Platformisation of Science: Conceptual Foundations

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Abstract

The digital platforms we are dealing with in this article are auxiliary tools that do not produce anything themselves but provide an infrastructure for service providers and users to meet. They have potentially unlimited scaling potential and have become the central places of exchange. In academia, we can also observe that research and its communication become more digital and that digital services are aiming to become platforms. In this article we explore the concept of digital platforms and their potential impact on academic research, firstly addressing the question: To what extent can digital platforms be understood as a specific type of research infrastructure?

We draw from recent literature on platforms and platformisation from different streams of scholarship and relate them to the science studies concept of research infrastructures, to eventually arrive at a framework for science platforms. Secondly, we aim to assess how science platforms may affect scholarly practice. Thirdly, we aim to assess to what extent science is platformised and how this interferes with scientific understandings of quality and autonomy. At the end of this article, we argue that the potential benefits of platform infrastructure for academic pursuits cannot be ignored, but the commercialization of the infrastructure for scholarly communication is a cause for concern. Ultimately, a nuanced and well-informed perspective on the impact of platformisation on academia is necessary to ensure that the academic community can maximize the benefits of digital infrastructures while mitigating negative consequences.

1. Introduction

The origin of the term "platform" can be traced back to the Middle French "plate-forme", which was defined as a level surface or a raised area along a railway track that enables passengers to access the trains. This definition emphasises the supportive role of platforms, serving as a structure for the operation of products or services, rather than creating something themselves (Belli, 2021). Likewise, the digital platforms we are dealing with in this article are auxiliary tools that do not produce anything themselves but provide an infrastructure for service providers and users to meet. However, unlike non-digital infrastructures such as train stations, digital platforms have potentially unlimited scaling concerning, for instance, their user base, data volume, technical features and geographic reach, rendering them more useful the more people use them (see on the difference between digital and non-digital platforms (de Reuver et al., 2018, pp. 126–127; Yoo et al., 2012).

For certain functions of social life, digital platforms have become the central places of exchange. Examples of such platforms include marketplaces (e.g., amazon, Alibaba, or eBay), social networking sites (e.g. Twitter, Instagram, or Tiktok), search engines (e.g., YouTube, Google, or Baidu), or payment systems (e.g., PayPal, Amazon Pay, or Skrill). In academia, we can also observe that research and its communication become more digital and

that digital services are aiming to become platforms (Fecher et al., 2021; Owen, 2006; Pleskach et al., 2020; for an overview of the literature see da Silva Neto & Chiarini, 2023). However, what effects this looming platformisation brings in science and what potential benefits and harms follow, remain unclear.

Given the increasing significance of digital platforms in scientific inquiry and their influence on the social structure of research, it is imperative to formulate a robust conceptual framework of digital science platforms. The extant literature on scientific digital platforms, however, exhibits a narrow focus on particular scientific practices and lacks a clear-cut definition of this phenomenon (for an overview see da Silva Neto & Chiarini, 2023).

Here, we explore the concept of digital platforms and their potential impact on academic research. To clarify the concept of platforms, we first address the question: To what extent can digital platforms be understood as a specific type of research infrastructure? To this end, we draw from recent literature on platforms and platformisation from different streams of scholarship and relate them to the science studies concept of research infrastructures, to eventually arrive at a framework for science platforms. Secondly, we aim to assess how science platforms may affect scholarly practice. To this end, we relate common platform practices to scientific practice. Thirdly, we aim to assess to what extent science is platformised and how this interferes with scientific understandings of quality and autonomy.

At the end of this article, we argue that the potential benefits of platform infrastructure for academic pursuits cannot be ignored, but the commercialization of the infrastructure for scholarly communication is a cause for concern. Studying the effect of platformisation and developing a well-informed perspective on its effects on academia can help understand and predict the benefits and risks for the academic community.

2. Science Platforms as a Research Infrastructure

In the field of science studies, infrastructures are widely understood as sociotechnical systems that match between the routines of work practice, technology, and wider-scale organizational resources. For instance, Bowker and Star (1999) argue that infrastructures are intertwined with other structures of

social arrangements and technologies, and support communities of practice (cf. Bowker & Star, 1998). In that line, Edwards et al. (2013) describes infrastructures as ecologies or complex adaptive systems that incorporate technological standards, social practices, and norms. Blanke and Hedges (2013) further explore the bottom-up nature of infrastructures, arguing that this understanding is crucial for an infrastructure to meet the needs of its users adequately. Hanseth et al. (1996) propose that infrastructures rely on a degree of standardization and compatibility if they are to function effectively (see also Larkin, 2013).

Given this context, one can assert that digital platforms serve as essential research infrastructures. They embody sociotechnical structures, support communities of practice, and integrate societal norms and values. The key characteristic defining these platforms as infrastructures lies in their intricate social and technical connectivity.

Technical connectivity emphasizes the role of platforms as an architecture that allows for vertical and horizontal integration of services, and ultimately for scaling. Unlike non-digital platforms that utilize a "stable core" and a "variable periphery" to achieve flexibility, digital platforms achieve this through coupled and reprogrammable interfaces between the platform and its complementors (Baldwin & Woodard, 2009). This is facilitated by the use of Application Programming Interfaces (APIs) and Software Development Kits (SDKs), which enable data flow with third parties and the integration of software with platform infrastructures (Bodle, 2011; Helmond et al., 2019; Poell et al., 2019). Such interconnectedness among platforms is what forms the basis for a platform ecosystem to emerge (Srnicek, 2017). As described by Gillespie and Helmond, platforms serve as programmable infrastructures that other software can be built upon and run. In that line, Tiwana (2014) defines digital platforms as "the extensible codebase of a software-based system that provides core functionality shared by apps that interoperate with it, and the interfaces through which they interoperate."

Social connectivity, on the other hand, emphasizes the role of platforms as intermediaries, linking different sets of users through their social infrastructure. Economists describe digital platforms as "multi-sided markets," bringing together different groups of users and producers (Rochet & Tirole, 2003). While platforms exist in the offline world, such as train stations, the difference in the digital world is their lack of physical and geographical limitations

(European Commission, 2016). As noted by Gillespie (2010), platforms provide the "architecture from which to speak or act". They are a "programmable digital architecture designed to organize interactions between users" (Van Dijck et al., 2018). In essence, the social connectivity of digital platforms is a key feature that enables them to function as intermediaries, linking different sets of users and thus creating multi-sided markets.

Da Silva Neto and Chiarini (2023) provide an insightful historical overview of scientific digital science platforms and a typology that includes a) associating scientific digital platforms with specific social subsystems, b) phases in the research system, and c) their integration into the research process. We find this third dimension particularly illuminating concerning the notion of platformisation. We argue that it signifies a comprehensive and continuous integration of platforms into the research process, ultimately leading to the execution of specific practices exclusively through the platform infrastructure, making them inherently "platformised". The mediating function of platforms between diverse social subsystems furthermore presents a salient perspective to examine the political economy of platformisation. However, it is in our view not a decisive factor in classifying digital science platforms, which can be identified as such even if they focus solely on the social organization of scientific pursuits. In our view, the defining features of digital science platforms are their social and technical connectivity and hence their capacity to scale in related areas such as human resources, data volume, technical features and geographical reach.

Our understanding of digital platforms implies that they go beyond providing administrative systems or individual tools to enhance research activity, they create space for technical scalability – that is an increasing volume of stored data, or number of functions generated by users or developed based on user-generated data; and at the same time for social scalability – in increasing the number of users, their diversity and geographical reach. To give an example, we consider disciplinary repositories primarily as a research infrastructure, but not a platform as it does not cover sociotechnical scalability to its full extent – in most cases they do not provide space for interaction and enhancement of their functionality based on user-input. On the other hand, services as offered by "Elsevier tools and databases" can be considered as a commercial platform as they offer instruments to design, amend research activities throughout the research cycle (analysis, adjustment of workflows). Similarly, the EOSC (European open science cloud) can be considered as a

platform, because apart from research data exchange, it offers not only space for data storage, but also tools for publication, analysis, broadening and improving its capabilities with the increasing number of users and their contributions.

3. Platform Practices and Scientific Practice

As sociotechnical systems, digital platforms are characterised by a symbiotic relationship between their technical and social connectivity. The interdependence of these two components is a fundamental aspect of platforms that gives rise to three core practices: 1) scaling, 2) standard-setting, and 3) integration of user data for setting up functionalities. By looking at what platforms do generally, we might better understand what they might do to the social and technical organization of science. In the following parts, we will briefly describe how each practice manifests on digital platforms in general and then introduce some examples from science.

3.1. Scaling

We understand scaling as the ability of platforms to systematically increase its potential in several areas relating to human and technical resources, such as the rising number of user requests; diversity of users (geographical reach); or adding technical features and data volume. Taken together all these factors enable productive growth within the platform setup (Bondi, 2000; Hill, 1990). The ability to scale highlights differences between analogue and digital platforms in that the computational infrastructure allows for reinforcing economic effects in unprecedented ways, leading to "explosive growth" (OECD, 2019). Notably, scaling (horizontal and vertical) (Michael et al., 2007) assumes that expansion and growth is possible without changing the nature of the scalable element or framework of the system that is meant to be expanded (Tsing, 2012). Horizontal scaling means adding more resources and services to a platform to increase its capacity, while vertical scaling involves giving more power to specific elements of the platform. The process of scaling in general assumes that it is possible to increase the capacity of the system without altering its essential characteristics or framework. From a user perspective, scaling creates direct and indirect network effects: with

an increasing number of users, the usefulness of a service increases (Katz & Shapiro, 1985; Shapiro & Varian, 1998).

The possibility to scale digital platforms has various implications for scientific practices. For example, on data collection and sharing, it allows for greater efficiency and reach. By means of vertical scaling the number of users and publications can increase which leads to improvement of searching algorithms and gives additional possibilities of building networks. Horizontal scalability can enhance machine readability of particular articles and their metadata, adding details to user profiles which can therefore alter the way content and scientists are found in comparison to other digital resources that work with a more limited dataset.

One of the most prominent current examples of how scalability works are the services provided by Elsevier. Generally, Elsevier offers a central point in research, allowing it to find and analyse data from thousands of publishers and giving access to its own journals. This way a great number of data sources are combined in one place and this gives researchers the possibility to make use of them from one point of access. A noteworthy example in this context is the service Mendeley that helps storing, organising and sharing research content. Based on one's own defined interests and saved publications, this service creates an individual profile that helps connecting with other researchers that work on a similar topic. Thus, theoretically, the more registered users, the higher the choice of potential collaborators in your field. Another relevant service in this context is ScienceDirect, a platform that provides researchers with new data and articles that are being published in their fields. It gives the opportunity to disseminate their research to the services' audience. The more articles are being published and the more researchers register, the wider the audience.

Another prominent example in this sense is the Latin America non-profit organisation AmeliCA which is a multi-level communication infrastructure for open science. As an infrastructure and platform, it supports independent open access publishing, especially in the Global South, by aggregating data and articles in a journal index, providing open and reusable publishing technology (XML markups suite) and training materials for advanced and independent scholarly publishing. The journal index shows which journals are available in the region, describes them and consolidates their articles on one platform. This qualifies as an example of horizontal scalability, because

it increases the impact of a journal by making it easier to find for scientists either to publish or to use its materials for their own research. At the same time, the platform adds more journals and respectively more articles and therefore proves the point of horizontal scalability. Similarly, multi-journal, CMS based national publishing platforms in the Netherlands (https://open-journals.nl/), Denmark (https://tidsskrift.dk/), Sweden (https://publicera.kb.se/) or Finland (https://journal.fi/) combine several publishing services, e.g. hosting and maintenance of journal infrastructure, providing PIDs and structured metadata, archiving and long-term storage of content, trainings in order to professionalise editorial processes, assistance with migration of content and registration in quality indexes (e.g. DOAJ) and, through the platform itself, several networking and outreach opportunities.

Other types of services that benefit from a growing number of users are social networks for researchers such as academia.edu or ResearchGate that help researchers to share publications, ask and answer questions as well as collaborate with other researchers. Naturally, the more researchers use the tool the more opportunities they get to create new partnerships and collaborations.

3.2. Standard Setting

The *Standard setting* is a key practice of digital platforms which entails the formalisation of both social and technical interactions. In essence, the role of platforms is to organise and structure information according to established arrangements and user-generated content, while providing the means to channel and measure it. This process of standardisation can be achieved through various means such as regulatory measures, including usage licenses, terms of service, and privacy policies. Technical standards are established through the use of metadata standards, APIs (Application Programming Interfaces), and SDKs (Software Development Kits), which allow for seamless integration and interaction with the platform. Social standards can be enforced through various means such as character limits, design elements, and time limits, which ensure a consistent user experience. Ultimately, standardisation on platforms helps to ensure uniformity, reliability, and efficiency, which are essential for the continued growth and success of digital platforms.

Standard setting is highly relevant to scientific practice, especially when it comes to data sharing and replicability. By providing established

arrangements and technical standards, digital platforms can help to ensure uniformity, reliability, and efficiency in scientific data sharing and exchange, ideally promoting greater transparency and reproducibility in scientific research. These practices of standardisation can be best witnessed in key areas that deal with archiving, distributing and indexing of scholarly content. Infrastructures such as open access repositories rely heavily on the usage of standardised metadata in order to properly deposit articles, books, data etc. Accordingly, data models (e.g. Dublin Core Metadata Element Set), principles (e.g. FAIR principles) and key indicators (e.g. the identifiers DOI, ORCID, ROR ID) all contribute to establishing a recognisable set of elements that gives discovery platforms (e.g. Web of Science) and community registries (e.g. DOAJ) its respective impact in the 'market of metrics'.

Particularly, the FAIR principles (GO FAIR, 2023) provide a common set of standards for data management and sharing that promotes consistency across different research projects and organisations. This makes it easier for researchers to access and use data from multiple sources, and it ensures that data – for instance research papers and research data, but also personal identification markers of researchers – is available in a consistent format, reducing the potential for errors and misinterpretations. Another level of standardisation touches upon the analysis of a research publications' content, not only metadata. This is illustrated by the project DeepGreen which basically represents a "data hub" that collects articles that are published in open access or can be published in open access via the green route. This service creates an excerpt of publications with the support of publishers and makes it then available in institutional or disciplinary repositories.

3.3. Use of user Data

The *use of user data* is a critical component of digital platforms, which rely on user traces and behavioural metadata to optimise their services. As "re-programmable software systems", platforms can collect vast amounts of data generated by users and are highly dependent on them as users are main contributors to maintaining social connectivity.

This data collection is facilitated by a variety of tools, including apps, plugins, sensors, and trackers that provide further insights into user behaviour (Gerlitz et al., 2019; Nieborg & Helmond, 2019; Poell et al., 2019). The

systematic collection and processing of user data has been widely documented in the literature, with scholars highlighting the crucial role played by such data in shaping the design and functionality of digital platforms (Helmond, 2015; Langlois & Elmer, 2013; Plantin et al., 2018; Poell et al., 2019). Although these practices are not unique to digital platforms, they emerge reliably in the digital setup and "their combination can magnify each of them" (OECD, 2019).

In recent years, academic publishers have modified their business models from content provision to data analytics, which involves the tracking of the usage data generated by researchers to assemble profiles of academic behaviour based on search requests, page visits, accesses, downloads (DFG-Committee On Scientific Library Services And Information Systems, 2021). The systematic collection and processing of user data has been widely studied in the literature, with scholars highlighting the crucial role played by such data in shaping the design and functionality of digital platforms. This trend particularly has implications for scientific practices, as digital tools can be adapted to user needs and become more effective through the analysis of user data.

Elseviers' services ScienceDirect and Mendeley can also be an example of how user analytics influence their operation and adapt it to the needs of users. Another prominent example is Elseviers' research and information management system PURE that brings together userdata from multiple sources, in order to "gain a comprehensive overview of all your research activities, collaborate beyond borders, maximise funding opportunities, promote open science activities and showcase the impact of your institution's achievements to the world" (https://www.elsevier.com/solutions/pure). From the behavior of millions of researchers that are using Elseviers' tools, the services can track and analyse how long they spend on a website, which search terms they use and which formats are being accessed most often. This information can be used to personalise the content and recommendations that users receive, ensuring that they are presented with information that is most relevant to their needs. Furthermore, by analysing user data, a service can identify which research topics are most popular among users. This information can be used to set the agenda for future research. Also, by analysing search queries, the services can identify where the search functionalities can be improved, for example, by adding new filters.

User data can also influence the implementation of a technical tool. In a study about digital research infrastructures (Fecher et al., 2021), the maker of the service Scholarly, which is an AI-based online tool that summarises research papers and can create direct links to cited publications, describes how he developed the tools' features in an iterative style, collecting feedback from users and adapting it respectively to their needs.

4. Political Economy of Science Platforms

While we use "platform" as a value-free term, "platformisation" implies a change in cultural and social practice that a platform promotes and responds to and furthermore a penetration of platform's technical extensions into the web and the process in which third parties make their data and architecture "platform-ready" (Helmond, 2015). The aim of this section is to trace and discuss the changes induced by platformisation in science. All three platform practices have important advantages for science, especially in terms of efficiency; on the other hand they also present severe risks.

To begin with, one of the consequences of platformisation practices as shown above is a stronger harmonisation or uniformisation of standards. This comes with clear advantages for research: In a fragmented landscape of science-related digital infrastructure, more uniform standards have the potential to promote transparent governance, efficient communication, and the smooth flow of data, rendering research overall more convenient and efficient (see e.g. Schonfeld, 2018). On the other hand, the need for compliance with platform standards can have negative repercussions for epistemic diversity. Strict adherence to design, layout, workflow, business models, and pricing structures may not always align with user interests (Helmond, 2015). The drive for uniformity can hinder innovation, limit the variety of discovery systems and research infrastructures, and constrain the development of a biblio-diverse ecosystem (de Reuver et al., 2018). Therefore, it is essential to balance the benefits of standardisation with the need for diversity to enable platform users to achieve their full potential.

The use of user data to improve services and make them more convenient is one of the core features of digital platforms and indeed a common explanation for their success. It establishes the basis for the personalisation and

algorithmic curation of internet searches and content suggestions. This has the advantage of making research faster and more convenient, thus increasing efficiency, for example through individualised reading suggestions based on search histories (see also DFG, 2021 at 4). Despite its clear benefits regarding the usability of services, the use of user data remains a highly contested area in the study of digital platforms. The turn of publishers to the data analytics business has made it clear that science is "no special case on the internet" (Reuter & Söllner, 2022). Criticism of the practice of "surveillance publishing" (Pooley, 2022) concerns privacy rights, informational self-determination, and academic freedom, for the massive collection and analysis of user (meta) data may facilitate science espionage as well as state surveillance of researchers in authoritarian states and beyond (DFG, 2021). Another much-discussed concern in relation to the use of data in general is the perpetuation of existing biases and inequalities (Wachter-Boettcher, 2017). The issue of filter bubbles and echo chambers and their potentially detrimental effect for freedom of opinion and expression as a cornerstone of democracy has extensively been discussed in the context of media (Khan, 2022; more differentiated Bruns, 2019).

The ability of platforms to *scale* has obvious advantages: Scalable platforms have great potential for scientific research, particularly in terms of speed, accessibility, and discoverability of results. Furthermore, as the above-described example of AmeliCA shows, platformisation bears the potential to work against the fragmentation of scholarly infrastructure and build a "supercontinent of scholarly publishing" (Schonfeld, 2018). For individual users, horizontal integration, leading to services that are "conveniently bundled" (DFG, 2021), could make research more efficient. For those running and maintaining research infrastructure, one can imagine that the net effect of the use of multi-level and multi-service publishing platforms is a significant reduction of research, opportunity, development, and distribution costs. Given the centralised structure and interoperability of these platforms, discovering, indexing and distributing content is made possible with little to no extra work by individual journal publishers (Wrzesinski et al., 2021). At the same time, resources for new and emerging publishing technologies can be pooled and more innovative solutions be developed – examples such as a frequently requested single source publishing suite (Borchert & Hoffmann, 2022) or a smooth integration of collaborative editing and review in existing editorial management systems are proof of that. In the for-profit area, however, the ability of platforms to scale raises significant concerns about

an emerging "knowledge industry" (Burgelman, 2021) and the perpetuation of the "oligopoly" of a handful of powerful players (Larivière et al., 2015). Chen et al. (2019) show that globally leading publishers, especially Elsevier, already acquired research infrastructure all along the research cycle. This danger has also been recognised in the latest version of the Budapest Open Access Initiative which recommends the use of research infrastructure "that minimises the risk of (…) corporate control." (Budapest Open Access initiative [BOAI], 2022).

5. Platformisation and Scientific Values

It can be assumed that platforms, as a special form of infrastructure, will continue to penetrate the practice of research, and therefore it is necessary to address the implications of this platformisation for the normative structure of science. Our assumption is that platformisation fundamentally affects the normative structure of science, and that there is a certain ambiguity inherent in the question of whether these implications are good or bad. A good reference point is the Mertonian principles, which provide a normative structure of science as a system. (Merton, 1973) Applied to the platform context, the five principles have certain ethical implications.

1. Regarding communalism, platforms may lower search costs and improve access to scientific content, but they may also introduce new intellectual property regimes that determine who owns the content on a platform. This could potentially have implications for the communal ownership of scientific findings and the public domain nature of science. High subscription prices to use platforms may furthermore perpetuate existing and even lead to new exclusions in the scientific community.

2. In terms of *universalism*, platforms can lower transaction costs and make scientific content more accessible, potentially contributing to more inclusivity in the scientific system. However, platforms may also standardise scientific statements, enforce formats that are unfamiliar to certain epistemic cultures, and shape the way scientific knowledge is produced and disseminated.

3. In terms of commercialisation, platforms may serve the interests of their providers, which may not always align with the scientific rationale of disinterestedness and contradict the ideal of objective science,

primarily interested in the pursuit of truth. The opacity of the algorithms used may introduce biases and steer research processes without sufficient awareness of users. This could introduce potential conflicts of interest in the production and dissemination of scientific knowledge. Taken from the general debate evolving around platform economies, commercial players are mostly interested in attracting more users to their platforms and mobilising them to contribute in ways that maintain practices and topics that are best suited to the interest of the majority of users.

4. Platforms could foster *originality*, as they allow for people and ideas to meet; however, they could also limit originality by reproducing biases, standardising the production of knowledge and making representation of knowledge more uniform.

5. Platforms can potentially increase transparency by inscribing scientific values in their legal and technical norms and standards, serving as a base for *skepticism*. However, if researchers are unable to access or comprehend the technical workings of a platform, it could potentially restrict their skepticism.

In conclusion, while platformisation may bring benefits such as increased accessibility and transparency for scientific knowledge and speed of discovery, it also poses significant challenges to the values and autonomy of science. It is crucial for science policy to take a proactive approach in regulating platforms and investing in public interest infrastructure to safeguard the integrity of scientific research. By doing so, we can ensure that the potential of platformisation to enhance scientific progress is realised while avoiding its pitfalls.

References

Baldwin, C. Y., & Woodard, C. J. (2009). The architecture of platforms: A unified view. In A. Gawer (Ed.), *Platforms, markets and innovation* (pp. 19–44). Edward Elgar Publishing. https://doi.org/10.4337/9781849803311

Belli, L. (2021). Platform. In L. Belli, N. Zingales, & J. Curzi (Eds.), *Glossary of platform law and policy terms* (1st ed., pp. 239–242). FGV Direito Rio.

Blanke, T., & Hedges, M. (2013). Scholarly primitives: Building institutional infrastructure for humanities e-Science. *Future Generation Computer Systems*, *29*(2), 654–661. https://doi.org/10.1016/j.future.2011.06.006

Bodle, R. (2011). Regimes of sharing, information. *Communication & Society*, *14*(3), 320–337. https://doi.org/10.1080/1369118X.2010.542825

Bondi, A. B. (2000). Characteristics of scalability and their impact on performance. *Proceedings of the 2nd International Workshop on Software and Performance (September 2000)* (pp. 195–203). https://doi.org/10.1145/350391.350432

Borchert, C., & Hoffmann, A. (2022). Open-Access-Publikationen mit OS-APS medienneutral und mit automatisiertem Corporate Design erstellen. *o-bib. Das offene Bibliotheksjournal / Herausgeber VDB*, *9*(4), 1–19. https://doi.org/10.5282/O-BIB/5859

Bowker G. C., & Star S. L. (1998). Building information infrastructures for social worlds—The role of classifications and standards. In I. Toru (Ed.), *Community computing and support systems, social interaction in networked communities* (pp. 231–48). Springer. https://doi.org/10.1007/3-540-49247-X_16

Bowker, G. C., & Star, S. L. (1999). *Sorting things out: Classification and its consequences* (First paperback edition). MIT Press.

Bruns, A. (2019). *Are filter bubbles real?* John Wiley & Sons.

Budapest Open Access initiative [BOAI]. (2022). *The Budapest open access initiative: 20th anniversary recommendations*. https://www.budapestopenaccessinitiative.org/boai20/

Burgelman, J.-C. (2021, January 20). *Scholarly publishing needs regulation*. ResearchProfessional News. https://www.researchprofessionalnews.com/rr-news-europe-views-of-europe-2021-1-scholarly-publishing-needs-regulation/

Chen, G., Posada, A., & Chan, L. (2019). Vertical integration in academic publishing. In L. Chan & P. Mounier (Eds.), *Connecting the knowledge commons — From projects to sustainable infrastructure*. OpenEdition Press. https://doi.org/10.4000/books.oep.9068

da Silva Neto, V. J., & Chiarini, T. (2023). The platformization of science: Towards a scientific digital platform taxonomy. *Minerva*, *61*(1), 1–29. https://doi.org/10.1007/s11024-022-09477-6

de Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: A research agenda. *Journal of Information Technology*, *33*(2), 124–135. https://doi.org/10.1057/s41265-016-0033-3

DFG-Committee On Scientific Library Services And Information Systems. (2021). *Data tracking in research: aggregation and use or sale of usage data by academic publishers. A briefing paper of the Committee on Scientific Library Services and Information Systems of the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)* [Report]. Zenodo. https://doi.org/10.5281/ZENODO.5937995

Edwards, P. N., Jackson, S. J., Chalmers, M. K., Bowker, G. C., Borgman, C. L., Ribes, D., Burton, M., & Calvert, S. (2013). *Knowledge infrastructures: Intellectual frameworks and research challenges*. The University of Michigan Library. https://hdl.handle.net/2027.42/97552

European Commission. (2016). *Online platforms accompanying the document communication on online platforms and the digital single market. Commission Staff Working Document {COM(2016) 288 final*. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016DC0288

Fecher, B., Kahn, R., Sokolovska, N., Völker, T., & Nebe, P. (2021). Making a research infrastructure: Conditions and strategies to transform a service into an infrastructure. *Science and Public Policy*, *48*(4), 499–507. https://doi.org/10.1093/scipol/scab026

Gerlitz, C., Nieborg, D. B., van der Vlist, F., & Helmond, A. (2019). Apps and infrastructures: A research agenda. *Computational Culture*, *7*. http://computationalculture.net/apps-and-infrastructures-a-research-agenda/

Gillespie, T. (2010). The politics of 'platforms'. *New Media & Society*, *12*(3), 347–364. https://doi.org/10.1177/1461444809342738

GO FAIR. (2023). *FAIR Principles*. https://www.go-fair.org/fair-principles/

Hanseth, O., Monteiro, E., & Hatling, M. (1996). Developing information infrastructure: The tension between standardization and flexibility. *Science, Technology, & Human Values*, *21*(4), 407–426. https://doi.org/10.1177/016224399602100402

Helmond, A. (2015). The platformization of the web: Making web data platform ready. *Social Media + Society*, *1*(2). https://journals.sagepub.com/doi/10.1177/2056305115603080

Helmond, A., Nieborg, D. B., & van der Vlist, F. N. (2019). Facebook's evolution: development of a platformas- infrastructure. Internet Histories. *Digital Technology, Culture and Society*, *3*(2), 123–146. http://dx.doi.org/10.25969/mediarep/14025

Hill, M. D. (1990). What is scalability? *ACM SIGARCH Computer Architecture News*, *18*(4), 18–21. https://doi.org/10.1145/121973.121975

Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *The American Economic Review*, *75*(3), 424–440. https://www.jstor.org/stable/1814809

Khan, I. (2022). Reinforcing media freedom and the safety of journalists in the digital age. Report of the Special Rapporteur on the promotion and protection of the right to freedom of opinion and expression. United Nations, Human Rights Council. https://digitallibrary.un.org/record/3973716?ln=en

Langlois, G., & Elmer, G. (2013). The research politics of social media platforms. *Culture Machine*, *14*. https://culturemachine.net/wp-content/uploads/2019/05/505-1170-1-PB.pdf

Larivière, V., Haustein, S., & Mongeon, P. (2015). The oligopoly of academic publishers in the digital era. *PLoS One*, *10*(6), e0127502. https://doi.org/10.1371/journal.pone.0127502

Larkin, B. (2013). The politics and poetics of infrastructure. *Annual Review of Anthropology*, *42*, 327–343.

Merton, R. K. (1973). The normative structure of science. In R. K. Merton (Ed.), *The sociology of science: Theoretical and empirical investigations* (pp. 267–280). University of Chicago Press.

Michael, M., Moreira, J. E., Shiloach, D., & Wisniewski, R. W. (2007). Scale-up x scale-out: A case study using Nutch/Lucene. *2007 IEEE International Parallel and Distributed Processing Symposium*, 1–8. https://doi.org/10.1109/IPDPS.2007.370631

Nieborg, D. B., & Helmond, A. (2019). The political economy of Facebook's platformization in the mobile ecosystem: Facebook Messenger as a platform instance. *Media, Culture & Society*, *41*(2), 196–218. https://doi.org/10.1177/0163443718818384

OECD. (2019). *An introduction to online platforms and their role in the digital transformation*. OECD. https://doi.org/10.1787/53e5f593-en

Owen, J. M. (2006). *The scientific article in the age of digitization* (Vol. 11). Springer Science & Business Media.

Plantin, J.-C., Lagoze, C., Edwards, P. N., & Sandvig, C. (2018). Infrastructure studies meet platform studies in the age of Google and Facebook. *New Media & Society*, *20*(1), 293–310. https://doi.org/10.1177/1461444816661553

Pleskach, V., Semenchenko, A., Goloblobov, D., Kalmykov, O., & Krasnoshchok, V. (2020). *Digitalization of science as a modern trend of the information society development*. https://ceur-ws.org/Vol-2740/20200146.pdf

Poell, T., Nieborg, D., & van Dijck, J. (2019). Platformisation. *Internet Policy Review*, *8*(4). https://doi.org/10.14763/2019.4.1425

Pooley, J. (2022). *Surveillance publishing* [Journal article]. Zenodo. https://doi.org/10.5281/ZENODO.6384605

Reuter, P., & Söllner, K. (2022). Datentracking in der Wissenschaft–ein Sonderfall? *ABI Technik*, *42*(2), 94–95. https://doi.org/10.1515/abitech-2022-0016

Rochet, J.-C., & Tirole, J. (2003). Platform competition in two-sided markets. *Journal of the European Economic Association*, *1*(4), 990–1029. https://doi.org/10.1162/154247603322493212

Schonfeld, R. C. (2018, May 3). *The supercontinent of scholarly publishing?* The Scholary Kitchen. https://scholarlykitchen.sspnet.org/2018/05/03/supercontinent- scholarly-publishing/

Shapiro, C., & Varian, H. R. (1998). *Information rules. A strategic guide to the network economy*. Harvard Business School Press. https://hbsp.harvard.edu/product/863X-HBK-ENG

Srnicek, N. (2017). *Platform capitalism*. John Wiley & Sons.

Tiwana, A. (2014). *Platform ecosystems: Aligning architecture, governance, and strategy*. Morgan Kaufmann.

Tsing, A. L. (2012). On nonscalability. *Common Knowledge*, *18*(3), 505–524. https://doi.org/10.1215/0961754X-1630424

Van Dijck, J., Poell, T., & De Waal, M. (2018). *The platform society: Public values in a connective world*. Oxford University Press.

Wachter-Boettcher, S. (2017). *Technically wrong: Sexist apps, biased algorithms, and other threats of toxic tech*. WW Norton & Company.

Wrzesinski, M., Riechert, P. U., Dubois, F., & Katzenbach, C. (2021). *Working with publication technology to make open access journals sustainable* [Working paper]. Zenodo. https://doi.org/10.5281/ZENODO.4558781

Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, *23*(5), 1398–1408. https://doi.org/10.1287/orsc.1120.0771