The agency of digital platforms in open science: governance, metrics, and ontological implications

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Abstract

This study aims to analyze how digital science platforms are reshaping traditional evaluation criteria by broadening the scope of objects recognized as legitimate scholarly output. The research, qualitative and exploratory in nature, conducts a documentary analysis of fifteen open science platforms, selected for their diversity in document formats, functionalities, metric indicators, and geographical scope. It examines aspects such as the types of hosted resources, available metrics and altmetrics, governance structures, authorship and versioning mechanisms, and emerging ontological challenges. The results reveal a plurality of scientific artifacts, such as software, datasets, preprints, workflows, and protocols, which challenge the historical centrality of the article and citation. The platforms function as visibility infrastructures, making multiple outputs computable and integrating traditional and emerging metrics, including techno-computational indicators. A strong geopolitical and institutional concentration is observed in the Global North, with a predominance of academic, governmental, and consortium-led institutions, although commercial platforms are also present. Finally, the study highlights an ontological and political shift, marked by the expansion of legitimacy regimes and the emergence of new models of authorship and governance. Although traditional metrics remain relevant, alternative indicators are gaining ground, promoting more pluralistic and contextualized forms of evaluation.

Keywords
Science platformization; Sociotechnical agency; Information metrics; Data governance; Ontology of science; Open science; Data repositories; Scientific reproducibility; Technical-computational metrics.

1. Introduction

Ontology, according to **Guarino** (1998), is a logical theory that seeks to render explicit the intended meaning of a formal vocabulary, reflecting the ontological commitment made concerning a specific conceptualization of the world. In the scientific field, this conceptualization manifests in structures that, although powerful, are not always explicit. Thus, what may be termed an *invisible ontology* emerges as a set of categories, rules, and metrics that operate behind the scenes of evaluation and tacitly shape the institutional recognition of knowledge. The very consolidation of scientific evaluation systems is deeply rooted in the construction of this ontology, a process whose origins can be observed in the efforts to quantify scientific activity proposed by **Price** (1963). In establishing the foundations of scientometrics, his foundational work also cautioned against the risks of transforming these same quantitative indicators into normative validation mechanisms.

The thought of **Price** (1963) is consolidated in the fact that this invisible ontology not only describes science but also actively participates in shaping it. Metric indicators thus assume a performative role by contributing to the definition of what is institutionally recognized as valid knowledge (**Krüger**, 2020). Far from being neutral instruments, they are constructions marked by sociotechnical values, assumptions, and historical contexts (**Herzog**; **Hook**; **Adie**, 2018). Such a process often culminates in what **Merton** (1973) described as the *Matthew Effect*, that is, a mechanism of accumulated advantage that reinforces existing inequalities in the scientific field.

This dynamic is rooted in the inherently social nature of science, where sociotechnical networks govern the production and legitimation of knowledge. While **Knorr Cetina** (2009) reveals the influence of the epistemic cultures of each field and **Longino** (1990) demonstrates the role of social values in investigation, it is from Actor-Network Theory that the concept of agency emerges as a powerful analytical tool. In this perspective, technical systems and artifacts themselves are not mere passive channels but rather actants that actively mediate and prescribe scientific practices (**Latour**, 2002). The agency of a sociotechnical system resides, therefore, in its capacity to inscribe a worldview into its code and architecture by defining what qualifies as a valid contribution, promoting certain impact indicators, and modulating forms of interaction. This agency materializes the co-production between science and social order identified by **Jasanoff** (2010), making its analysis a central objective for understanding how knowledge is governed in contemporary science.

The act of measuring, in this sense, becomes the privileged locus where this entire sociotechnical web, composed of values, cultures, and the agency of multiple actors, materializes as an exercise in imposing norms. This is particularly evident in traditional bibliometric systems, whose architecture and selective coverage have historically favored certain models of scientific production over others (**Khorasani** *et al.*, 2022). Furthermore, traditional bibliometric systems sometimes reproduce structural biases of a disciplinary, linguistic, and geographical nature, thereby excluding peripheral knowledge or knowledge disseminated in alternative formats. Even consolidated indicators such as the Impact Factor and the h-index (**Schumann**; **Calabró**, 2024; **Fire**; **Guestrin**, 2019) exhibit certain limitations, especially when they become a strategic target and lose their original function, simplifying evaluation criteria and excluding non-conventional formats (**Koltun**; **Hafner**, 2021).

It is in response to these profound limitations that the Open Science movement has gained global momentum. More than a simple demand for free access to articles, Open Science proposes a fundamental restructuring of scientific practices, advocating for greater transparency, collaboration, and the sharing of all research products (*BOAI*, 2002; **Willinsky**, 2006).

In this context, the *Measurement School* of Open Science, as proposed by **Fecher** and **Friesike** (2014), focuses on alternative metrics for evaluating scientific impact. The fundamental principle of this school is that as the academic workflow migrates to the web, previously hidden interactions leave online traces. This fertile new ground has given rise to altmetrics, which in the current discourse are redefined as process-based indicators that capture engagement with and the use of research outputs beyond traditional citations (**Díaz-Faes**; **Zahedi**, 2024). Examples include the frequency with which an article is shared, saved to a bibliographic manager, or discussed on a blog. Such metrics consider not only the final publication but also the process of research and collaboration (**Priem** *et al.*, 2010; **Burns**, 2018; **Jarić**; **Pipek**; **Novoa**, 2025; **De Giusti**; **Villarreal**, 2025).

The emergence of altmetrics, in this sense, is not an isolated phenomenon but part of a broader critical movement that converges toward a re-evaluation of the very foundations of scientific assessment. This re-evaluation questions not only the indicators but also the values and assumptions that underpin them (*International Science Council*, 2025). Bibliometrics itself has responded to this call by incorporating more critical and methodological approaches (**Van Raan**, 2019; **Basile**; **Giacalone**; **Cozzucoli**, 2022) and proposing indicators more sensitive to the particularities of each area (**Hicks** *et al.*, 2015).

However, the central point of the debate lies in a gap that these contributions have not yet filled: the absence of an ontological model that makes explicit the constituent elements of the metric field and their interrelations. Such a model would permit the critical integration of different evaluation paradigms and instruments by broadening the understanding of evaluation systems, which are often based on restrictive normative conceptions that are insensitive to the epistemological diversity of contemporary science (**Tsakonas**; **Papatheodorou**, 2011). These impasses have spurred the emergence of new digital infrastructures, which offer potential support for the development of new indicators capable of reflecting the complexity and diversity of contemporary science. In the same vein, initiatives like the *Coalition for Advancing Research Assessment* (*CoARA*, 2025) have promoted institutional commitments aimed at reforming evaluation systems, advocating for more inclusive, qualitative, and pluralistic approaches, in line with the transformations observed in the digital infrastructures of science.

In this transformational landscape, digital science platforms emerge as key actors. Within the scientific field, they are defined as the digital governance systems of virtual spaces that leverage network effects for one (or more) phase(s) of the scientific research process (**Da Silva Neto**; **Chiarini**, 2023), a conceptualization that fits within the broader understanding of a digital platform as a service, enabled by software, that mediates the interactions between agents (**Derave** *et al.*, 2024). In practice, these platforms act as online systems that facilitate interaction among researchers, companies, governments, and society, supporting all phases of the research cycle, from data collection to the dissemination of results (**Fecher** *et al.*, 2024).

The need for these new digital infrastructures, such as *Zenodo*, *Figshare*, and *GitHub*, represents a step beyond the reproduction of traditional evaluation models. They establish new *metric regimes* that reflect contemporary scientific practices of open science, such as software versioning, technical reuse of data, and distributed authorship. This evolution is crucial because, as **Thelwall** (2019) points out, research evaluation cannot be restricted to articles, making it imperative to recognize the value of various other outputs, such as software, data, and videos. In this sense, these platforms constitute privileged sources for the emergence of new metrics capable of capturing dimensions of impact rarely measured by classic models, by following the digital traces that scientific publications leave in the online ecosystem (**Krüger**, 2020).

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Despite this potential, the full integration of these new approaches faces significant challenges. The standardization of metadata and the formal citation of data and software are primary technical obstacles (*Data Citation Synthesis Group*, 2014; **Smith** *et al.*, 2016). Added to these is the complexity of integrating these new artifacts into existing institutional evaluation systems (**Katz** *et al.*, 2014; **Hicks** *et al.*, 2015). This scenario is aggravated by the fragmentation of the infrastructure ecosystem: the heterogeneity of data models among repositories limits the full exploitation of these platforms' potential, making interoperability a critical challenge (**Baglioni** *et al.*, 2025).

In this context, although significant advances are occurring, such as the recognition of collaborative knowledge (**Oliveira**, 2024) and the materialization of emerging epistemologies in digital platforms (**Borgman** *et al.*, 2016), a gap remains. There is a lack of an ontological model that would allow for organizing, relating, and contextualizing the various indicators generated by these ecosystems, thereby exploring their full analytical potential. It is precisely the disparity between the diversity of new indicators and the absence of a framework to guide their joint interpretation that constitutes the justification for this study.

Building upon this observation, this article aims to analyze how digital science platforms, as central infrastructures of Open Science, reformulate the hegemonic criteria for knowledge validation while simultaneously revealing and reshaping the underlying ontology of scientific practices. To this end, the study maps selected platforms via *FAIRsharing.org*, with the analysis focused on governance characteristics, their data models, functional type, versioning standards, authorship mechanisms, and their set of indicators (metric, altmetric, and computational). The approach is interdisciplinary, articulating contributions from authors in Information Science, metric studies, and the Sociology of Science, with an emphasis on the epistemological impacts of digital transformations on scientific evaluation.

2. Methodological procedures

This exploratory and descriptive study utilizes the *FAIRsharing.org* directory as its primary data source. *FAIRsharing.org* is a searchable portal containing manually curated descriptions of standards, databases, and policies, whose resources are persistently identifiable via Digital Object Identifiers (DOIs). The choice of this directory is justified by its comprehensiveness and the robustness of its curation. According to **Sansone** *et al.* (2019), the platform was developed as an informational resource to guide users in selecting appropriate resources and to promote their harmonization. Additionally, its management combines a community-driven approach with the work of internal curators and the support of the resource maintainers themselves, which ensures the identification of relevant and high-quality platforms.

The data collection, conducted in March 2025, commenced with the application of three filters on the *FAIRsharing* portal. The filters *record type*: *database* and *record type: repository* were used to select infrastructures that function as research repositories and databases. To these, the filter *subjects: subject agnostic* was added a fundamental criterion to focus the analysis on multidisciplinary platforms rather than domain-specific repositories. The combination of these filters yielded a preliminary set of 39 platforms, to which the inclusion and exclusion criteria were subsequently applied.

The inclusion criteria were: (a) diversity of hosted formats, with support for multiple types of scientific artifacts (e.g., documents, preprints, datasets, software, videos, and protocols); (b) explicit availability of impact, engagement, or usage indicators, such as bibliometric metrics (citation counts), altmetrics (views, downloads, shares, social media mentions), and technical-computational metrics (code executions, workflow reuses, and social metrics in repositories such as stars and forks); (c) unrestricted public access, considered essential for the transparency and replicability of the analyzed data; and (d) use of open and permissive licenses, such as *Creative Commons Zero* (CC0), *Creative Commons Attribution* (CC BY), *MIT License*, *Apache License*, or *GNU GPL*. The adoption of these licenses is aligned with the principles of *Open Science*, which advocate for the maximum dissemination and reuse of scientific knowledge. They ensure not only access but also the legal right to use, modify, and redistribute data, software, and other scientific resources. This criterion is also consistent with the Open Knowledge approach, proposed by the *Open Knowledge Foundation* (2025), which establishes requirements for the openness and interoperability of knowledge.

The exclusion criteria were: (a) platforms with restricted access or requiring institutional credentials for use; (b) those that did not provide impact, engagement, or usage indicators on their public interfaces; (c) inactive or defunct platforms; and (d) platforms focused predominantly on traditional formats (theses, dissertations, published articles) or that acted merely as aggregators or discovery tools, without actively hosting multiple scientific formats or directly providing metrics.

The application of these criteria resulted in a final corpus of 15 digital science platforms: *SciELO Data, Zenodo, Figshare, Dryad Digital Repository* (*Dryad*), *The Open Science Framework* (*OSF*), *DepositAr, OpenML, Archive ouverte* (*HAL*), *GitHub, Protocols.io, WorkflowHub, Science Data Bank* (*ScienceDB*), *E-cienciaDATOS, DataverseNL*, and *Mendeley Data*.

Once the corpus was defined, data were collected directly from each platform by analyzing their websites and documentation (docs, FAQs, about, help, or guides sections). The extracted information was then systematized in *Microsoft Excel* spreadsheets, which served as the basis for creating the subsequent tables and figures. The analysis was organized according to a set of descriptive categories that covered: (i) Governance and Institutional Context, including country of origin, year of creation, maintaining institutions, and organization type; (ii) Scope of Content and Metrics, which encompassed the typologies of accepted artifacts and the spectrum of offered indicators; and (iii) Technical Architecture and Openness Policies, a category detailing the software infrastructure, versioning and authorship recognition mechanisms, metadata standards, adopted license models, and data governance policies, such as curation processes and conditions for deposit and access.

3. Results and discussion

The temporal analysis in Table 1 reveals a notable concentration in the creation of digital science platforms starting from 2008. With the exception of *HAL* (2001), all other 14 platforms in the corpus emerged between 2008 and 2020. This concentration is not accidental but rather a direct response to structural changes in open science policies and the intensification of the debate on research evaluation. The period coincides not only with the strengthening of data-sharing mandates by major funding agencies but also with the emergence of new paradigms, such as the FAIR Principles, whose foundations were laid in 2014. It is in this context that seminal documents like the *Altmetrics Manifesto* (2010), the *DORA Declaration* (2012), and the *Leiden Manifesto* (2015) were consolidated, criticizing the exclusive reliance on traditional metrics. It was precisely this confluence of political pressure, new principles, and intellectual debate that drove the emergence of platforms like *Figshare* (2010), *OSF* (2011), and *Zenodo* (2013), all fundamentally oriented toward the dissemination and reproducibility of a broader range of research products.

Regarding the hosting country of the platforms (Table 1), a marked geographical concentration of digital science infrastructure is evident, with 12 based in the Global North, specifically in the United States and Europe. North American prominence is particularly notable, as the country hosts four of these platforms, accounting for over 25% of the analyzed corpus. In contrast, the Global South and Asia are represented by only three initiatives: *SciELO Data* (Brazil), *ScienceDB* (China), and *DepositAR* (Taiwan). This geopolitical asymmetry in digital infrastructures, a form of politics embedded (**Star**, 1999), aggravates the condition of peripheral science by reinforcing a cycle of dependence in which researchers orient their work toward the agendas and reward systems of global centers, to the detriment of local research priorities (**Vessuri**, 1987).

From the perspective of organization type (Table 1), the analysis reveals a diverse ecosystem with a strong predominance of non-commercial models. Eleven platforms are maintained by a range of public or community-based actors, including government bodies, intergovernmental organizations, academic consortia, and non-profit organizations, while four platforms are controlled by commercial entities.

This coexistence of models can be understood as the materialization of the platformization of science. Most of these infrastructures are positioned in the *Science and State* subsystems, while the four commercial platforms are situated in the *Market* subsystem. This arrangement, however, is not without tension; it reflects a dispute among different logics and interests for control over digital infrastructure, confirming the thesis that the platformization of science is a complex and non-linear process, not a simple technological evolution (**Da Silva Neto**; **Chiarini**, 2023).

Table 1. Governance characteristics of the Digital Science Platforms

Platform	Hosting Country	Year of Creation	Maintaining Institution(s)	Organization Type
SciELO Data	Brazil	2020	*Foundation for Scientific and Technological Development in Health* (*Fiocruz*), *FAPESP*, *CNPq* (linked to the *SciELO* program)	Academic/ Governmental
Zenodo	Switzerland	2013	*CERN* (*European Organization for Nuclear Research*) / *OpenAIRE* (funded by the *European Commission*)	Academic/ Intergovernmental Organization (IGO)
Figshare	UK	2010	*Digital Science* (commercial company)	Commercial
Dryad	USA	2008	*Dryad* (consortium of research institutions and publishers)	Non-profit Consortium
OSF	USA	2011	*Center for Open Science* (*COS*)	Non-profit
DepositAR	Taiwan	2018	*Academia Sinica* (*Institute of Information Science*)	Academic/Non-profit
OpenML	Netherlands	2013	*Leiden University*, *Jheronimus Academy of Data Science* (*JADS*)	Academic
HAL	France	2001	*Centre pour la Communication Scientifique Directe* (*CCSD - CNRS*, *Inria*, *Inrae*)	Governmental/ Academic
GitHub	USA	2008	*Microsoft* (since 2018)	Commercial
Protocols.io	USA	2014	*Springer Nature*	Commercial
WorkflowHub	UK	2020	*ELIXIR* (*European life sciences data infrastructure*)	Academic/Pan-European Organization
ScienceDB	China	2015	*Chinese Academy of Sciences* (*CAS*)	Governmental/ Academic
E-cienciaDATOS	Spain	2016	*Madroño Consortium*	Academic
DataverseNL	Netherlands	2014	*Data Archiving and Networked Services* (*DANS - KNAW* and *NWO*)	Governmental/ Academic
Mendeley Data	Ireland	2015	*Elsevier* (commercial company)	Commercial

Furthermore (Table 2), the analysis reveals the growing diversity in the scope of content hosted by these digital platforms, which, by incorporating multiple formats, surpass the traditional model centered on the article. This expansion recognizes that research generates a variety of products (**De Giusti**; **Villarreal**, 2025) and signals an ontological reconfiguration of the notion of scientific production. This change challenges the reward system of science, which has historically favored established channels and formats through a process of accumulated advantage (**Zuckerman**, 1977). Such heterogeneity can be understood from the perspective of the pragmatic school of open science, which values the modularization of the research process and the recognition of diverse objects to make knowledge creation more collaborative (**Fecher**; **Friesike**, 2013).

Table 2. Scope of Content and Emerging Metrics of the Platforms

Platform	Scope of Content	Metric, Altmetric, and Computational Execution Indicators
SciELO Data	Research datasets associated with articles and preprints from the *SciELO* network	Downloads, views, shares, and citations via *Make Data Count* (*MDC*); API access
Zenodo	Any file type, categorized into: publications (articles, books, chapters, theses), posters, presentations, datasets, images, videos/audio, software, lesson materials	Downloads, views, citation export; altmetrics via *OpenAIRE*/*DataCite*; data volume
Figshare	Any file type, categorized into: papers, theses, datasets, filesets, media (video/audio), posters, figures, code, books, software, workflow, figures	Downloads, views, citations via DOI (*Dimensions*); altmetrics on social media, blogs, etc.
Dryad	Exclusive focus on datasets (accepts multiple file formats as part of the dataset)	Downloads, views, citations via DOI; altmetrics on multiple social networks
OSF	Any research artifact, including: articles, preprints, datasets, software, models, protocols, educational materials, etc.	Views, downloads, preregistration records, citation export; altmetrics on multiple social networks; Plaudit
E-cienciaDATOS	Datasets, institutional documents, spreadsheets, images, code, audio, video, and structured metadata	Downloads, views, and citations via DOI (*Make Data Count*); citation export; FAIR metadata
OpenML	Datasets, tasks, flows (learning pipelines), runs, collections, benchmarks, performance evaluation metrics	Views, downloads, runs, likes, issues; support for experiment execution
HAL	Scientific articles, preprints, theses, book chapters, communications, reports, patents, software, videos, HDR, Sound	Downloads, views, citations via DOI, citation export; integration with Altmetric
GitHub	Source code repositories, software, technical documentation, wikis, datasets, websites, project files	Stars, watchers, forks, issues, pull requests, actions, projects, security insights, and usage metrics; contributions
Protocols.io	Research protocols, methodologies, and tutorials (allows attachment of any type of support file)	Views, downloads, comments, followers, likes, forks; altmetrics
WorkflowHub	Scientific workflows, SOPs, and associated materials like publications, documents, and datasets	Views, downloads, and citation exports
ScienceDB	Datasets, codes, figures, software packages, presentations, and multimedia (audio and video)	Downloads, views, likes, citations via DOI and CSTR; altmetrics; access via API and FTP
DepositAR	Datasets (supports multiple file formats such as text, image, audio, video, software, code, etc.)	Downloads; altmetrics on *Twitter* and *Facebook*; followers; integration with Binder; access via API, ARK identifier
DataverseNL	Any file type, with a focus on datasets, documents, spreadsheets, images, code, geospatial data, and 3D models	Downloads, citations via DOI; altmetrics; dataset metrics; API access
Mendeley Data	Datasets (accepts multiple file formats such as text, spreadsheets, images, audio, and video)	Downloads, views, citations via DOI; citation export

This new theoretical perspective allows us to see science as a hybrid collective of humans and non-humans, whose agency is distributed across networks of knowledge production and reuse (**Latour**, 1994). By valuing not only the final product but also the multiple stages and contributions of the scientific process, an expanded conception of science emerges, one that is closer to the real dynamics of knowledge construction and reproducibility (**Cousijn** *et al.*, 2022).

The analysis of the content scope of the 15 platforms (Table 2) reveals a substantial expansion of the concept of scientific production. Notably, only one-third of the corpus (five platforms) remains primarily dedicated to traditional formats, such as articles, preprints, and theses. In contrast, the vast majority of these infrastructures (12 platforms) already support datasets, consolidating them as a first-order scientific product. Additionally, more than half of the corpus (eight platforms) encompass software and code, while another eight accept media formats. More incipiently, highly specialized categories representing the research process itself are also emerging, such as protocols (two platforms) and workflows (three platforms).

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This plurality of formats is not merely a technical feature but the materialization of a profound ontological shift. The consolidation of datasets as a first-order scientific product and the rise of software as a legitimate result demonstrate that the digital ecosystem is redefining what constitutes a valuable contribution. Digital science platforms, in this sense, act as agents that actively challenge the historical centrality of the article. They do so through their algorithms, which function as new machineries of knowledge production by giving visibility to and defining the relevance of a range of products previously confined to the backstage of research (**Gillespie**, 2014). In doing so, they exercise their agency (**Latour**, 2002), thereby building a new order in which reproducibility (through data and code) and process transparency (through protocols and workflows) become, in themselves, objects of evaluation. This evolution materializes one of the great aspirations of the responsible metrics movement (**Wilsdon** *et al.*, 2015) by shifting the focus of measurement from the passive consumption of a final product to an assessment of active engagement and validation by the community itself (**Ravenscroft** *et al.*, 2017).

The analysis of the indicators offered by the platforms (Table 2) reveals the consolidation of a hybrid measurement ecosystem. Usage and citation metrics, which combine traditional and digital logics, form the basis of this scenario: downloads are universal, present in all 15 platforms, while formal citation via Doi remains robust, offered by 10 platforms (67%). *Altmetrics*, which capture social engagement, already show a majority presence, being available on nine platforms; among them, mentions on *Facebook* (seven platforms) and *Twitter/X* (five) stand out, as well as indicators like likes (three platforms), followers (two), and comments (one). The key innovation, however, lies in the emergence of technical-computational metrics, present on three platforms (*GitHub*, *OpenML*, and *Protocols.io*), which measure interactions such as stars, watchers, forks, issues, and runs.

This hybrid landscape reflects what **Haustein** (2016) identifies as one of the grand challenges in altmetrics: its profound heterogeneity. **Haustein** (2016) questions why acts as diverse as a mention on *Twitter*, a reader count on *Mendeley*, a *like* on *Facebook*, and the reuse of a dataset should share a common meaning. Thus, the observed spectrum of metrics, ranging from simple access (views) to technical application (forks), demonstrates that platforms are capturing different acts and levels of engagement with scientific production, rather than a single measure of impact.

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The *OSF* platform, in turn, ventures into innovative territory by integrating *Plaudit*, an open endorsement system that allows the academic community to evaluate works based on qualitative criteria such as *robust, clear* or *exciting* (*Challenges and Issues of Modern Science*, 2025). This move toward qualitative altmetrics represents a contemporary manifestation of the transition from an evaluation model focused on counts to one that privileges transparent validation by the scientific community itself.

While *OSF* innovates in the qualitative dimension, the *Zenodo* platform distinguishes itself by introducing a metric that is quantitative in nature yet equally contemporary: *Data volume*, which measures the amount of data actually transferred. This indicator, inherited from a *Big Data* culture in which volume is the most defining characteristic, suggests a dimension of value (**Khan** *et al.*, 2016). The focus shifts from access to computational impact and intensive data reuse, an aspect that most other platforms do not yet measure (Table 2).

The presence of functionalities that enhance the auditability and reusability of metrics is also noteworthy, such as *citation export*, present on seven platforms. Additionally, Table 2 reveals that platforms do not operate in isolation but are integrated into an ecosystem of metric services. This interconnection is manifested in the use of standards like *Make Data Count* (*MDC*), integration with impact aggregators like *OpenAIRE/DataCite (Zenodo)*, *Dimensions* (*Figshare*), and *Altmetric* (*HAL*), and the incorporation of execution tools for reproducibility, such as *Binder* (*DepositAR*). This denotes the emergence of a distributed evaluation infrastructure, where metric value is constructed from the interconnection of multiple agents and standards.

The functional typology (Table 3), employed herein is based on the proposal by **Da Silva Neto** and **Chiarini** (2023), who differentiate digital science platforms according to their primary objectives. The *deposit and dissemination* category includes platforms focused on archiving and sharing a wide range of scientific outputs. *Institutional management and curation* refers to infrastructures that serve as formal repositories for specific institutions. Finally, the *scientific production and collaboration* category encompasses platforms that provide tools for collaborative work and for conducting the research itself. This distinction is crucial, as the functions of each platform directly correspond to the perspectives advocated by the different schools of Open Science thought, as proposed by **Fecher** and **Friesike** (2014).

From this perspective, the *Infrastructure School*, which focuses on building the technological ecosystem, is the most representative, embodied by ten platforms: the seven for deposit and dissemination and the three for institutional management and curation (*E-cienciaDATOS*, *HAL*, and *DataverseNL*). In contrast, the *Pragmatic School* is represented by the four production and collaboration platforms (*OpenML*, *GitHub*, *Protocols.io*, and *WorkflowHub*), joined by the *OSF* platform, which is hybrid in nature. This group embodies the *Science-as-a-Service* concept, wherein the infrastructure itself becomes a foundation for the creation of new tools and reproducible research (**Dooley**; **Brandt**; **Fonner**, 2018).

Table 3. Functional Typology and Technological/Software Platform Infrastructure

Platform	Functional type	Technological infrastructure / software platform
SciELO Data	Deposit and dissemination infrastructure	*Dataverse*
Zenodo	Deposit and dissemination infrastructure	*InvenioRDM*
Figshare	Deposit and dissemination infrastructure	Proprietary platform (*Digital Science*)
Dryad	Deposit and dissemination infrastructure	Open-source software (*Ruby-on-Rails*)
OSF	Deposit and scientific collaboration infrastructure	Open-source software
E-cienciaDATOS	Institutional management and curation infrastructure	*Dataverse*
OpenML	Scientific production and collaboration infrastructure	Open-source software with backend and frontend
HAL	Institutional management and curation infrastructure	Own open-source software technology
GitHub	Scientific production and collaboration infrastructure	Proprietary platform built on *Git* software (*Microsoft*)
Protocols.io	Scientific production and collaboration infrastructure	Proprietary platform (*Springer Nature*)
WorkflowHub	Scientific production and collaboration infrastructure	Open-source software (*RO-Crate*)
ScienceDB	Deposit and dissemination infrastructure	Own and customized software
DepositAR	Deposit and dissemination infrastructure	*Dataverse*
DataverseNL	Institutional management and curation infrastructure	*Dataverse*
Mendeley Data	Deposit and dissemination infrastructure	Proprietary platform (*Elsevier*)

Regarding the technological infrastructure, Table 3 reveals a clear division. Eleven of the fifteen platforms (73%) are supported by open-source or self-developed software, with systems like *Dataverse* and *InvenioRDM* standing out. In contrast, four platforms (27%) operate on proprietary systems controlled by large corporations such as *Elsevier* (*Mendeley Data*), *Microsoft* (*GitHub*), *Digital Science* (*Figshare*), and *Springer Nature* (*Protocols.io*). This dichotomy has direct implications for the governance of indicators. This choice of architecture is, in itself, an act of agency (**Latour**, 2002), in which open-source platforms perform a discourse of transparency by favoring *producibility*, the ability to reproduce and audit the generation of metrics, while proprietary ones exercise a power of governance by maintaining centralized control over their algorithms (**Priem**; **Hemminger**, 2010).

This division, however, is not merely a technical or business choice. As **Gillespie** (2010) points out, it is a manifestation of the "politics of platforms," which position themselves not as neutral infrastructures but as actors that actively perform and impose the rules of knowledge validation. In the academic context, **Guédon** (2017) analyzes this movement as a dangerous transition, in which control over the infrastructure allows the same actors who historically dominated the distribution of articles to also govern the data lifecycle and evaluation metrics. In the scientific field, where there is a struggle to define what constitutes legitimate capital (**Bourdieu**, 2004), the rise of proprietary platforms introduces a commercial logic that redefines the criteria for consecration.

Regarding Table 4, all 15 platforms incorporate scientific versioning mechanisms, a fundamental feature for ensuring transparency, traceability, and reproducibility (**Barker** *et al.*, 2022). However, the support for this functionality is heterogeneous in its implementation; while platforms like *OSF*, *Zenodo*, and *GitHub* provide detailed histories and distributed control, others offer different approaches, such as versioning via *CKAN* in *DepositAR* or through the *Dataverse* system used by *SciELO Data*. This variation indicates that, despite advances, the adoption of a universal versioning standard remains a challenge, which can affect the consistency of reproducibility across diverse digital environments.

The analysis of authorship recognition mechanisms (Table 4) shows a significant advance beyond the traditional paradigm, which focused only on the authors of the article. The majority of platforms (eleven) already integrate persistent identifiers like *ORCID*, which enables formal, transparent, and unambiguous contribution attributions. The remaining four platforms (*GitHub*, *OpenML*, *DepositAR*, and *E-cienciaDATOS*) have partial or alternative identification mechanisms, such as their own user profiles or non-mandatory support for *ORCID*. This shift to more granular and persistent identification systems signals the transition from a model of *authorship* to one of *contributorship*. Aligned with taxonomies like *CRediT*, this new model increases the visibility of the multiple and diverse forms of contribution in research, mitigating historical inequalities related to gender, seniority, or disciplinary area, where technical or data management work was often invisibilized (**Holcombe**, 2019; **Allen**; **O'Connell**; **Kiermer**, 2019). This change is crucial for data-driven science,

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where the absence of formal credit mechanisms for the collection and curation of datasets has historically been one of the main barriers to data sharing and the advancement of *Open Science* (**Borgman** *et al.*, 2016).

Table 4. Versioning, Attribution, Metadata, and Licensing Mechanisms of the Platforms

Platform	Versioning	Authorship Recognition	Available Metadata	Licenses and Tools for Metrics
SciELO Data	Yes (via *Dataverse* system, with versions and history)	Traditional authorships (*ORCID*)	Yes, interoperable metadata (*DataCite*, *DDI*, *Dublin Core*)	CC BY 4.0 license; limited tools, no clear APIs
Zenodo	Yes (versions with DOI)	Yes (*ORCID*, traditional authorships)	Yes, interoperable metadata (*DataCite*, *Dublin Core*, MARC)	CC0 1.0, CC BY 4.0 licenses; DOIs, APIs, metric dashboards
Figshare	Yes (version control with specific and fixed DOIs)	Yes (*ORCID* and multiple authors)	Yes, interoperable metadata (*DataCite*, *Dublin Core*)	CC0 1.0, CC BY 4.0 licenses; DOIs, APIs, public statistics
Dryad	Yes, complete and robust versioning	Yes (*ORCID*)	Yes, interoperable metadata (*DataCite*, *Dublin Core*, *MODS*, *OAI-ORE*, *RDF Data Cube*)	CC0 1.0 license (data); APIs for use and download
OSF	Yes (complete version history)	Yes (*ORCID*)	Yes, interoperable metadata (*DataCite*, *ABCD*)	Licenses including CC BY 4.0, *MIT*, *Apache* 2.0; DOIs, versioning, integration with repositories
DepositAR	Yes (versioning via *CKAN*)	Partial	Yes, *DCAT* metadata	CC0 1.0, CC BY 4.0 licenses; APIs, interoperability
OpenML	Yes (versioned tasks and runs)	Partial	Partial, technical metadata available via *REST API*, but no identifiable standard	CC0 1.0 license (data); DOIs, APIs for runs
HAL	Yes	Yes, supports *ORCID*, *ISNI*, and *ResearcherID*	Yes, interoperable metadata (*DataCite*, *Dublin Core*, *OAI-ORE*)	CC BY 4.0, CC BY-NC licenses; DOIs
GitHub	Yes (distributed *Git* control)	Partial, no formal integration with *ORCID*, only *GitHub* users	Partial, technical metadata (commits, branches), but no interoperable scientific standards.	Open source licenses (MIT, GPL v3.0, *Apache* 2.0); REST API
Protocols.io	Yes (complete protocols)	Yes (*ORCID*)	Yes, structured metadata accessible via *REST API*	*Open Access Protocol* license; DOIs, API

WorkflowHub	Yes (work-flow versioning)	Yes (*ORCID*)	Yes, structured and interoperable metadata	CC0 1.0 license; DOIs, APIs for execution and reuse
ScienceDB	Yes	Yes	Yes, *Dublin Core* metadata	Varied licenses (CC BY-NC-SA 4.0); limited tools
E-cienciaDatos	Yes (complete versioning)	Partial (support for *ORCID* available, but not mandatory)	Yes, rich and interoperable metadata (*Dublin Core*, *Schema*, and *DataCite*)	Varied licenses (CC BY 4.0, CC0 1.0); *REST APIs*
DataverseNL	Yes (versioning via *Dataverse*)	Yes (*ORCID* and dataverse standard)	Yes, interoperable metadata (*DDI*, *Dublin Core*)	CC0 1.0, CC BY 4.0 licenses; detailed APIs
Mendeley Data	Yes	Yes (*ORCID*)	Yes, metadata (*Dublin Core*)	Varied licenses (CC BY 4.0, *Elsevier*-specific, and some restrictive); APIs, dashboards

The analysis of Table 4 reveals that the use of structured scientific metadata is a consolidated practice, with 13 platforms making it available in an interoperable manner. The most recurrent standard is the *Dublin Core* schema (nine platforms), and data availability is enhanced by access via APIs, a functionality offered by 13 platforms. This architecture, based on interoperable metadata and APIs, is not merely a technical feature, it is the backbone that supports the promise of Open Science, ensuring that new scientific products are findable, accessible, and reusable (**Wilkinson** *et al.*, 2016; **Barker** *et al.*, 2022). Indeed, metadata are crucial for interoperability between repositories; by following common standards, they allow data to be shared and reused more effectively between different systems and organizations (**Ávila Barrientos**, 2024).

As detailed in Table 4, the licensing policies show a clear trend towards openness, with twelve platforms adopting models such as *Creative Commons* (*CC0* or *CC BY*) that favor unrestricted circulation and reuse. This practice aligns with the principle of knowledge as a public good (*BOAI*, 2002). The adoption of such open licenses is particularly critical because, as **Stodden** (2014) explains, traditional copyright acts as a barrier by prohibiting the reproduction and modification of code and data essential to reproducible computational research. Open licenses, therefore, provide the necessary legal framework to permit the reuse and verification of scientific results. In contrast, four platforms utilize more specific or varied licenses, which, while reflecting the diversity of the hosted objects, may introduce technical and legal barriers to this reuse (**Grabus**; **Greenberg**, 2019).

Furthermore, transparency is reinforced by the provision of monitoring tools. In addition to APIs, five platforms (*Zenodo*, *Figshare*, *GitHub*, *DataverseNL*, and *Mendeley Data*) offer dashboards or public statistics on use and impact. These tools are crucial for the reproducibility and technical evaluation of digital science, although their absence or limitation on the other platforms still represents an obstacle to the full auditability of the entire ecosystem (Table 4).

Regarding data curation, Table 5 reveals a heterogeneous distribution of models. The predominance of manual curation, adopted by nine platforms (*SciELO Data*, *Figshare*, *Dryad*, *OSF*, *HAL*, *Protocols.io*, *ScienceDB*, *DepositAR*, and *Mendeley Data*), and the use of hybrid approaches in four others (*Zenodo*, *E-cienciaDATOS*, *GitHub*, and *DataverseNL*), demonstrate the continued centrality of human judgment. Fully automated curation, in turn, is an exception, operated only by the *OpenML* platform. This diversity points to a transition in digital infrastructures, in which FAIR paradigm principles favor more flexible curation strategies with increasing integration between human and computational capabilities (**Wilkinson** *et al.*, 2016; **Bozada** *et al.*, 2021). This coexistence of models can be understood, more deeply, as the manifestation of different epistemic cultures (**Knorr Cetina**, 2009) regarding how to validate knowledge in the digital age: one that still values human expertise as a seal of quality and another that privileges algorithmic scalability.

Table 5. Curation, Condition, and Citation Mechanisms of the Platforms

Platform	Data Curation	Data Deposit Condition	Data Access Condition	Related Publication Citation
SciELO Data	Manual	Controlled (from *SciELO* journals or preprints)	Open (After article publication)	Yes
Zenodo	Manual/Automatic	Open	Defined by the author (Open, Embargoed, Restricted)	Yes
Figshare	Manual (*Figshare* curation services)	Controlled (requires registration)	Defined by the author (Public, Private, Embargoed)	Yes
Dryad	Manual (*Dryad* curation support)	Open (requires ORCID/ROR)	Open (After article publication)	Yes
OSF	Manual (Requires metadata)	Controlled (requires registration)	Defined by the author (Public or Private)	Yes
e-cienciasdatos	Manual/Automatic	Controlled (partner institutions)	Open (as per institutional policy)	Yes
OpenML	Automatic	Open	Open	No
HAL	Manual (prior curation)	Controlled (requires login)	Defined by the author	Yes
GitHub	Manual/Automatic	Controlled (requires registration)	Defined by the author (Public/Private Repository)	Yes
Protocols.io	Manual (format and metadata)	Open	Defined by the author (Public or Private)	Yes
WorkflowHub	Not found	Controlled (requires registration)	Defined by the author (Public or Private)	No
ScienceDB	Manual	Open	Defined by the author (Generally Open)	Yes
DepositAR	Manual	Open	Open	No
DataverseNL	Manual/Automatic	Controlled (partner institutions)	Defined by the author/institution	Yes
Mendeley Data	Manual (Librarians)	Controlled (requires registration)	Defined by the author (Public or Private)	Yes

Table 5 also shows that nine platforms adopt controlled deposit conditions, requiring some form of authentication, such as user registration, institutional affiliation, or a link to specific networks. The other six platforms operate with open deposit, although this is often linked to some form of identification, such as an *ORCID*. The existence of these conditions reinforces the mediated nature of the data publication process, in which access to deposit is conditioned on technical or institutional criteria, in line with models that provide for review to ensure the quality and reusability of the data (**Kim**; **Yakel**; **Faniel**, 2019).

As for the data access condition for the 15 listed platforms, a predominance of the researcher-controlled model is observed. The majority (10 platforms) allow access to be *Defined by the author*. This group includes generalist repositories like Zenodo and Figshare, as well as platforms like *OSF* and *GitHub*, offering flexibility for data to be kept public, private, or under embargo. The five remaining platforms adopt a primarily *Open Access* policy, although in some cases this is conditioned on the publication of an associated article or specific institutional policies, as with *SciELO Data*, *Dryad*, and *DepositAR*.

The different models of curation and data deposit conditions (Table 5) reveal a spectrum of invisible ontologies. On the one hand, platforms like *SciELO Data*, with controlled deposit linked to journals, maintain a hierarchical model; on the other, platforms like *OpenML* (automatic curation) and *Zenodo* (open deposit) indicate a more decentralized ontology, where legitimacy is built from technical functionality or validation by the community itself. These governance choices are sociotechnical decisions that embody views on how science should be validated, showing that platforms are agents of ontological change in the scientific field (**Da Silva Neto**; **Chiarini**, 2023).

Regarding the citation of related publications (Table 5), a functionality present in twelve of the platforms, a reinforcement of the connection with the traditional publication system is observed. However, this very functionality, by creating an explicit and traceable link between digital artifacts and formal literature, constitutes a new source of data for metric studies, allowing for analyses of the impact and use of products like data and software (*Data Citation Synthesis Group*, 2014). Conversely, the deliberate absence of this functionality on three platforms (*OpenML*, *WorkflowHub*, and *DepositAR*) points to the emergence of a new model, suggesting that these platforms do not merely react to a crisis in metrics but actively create their own metric fields, in which reproducibility and functionality (**Gawer**, 2021) become the new criteria of value.

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4. Conclusions

This study has demonstrated that digital science platforms are driving a reconfiguration of scientific evaluation systems. Driven by the principles of Open Science, this transformation manifests across three central dimensions: the legitimization of a plurality of new artifacts beyond the traditional article (software, datasets, preprints, and workflows); the emergence of new forms of measurement based on engagement and technical reuse (altmetrics and technical-computational metrics); and the consolidation of new governance models in which the platforms themselves act as regulatory agents. This tripartite movement, taken together, represents not a mere technical adjustment but rather the struggle to redefine what constitutes legitimate scientific capital in the contemporary scientific field (**Bourdieu**, 2004).

This transformation represents a fundamental ontological shift, wherein platforms act as visibility infrastructures that expand regimes of legitimacy and redefine what constitutes valid knowledge (**Krüger**, 2020). It is in this context that indicators such as downloads, stars, and forks emerge not merely as complementary metrics but as the tools through which platforms exercise their regulatory power. By establishing their own regimes of value, both commercial and academic platforms exert a new form of governance that challenges the evaluative monopoly of traditional institutions (**Gawer**, 2021).

However, the apparent technological neutrality of this restructuring runs up against established geopolitical and institutional realities. A key finding is the marked institutional and geographical concentration of these platforms in the Global North, primarily the United States, the United Kingdom, and continental Europe. This centralization contrasts with the epistemic plurality promised by *Open Science*, running the risk of deepening historical asymmetries in the definition of technical and evaluative standards (**Bezuidenhout**; **Chakauya**, 2018; **Oliveira**, 2024). This movement, therefore, does not represent a complete replacement of the old system but rather the emergence of a tense, hybrid evaluation ecosystem. These new infrastructures, with their innovative potential, coexist with the challenges of their own centralization and the resilience of the traditional system.

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Within this complex landscape, it is necessary to acknowledge that traditional metrics, such as citation counts and the impact factor, remain relevant for scientific evaluation. However, as highlighted by **Rushforth** and **Hammarfelt** (2023), the advance of responsible metrics has promoted the incorporation of multiple dimensions and sources of evidence, extending evaluation beyond conventional indicators by valuing the social, technical, and collaborative aspects of scientific production.

This movement aligns with the recommendations of the European Commission's report on next-generation metrics, which defines the principles for their responsible use as: *Robust-*

ness (based on the best possible data), *Humility* (supporting, not replacing, qualitative judgment), *Transparency* (with open processes), *Diversity* (reflecting multiple research paths), and *Reflexivity* (anticipating their potential effects) (**Wilsdon** *et al.*, 2017).

It is precisely in promoting a more transparent, diverse, and robust evaluation that the agency of digital science platforms (**Latour**, 2002) becomes most apparent. By actively exercising this agency, they promote an ontological rupture with consolidated bibliometric systems, shifting the focus from a restricted final product (the article and its citations) to a procedural ecosystem capable of recognizing and measuring the plurality of artifacts and engagements that constitute the "long tail of science" (**Borgman** *et al.*, 2016, p. 129).

Future research should investigate the integrated application of the bibliometric, altmetric, and technical-computational indicators mapped in this study, evaluating their suitability and impact in different areas of knowledge. Furthermore, future work should analyze the technical challenges that persist for the interoperability of this fragmented ecosystem, such as the standardization of metadata and citation models for new scientific products. Finally, longitudinal studies are needed to track the evolution of these metric regimes and their eventual consolidation or hybridization over time.

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