645/pag.v11i4.7031.

[353] European Commission, "Commission Staff Working Document a Chips Act for Europe - SWD(2022) 147 Final PART 1/4," Digital-Strategy.ec.europa.eu (Brussels: Directorate-General for Communications Networks, Content and Technology, May 11, 2022), https://digital-strategy.ec.europa.eu/en/library/european-chips-act-staff-working-document.

[354] Joshua Pearce, "How Open Source Hardware Increases Security," Opensource.com, 2018, https://opensource.com/article/18/10/cybersecurity-demands-rapid-switch-open-source-hardware.

[355] FOSSI Foundation, "Roadmap and Recommendations for Open Source EDA in Europe," Fossi-foundation.org, 2024, https://fossi-foundation.org/resources/eu-roadmap.

The EU has strongly supported RISC-V development through initiatives like the European Processor Initiative (EPI) and the EuroHPC Joint Undertaking. Since 2018, these programs have advanced open source EDA tools, with **EuroHPC allocating €270 million in 2022 for high-performance RISC-V processors and accelerators**[356]. Current EU projects supporting RISC-V are the "Codasip High-end processor IP and high-level design tools for RISC-V" project funded under the European Innovation Council (EIC)[357], TRISTAN (Together for RISc-V Technology and ApplicatioNs), a Digital, Industry and Space program co-funded by the French government through BPI France as part of its "France 2030"[358] or the "High Performance, Safe, Secure, Open Source Leveraged RISC-V Domain-Specific Ecosystems" (ISOLDE) project funded under Horizon Europe[359].

Additionally, European countries have launched national programs to support open source in the semiconductor industry. One example is **Germany's „Design Instruments for Sovereign Chip Development with Open Source (DE:Sign)"** program. The program supports open source EDA tools, IP libraries, and innovative chip designs. Since May 2024, 15 selected De:Sign Initiative R&D projects have been running, with a total amount of grants of 29,6 million euros[360].

2.2.3.3 European policies to promote open source for cloud computing and AI development

The EU and its member states have increasingly integrated Digital Commons into their industrial policies to reduce reliance on foreign-controlled cloud providers and proprietary AI technologies. These efforts aim to strengthen digital sovereignty, foster innovation, and address risks such as economic dependency and data security vulnerabilities. Key initiatives include Gaia-X, the Important Project of Common European Interest (IPCEI) on Cloud Infrastructure and Services, and targeted investments in open source AI resources like scikit-learn.

Gaia-X, launched in 2020 by Germany and France, seeks to **create a federated and transparent cloud ecosystem governed by European values**. Its goal is to address Europe's dependence on non-European hyperscalers, which dominate the market and pose risks related to surveillance and data sovereignty. While the project has shifted toward providing voluntary certification frameworks for cloud services, it remains a foundational effort in

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[356] Mark Mantel, "270 Millionen Euro Für CPUs Und Beschleuniger: EuroHPC Fördert RISC-V-Technik," Heise Online, December 21, 2022, https://heise.de/-7434898.

[357] European Commission, "Codasip High-End Processor IP and High-Level Design Tools for RISC-V," CORDIS - EU Research results (Publications Office of the European Union, November 10, 2022), https://cordis.europa.eu/project/id/190101116/results.

[358] European Commission, "Together for RISc-V Technology and ApplicatioNs," CORDIS - EU Research results (Publications Office of the European Union, December 2, 2022), https://cordis.europa.eu/project/id/101095947/reporting.

[359] European Commission, "High Performance, Safe, Secure, Open-Source Leveraged RISC-V Domain-Specific Ecosystems (ISOLDE)," EU Funding & Tenders Portal (Directorate-General for Research and Innovation), accessed December 5, 2024, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999723323/project/101112274/program/43108390/details.

[360] Tina Tauchnitz and Korbinian Schreiber, "German Microelectronics Design Initiative," Free Silicon Foundation (F-Si) (Free Silicon Conference | Paris | 19-21 June 2024: Federal Ministry of Education and Research (BMBF), 2024), https://wiki.f-si.org/images/9/9f/German_Microelectronics_Design_Initiative_FSiC_2024_r1.pdf.

Europe's pursuit of cloud infrastructure independence[361]. Initially envisioned as a cornerstone for European digital autonomy, Gaia-X has faced challenges. Divergent member objectives diluted its focus, and its governance structure limited its ability to enforce standards[362]. The **IPCEI on Cloud Infrastructure and Services** complements Gaia-X by focusing on the development of open source middleware and a unified reference architecture. Funded with **€1.2 billion in public investment**, matched by €1.4 billion from private stakeholders, the initiative has been considered **the "largest open source project in EU history"**. IPCEI emphasizes scalable and interoperable solutions that use permissive licenses to maximize spillover benefits[363].

In AI development, the EU has supported open source initiatives to ensure accessibility and innovation, notably through the already mentioned European High-Performance Computing Joint Undertaking (Euro HPC), which provided funding for research and innovation in open chip designs. The **ALT (Alliance for Language Technologies) European DIgital Infrastructure Consortium (EDIC)**, established in February 2024, is another example that focuses on supporting multilingual and multimodal Large Language Models (LLMs). The initiative pools open language datasets from across the EU, including resources for underrepresented languages with fewer than 10 million speakers. The ALT-EDIC pools public and private funding to support the development of open source language models and provides tools for fine-tuning them, especially for SMEs[364]. A notable national example is **France's €32 million grant for scikit-learn, an open source Python library for machine learning**. Developed at the French Institute for Research in Computer Science and Automation (Inria), scikit-learn is widely used in research and industry, earning its reputation as a "Swiss army knife" of machine learning[365].

2.2.3.4 European policies to promote Digital Commons for mobility

Amid global challenges, value chain tensions, the need for innovation, and the transition to green transportation, the need for the European automotive industry to embrace large-scale collaboration on open technologies, to ensure its transition to software-defined vehicles, maintain sovereignty over critical components, and enhance its competitiveness has been

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[361] Marco Berlinguer, "The Matrix: Is There a European Way to Cloud Computing?," Transform!Europe, May 5, 2024, https://transform-network.net/publication/the-matrix-is-there-a-european-way-to-cloud-computing/.

[362] Interview by Mark Scott, with Francesco Bonfiglio, "Why Europe's Cloud Ambitions Have Failed," AI Now Institute (Part of: Europe's AI Industrial Policy, October 15, 2024), https://ainowinstitute.org/publication/xi-why-europes-cloud-ambitions-have-failed.

[363] Marco Berlinguer, "The Matrix: Is There a European Way to Cloud Computing?," Transform!Europe, May 5, 2024, https://transform-network.net/publication/the-matrix-is-there-a-european-way-to-cloud-computing/.

[364] European Commission, "ALT-EDIC," European Language Data Space (Directorate-General for Communications Networks, Content and Technology, 2023), https://language-data-space.ec.europa.eu/related-initiatives/alt-edic_en.

[365] Cailean Osborne, "Public-Private Funding Models in Open Source Software Development: A Case Study on Scikit-Learn," ArXiv (Cornell University), April 9, 2024, https://doi.org/10.48550/arxiv.2404.06484.

highlighted[366]. The European Union is therefore beginning to integrate Digital Commons and open technologies into its industrial policy for the automotive sector. In 2023, the European Commission released a **"Concept Paper on an Open European Software-Defined Vehicle Platform for the Vehicle of the Future"**. This initiative, developed in collaboration with German, French, and Italian car manufacturers' associations, proposes a unified open platform for "non-differentiating pre-competitive software developments". It focuses on creating a standardized, open reference architecture and interoperable software elements, such as middleware and interfaces, to foster collaboration across automakers.pen hardware and software technologies will be important[367]. A Working Group has mentioned the importance of collaboration on both software and hardware components in its paper "The Road towards a High-Performance Automotive RISC-V Reference Platform"[368]. Collaboration also extends to data-sharing. **Catena-X is an initiative aimed at fostering "radical collaboration" and data exchange across the automotive industry**. OSS plays a central role in Catena-X, ensuring interoperability, scalability, and innovation within the ecosystem. Members include a wide spectrum of industry stakeholders, such as BMW, Mercedes-Benz, Bosch, and Siemens. The initiative is supported by the European Union through NextGenEU funding and the Federal Ministry of Economic Affairs and Climate Action of Germany[369].

The **Fabrique des Mobilités**, established in 2017 as an initiative by the French environmental agency ADEME, aims to **transform mobility systems through the creation and support of Digital Commons**. It focuses on fostering ecological transition in mobility by promoting resource efficiency, lightweight vehicle development, and digital infrastructure that enhances sustainable mobility and public policy in this field. Acting as an intermediary, the Fabrique brings together diverse public and private stakeholders to collaborate on shared resources. It also develops tools and guides to help communities and organizations better understand and manage mobility-related Digital Commons[370]. To achieve its goals, the Fabrique employs commons-based approaches that facilitate mutualization, build sustainable governance models, and promote data sharing. Projects like Affluence TC, which visualizes public transport flows using AI, and AequilibraE, an open source traffic simulation tool, exemplify the practical applications of Digital Commons in addressing mobility challenges. By aligning

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[366] Johan Linåker and Astor Nummelin Carlberg, "Vision Paper: Open Source Software in the Automotive Industry," Eclipse Foundation, February 2, 2024, https://newsroom.eclipse.org/news/announcements/vision-paper-open-source-software-automotive-industry.

[367] European Commission, "Concept Paper on an Open European Software- Defined Vehicle Platform for the Vehicle of the Future," Digital-Strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, June 2023), https://digital-strategy.ec.europa.eu/en/library/concept-paper-open-european-software-defined-vehicle-platform.

[368] Report from European Working Group, "The Road towards a High-Performance Automotive RISC-V Reference Platform" (Electronic Components and Systems (ECS) Strategic Research and Innovation Agenda (ECS-SRIA) , April 14, 2023), https://ecssria.eu/Roadmap_RISC-V_v240216_Final.pdf.

[369] Catena-X, "About Us ," Catena-x.net, 2024, https://catena-x.net/en/1/about-us.

[370] Marguerite Grandjean, "Guide Méthodologique Des Communs Numériques de La Mobilité - Communauté de La Fabrique Des Mobilités," Lafabriquedesmobilites.fr (FabMob, 2022), https://wiki.lafabriquedesmobilites.fr/wiki/Guide_m%C3%A9thodologique_des_Communs_Num%C3%A9riques_de_la_Mobilit%C3%A9.

public investment with shared private benefits, the Fabrique highlights the potential of commons to enable durable, locally driven mobility solutions[371].

2.2.4 Digital Public Infrastructure (DPI) to accelerate the digital transformation

The discourse on Digital Public Infrastructure (DPI) is primarily driven by the example of India's industrial strategy, which is centered on **generative foundations for public and private digital services and transactions.** It allows public institutions to centrally manage a set of open application programming interfaces (APIs) that can be used by both the public and private sectors to develop services[372]. The approach to DPI reflects an optimism about the role of digital technologies in advancing societal and economic goals. It is underpinned by the belief that accelerating digital transformation can drive economic and social development, making it a key focus for modernization efforts. At the same time, the governance model of DPI typically emphasizes a stronger role for the state, coupled with reduced reliance on foreign infrastructures. This approach has enabled DPI to gain support and promotion from a broad spectrum of stakeholders, including public institutions, international agencies, and the private sector[373].

The Universal DPI Safeguards Framework led by the United Nations Secretary-General's Envoy on Technology (OSET) and the United Nations Development Programme (UNDP) has developed **a broad definition of DPI, which nonetheless mentions the importance of interoperability and reliance on open standards**. It defines 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"[374]. The core pillars of DPI in the context of international multilateral discussions typically include data exchange, identity, and payment systems[375].

India's DPIs - often referred to as the India Stack - were mostly developed through public-private partnerships that are closely associated with India's non-profit organization iSPIRIT, which represents the Indian software industry. Aadhaar, launched in 2010, is the world's

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[371] Conseil national du numérique (CNNum), "Les Communs Pour Transformer La Mobilité. Échange Avec La Fabrique Des Mobilités | CNNum | Traducteur et Éclaireur Des Transformations Numériques," Cnnumerique.fr, January 29, 2024, https://cnnumerique.fr/paroles-de/les-communs-pour-transformer-la-mobilite-echange-avec-la-fabrique-des-mobilites.

[372] 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-publicinfrastructure/.

[373] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

[374] 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.

[375] Institute for Innovation and Public Purpose, "DPI Mapping Project - About," dpimap.org (Institute for Innovation and Public Purpose - University College London), accessed December 4, 2024, https://dpimap.org/about.

largest biometric ID system and serves as a foundational platform for accessing various public and private services through its open APIs[376]. While the India Stack, which incorporates Aadhaar, has been praised for fostering innovation and streamlining government services, it has also drawn criticism for security and privacy concerns tied to its centralized design. Researchers have criticized the top-down implementation of DPI, noting that it was developed with limited involvement from civil society. They argue that while these systems have improved access and efficiency for some, they have also excluded marginalized populations. Furthermore, the public-private model underlying the deployment of DPI has been criticized for socializing risks while allowing profits to be privatized[377].

The **Brazilian Pix Payment System** serves as another example of a DPI, distinguished by a stronger role of the state in its governance. Introduced by the Central Bank of Brazil in 2020, is a digital payment infrastructure enabling real-time, cost-free money transfers. Since its implementation, Pix has been adopted by 70% of Brazil's population. The system replaced reliance on international payment networks such as Visa and Mastercard, which previously charged a 3% transaction fee and centralized data collection. Researcher Luca Belli highlights three key benefits of a domestic public digital payment infrastructure: simplifying and expanding access to payments, reducing reliance on foreign networks that concentrate market power and control data, and enabling the Central Bank of Brazil to gain direct economic insights[378].

Although the global discourse on DPI is less influenced by European actors, the EU has initiated several projects that can be regarded as foundational "building blocks" for DPI. These projects frequently emphasize decentralized approaches, open source technologies, and community involvement in their development. European civil society reactions to the DPI model have indeed suggested **a commons-based governance model for DPI - to ensure transparency, inclusivity, and accountability**[379]. As already mentioned earlier in this report, initiatives such as Gaia-X aim to establish standards for secure and trustworthy environments while fostering decentralized ecosystems of cloud service providers. Likewise, the European Open Science Cloud (EOSC) integrates public interest principles, such as open science, into these infrastructures, embedding societal values within the governance of digital ecosystems. However, progress in implementing DPI at the EU level has been relatively slow, hindered by regulatory complexity and the need for coordination between member states. Examples of initiatives that could be regarded as DPI include the EU Digital

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376 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

377 Mila Samdub and Chand Rajendra-Nicolucci, "What Is Digital Public Infrastructure? Towards More Specificity," Tech Policy Press, November 25, 2024, https://www.techpolicy.press/what-is-digital-public-infrastructure-towards-more-specificity/.

378 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-digitalcommons-in-india-and-brazil/.

379 Renata Avila et al., "Policy Brief: Governing Digital Public Infrastructure as a Commons" (Open Knowledge Foundation, July 15, 2024), https://blog.okfn.org/2024/07/15/policy-brief-governing-digital-public-infrastructure-as-a-commons/.

Identity and Digital Identity Wallets, the Digital Euro, as well as data exchange systems and Common European Data Spaces (already described in the previous section).

The European Commission's Digital Euro proposal, published on June 28, 2023, aims to establish a regulatory framework for a Euro-denominated Central Bank Digital Currency (CBDC). This initiative, designed to supplement cash and modernize the euro in line with technological advancements, seeks to provide a public alternative to private digital payment systems and address the diminishing use of physical cash. The Digital Euro would ensure that the euro remains an effective and uniform currency for online and offline transactions across the Eurozone[380]. Civil society reactions to the Digital Euro project highlighted the importance of incorporating open technologies to improve the proposal. Recommendations include strengthening democratic oversight by ensuring key design decisions are addressed within the legal framework to enhance accountability, improving privacy safeguards to meet and providing clear guarantees against payment tracking to ensure user trust, and mandating the use of OSS to promote transparency, reduce reliance on private vendors, and reinforce the public nature of this infrastructure[381].

The EU Digital Identity Wallet has been announced by the European Commission as a secure and user-friendly digital tool designed to enable European citizens and businesses to authenticate their identity for interactions across both public and private sectors. Its development follows the European Commission's 2021 Recommendation, which established a unified technical framework, common standards, and best practices. The wallet is currently being tested through four large-scale pilot projects launched in April 2023. These pilots involve over 250 private companies and public authorities from 25 member states, as well as Norway, Iceland, and Ukraine[382]. The European Commission has also developed a prototype under the Digital Europe Programme, which includes code libraries and a sample application to support testing and refinement of the wallet's specifications. The wallet's development emphasizes open source technologies, ensuring transparency and accessibility. This approach enables member states and other stakeholders to adapt and build their own digital wallets based on shared resources. The initial reference implementation, along with the technical Architecture and Reference Framework, is publicly available on GitHub[383]. Additionally, the EU has funded, through the NGI initiative, the project TALER. The project is a privacy-friendly digital payment system developed by the GNU community and Taler Systems SA[384].

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380 European Commission, "Proposal for a Regulation of the European Parliament and of the Council on the Establishment of the Digital Euro," EUR-Lex, 2023, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023PC0369.

381 Paul Keller, "The Case for the Digital Euro — Built as Public Digital Infrastructure – Open Future," Open Future, 2023, https://openfuture.eu/blog/digital_euro/.

382 European Commission, "European Digital Identity," commission.europa.eu (Directorate-General for Communication, 2021), https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-digital-identity_en.

383 European Commission, "EU Digital Identity Wallet Pilot Implementation," digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, October 5, 2023), https://digital-strategy.ec.europa.eu/en/policies/eudi-wallet-implementation.

384 NGI, "NGI Taler," NGI.eu Portal (Next Generation Internet (NGI), January 9, 2024), https://ngi.eu/ngi-projects/ngi-taler/.

2.2.5 Digital Public Goods (DPGs) for international collaboration on sustainable development

In international cooperation, the growing emphasis on Digital Commons and Digital Public Goods is preceded by a broader movement advocating for open access to resources that started in the early 2000s, as highlighted earlier in this report. Numerous international organizations have advanced **policies promoting open data and knowledge sharing**. The World Bank has been a key player in promoting open data, both by making its own datasets publicly accessible and by advocating for the global pooling of government data[385]. Collaborative efforts have also emerged through alliances such as the **Open Government Partnership[386], the Open Data for Development Partnership (OD4D)[387], or UNESCO's initiatives on Open Education Resources**[388]. These efforts align with the Sustainable Development Goals (SDGs) but also address broader concerns such as censorship and human rights. For instance, the **Open Technology Fund, established in 2012 with U.S. government funding, has supported open technologies aimed at ensuring internet freedom**[389].

Many policies have also supported the infrastructure and human capacity needed to contribute and use Digital Commons for local development purposes. For example, collaborative environments such as FabLabs have been encouraged to foster the co-creation of digital resources[390]. The **WAZIHUB project**, funded by the EU's Horizon 2020 research and innovation program, for instance aimed to foster IoT and Big Data innovations across Africa by collaborating with African Tech Hubs. Bringing together 10 African and 4 European partners, the project focuses on creating open innovation environments where entrepreneurs and developers can receive training, adapt IoT technologies, and develop businesses tailored to local needs[391].

Early efforts to formalize a coordinated approach to Digital Public Goods can be seen in the initiatives of the **Digital Impact Alliance (DIAL)**, established in 2014. DIAL works with diverse stakeholders, including UN agencies, philanthropic organizations such as the Bill and

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385 World Bank Group, " World Bank Support for Open Data : 2012 - 2017 " (Washington, D.C.: World Bank Group, June 1, 2017), https://documents1.worldbank.org/curated/en/760871509531665876/pdf/120801-WP-P133276-PUBLIC.pdf.

386 Open Government Partnership, "About," opengovpartnership.org (Open Government Partnership), accessed November 6, 2024, https://www.opengovpartnership.org/about/.

387 International Development Research Centre (IDRC), "Open Data for Development," IDRC - International Development Research Centre, accessed December 6, 2024, https://idrc-crdi.ca/en/initiative/open-data-development.

388 "Open Educational Resources," www.unesco.org, accessed December 6, 2024, https://www.unesco.org/en/open-educational-resources.

389 Wikipedia Contributors, "Open Technology Fund," Wikipedia (Wikimedia Foundation, November 7, 2024), https://en.wikipedia.org/wiki/Open_Technology_Fund.

390 Chaminda Hettiarachchi and Pubudu Senaratne, "Digital Fabrication Labs (FabLabs) for Implementing Sustainable Development Goals (SDGs) in Solidarity and Social Economy (SSE) in Sri Lanka," SSE Knowledge Hub for the SDGs, March 20, 2020, https://knowledgehub.unsse.org/knowledge-hub/digital-fabrication-labs-fablabs-for-implementing-sustainable-development-goals-sdgs-in-solidarity-and-social-economy-sse-in-sri-lanka/.

391 WAZIUP e.V, "WaziHub," Waziup.org, 2020, https://www.waziup.org/research-innovation/projects/wazihub/.

Melinda Gates Foundation, national development agencies, and various NGOs, to integrate digital tools into international development programs and enhance outcomes across sectors. A key milestone of its work was the creation of the widely endorsed **"Principles for Digital Development."** Among these nine principles, one specifically emphasized the use of open standards, open data, OSS, and open innovation. This commitment to free licensing enhances other principles, such as adaptability to local contexts, scalability across regions, sustainability in maintenance and development, resource reuse and improvement, and robust data protection[392].

In 2018, a UN high-level panel recommended creating a platform for sharing Digital Public Goods (DPGs) to support the SDGs. This led to the **establishment of the Digital Public Goods Alliance (DPGA),** which focuses on advancing DPGs to accelerate SDG achievement in low- and middle-income countries[393]. As of November 2023, its board includes the EkStep Foundation, the German Federal Ministry for Economic Cooperation and Development (BMZ), the Norwegian Agency for Development Cooperation (Norad), the Sierra Leone Directorate of Science, Technology and Innovation (DSTI), the United Nations Development Programme (UNDP), and UNICEF[394].

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)**"**[395]. This definition builds on the classic economic definition of public goods and its emphasis on non-exclusive access. Digital goods therefore need to be licensed under an approved open license. In addition, the definition includes a normative aspect, which is meant to ensure privacy adherence, and relevance to SDGs. The DPGA maintains a registry of certified DPGs aligned with a defined standard. It also facilitates funding and collaborates with governments to promote local ownership of technology solutions[396].

The expected benefits of the mobilization of DPGs in international development cooperation are linked to their scalable, interoperable, and flexible nature, which should help governments to deploy **solutions that are free from vendor lock-ins and proprietary technology silos**[397].

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[392] Digital Impact Alliance (DIAL), "Principles for Digital Development," Digital Impact Alliance, December 9, 2022, https://dial.global/work/principles-for-digital-development/.

[393] UN Secretary-General's High-level Panel on Digital Cooperation, "The Age of Digital Interdependence," United Nations, June 2019, https://www.un.org/en/pdfs/HLP%20on%20Digital%20Cooperation%20Report%20Executive%20Summary%20-%20ENG.pdf.

[394] Digital Public Goods Alliance (DPGA), "Governance," Digital Public Goods Alliance - Promoting digital public goods to create a more equitable world, November 25, 2021, https://www.digitalpublicgoods.net/governance.

[395] 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/.

[396] Digital Public Goods Alliance (DPGA), "DPGA Strategy 2023-2028," Digital Public Goods Alliance - Promoting digital public goods to create a more equitable world, November 25, 2021, https://www.digitalpublicgoods.net/digital-public-goods-alliance-strategy-2023-2028.

[397] Liv Marte Nordhaug and Lucy Harris, "Digital Public Goods: Enablers of Digital Sovereignty," OECD Library (Paris: Organization for Economic Cooperation and Development (OECD), December 21, 2021), https://doi.org/10.1787/c023cb2e-en.

By emphasizing on a "building blocks" approach, some authors claim that the co-creation of open source components that address diverse use cases will **reduce costs for governments by mutualizing resources while promoting equitable access to technology** and innovation[398]. MOSIP was for instance developed by the Indian government as a modular and open source version of Adhaar, to allow other countries to reuse it to build and improve their own national identity systems. However, in order to to be tailored to local contexts, according to literature, the success of DPGs depends not only on their software features but also on systemic transformations in policy, governance, infrastructure, human capacity and administration practices[399][400]. Transparency, interoperability, and fiscal sustainability are important for their effective implementation[401]. For these reasons, several development cooperation programs have been launched to provide technical assistance to low- and middle-income countries in the deployment of such Digital Public Goods, supported both by the European Union and/or some of its member states. Two of such programmes are the GovStack initiative and the 50-in5 campaign. Such initiatives contribute to the deployment of European open source technologies like X-Road[402].

The **GovStack initiative is a multi-stakeholder collaboration founded in 2020** by the International Telecommunication Union (ITU), Estonia, Germany, and the Digital Impact Alliance (DIAL) at the United Nations Foundation. It aims to accelerate global digital government transformation by providing governments with a standardized framework and toolkits for digital public service delivery[403]. The initiative emphasizes interoperable digital architectures grounded in European values and supports country-specific adaptations. **GovStack provides resources such as technical specifications for "building blocks"**—modular and reusable components for digital services—alongside testing sandboxes, communities of practice, and forums for knowledge exchange. While it does not develop software directly, GovStack establishes the technical foundations for these building blocks, enabling compliance evaluation and adaptation. The initiative draws on best practices from countries like Estonia, India, and Singapore to outline an open source, whole-of-government approach to digitization. Technical assistance is provided in selected countries, but all resources developed by GovStack are freely available for all countries[404]. The EU is co-financing GovStack, for instance through the Multi-Donor Action "Initiative for Digital

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[398] Anit Mukherjee and Shankar Maruwada, "Fast-Tracking Development: A Building Blocks Approach for Digital Public Goods," Center for Global Development | Ideas to Action, September 2021, https://www.cgdev.org/publication/fast-tracking-development-building-blocks-approach-digital-public-goods.

[399] Brian Nicholson et al., "Digital Public Goods for Development: A Conspectus and Research Agenda," IFIP Advances in Information and Communication Technology 657 (January 1, 2022): 455–70, https://doi.org/10.1007/978-3-031-19429-0_27.

[400] Sundeep Sahay, "Free and Open Source Software as Global Public Goods? What Are the Distortions and How Do We Address Them?," The Electronic Journal of Information Systems in Developing Countries 85, no. 4 (February 8, 2019), https://doi.org/10.1002/isd2.12080.

[401] Eve Elie, Vinuri Dissanayake, and Aaron Snow, "Landscape Scan of Digital Public Goods Use in Government," The Beeck Center for Social Impact + Innovation at Georgetown University, October 2024, https://beeckcenter.georgetown.edu/report/landscape-scan-of-digital-public-goods-use-in-government.

[402] Giulia Guadagnoli, "Open Source in International Cooperation - a Conversation with Petteri Kivimäki on X-Road.," Interoperable Europe Portal, August 9, 2021, https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/open-source-international-cooperation.

[403] GovStack, "About," GovStack, October 24, 2024, https://www.govstack.global/about/.

[404] GovStack, "FAQs," GovStack, July 25, 2024, https://www.govstack.global/about/faq/.

Government and Cybersecurity" (IDGC) in the Horn of Africa, together with Germany, France, and Spain[405].

The **50-in-5 campaign**, launched on November 8, 2023, is a country-led advocacy initiative aimed at supporting the rapid **design, implementation, and scaling of DPI in 50 countries within five years**. The campaign is supported by institutions such as the Bill & Melinda Gates Foundation, Co-Develop, Digital Public Goods Alliance (DPGA), GovStack, UNICEF, United Nations Development Programme (UNDP), and USAID. Its primary goals include: accelerating DPI adoption through knowledge exchange and the use of open standards and Digital Public Goods, reducing costs and implementation timelines, promoting the development of local engineering capacity and vendor ecosystems[406].

2.3 Policies Supporting the Distributed Ownership of Critical Digital Resources

Section 2.3 reviews policies that empower citizens and society through distributed ownership of critical digital resources. Governments increasingly recognize the importance of Digital Commons in maintaining essential technological infrastructure relied upon by states, industries, and individuals. Initiatives like the Sovereign Tech Agency map these dependencies and support Digital Commons while valuing their own governance models and respecting their independence. Similarly, the Next Generation Internet (NGI) fosters trust and decentralization by funding projects that promote interoperability and user control. Various local initiatives demonstrate how Digital Commons can offer alternatives to for-profit platforms, such as platform cooperatives that ensure fair conditions for workers and greater control over intermediation services. In the field of open data, community and government approaches are increasingly blended. EU-supported projects like Citizen Observatories and partnerships such as the French IGN-OpenStreetMap integrate citizen-generated data into policymaking and public resources. Various governance frameworks are being tested across still scattered initiatives to balance public oversight with community ownership, ensuring equitable access, sustainability, and alignment with public interest goals.

2.3.1 Definitions

Digital Commons are increasingly regarded by policymakers as essential tools for advancing digital sovereignty. The term "digital sovereignty" is contested, encompassing diverse dimensions such as technical security, economic resilience, and geopolitical autonomy[407]. In Europe, its prominence has grown significantly in response to events such as the Snowden revelations on mass surveillance, the dominance of a few private firms in the European digital landscape, the weaponization of digital technologies and infrastructure in recent conflicts, commercial disputes over emerging technologies like 5G, and the vulnerabilities in value chains exposed during the COVID-19 pandemic. These developments raise questions

[405] GovStack, "Digital Leaders Spotlight: Kenya," GovStack, September 30, 2024, https://www.govstack.global/showcase/digital-leaders-spotlight-kenya/.

[406] 50-in-5, "Implementing Digital Public Infrastructure, Safely and Inclusively," 50-in-5, accessed December 6, 2024, https://50in5.net/.

[407] Samuele Fratini et al., "Digital Sovereignty: A Descriptive Analysis and a Critical Evaluation of Existing Models," Digital Society 3, no. 3 (November 14, 2024), https://doi.org/10.1007/s44206-024-00146-7.

about the European Union's ability to enforce its norms and values such as privacy, as demonstrated by its reliance on U.S. tech companies during the COVID-19 contact tracing initiatives[408].

Digital technologies **challenge foundational principles of sovereignty, such as territoriality and authority**, as the internet transcends national boundaries. The concept extends to control over software, hardware, data, and networks, whose value chains are global and interdependent. Digital technologies are particularly susceptible to vulnerabilities such as backdoors in operating systems, third-party services, and hardware, which can lead to unauthorized access and jeopardize national security, trade secrets or individual's rights[409]. Sovereignty, therefore, increasingly "depends on more than supranational alliances or international legal instruments, military might or trade: it depends on **locally owned, controlled, and operated innovation ecosystems, able to increase states' technical and economic independence and autonomy.**" This perspective has given rise to strategies by "humans and organizations" emphasizing how to" build, develop, use, co-opt, and resist digital infrastructures."[410]

Digital Commons differ significantly from classical public goods and traditional infrastructures in several ways. Unlike material goods, digital goods are inherently easy to distribute across time and space, often at minimal cost, making them replicable and shareable on a global scale. Their digital nature allows them to be **reprogrammed, modularized, recombined, and adapted to diverse local contexts**, fostering flexibility and broad applicability[411]. This adaptability creates network effects, amplifying their value as their usage grows. Some scholars have even described digital goods as "anti-rivalrous" for this reason[412]. Another key distinction lies in how Digital Commons combine to form infrastructure. Rather than conforming to a hierarchical model, Digital Commons are better understood as a dynamic "stack," a concept introduced by Benjamin Bratton. The stack represents the interconnected layers of global digital infrastructure, encompassing hardware, software, protocols, and data[413]. Unlike traditional, fixed, and ordered systems, the stack is flexible, allowing for varying interpretations and uses depending on individual priorities and goals. Expanding on this metaphor, Marco Berlinguer described **modern technological**

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[408] European Institute of Innovation and Technology (EIT), "European Digital Infrastructure and Data Sovereignty" (Brussels, Belgium: EIT Digital, September 24, 2021), https://eit.europa.eu/library/european-digital-infrastructure-and-data-sovereignty.

[409] Gaël Duval, "From Sovereign Operating Systems to the Sovereign Digital Chain," in Reflections on Programming Systems Historical and Philosophical Aspects, ed. Giuseppe Primiero and Liesbeth De Mol (Switzerland: Springer Cham, 2018), 261–71, https://doi.org/10.1007/978-3-319-97226-8_9.

[410] Francesca Musiani, "Infrastructuring Digital Sovereignty: A Research Agenda for an Infrastructure-Based Sociology of Digital Self-Determination Practices," Information, Communication & Society Special Issue AoIR 2021, "Independence" (March 2022): 1–16, https://doi.org/10.1080/1369118x.2022.2049850.

[411] Jonathan Zittrain, The Future of the Internet (Penguin UK, 2009).

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

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

infrastructure as an "accidental megastructure" of Digital Commons, emphasizing its unplanned yet deeply interdependent and collaborative nature[414].

To account for the variety of stakeholders involved and the global nature of digital value chains, the definition of digital sovereignty adopted in this section will be inspired by the definition used by Germany's Sovereign Tech Agency, which encompasses these different stakeholders and focuses on technological self-determination rather than strict independence and autonomy. It defines **digital sovereignty as the "self-determined use of digital technologies and systems by individuals, industry, and governments"**[415]. In this context, Digital Commons become strategic enablers of sovereignty: due to their transparency and reviewability, they allow actors to audit and verify the systems and solutions they are depending on, without necessarily having to reproduce all these systems internally.

The previous sections have shown the importance of Digital Commons as a way to regulate some of the protocols and rules that shape the internet in supporting interoperability and standards. They also have shown the role they play as part of economic strategies to support industries and infrastructures. This section will focus on the policies that support **Digital Commons as alternative institutions to profit-driven models of technological governance**. These policies focus on collaboration against competition, public interest against extractive business models, and on democratic decision-making against centralized infrastructures.

2.3.2 Overview of policy trends

Digital Commons are increasingly seen by policymakers as essential tools for ensuring digital sovereignty because of the security, control, and autonomy they provide. They enhance **security by providing transparency, auditability, and verifiability**, allowing systems to be scrutinized and strengthened against vulnerabilities. By being freely available, reproducible, and editable, Digital Commons **grant users control over their technologies, enabling them to develop and tailor services, tools, and infrastructure** according to specific needs and priorities. Furthermore, they support autonomy by **fostering interoperability, opening markets, and reducing dependency** on single vendors or proprietary technologies[416].

These arguments have historically been developed to support the adoption of OSS by public sector organizations (see section 1). According to a recent report that analyzed OSS policies in 16 countries, "selected for their high performance in digital government and administration based on major international digital maturity indexes", Digital Commons are considered to be "a means to empower sovereign decisions on use of technology". The authors of the report, Johan Linaker and Sachiko Muto, mention examples from France, Sweden, Luxembourg, Germany and Spain.

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[414] Marco Berlinguer, "Digital Commons as New Infrastructure," Umanistica Digitale, no. 11 (2021), https://doi.org/10.6092/issn.2532-8816/13695.

[415] Sovereign Tech Agency, "Mission | What Is Digital Sovereignty?," Sovereign Tech Agency, accessed December 8, 2024, https://www.sovereign.tech/mission#what-is-digital-sovereignty.

[416] Marco Berlinguer, "The Matrix: Is There a European Way to Cloud Computing?," Transform!Europe, May 5, 2024, https://transform-network.net/publication/the-matrix-is-there-a-european-way-to-cloud-computing/.

In France, the “Law for a Digital Republic” mandates that **public administrations maintain control, sustainability, and independence in their information systems**. Sweden incorporates digital sovereignty into public sector-specific policies, with initiatives such as eSam, a collaboration among over 30 public sector organizations, exploring OSS-based tools like Nextcloud, Element, and Jitsi for secure data hosting and management. The Swedish Insurance and Tax Agencies are also investigating public sector alternatives for communication and collaboration. Similarly, Germany has developed OpenDesk, a suite of OSS solutions tailored for public administration needs, aligning with efforts in Sweden. In Luxembourg, digital sovereignty drives initiatives like LuxChat, an OSS-based instant messaging service for public sector use, ensuring secure and controlled data usage. France develops a similar solution with the Tchapp project. In the Basque Country, the public sector has fully transitioned to OSS operating systems and productivity tools, partly to localize software into the regional language, reinforcing regional independence[417]. Another local example it the policy adopted by the French city of Lyon, which decided to offer a personal cloud based on Cozy Cloud’s open source technology to all its residents, in order to allow them to enjoy access to a data infrastructure respectful of their digital rights[418].

Beyond the adoption of OSS in the public sector, policies have increasingly aimed to **support individuals and communities engaged in Digital Commons**. The French National Agency for Territorial Cohesion (ANCT), a public body that supports local authorities, for instance developed a toolkit on Digital Commons as part of a strategy to create a public interest digital sphere and to empower citizens, by improving their capacities to take part in the development of digital resources[419].

Such policies are part of a movement that aims to support an internet for the people, by **deprivatizing key infrastructures[420] and creating digital public spaces[421]**. These efforts seek to bolster the security of foundational digital infrastructures, uphold public values such as trust and openness, create alternatives to for-profit applications, and empower communities while enhancing citizen participation. Such policies give rise to innovative support mechanisms and hybrid institutions that blend public and civic forms of engagement. For example, the German Sovereign Tech Agency, formerly the Sovereign Tech Fund, supports OSS developers through fellowships, and the French Environmental Agency ADEME has launched “Call for Commons” to promote collaboration between ecosystem members on shared resources instead of competition.

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[417] Johan Linåker and Sachiko Muto, “Software Reuse through Open Source Software in the Public Sector - a Qualitative Survey on Policy and Practice,” DIVA Portal (RISE Research Institutes of Sweden AB, 2024), https://www.diva-portal.org/smash/get/diva2:1848137/FULLTEXT01.pdf.

[418] Métropole de Lyon, “Mon Cloud Personnel ,” Grandlyon.com, accessed December 9, 2024, https://www.grandlyon.com/services/numerique/mon-cloud-personnel.

[419] Agence nationale de la cohésion des territoires (ANCT), “Les Communs Numériques : Un Modèle Innovant de Développement Des Ressources Numériques | Les Bases Du Numérique d’Intérêt Général,” Gouv.fr, 2023, https://lesbases.anct.gouv.fr/ressources/les-communs-numeriques-un-modele-innovant-de-developpement-des-ressources-numeriques.

[420] Ben Tarnoff, Internet for the People (New York: Verso Books, 2022).

[421] 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.

2.3.3 Support for trust and decentralization: the Next Generation Internet (NGI) initiative

The Next Generation Internet (NGI) initiative supports research and development in **open internet technologies under the banner of an "Internet of Trust".** The initiative focuses on solutions that align with European values such as openness, privacy and transparency, in line with key EU regulations, including the GDPR, the DSA, the DMA, and the Cyber Resilience Act. It aims to support trust, sovereignty, and user control in the digital space by funding decentralized, open source solutions. Between 2019 and 2024, the initiative has supported more than 1000 projects with about **140 million euros of funding via Horizon Europe**. Additional funding of €32 million is planned until 2027[422].

The initiative employs two funding mechanisms: Research and Innovation Actions (RIAs), focused on supporting technology development, and Coordination and Support Actions (CSAs), which emphasize scaling through outreach and collaboration. RIAs are designed to **fund grassroots projects across internet layers—ranging from hardware to applications, through a cascade funding mechanism**. This funding mechanism - also referred to as Financial Support for Third Parties (FSTP) means that intermediary coordinators with technical knowledge are responsible for disbursing funding to third-party recipients. This approach allows projects to get funded more easily, while limiting the resources they need to allocate to grant proposals or project reporting. A large part of the grants ranges from €5,000 to €50,000, targeting individuals, startups, and SMEs, tied to milestones to be completed by the project owners.[423]

A survey of 291 NGI-funded projects conducted by Gartner on behalf of the European Commission has shown that the initiative **contributes to the promotion of interoperability and open standards (see section 2.1).** NGI-funded projects have actively contributed to internet standards, engaging with organizations like W3C and IETF to improve protocols such as Solid, WebAuthn, and DNSSEC. Over half of the projects collaborated with standardization bodies, advancing open standards and fostering interoperability across the digital ecosystem. The impact study also shows that the NGI initiative can be considered as a part of an industrial strategy (see section 2.2), as it participates in the **development of alternative open technologies**, in a wide range of solutions from social media platforms to cybersecurity tools and identity management systems. One example highlighted by the impact study is NGI's support for some of the lead projects of the Fediverse, like Mastodon. Finally, the initiative is also considered as an **important support mechanism for the Digital Commons ecosystem at large**. 41% of the survey respondents indeed participated in larger OSS community efforts. Around 76% of projects have external contributors, ranging from small groups (under 10 people) to large communities (over 50 people). The survey estimates that each NGI-funded contributor has engaged approximately 50 community members, amounting to around 80,000 individuals actively contributing to NGI-supported OSS projects through coding, testing, and bug reporting. The impact study highlights positive feedback on

[422] European Commission, "Next Generation Internet Initiative," digital-strategy.ec.europa.eu (Directorate-General for Communications Networks, Content and Technology, November 22, 2021), https://digital-strategy.ec.europa.eu/en/policies/next-generation-internet-initiative.

[423] Cailean Osborne et al., "A Toolkit for Measuring the Impacts of Public Funding on Open Source Software Development," November 8, 2024, https://doi.org/10.48550/arxiv.2411.06027.

NGI's funding model but emphasizes the need for ongoing financial support and clearer guidelines to enhance project impact. Key suggestions included diversifying funding mechanisms, simplifying monitoring processes, and expanding educational programs. Additionally, grantees recommended fostering collaboration between projects, addressing scaling and user adoption challenges, and investing in community-building resources[424].

2.3.4 Collaboration with communities to secure critical dependencies in open technologies

As discussed in Section 2.2, Digital Commons, particularly OSS, have become integral to modern infrastructures, with their presence embedded in nearly all software code. This widespread reliance on OSS has heightened awareness of its critical role in ensuring the security of digital infrastructures for governments, industries and societies at large. 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. More and more attention is being paid to the maintenance required by digital technologies, which has historically been associated only with innovation. Maintenance is essential to keep software up to date and compatible with new systems, to fix bugs, or to patch security vulnerabilities[425]. Some studies indicate that software maintenance costs are steadily increasing, with estimates suggesting that approximately 90% of a software's total lifecycle cost is attributed to its maintenance phase[426].

Several high-profile vulnerabilities in widely used FOSS programs have sparked global concern, as these components are often relied upon by millions of organizations, including major tech companies, as well as critical government entities. These incidents have highlighted the intricate web of "dependencies" in modern digital systems and exposed the limited awareness among even the most advanced organizations regarding the maintenance, updates, and security of these foundational technologies. The Heartbleed vulnerability, for instance, revealed that a crucial security application used globally was maintained by only a small group of voluntary developers, operating with minimal resources[427]. These events highlight the "tragedy of the Digital Commons," where **foundational OSS benefits many but lacks sufficient contributions for its upkeep**[428]. Some private initiatives have been launched to address this issue. Notable examples include the Core Infrastructure Initiative, coordinated

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[424] Clémentine Valayer, "Benchmarking the Impact of the next Generation Internet Initiative," Publications Office of the EU (Directorate-General for Communications Networks, Content and Technology, 2024), https://op.europa.eu/en/publication-detail/-/publication/257ae66f-23c7-11ef-a195-01aa75ed71a1/language-en.

[425] Nadia Eghbal, "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-laborbehind-%20our-digital-infrastructure/.

[426] Sayed Dehaghani and Nafiseh Hajrahimi, "Which Factors Affect Software Projects Maintenance Cost More?," Acta Informatica Medica 21, no. 1 (2013): 63, https://doi.org/10.5455/aim.2012.21.63-66.

[427] Marco Berlinguer, "The Matrix: Is There a European Way to Cloud Computing?," Transform!Europe, May 5, 2024, https://transform-network.net/publication/the-matrix-is-there-a-european-way-to-cloud-computing/.

[428] 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.

by the Linux Foundation, which later developed into the Open Source Security Foundation. The foundation is mostly funded by the tech industry but also received support by the US government[429]. A more recent example is GitHub's Secure OSS Fund[430].

The **EU-FOSSA (Free and Open Source Software Auditing)** represents a significant EU initiative aimed at enhancing the security of critical OSS. The project originated in 2015 when the European Parliament, on the initiative of MEP Felix Reda, allocated €1 million for a pilot program by the European Commission to audit key OSS used by the EU. Following public consultation, Apache HTTP Server and KeyPass were chosen for detailed security assessments. Building on this, **EU-FOSSA 2** launched with a €2.6 million budget and included broader efforts such as **best-practice studies on the use of OSS in public administrations, licensing challenges, IT support, and engagement with OSS community leaders** to address obstacles and implement solutions. EU-FOSSA 2 concluded in June 2020 and is regarded as a success: the initiative has fostered closer collaboration between EU institutions and the OSS community, moving the European Commission from merely being an OSS user to actively contributing to its security, reliability, and sustainability[431]. Hackathons and bug bounty programs to identify and fix vulnerabilities in critical tools have been established at the national level as well. One example is **France's BlueHats challenge**, which was giving out prizes for maintainers that sustain some of these essential tools[432].

More recently, the **"Free and Open Source Solutions for European Public Services" (FOSSEPS) pilot** was initiated by the European Parliament to map the common dependencies of European institutions on OSS. The resulting report presented a list of 30 critical OSS projects but also highlighted the "complexity of the subject". The authors observed that most "public services do not have adequate technology tools to establish open source software dependencies" and that the collaboration with external community initiatives needs to be strengthened[433]. Such an approach requires a shift from traditional security approaches targeting national industrial players to fostering a decentralized global digital landscape, with sustainable OSS ecosystem support through targeted investments, dependency tracking, risk assessments, and grassroots-level needs identification. This requires **internal expertise within dedicated public institutions and ongoing dialogue with OSS communities**, exemplified by the **German Sovereign Tech Agency**, an initiative launched by the Federal Ministry for Economic Affairs and Climate Protection (BMWK) in 2022. The objective of the agency is conducting vulnerability research, improving software quality, and

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[429] Wikipedia Contributors, "Open Source Security Foundation," Wikipedia (Wikimedia Foundation, July 12, 2024), https://en.wikipedia.org/wiki/Open_Source_Security_Foundation.

[430] GitHub, "GitHub Secure OSS Fund," GitHub Resources, accessed December 9, 2024, https://resources.github.com/github-secure-open-source-fund/.

[431] Knut Blind et al., The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness and Innovation in the EU Economy: Final Study Report, Publications Office of the European Union, European Commission: Directorate-General for Communications Networks, Content and Technology (Luxembourg: Publications Office of the European Union, 2021), https://op.europa.eu/en/publication-detail/-/publication/29effe73-2c2c-11ec-bd8e-01aa75ed71a1/language-en.

[432] Gijs Hillenius, "Les Blue Hats," Interoperable Europe Portal, December 14, 2018, https://interoperable-europe.ec.europa.eu/collection/open-source-observatory-osor/news/les-blue-hats.

[433] Saranjit Singh Arora, "FOSSEPS Critical Open Source Software Study Report," Interoperable Europe Portal, August 2, 2022, https://interoperable-europe.ec.europa.eu/collection/fosseps/news/fosseps-critical-open-source-software-study-report.

funding maintainers of critical digital infrastructure. As of november 2024, the agency has received more than 500 funding applications totaling a demand of more than 114 million euros. The fund uses public procurement to contract individuals or organizations to improve the maintenance of software. It has also organized competitions and recently started to support maintainers through fellowships. The fund's budget was 13 million euros in 2022, rising to about 22 million euros in 2023. The German government has stated that it plans to turn the fund into an agency and further increase this amount to 29 million euros in the next federal budget[434]. Another example of collaboration between public institutions and communities to increase cybersecurity is the "**Commons Studio" developed by the Campus Cyber in France**. It aims to aggregate cybersecurity solutions, foster active communities, and promote collaborative development through multi-partner networks to create robust cybersecurity products[435].

2.3.5 Promotion of collective ownership of platforms in key economic sectors

Platform Cooperatives are collectively owned and democratically governed platforms. They have been conceptualized as an alternative to capital-funded platforms that prioritize profit over community welfare. Coined by Trebor Scholz in his 2014 article "Platform Cooperativism vs. the Sharing Economy," the term highlights the exploitation of workers and users by conventional gig-economy platforms and advocates for alternative, equitable models[436]. 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."[437] Various regulatory efforts have been made to mitigate some of the negative externalities and impacts of platform work. The most recent European effort is the Platform Work Directive[438].

Platform Cooperatives do not only address precarious employment and access to social protection but also issues of **fair wealth distribution and democratic governance**, in contrast to value extraction and opaque algorithmic decision-making. In this context, they are perceived as a solution to increase productivity while creating quality employment, fostering community entrepreneurship, and supporting territorial resilience[439]. The values of platform

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434 Falk Steiner, "More than Funding: Sovereign Tech Fund to Become an Agency," Heise Online, November 4, 2024, https://heise.de/-10003941.

435 Campus Cyber, "Commons Studio - Wiki Campus Cyber," Campuscyber.fr, accessed December 9, 2024, https://wiki.campuscyber.fr/Studio_des_communs/en.

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

437 European Commission, "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.

438 Eurofound, "Initiatives to Improve Conditions for Platform Workers: Aims, Methods, Strengths and Weaknesses, New Forms of Employment Series," www.eurofound.europa.eu (Publications Office of the European Union, Luxembourg., 2021), https://www.eurofound.europa.eu/en/publications/2021/initiatives-improve-conditions-platform-workers-aims-methods-strengths-and.

439 Co-communs working group, "Towards a People and Planet-Oriented (Digital) Transition in Europe : Platform Cooperatives and Their Fundamental Role in the Context of Recovery ," La Coop des Communs, August 17, 2020, https://coopdescommuns.org/fr/platform-cooperatives-and-their-role-in-the-context-of-recovery/.

cooperative initiatives are closely aligned with the principles of Digital Commons. Both rely on community self-governance and offer an alternative to extractive technology management[440]. Additionally, Platform Cooperatives frequently depend on Digital Commons, like OSS, and can serve as legal structures for managing shared resources, such as Data Commons[441].

Collectively owned platforms include various alternatives that can range from platforms established and owned by public institutions to platforms managed by informal collectives. A study conducted by the European Foundation for the Improvement of Living and Working Conditions in 2022 has identified **more than 60 platform cooperative initiatives in Europe** (see figure). The study shows that Platform Cooperatives are transforming the platform economy by prioritizing worker rights, sustainability, and local development. Two examples—out of many more—include Les Coursiers Nancéiens, a French cargo-bike delivery service promoting local and eco-friendly commerce, and Fairbnb, an Italian rental platform investing profits in local community projects[442].

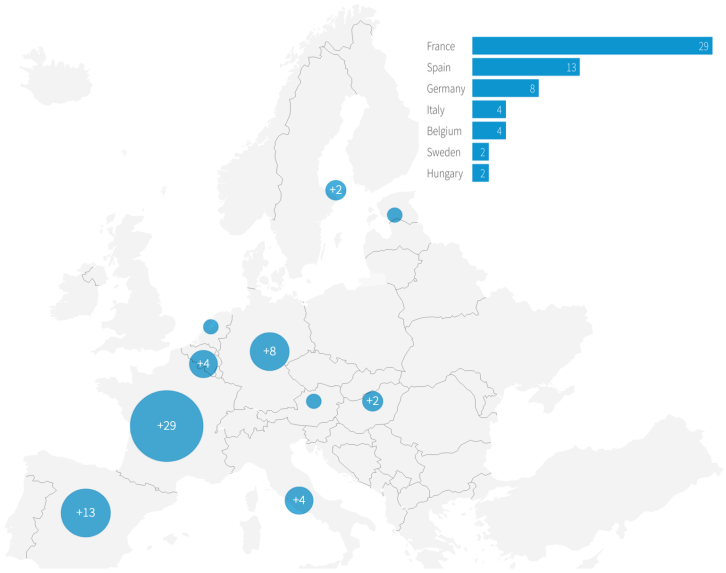

Figure 14: Number of platform cooperatives in selected Member States (Source: Beate Steurer, "Platform cooperatives ensure caring in the sharing economy")

The report "Platform Cooperatives and Employment" by the OECD has identified several types of policies that support measures that have already been implemented in the field of Platform Cooperatives:

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[440] 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/.

[441] Michael Max Bühler et al., "Unlocking the Power of Digital Commons: Data Cooperatives as a Pathway for Data Sovereign, Innovative and Equitable Digital Communities," Digital 3, no. 3 (September 1, 2023): 146–71, https://doi.org/10.3390/digital3030011.

[442] Beate Steurer, "Platform Cooperatives Ensure Caring in the Sharing Economy," Eurofound (European Foundation for the Improvement of Living and Working Conditions, 2022), https://www.eurofound.europa.eu/en/blog/2022/platform-cooperatives-ensure-caring-sharing-economy.

- The policies include **funding opportunities that support their establishment and growth**. For example, Spain's *Goteo.org* crowdfunding platform mobilizes community contributions and match-funding schemes to provide cooperatives with capital. Other support mechanisms include tax benefits. In the United States, tax relief programs encourage business owners to transition their companies into worker cooperatives, ensuring shared ownership and democratic governance.

- The report also mentions the importance of **legal frameworks for cooperative statutes**. France's *Cooperative for Activity and Employment (CAE)* is a prime example, enabling member-entrepreneurs to access employment protections while maintaining cooperative membership. These legislative measures update traditional cooperative laws, introduce new employment categories like "employee-entrepreneur," and ensure cooperatives can operate effectively in modern economic contexts.

- **Public procurement** has been leveraged in some cases to create markets for Platform Cooperatives. For instance, *CoopCycle*, a cooperative for bicycle couriers operating in Europe, has secured contracts with local authorities by emphasizing its social and environmental contributions in bidding processes.

- **Technical assistance and business support services** are also identified as an important enabler for cooperatives. Initiatives such as New York City's *Worker Cooperative Business Development Initiative* offer mentoring, workshops, and funding opportunities to strengthen cooperative governance and operations. By building capacity, these programs address skills gaps and foster entrepreneurial resilience within the cooperative ecosystem[443].

The report "Policies for Cooperative Ownership in the Digital Economy" by the Platform Cooperativism Consortium and the Berggruen Institute has examined government policies affecting collectively owned platforms in various regions. 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,” an approach that is reminiscent of approaches advocating a form of industrial policy[444].

2.3.6 Support for community participation in the development of digital goods and services

[443] OECD, “Platform Cooperatives and Employment: An Alternative for Platform Work,” OECD Local Economic and Employment Development (LEED) Papers, No. 2023/16 (Paris: OECD Publishing, 2023), https://doi.org/10.1787/3eab339f-en.

[444] 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/.

The adoption of Digital Commons by public institutions can serve as a tool to enhance transparency and build trust in public digital services by shedding light on the data they collect and how it is processed. This transparency empowers citizens and society to hold public sector organizations and policymakers accountable, allowing them to advocate for changes when necessary. A more recent trend goes beyond the adoption of open source or open data policies to create trust and considers that Digital Commons are also an opportunity for governments to co-create digital goods and services together with citizen communities. In this context, Digital Commons are mobilized for public policy purposes such as social or ecological goals for instance.

This trend can be observed for instance in the field of data governance. Data Commons initiatives, which facilitate collaboration among diverse stakeholders by pooling data under shared governance models, are gaining traction. While they are currently praised for their potential to drive economic growth and foster innovation, some activities and scholars consider Data Commons as more than just tools for data management and circulation and emphasize their historical role in empowering local communities with greater control over digital resources and **enhancing citizen participation and democratic engagement**[445].

Data Commons and citizen science initiatives have historically supported **public engagement in data collection and analysis, leveraging crowdsourcing methods** to gather insights across various sectors, from environmental monitoring to health data. Since the beginning these practices were based on the idea of knowledge as a commons and that citizen participation and empowerment were a goal in itself[446]. Early policies have integrated citizen science into formal frameworks, notably at international and national levels, to build bridges between science and the public. For instance, the International Science Council (ISC) has worked on creating frameworks to integrate citizen science data into official statistics and Sustainable Development Goals (SDGs) reporting, particularly for climate change and biodiversity monitoring[447]. The European Union's Horizon 2020 and Horizon Europe programs explicitly promote **citizen science projects**, such as the “Citizen Observatories” and “Doing It Together Science”. These initiatives fund projects that collect and apply citizen-generated data for public benefit, for instance for projects that support environmental monitoring and public health in the context of the EU’s Green Deal[448]. In the same vein, the EU-Citizen Science platform fosters collaboration across member states by providing a hub for citizens and researchers, encouraging engagement in data collection and science-driven solutions[449].

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[445] van Maanen, Gijs, and Charlotte Ducuing, and Tommaso Fia. 2024. "Data commons". Internet Policy Review 13 (2). DOI: 10.14763/2024.2.1748. https://policyreview.info/glossary/data-commons.

[446] Vohland, Katrin, Anne Land-Zandstra, Luigi Ceccaroni, Rob Lemmens, Josep Perelló, Marisa Ponti, and Katherin Wagenknecht, eds. The Science of Citizen Science. 1st ed. Cham: Springer, 2021. https://doi.org/10.1007/978-3-030-58278-4.

[447] Alex de Sherbinin et al., “The Critical Importance of Citizen Science Data,” Frontiers in Climate 3 (March 25, 2021), https://doi.org/10.3389/fclim.2021.650760.

[448] Bruno J Strasser and Muki Haklay, “Citizen Science: Expertise, Democracy, and Public Participation,” ResearchGate (Bern: Swiss Science Council SSC , September 2018), https://www.researchgate.net/publication/334361971_Citizen_Science_Expertise_Democracy_and_Public_Participation.

[449] EU-Citizen.Science consortium, “European Citizen Science Platform: About,” Eu-citizen.science, 2020, https://eu-citizen.science/about/.

At the national level, several countries have **incorporated citizen science into their policy frameworks**. Examples include Austria's explicit reference to Citizen Science in its national European Research Area (ERA) Action Plan, and the integration of Citizen Science into national research programs in Belgium and Romania. Slovenia has incorporated Citizen Science into its national Open Science action plan, while Belgium, Germany, and Hungary have established new practitioner networks or research centres dedicated to Citizen Science. Germany's Federal Ministry of Education and Research has supported citizen science since 2013, establishing the *Bürger schaffen Wissen* (Citizens Create Knowledge) platform, which hosts diverse citizen science projects. Austria has also integrated citizen science into its national ERA Action Plan, aligning these activities with broader national and EU objectives to enhance public engagement and educational outcomes in science[450]. Switzerland, too, promotes citizen science as a means to enhance democratic engagement, particularly in ecological and environmental monitoring, as endorsed by the Swiss Science Council (SSC). Local governments have also implemented citizen science programs that encourage collaboration between community groups and local authorities. For instance, Ireland's Local Agenda 21 Environmental Partnership Fund funds environmental projects that bring together civil society and local councils to address issues such as pollution and waste management[451].

More recent policy developments have focused on broadening the role of Data Commons and citizen science beyond academia to integrate them into government practices at multiple levels. Several examples of local initiatives demonstrate the benefits of involving citizens and academic institutions to build trust and ensure inclusivity in public policies[452]. Governments have started to **institutionalize collaboration with civil society for data collection**, often including such organizations in decision-making processes and strategies for data use. An international example is South Africa's framework for integrating citizen-based monitoring into government processes, which showcases how citizen-generated data can complement official statistics and support inclusive governance[453]. A significant example of this trend in Europe is the **partnership between the French National Institute of Geographic and Forest Information (IGN) and OpenStreetMap (OSM)**, where both entities share and maintain geographic data for public use in France. This collaboration demonstrates a successful model of public-commons cooperation, combining IGN's structured, official datasets with OSM's crowd-sourced, frequently updated mapping information. The outcome is a Data Commons that benefits from the strengths of both actors, making geographic information accessible and reliable for various stakeholders. This partnership underscores how Data Commons initiatives can bridge formal institutional knowledge and community-driven data,

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[450] Margaret Gold, "Mutual Learning Exercise on Citizen Science Initiatives – Policy and Practice" (Luxembourg: Publications Office of the European Union, 2023).

[451] Bruno J Strasser and Muki Haklay, "Citizen Science: Expertise, Democracy, and Public Participation," ResearchGate (Bern: Swiss Science Council SSC , September 2018), https://www.researchgate.net/publication/334361971_Citizen_Science_Expertise_Democracy_and_Public_Participation.

[452] Digital Commons Policy Council. Best Practices Guide for Digital Commons - Government Relations. DCPC/N&MRC, University of Canberra, 2024. https://doi.org/10.60836/tsx6-wc02.

[453] Matlala, Lesedi S. "Improving Citizen-Based Monitoring in South Africa: A Social Media Model." African Evaluation Journal 12, no. 1 (2024): 1-13. Accessed November 7, 2024. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S2306-51332024000100007&lng=en&nrm=iso. https://dx.doi.org/10.4102/aej.v12i1.719.

fostering an inclusive, transparent approach to data governance that enhances civic engagement and accountability[454].

The “Global Trends in Government Innovation” 2023 report[455] provides many examples across Europe of new ways of engaging citizens beyond data collection, in order to associate citizens in the design of public services and public policies:

- **Germany's Update Deutschland initiative** builds on the success of the “#WirVsVirus” hackathon, transforming COVID-19 recovery into a collaborative national laboratory. It addresses pressing community challenges such as loneliness and social inequality by testing and implementing hundreds of solutions through partnerships at all federal levels, emphasizing grassroots innovation and participation.

- In Lithuania, the **Create Lithuania Programme** introduced a Guide to Civic Participation in Public Space Projects in 2022. This step-by-step resource provides municipalities with a structured approach to co-designing spaces alongside citizens, drawing on international best practices and diverse expertise. The guide is actively being implemented across municipalities, training public servants and fostering meaningful civic engagement.

- **France’s Citizen Initiative Accelerator (AIC)**, launched in 2021, supports citizen-led projects that promote public good by offering six months of tailored assistance and building a network of administrative and civil society partners. The program fosters new collaboration models between the state and civil society, ensuring long-term sustainability through follow-up sessions, community building, and systematic evaluation.

- In Ukraine, **ReStart Ukraine** focuses on post-war recovery by co-creating tools to help municipalities plan reconstruction. Through data collection, risk mapping, and combining local and global expertise, the initiative emphasizes participatory and inclusive recovery. A pilot in Chernihiv showcased the effectiveness of this approach in fostering dialogue among diverse stakeholders and generating innovative recovery strategies tailored to local needs.

The **"Call for Commons" by ADEME (Agence de la Transition Écologique)** is a French initiative designed to support the development of Digital Commons that align with ecological and social objectives. Launched in 2021, the program is part of ADEME's broader strategy to foster sustainable digital solutions by encouraging open, collaborative approaches to addressing environmental challenges. The initiative emphasizes the creation and growth of shared resources, such as software, data, and methodologies, that are freely accessible and benefit the public. What sets the Call for Commons apart is its innovative approach to funding and collaboration. **Unlike traditional grant programs that encourage competition**

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[454] Renée Zachariou et al., “Guide Des Communs - Une Expédition OuiShare Au Coeur de L’IGN,” IGN (Paris: IGN/DIRCOM, October 2023) https://www.ign.fr/files/default/2023-10/guide_communs_ouishare.pdf.

[455] Organisation for Economic Cooperation and Development (OECD), “Global Trends in Government Innovation 2023,” OECD Public Governance Reviews (Paris: OECD Publishing, May 15, 2023), https://doi.org/10.1787/0655b570-en.

between applicants, this initiative fosters cooperation within ecosystems. Successful projects are selected not just for their individual merit but also for their potential to contribute to a broader, collective framework of commons. This includes support for collaborative governance structures, shared ownership models, and the development of networks that prioritize mutual benefit over market competition. By doing so, the initiative aims to strengthen ecosystems of collaboration and ensure long-term sustainability of the commons it supports[456].

Despite these advances, the shift toward citizen empowerment and community-driven governance presents several challenges. Sebastien Shulz discusses limitations within traditional co-production models, where resources are initially developed through collaboration but may lack inclusive, community-oriented governance structures. Moving towards "commonization"—where Digital Public Goods are managed under a community-based, commons structure—aims to ensure equitable access and long-term sustainability. However, this approach requires **a shift in control from original creators to a broader community, which can create tensions in decision-making and responsibility sharing**. Additionally, as governments increasingly institutionalize citizen-based data collection, concerns about data quality, resource management, and data sovereignty arise[457].

A case study analysis conducted in the context of this project has identified **various governance models that facilitate collaboration between public administrations and community-driven initiatives**. These models range from community-led governance, where external community maintainers independently manage projects (e.g., the Barcelona City Council and the Decidim Association), to co-governance structures, which share responsibilities in mixed frameworks, such as the European Open Science Cloud's tripartite model. Neutral public maintainers, like public research agencies and academic institutions (e.g., Inria for scikit-learn), can sometimes serve as impartial stewards of digital resources. In contrast, some public oversight models feature stronger governmental control, particularly in regulated domains such as public service delivery (e.g., OpenCoDE)[458].

While the analysis of these case-studies do not bring to light a single model for public-commons relations, show the potential of these collaborations **to be tailored to match the political sensitivity of sovereignty and security concerns**. Across all models, governments retain an **oversight role to ensure community-driven activities align with the public interest**, but their involvement can vary, as they sometimes act as maintainers, sustainers, users, or contributors. Depending on the context and governance approach, models of public support can include grants, calls for proposals, consortium building, public procurement, and even indirect aid such as staff support, office space, and access to infrastructure[459].

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[456] Labo Société Numérique (ANCT), "What Is a 'Appel à Communs'? A Look Back at ADEME's Innovative Initiative," Gouv.fr, 2023, https://labo.societenumerique.gouv.fr/en/articles/what-is-a-common-call-back-on-lademes-innovative-initiative/.

[457] 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.

[458] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

[459] Krewer, Jan, and Zuzanna Warso. "Digital Commons as Providers of Public Digital Infrastructures". Open Future Foundation, November 13, 2024. https://doi.org/10.5281/zenodo.14229950.

2.4 Intermediary Summary: Policies Supporting Digital Sovereignty

Beyond policies supporting Digital Commons as open global digital resources, this part of the report has analyzed policies supporting the collective management of critical digital resources to counter the dominance of large platforms and support digital sovereignty. Digital sovereignty can be interpreted as the capacity to set or influence rules governing digital communications and services, as the ability to have control over critical infrastructure without relying over on foreign technologies, but also as the ability of individuals, communities and organizations to have a self-determined use of the tools and systems that shape their digital lives.

Section 2.1 reviewed policies that mobilize Digital Commons, especially open standards, to increase their capacity to define, set, or influence rules governing digital communications and services. The political economy of the internet is increasingly shaped by concerns about dominant platforms and digital sovereignty, leading to the politicization of critical infrastructure and positioning interoperability and open standards as key areas of focus. Governments, particularly in Europe, have increased their involvement in standard-setting, as exemplified by the EU's 2022 Standardisation Strategy. In parallel, the EU has begun to establish internal initiatives, such as the Interoperable Europe Act (IEA), to harmonize public sector services across its member states. Regulatory frameworks such as the Digital Markets Act (DMA) also mandate third-party interoperability for gatekeeper platforms. Inspired by successful initiatives such as Europeana, the Nordic Institute for Interoperability Solutions (NIIS), and the European Open Science Cloud (EOSC), the EU aims to support Common European Data Spaces with data sharing rules co-defined by participating stakeholders.

Policies increasingly recognize Digital Commons, particularly OSS, as critical components of modern infrastructure and industrial strategies. Section 2.2 reviewed policies that mobilize this mode of production to stimulate and steer economic development. Successful examples include South Korea and China, which have supported domestic industries by investing in OSS. The EU is adopting similar strategies in areas like semiconductor design, cloud computing, artificial intelligence, and sustainable mobility, with initiatives such as RISC-V and Gaia-X. Private companies leverage Digital Commons to crowdsource innovation, set industry standards, and consolidate control. Similarly, governments focus on the interoperability and scalability of Digital Public Infrastructure (DPI) and Digital Public Goods (DPGs), collaborating with external stakeholders while maintaining control over norms and standards.

Section 2.3 reviewed policies that empower citizens and society through distributed ownership of critical digital resources. Governments increasingly recognize the importance of Digital Commons in maintaining essential technological infrastructure relied upon by states, industries, and individuals. Initiatives like the Sovereign Tech Agency map these dependencies and support Digital Commons while valuing their own governance models and respecting their independence. Similarly, the Next Generation Internet (NGI) fosters trust and decentralization by funding projects that promote interoperability and user control. Various local initiatives demonstrate how Digital Commons can offer alternatives to for-profit

platforms, such as platform cooperatives that ensure fair conditions for workers and greater control over intermediation services. In the field of open data, community and government approaches are increasingly blended. EU-supported projects like Citizen Observatories and partnerships such as the French IGN-OpenStreetMap integrate citizen-generated data into policymaking and public resources. Various governance frameworks are being tested across still scattered initiatives to balance public oversight with community ownership, ensuring equitable access, sustainability, and alignment with public interest goals.

Conclusion

The concept of Digital Commons encompasses a diverse range of systems and solutions that are collaboratively owned, developed, and maintained by communities rather than single entities. These commons operate on principles of peer collaboration rather than hierarchical control or market pricing. Initially emerging from grassroots efforts, many Digital Commons—such as Wikipedia and Apache—have **millions of everyday users**. Today, open source software (OSS) constitutes 76% of all software code, growing to **form the backbone of global digital infrastructures**.

Studies have estimated that OSS contributes €65–€95 billion to the EU's GDP, comparable to the air and water transport sectors combined. Globally, OSS's market value is estimated at 8.8 trillion dollars. Beyond software, Wikimedia Commons' images alone have been valued at 28.9 billion dollars. These numbers show the **performance of Digital Commons as a mode of production**. They have formed a stack of technologies that has become increasingly complex and intertwined, a stack on which everybody, from major tech companies, to governments, global industries and societies are dependent on.

Three Archetypes of Policy Approaches

This report outlines the evolving policy landscape surrounding Digital Commons in Europe for the past 20 years. The report identifies three archetypes of policies that reflect differing perspectives on Digital Commons. These categories illustrate how Digital Commons are framed and supported across various contexts:

Digital Commons as global open resources

Policies in this category emphasize Digital Commons as shared resources that transcend borders, promoting collaboration and open access to data, software, and knowledge. Milestones like the 2003 Directive on Public Sector Information Reuse and the European Commission's 2012 recommendation for open access to publicly funded research laid the groundwork for embedding openness into digital policy frameworks. These efforts emphasize the economic benefits of making information and knowledge accessible and aimed to support transparency and citizen empowerment.

Digital Commons as industrial infrastructure

The second set of policies emulates approaches by companies like Google and Tesla that have strategically leveraged Digital Commons to crowdsource research and innovation, set industry standards and consolidate control. European countries have begun embedding Digital Commons into industrial strategies, particularly in areas like AI, cloud computing, and microchip designs. Initiatives such as the EU's €270 million investment in the RISC-V project represent efforts to harness Digital Commons for technological independence and competitiveness.

Digital Commons as alternative institutions

The third type of policies also recognize Digital Commons as more democratic alternatives to market-driven or state-owned digital infrastructures, fostering transparency and civic engagement around the management of non-extractive technologies. Initiatives like Europeana and the European Open Science Cloud demonstrate how Digital Commons can underpin data sharing and collaboration across public institutions, private sectors and communities.

Over the past decade, policies have **shifted from an emphasis on open access toward governance and collective management of digital infrastructures**. This evolution reflects growing concerns about digital sovereignty, driven by events like the Snowden revelations, the centralization of power by dominant platforms, and global tensions around digital value chains, for instance regarding microchips. This shift also highlights the naivety of early open internet utopias, which prioritized the technical abundance of data and content while overlooking cognitive and social realities. Economists of immaterial public goods failed to consider the constraints of the attention economy, a cornerstone of the platform model, or the essential processes of learning and appropriation that underpin effective knowledge sharing. The report reveals the tensions between the ideals of openness and the realities of competition and power in the digital economy. It also observes that the collaboration between public institutions and Digital Commons does not follow a single model.

Tensions Between Openness and Digital Sovereignty

Openness remains a key element to advance digital sovereignty. The four freedoms of OSS for instance allows users to check software for vulnerabilities and to avoid vendor-lock, therefore providing them with greater control and autonomy over technologies.

The EU has historically championed principles of openness and collaboration, against a Hobbesian, conflict-driven view of cyberspace. The **EU's historical support for open internet principles,** or EU countries' investments in global shared digital resources, exemplified by their support for the Digital Public Goods Alliance, embody this ethos. Large technological projects like Galileo, the European GPS system, which emphasizes public standards, transparency, and the demilitarization of technological infrastructures also serve as prime examples. However, these ideals are increasingly challenged by global tensions, cybersecurity threats, and competition within digital value chains. For example, initiatives like Gaia-X reflect the EU's **struggles to balance the principles of open access and rules on state aid with the need to establish the conditionalities that support local ecosystems**. This delicate balancing act highlights the **tension between fostering global collaboration and safeguarding regional digital sovereignty**.

Additionally, the geographical establishment and governance of major open source foundations have become highly politicized in recent years. Examples include the creation of an independent Linux Foundation in Europe, China's establishment of the OpenAtom Foundation to support domestic platforms, or the restriction of GitHub access for Russian developers after the invasion of Ukraine. The relocation of the Risc-V Foundation to Switzerland, following U.S. concerns over Chinese involvement in the project, while the U.S. continues to promote open source in fields like 5G to counter Chinese technological

dominance, reflect the **strategic interplay between Digital Commons and national industrial interests**.

Emerging Models of Public-Commons Collaborations

New governance models are essential for guiding the development and management of next-generation digital infrastructures. Beyond resources, **institutions are seen as the decisive factor to enable long-term innovation and resilience**.

According to Marco Berlinguer, European policymakers have historically supported privatization and diminished the role of public institutions on technologies and technology standards. Consequently, public administrations often lack the capacity, incentives, and speed to address the complexities of evolving digital ecosystems. However, he claims that both Europe and China are currently spearheading innovative **strategies to reclaim sovereignty and foster economic development, blending standardization, modularity and Digital Commons.** Interoperability has emerged as a cornerstone of this strategy, enabling ecosystems that are transparent, trustworthy, and decentralized. The NGI initiative is a prime example of such a strategy. The NGI cascade funding - which is based on the disbursement of funding by intermediaries - shows the **need for public institutions that have technical skills and knowledge**, that allow them to **understand critical dependencies,** and to to effectively collaborate with Digital Commons on public priorities.

A case study analysis conducted in the context of this project has identified **various governance models that facilitate collaboration between public administrations and community-driven initiatives**. These models range from community-led governance, where external community maintainers independently manage projects (e.g., the Barcelona City Council and the Decidim Association), to co-governance structures, which share responsibilities in mixed frameworks, such as the European Open Science Cloud's tripartite model. Neutral public maintainers, like public research agencies and academic institutions (e.g., Inria for scikit-learn), can sometimes serve as impartial stewards of digital resources. In contrast, some public oversight models feature stronger governmental control, particularly in regulated domains such as public service delivery (e.g., OpenCoDE).

Across all models, governments retain an **oversight role to ensure community-driven activities align with the public interest**. Their involvement varies, acting as maintainers, sustainers, users, or contributors. Depending on the context and governance approach, models of public support can include grants, calls for proposals, consortium building, public procurement, and indirect aid such as staff support, office space, and access to infrastructure. Emerging governance models demonstrate the **potential of public-commons collaborations to be tailored to match the political sensitivity of sovereignty and security concerns**.

Key challenges for communities include **securing consistent funding for maintenance and governance processes** while navigating procurement rules or relying on project-based innovation support. Public administrations face **difficulties in ensuring stable support beyond initiatives driven by individual bureaucratic entrepreneurs, adapting to changes in political priorities, and fostering inclusive collaboration with large ecosystems without favoring specific actors**.

Recommendations on Current Gaps and Challenges

Mainstreaming Digital Commons into European policies

Digital Commons have demonstrated value in public sector modernization and as tools for fostering innovation and digital sovereignty. However, their integration remains uneven, with varying levels of maturity among member states. While some focus on adopting open source tools in public administration, others have begun embedding them strategically into production models and governance mechanisms. A consistent European approach should guide these efforts, enabling Digital Commons to complement markets and public institutions.

To effectively harness the potential of Digital Commons, it is essential to **integrate them more comprehensively into European policy frameworks**. This requires embedding the culture and practices of Digital Commons across all member states. The EU should incorporate Digital Commons metrics into European digital indicators to better track adoption and impact. It should also integrate them more into programs and policies that support research and innovation, the digital transformation of SMEs, industries and governments, or competitiveness. The EU should also build up public sector capacity to understand dependencies and collaborate with ecosystems by proactively supporting the establishment of Open Source Program Offices (OSPOs) at national levels to coordinate and implement Digital Commons strategies effectively.

Investing in technologies and the institutions that sustain them

To ensure the sustainability of Digital Commons, it is critical to support not only the technologies themselves but also the institutions that maintain and govern them. Successful examples of Digital Commons that have reached large scales have always established strong governance models. Similarly, European initiatives such as Europeana / the Common European Data Space for Cultural Heritage or the Open Science Cloud demonstrate the importance of institutional frameworks to achieve public goals.

Fragmented, short-term funding models, often focused on innovation, overlook the need for long-term maintenance and strategic development. The Sovereign Tech Fund provides a promising model, combining support for critical maintenance work with strategic investments in the individuals and institutions behind key digital infrastructure.

Scaling impact by increasing financial support and pooling resources

Current efforts to support Digital Commons in Europe often suffer from **fragmentation, with overlapping national projects and a lack of coordinated resource pooling**. This fragmentation limits their impact and leads to inefficiencies. Addressing these gaps requires enhancing collaboration among member states and pooling resources to maximize the collective benefits of Digital Commons initiatives. The collaboration between Estonia and Finland via the Nordic Interoperability Institute is a great example of the benefits of such a

pooling of resources. Announcements of collaboration on sovereign office suites between European countries highlight this trend.

The EU should establish **mechanisms for better coordination and resource integration, such as long-term institutional frameworks like a Digital Commons European Digital Infrastructure Consortium (DC EDIC)**. Such institutions should create a strong dialogue with Digital Commons communities and private stakeholders supporting Digital Commons in Europe. It should also implement new funding approaches, like the “call for commons” model, which emphasizes collaboration over competition, and provide stable, long-term grants to sustain and scale Digital Commons ecosystems

Mobilizing Digital Commons to achieve the green transition

European policies have begun leveraging Digital Commons as a tool for industrial policies to achieve technological objectives, enhance competitiveness, and promote technological independence. While these efforts should be expanded, it is crucial to **ensure that such policies address broader public policy goals, not just technological outcomes**.

Digital Commons offer a significant opportunity to advance the EU’s green transition by fostering open, collaborative platforms for developing and sharing environmentally friendly technologies. However, their potential remains underutilized. Despite advantages like accessibility, adaptability, and innovation, their integration into environmental policy frameworks has been limited. A notable example is the "Commons Fabrics" initiative by France's environmental agency ADEME, which uses collaboration to address systemic issues, such as mobility, and drive transformative change.

The EU should establish **a digital ecosystem that supports technological progress while aligning with its sustainability objectives**. To achieve this, Digital Commons should be strategically integrated into green policies and initiatives, including the development of Open Source Hardware, the right to repair, eco-patents, and energy-efficient data solutions.

Abbreviations

AI	Artificial Intelligence
API	Application Programming Interface
BOAI	Budapest Open Access Initiative
CC	Creative Commons
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CERN	European Organization for Nuclear Research
DGA	Data Governance Act
DMA	Digital Markets Act
DNS	Domain Name System
DPGA	Digital Public Goods Alliance
DPI	Digital Public Infrastructure
DSA	Digital Services Act
EC	European Commission
EDIC	European Digital Infrastructure Consortium
EIF	European Interoperability Framework
EOSC	European Open Science Cloud
ERA	European Research Area
ETSI	European Telecommunications Standards Institute
EU	European Union
EUPL	European Public Licence
FLOSS	Free Libre Open Source Software
FOSSA	Free and Open Source Software Auditing program
FOSSEPS	Free and Open Source Solutions for European Public Services
FRAND	Fair, Reasonable, and Non-Discriminatory
FSF	Free Software Foundation
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GLAM	Galleries, LIbraries, Archives and Museums
GPL	General Public License
HTTP	Hypertext Transfer Protocol
IAB	Internet Architecture Board
ICANN	Internet Corporation for Assigned Names and Numbers
ICT	Information and Communication Technology
IEA	Interoperable Europe Act
IEEE	Institute of Electrical and Electronics Engineers

IETF	Internet Engineering Task Force
IGF	United Nations Internet Governance Forum
INRIA	French Institute for Research in Computer Science and Automation
IoT	Internet of Things
IP	Internet Protocol
IPCEI	Important Project of Common European Interest
ISA	Programme on interoperability solutions for European public administrations
ISA2	Programme on interoperability solutions and common frameworks for European public administrations, businesses and citizens
ITU	International Telecommunication Union
MIT	Massachusetts Institute of Technology
MOOC	Massive Open Online Course
NGI	Next Generation Internet
NIIS	Nordic Institute for Interoperability Solutions
OA	Open Access
OECD	Organisation for Economic Co-operation and Development
OER	Open Education Resource
OGP	Open Government Partnership
OKF	Open Knowledge Foundation
OSH	Open Source Hardware
OSHWA	Open Source Hardware Association
OSI	Open Source Initiative
OSOR	Open Source Observatory
OSPO	Open Source Program Office
OSS	Open Source Software
PSI	Public Sector Information
RISC	Reduced instruction set computer
SDG	Sustainable Development Goal
SME	Small and medium-sized enterprises
TCP	Transmission Control Protocol
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
W3C	World Wide Web Consortium
WSIS	United Nations World Summit on the Information Society
WWW	World Wide Web