Recommendations on Open Science Rewards and Incentives – Guidance for Multiple Stakeholders in Research

RDA Supporting Output

DOI: 10.15497/RDA000117

Authors: Laurence Mabile, Hanna Shmagun, Christopher Erdmann, Anne Cambon-Thomsen, Mogens Thomsen, Florencia Grattarola, and the RDA Sharing Rewards and Credit (SHARC) IG

Published: 29 October 2024

Version: 1

Abstract: Open Science contributes to the collective building of scientific knowledge and societal progress. However, academic research currently fails to recognise and reward efforts to share research outputs. Yet it is crucial that such activities be valued, as they require considerable time, energy, and expertise to make scientific outputs usable by others, as stated by the FAIR principles. To address this challenge, several bottom-up and top-down initiatives have emerged to explore ways to assess and credit Open Science activities (e.g., Research Data Alliance, RDA) and to promote the assessment of a broad spectrum of research outputs, including datasets and software (e.g., Coalition for Advancement of Research Assessment, CoARA). As part of the RDA-SHARC (SHAring Rewards and Credit) interest group, we have developed a set of recommendations to help implement various rewarding schemes at different levels. The recommendations target a broad range of stakeholders. For instance, institutions are encouraged to provide digital services and infrastructure, organise training and cover expenses associated with making data available for the community. The funders should establish policies requiring open access to data produced by funded research and provide corresponding support. The publishers should favour open peer-review models and open access to articles, data and software. Government policymakers should set up a comprehensive Open Science strategy, as recommended by UNESCO and followed by a growing number of countries. The present work details different measures that are proposed to the stakeholders. The need to include sharing activities in research evaluation schemes as an overarching mechanism to promote Open Science practices is specifically emphasised.

Impact: RDA-SHARC's recommendations are meant to be adopted by researchers and the various stakeholders of the research environment and evaluation system in order to enable rewarding schemes for open science activities. The objective is to fill the gaps between the current OS activities and the recognition system. The ultimate goal is to foster and facilitate open science practice in all scientific communities.

Contribution to United Nations SDGs: We believe that our research output emphasising the need to seamlessly integrate Open Science practices in research evaluation and rewarding schemes is particularly associated with two Sustainable Development Goals: Reduced Inequality and Partnerships for the Goals.

Reduced Inequality: Our recommendations aim to address the inequalities that are linked to current evaluation and reward systems, driven by narrow and inappropriate definitions of research excellence.

Partnerships for the Goals: Our recommendations encourage cooperation between multiple stakeholders to share knowledge, expertise and resources for implementing rewards and recognition for Open Science practices. These practices, when properly incentivised and widely adopted, have the potential to accelerate progress across a broader scope of Sustainable Development Goals.

Language: English

RDA webpage: https://www.rd-alliance.org/groups/sharing-rewards-and-credit-sharc-ig/outputs/?output=142427

RDA-SHARC Recommendations website: https://bienflorencia.github.io/rda-sharc-reco/

Citation and Download: Mabile, L., Shmagun, H., Erdmann, C., Cambon-Thomsen, A., Thomsen, M., Grattarola, F., & RDA Sharing Rewards and Credit (SHARC) IG. (2024). *Recommendations on Open Science Rewards and Incentives: Guidance for multiple stakeholders in Research*. Research Data Alliance. https://doi.org/10.15497/RDA/000117

Recommendations on Open Science Rewards and Incentives

Guidance for multiple stakeholders in Research

Laurence Mabile[1], Hanna Shmagun[2], Christopher Erdmann[3], Anne Cambon-Thomsen[1,4], Mogens Thomsen[1], Florencia Grattarola[5]

[1]CERPOP, INSERM and Université Toulouse III Paul Sabatier, Toulouse, France
[2]Korea Institute of Science and Technology Information, Seoul, South Korea
[3]SciLifeLab, Uppsala, Sweden
[4]CNRS, Toulouse, France
[5]Czech University of Life Sciences Prague, Czech Republic

Table of contents

Abstract

Open Science contributes to the collective building of scientific knowledge and societal progress. However, academic research currently fails to recognise and reward efforts to share research outputs. Yet it is crucial that such activities be valued, as they require considerable time, energy, and expertise to make scientific outputs usable by others, as stated by the FAIR principles. To address this challenge, several bottom-up and top-down initiatives have emerged to explore ways to assess and credit Open Science activities (e.g., Research Data Alliance, RDA) and to promote the assessment of a broad spectrum of research outputs, including datasets and software (e.g., Coalition for Advancement of Research Assessment, CoARA). As part of the RDA-SHARC (SHAring Rewards and Credit) interest group, we have developed a set of recommendations to help implement various rewarding schemes at different levels. The recommendations target a broad range of stakeholders. For instance, institutions are encouraged to provide digital services and infrastructure, organise training and cover expenses associated with making data available for the community. Funders should establish policies requiring open access to data produced by funded research and provide corresponding support. Publishers should favour open peer-review models and open access to articles, data and software. Government policymakers should set up a comprehensive Open Science strategy, as recommended by UNESCO and followed by a growing number of countries. The present work details different measures that are proposed to the stakeholders. The need to include sharing activities in research evaluation schemes as an overarching mechanism to promote Open Science practices is specifically emphasised.

Keywords: Open Science, Open Access, FAIR, rewards, sharing, research evaluation

1 Introduction

1.1 Why open science is important

Science is a cumulative process (Merton, 1973) that relies on previous knowledge considering all types of research outputs (Dasgupta & David, 1994; Walsh, Cohen, & Cho, 2007). Although sharing research outputs as common goods should be the common rule, this is actually not the case.

The Open Science (OS) movement was forged in response to this concern. It refers to a range of activities (Grattarola et al., 2024) including sharing research outputs. OS enables replication, improves productivity, limits redundancy, and helps create more robust research methods and a rich network of resources, thus increasing research efficiency (Murray & O'Mahony, 2007; Shibayama & Baba, 2011; Walsh et al., 2007). In the end, it contributes to the collective building of scientific knowledge and societal progress (Cole, Klebel, Apartis, & Ross-Hellauer, 2024).

1.2 How modern science is recognised

To appreciate any contribution to science, credit and recognition are a prerequisite to any 'reward mechanism' and need to be mapped in the overall research assessment scheme. Crediting is the explicit recognition for one's contribution to a work, the process whereby the origin of a scientific work is attributed to an individual, a group of individuals or an institution (Merton, 1973; Shibayama & Baba, 2011; Walsh et al., 2007). It is the first step in recognising the value of one's work and is generally quantified by a series of metrics. It is an important process which builds scientists' reputation. Crediting can be seen as a milestone in the process of rewarding which encompasses several elements such as academic promotion, grants, dedicated staff and support materials that help produce subsequent discoveries (Latour & Woolgar, 1979; Shibayama & Lawson, 2021). In the case of published discoveries, credit is allocated by the community through attribution, peer review approval, and citation. It can also come from patenting in some specific cases (ALLEA, 2023). Sharing intermediate or pre-publication outputs is however far less established as it is more complex and does not necessarily fit into the conventional crediting

system of science (Shibayama & Lawson, 2021). A number of studies have underlined that academic research fails to recognise, value, and reward efforts to open up the scientific process (Hicks, Wouters, Waltman, Rijcke, & Rafols, 2015; Munafò et al., 2017; Wilsdon et al., 2015; Wouters et al., 2015). Yet it is crucial that these activities be valued as they require considerable time, energy and expertise to make outputs findable and accessible and for data and software to be compliant with international standards making them interoperable and reusable by others, as stated by the FAIR principles (Wilkinson et al., 2016).

1.3 The current sharing practice of academics

In the 'publish or perish' culture, some outputs (such as data, databases, or algorithms) may provide academics with an advantage under high competition which can lead them not to share those (Dasgupta & David, 1994; Haas & Park, 2010; Haeussler, Jiang, Thursby, & Thursby, 2014; Merton, 1973). Moreover, some commercialisation contexts, regulatory constraints, privacy issues or data reuse concerns as well as shortage of funds, lack of time or of capacities and technical resources, could also be barriers (Haas & Park, 2010; Walsh et al., 2007). As a result, the amount of outputs shared through open mechanisms is still limited in many communities or disciplines, and a lot of resources are shared in one-to-one transactions (Shibayama & Baba, 2011; Tenopir et al., 2015; Wallis, Rolando, & Borgman, 2013). Thus, the degree of openness is still mainly at the discretion of individual academics (Blume, 1974; Hackett, 2008; Nelson, 2016). However, academics broadly agree that open sharing is beneficial to science and numerous studies showed that when requested, it is respected (Czarnitzki, Grimpe, & Pellens, 2015; Haas & Park, 2010; Shibayama & Baba, 2011; Walsh et al., 2007). Now a clear consensus on how outputs should be shared and rewarded needs to be established.

1.4 The current normative incentives for sharing

Since the Budapest Declaration (BOAI, 2002), that specifically propelled the Open Access (OA) concept, governments, funders, research organisations and publishers are increasingly adopting formal OS policies (Manco, 2022) with a primary focus on OA to publications and underlying research data. Pioneers in adopting such policies include, for example, Scientific Electronic Library Online (SciELO), the National Institutes of Health (NIH), White House's Office of Science and Technology Policy (OSTP), Gates Foundation, Wellcome Trust, UK research councils, Harvard University and Queensland University of Technology. In spite of this, the sharing activities are often not sufficiently recognised or credited

in formal assessments of researchers and project proposals, discouraging researchers from engaging in sharing activities (Arthur et al., 2021).

Efforts to address this challenge have led to the rise of several initiatives within the Responsible Research Assessment (RRA) movement. Notable examples are the DORA declaration (DORA, 2012), the Dutch initiative 'Science in Transition' (Dijstelbloem, Huisman, Miedema, & Mijnhardt, 2013), the Leiden Manifesto (Hicks et al., 2015) and the Metric Tide (Wilsdon et al., 2015). While these initiatives have not directly focused on recognising and rewarding OS practices, they have significantly contributed to promoting responsible metrics and the assessment of a broad spectrum of research outputs, including datasets and software.

The most notable initiatives that explicitly incorporated OS into the RRA discourse have emerged in the European Union. For example, the European Commission established a Working Group in 2016 on rewards under OS that formulated the OS Career Assessment Matrix (OS-CAM), suggesting various criteria for incorporating OS activities in the formal evaluations of researchers at all career stages (European Commission, Directorate-General for Research and Innovation et al., 2017). Moreover, the European Research Area Policy Agenda for 2022-2024 (EC DGRI, 2021) has set the transformation of research assessment systems as a priority strategic action, including the rewarding of OS practices as part of this necessary change, further supported by the *Conclusions of the Council of the European Union on Research Assessment and Implementation of OS* (EU Council, 2022). In line with this agenda, the Coalition for Advancing Research Assessment (CoARA, 2022) was formed in 2022, as an initiative from several European organisations, bringing together stakeholders from the research ecosystem across 164 countries to enhance and harmonise research assessment practices, with an emphasis on recognising and rewarding behaviours underpinning OS activities. Additionally, the Horizon Europe programme has incorporated OS into its evaluation of all research proposals and project assessments, showcasing a prime example of how these practices can be embedded in funder evaluation schemes (EU AGA, 2023; EU Parliament and Council, 2021). Also, the ongoing Horizon Europe projects 'GraspOS' (EU Horizon RIA GraspOS project, 2023) and 'OPUS' (Open and Universal Science (OPUS) project, 2022) have been specifically designed to support the reforms of research assessment systems that include OS practices. Lastly, cOAlition S funders, including the European Commission, have recently introduced a proposal named 'Towards Responsible Publishing' (cOAlition S, 2023), which calls for the incorporation of OS practices into funders' assessment policies and the elimination of journal metrics in the evaluation of researchers.

Some countries have also initiated steps to integrate OS practices into their research assessment schemes, with notable efforts seen in the Netherlands (VNSU, NFU, KNAW, NWO, & ZonMw, 2019), France (CNRS, 2019), Norway (UHR Working Group, 2021), Finland (Working group for responsible evaluation of a researcher, 2020) and in Latin America and

the Caribbean (CLACSO, 2019). Details and more initiatives are given by Rijcke et al. (2023). Simultaneously, bottom-up international initiatives have emerged to explore more immediate ways to assess and credit OS activities. Notably, the data science community is getting organised under the umbrella of the Research Data Alliance (RDA) to articulate related concerns and offer recommendations (e.g., RDA-EoR IG, 2023; RDA-SHARC IG, 2017; and CODATA WG, 2024).

1.5 Objective

In this paper, we provide a set of recommendations developed by the RDA-SHARC interest group to help implement various rewarding schemes for opening up science. These recommendations specifically emphasise the need to include sharing activities in research evaluation schemes as an overarching, valuable, and hopefully efficient mechanism to promote OS practices. The recommendations target a broad range of stakeholders in research and innovation systems, as highlighted by the UNESCO Recommendation on OS (UNESCO, 2021), emphasising the collaborative effort of individual researchers, research institutions and any organisation performing research (public and private), funders, government policymakers and publishers in transforming the research culture towards OS (Nosek et al., 2023).

2 Methodology

2.1 Our values

Before making precise proposals, the ethical framework and the values of science have to be underlined. In the 20th century, the CUDOS norms were characteristics of the science ethos according to Merton (Merton, 1942, 1973): Communalism, Universalism, Disinterestedness, Organised Scepticism. However, this system that isolated the scientific community from the rest of the society does not correspond anymore with the more inclusive science and society landscape. The scientific integrity principles and responsibilities, as set out for example in the Second World Conference on Research Integrity (2010), the UNESCO recommendation on Science and Scientific researchers (UNESCO, 2017), the UNESCO Recommendation on OS (UNESCO, 2021) and the European Code of Conduct for Research Integrity revised in 2023 (ALLEA, 2023) mandatory in all EU funded projects, constitute representative international efforts to encourage the development of unified policies with the long-range goal of fostering greater integrity in research worldwide. As these general rules address facets of the research practices and tend to be taken into account both in education and in research assessment criteria, they constitute a general framework for all recommendations below.

2.2 Preparatory step: Identifying the needs and research focus areas

The first step of our work was a Birds of a Feather (BoF) session held during Research Data Alliance Plenary 9 (Figure 2.1, step 1). The session focused on the hurdles involved in opening up data and other research outputs in the research process, as well as on rewarding schemes and the extent of their use or absence regarding sharing data and other outputs. The discussions spurred i) the creation of the RDA-SHARC interest group that first focused on the design of a human readable FAIR assessment tool (David et al., 2024) and ii) the establishment of a core evolving sub-working group gathering active members developing guidance and recommendations.

As part of this core group (namely, the authors of the present work), we further refined the needs related to recognition throughout i) additional interactive working sessions at RDA plenaries 11, 12, 13, 14, 15, 17, 19 and 20, ii) regular teleconference meetings, emails and asynchronous exchanges (e.g., via Google Doc).

2.3 Agreeing on terms and concepts: terminology

The preparatory step led us to develop a terminology with regards to rewarding in science as a common understanding of the terms and concepts mapping this landscape (Figure 2.1, step 2). We identified all related terms we could think of as to research recognition schemes and categorised them as different types of possible rewards and reward mechanisms (see our Terminology A).

From the literature, we agreed that types of rewarding can range from intangible reputational rewards such as recognising the contribution made by collaborators through acknowledgments and citations (Hicks, 2012), to co-authorship (Latour & Woolgar, 1979) and other tangible rewards (e.g., funds, prizes, career advancement, hiring, and patents) (Haeussler et al., 2014; Nelson, 2016; Shibayama & Lawson, 2021). Opportunities of future collaboration were also reported as possible rewards for sharing (Haeussler et al., 2014; Shibayama & Lawson, 2021).

2.4 Developing mapping tools

To further facilitate the use of our recommendations, as a third step (Figure 2.1) we built several mapping tools that compiled existing policies and rewards related-tools:

- OS Policies B.1, gathers brief descriptions and links to the main OS policies across many countries, pointing to rewards related information whenever specified;
- Rewarding tools B.2, OS Funds B.3, OS Badges/Certificates/Tokens B.4, OS Champions B.5, display examples of existing rewarding tools that were brought to our attention along the various discussions conveyed within SHARC's meetings, RDA plenaries and as a result of the SHARC OS survey (described in the next section).

2.5 Developing recommendations

The fourth step focused on developing actionable recommendations based on the gaps identified during the SHARC IG working sessions and meetings (Figure 2.1, step 4). These

recommendations aimed to i) guide researchers and scientists in the existing rewarding landscape as to how to get some credit in practice, and ii) raise awareness among a number of actors who are part of the research assessment system on which rewarding mechanisms (so far missing) to provide and implement to make the whole system work.

To that aim, a survey was first designed to identify perceptions and expectations of various research communities regarding how OS activities are taken into consideration and rewarded; this survey was sent out to the RDA community at large and various other networks related to members of our core group. Details of the survey methodology and results are available in Grattarola et al. (2024). We then developed the set of recommendations as a multiple-step process based on the results of the survey with back-and-forth exchanges between members of the RDA-SHARC core group and participants in the RDA-SHARC sessions.

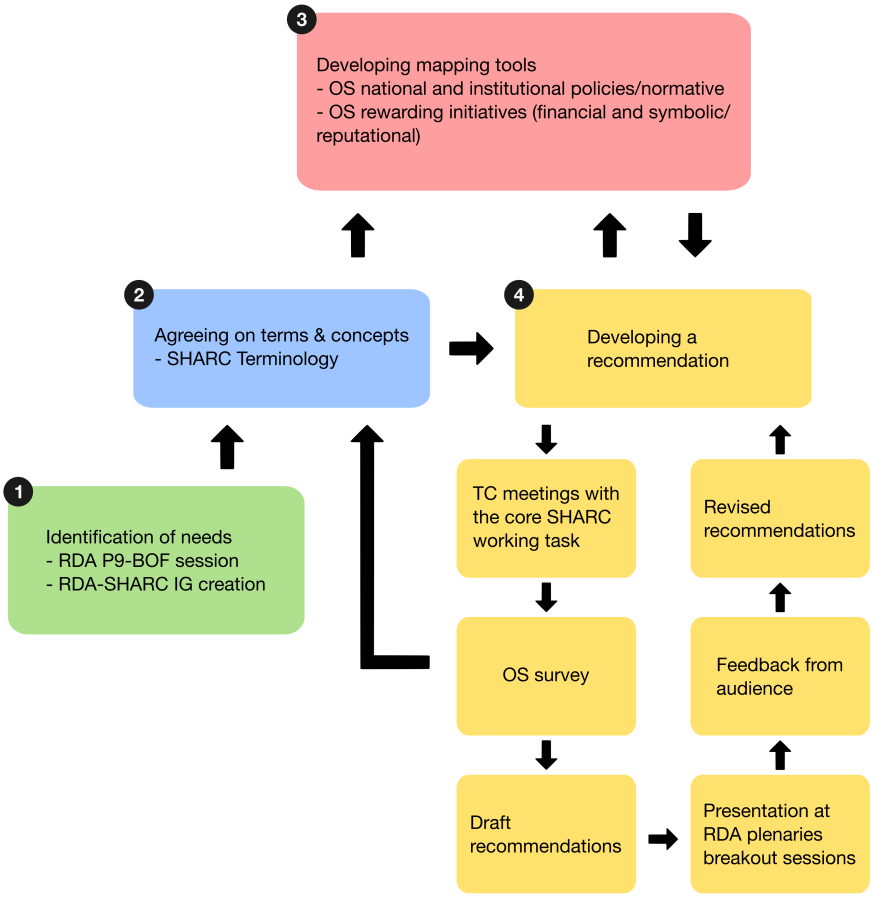

Figure 2.1: Flowchart of developing the RDA-SHARC IG Recommendations on Open Science rewards and incentives to various stakeholders. The process included 4 steps, namely: 1) identifying the needs and research focus areas, 2) agreeing on terms and concepts (developing rewards-related terminology), 3) mapping existing policies and rewarding initiatives, 4) developing a set of recommendations as a single cycle series of steps involving SHARC IG meetings, a global survey and feedback from RDA sessions.

3 Recommendations

The summary of our recommendations is presented and discussed in the following sections.

- Recommendations to **research performing organisations** 3.1
- Recommendations to **funders** 3.2
- Recommendations to **publishers** 3.3
- Recommendations to **government policy-makers** 3.4
- Recommendations to **researchers** 3.5

3.1 To research performing organisations

To gain insight and learn how to support OS activities, institutions should first join RRA and OS related communities/initiatives (e.g., CoARA, RDA) and encourage their personnel to be active in them. Formal OS policies should be adopted and posted on institutional websites, ideally in a discoverable and usable format (e.g. human and machine readable), and communicated to the communities they serve. Important to these policy measures, research outputs should be deposited in community trusted repositories (e.g., institutionally supported repositories, CoreTrustSeal) and made publicly available and reusable under permissive licences. To make these outputs fully reusable, a data management plan (DMP) should be required for all research projects and FAIR principles should be applied as much as possible. In particular, all publications (co)-authored by researchers/staff and students should contain 'Data Availability Statements' and data citation references (which applies to other research outputs such as software).

Furthermore, OS practices expected by a policy should be monitored and rewarded, implying that they should be considered as part of criteria for recruitment and evaluation. A prerequisite for OS monitoring is engagement with persistent identifier (PID) infrastructures, such as Datacite which enables tracking OS activities and outputs through relevant metadata. Even though openly shared datasets, software, protocols, and other research outputs are increasingly accompanied with Digital Object Identifiers (DOIs) and can be

tracked, these efforts are not always fully credited as part of research evaluation and recruitment procedures. There is a need to develop new metrics and indicators for evaluating OS practices, aligning with principles of openness, transparency, and collaboration, and thereby crediting the creator. Assessing scientific production traditionally relies on citation-based metrics from databases like Web of Science, or Google Scholar. However, further discussions in the research community have moved beyond traditional metrics [from PubMed Medline, Scopus etc.; Datacite (2024)] and have explored alternative approaches potentially more suited to OS activities (Bosman, Debackere, & Cawthorn, 2024; Das, 2015; Ugwu Okechukwu, Ugwu Jovita, Alum Esther, & Obeagu, 2023).

Capacity building is critical to implement OS policies. Improvements in OS capacity building should be made by incorporating OS education into research workflows (such as in curricula, training programs, and working groups), so as to become part of the culture. Infrastructures and material resources for OS such as providing digital services and tools should be facilitated by institutions (e.g., FAIR data management service, DMP tools, tools for anonymization, and guidance towards trusted repositories). Notably, OS practice should be facilitated and streamlined by services wherever relevant such as automated metadata completion via persistent identifiers and transfer and communication of copyrights and intellectual property rights should be retained to comply with OA and OS requirements.

Another important aspect is the financial support for OS, including PID-related costs such as DOI registration for all research outputs such as datasets, costs associated with research data/software management, investments in national/regional OS initiatives such as Diamond OA. In order to support OS activities, it is important to include related costs in funding applications, create funding opportunities to work with relevant OS communities, and establish other incentives for OS activities. Various types of OS rewarding solutions need to be explored and implemented, ranging from awards, salary bonuses, champions, badging schemes, to additional free time (e.g., sabbaticals), depending on context. These should also be integrated and recognized as part of recruitment, promotion and tenure schemes (e.g., recognizing open access to research outputs). Token recognition systems (e.g. blockchain backed) are also emerging as a new opportunity to reward the contributions that academics make to the scientific ecosystem. Academics would be awarded token bounties for undertaking common but vital tasks such as peer review, committee work, and writing reports (Finke & Hensel, 2024). These tokens would serve as a validated record of scientific contribution that could be used in the research evaluation scheme. This adds to already present citation mechanisms, including data, software, and other research outputs as recognition.

Table 3.1: Recommendations to Research performing organisations

Table 3.1

Recommendation scope	Recommended action	Examples
Promoting RRA	Participate in building & promoting relevant frameworks and initiatives related to responsible research assessment (e.g., join forums such as the CoARA: Coalition for Advancing Research Assessment)	Sign CoARA Agreement
Engaging with OS communities	Be part of the OS conversation by joining relevant communities, such as the Research Data Alliance	List of OS communities of practice
Adopting formal OS policies	Establish institutional prerequisites to enable the practice of OS	
	* Post institutional OS policies in a visible and easy to find place (website), including all facets of OS (publications, data, software, citizen science)	
	* Mandate deposit of ALL research outputs (e.g., publications, datasets, code) in the institutional or other compliant repository to be publicly available under an open licence (no later than the time of an associated publication, as much as possible)	OS at Finnish Meteorological Institute
	In case of legitimate constraints - 'dark' deposit with open metadata. 'A 'dark' deposit (or restricted deposit) is a work in a repository whose full text stays hidden from the public (not OA). However, metadata associated with these deposits is publicly accessible so that authors' scholarly records are discoverable	
	* Mandate for a DMP/software management plan for all research projects, which the staff/postgraduate students are involved in	
	* Require to manage research data in line with the FAIR principles	
	* Ensure that all publications (co)-authored by the staff/postgraduate students contain data availability statements	
	* Encourage that the staff/postgraduate students retain sufficient IP rights to comply with the OA requirements	Harvard University's Rights Retention policy

		UK Institutional Rights Retention policies
	* Minimise the administrative burden generated by some OS activities and provide support to facilitate these steps while promoting trust and transparency	
	Include criteria for open research activities in recruitment, evaluation and rewarding policies	
	* Consider/create indicators (qualitative and/or quantitative) in general as well as disciplinary data-level metrics for crediting data sharing in the evaluation schemes	CoARA agreement on RRA
		DORA RRA documents
	* Boost appreciation of the researchers who excel in Research Data Management & OS practices, including well-documented, FAIR and open digital outputs, during their annual reviews by integrating these activities into the institutional research evaluation scheme	EC's OS Career Assessment Matrix (OS-CAM)
		NOR-CAM Assessment Framework
		TU Delft strategic-plan-2025
		BIH QUEST programme
		Researcher assessment at FMI
	* Promote that non-OA (closed, i.e.only accessible over paywall) outputs should not be reported for performance evaluation procedures	CNRS policy
OS Capacity building	Provide OS capacity building support	
	* Provide OS courses (ideally as part of the annual mandatory training for research staff and mandatory subjects for postgraduate students)	FAIR & OS training initiatives
		UNESCO 's index
		Mandatory OS course for PhD candidates at Maastricht University
		Mandatory OS course for PhD candidates at Erasmus University Rotterdam

	* Organise institutional working groups, workshops	
	* Provide digital training materials, newsletters	
	* Ensure that the various facets of OS are coherently developed and do not work in silos	
	* Establish dedicated human resources/units, such as OS regulatory adviser, data stewards & managers, appoint professionalised Data Stewards, and engage libraries	TU Delft Data Stewardship project and Data Champions initiative
	* Facilitate collaboration with related OS groups and people	CNRS DDOR
OS infrastructure	Provide infrastructure and material resources for OS	
	* Provide or work with a trusted repository (certification based on CoreTrustSeal, Nestor Seal DIN31644 or ISO16363)	EC's expectations for trusted repositories
	* Provide digital services & operational tools (e.g., DMP tool, FAIR data management, anonymisation and analysis tools, entry points for OS help)	
	* Develop/refine systems which track/monitor research outputs, including OS outputs	Korean NTIS platform
OS funding	Provide financial support for OS	
	* Cover costs associated with registering PIDs (e.g., DOIs) for all research outputs, including datasets	
	* Determine reasonable OA costs to support while transitioning to the Diamond OA model	New Gates Foundation's OA policy
	* Cover costs associated with research data/software management	RADS Initiative: estimates of institutional expenses for public access to research data
	* Provide templates for cost calculation of OS activities in order to facilitate their inclusion in funding applications	
	* Financially support sustainable tools, initiatives and infrastructure development for OS locally, nationally and internationally	SCOSS
		Liverpool University Press's Opening the Future programme for Diamond OA books

		2024 Report on the Sustainability of Diamond OA in Europe
OS rewards	Implement various types of rewards	
	* Awards, gifts to researchers that contribute very actively to OS	Open Research Awards: a Primer from UKRN
	* Organise free time (sabbatical time)	
	* Salary bonus to researchers being actively engaged with OS	
	* Create data champions schemes	TU Delft Data Champions initiative
	* Create OS stamp/badge/label (e.g., in a PhD Degree Certificate)	Examples of OS Badges/Certificates/Tokens Table B.4

3.2 To funders

For funders to support OS, it is important that they develop policies that require, or at a minimum, encourage OS activities in their communities and integrate them into their proposal workflows. To develop these policies, funders should gain a better understanding of current open research practices and capabilities, by conducting landscape analyses, engaging with the OS community, leveraging expertise, and identifying initial steps (i.e. low hanging fruits) that can be taken to monitor and guide these activities. Mapping key stakeholders in OS would be prudent, to avoid being overwhelmed and to interface with the OS community via these stakeholders. For reference, the Aligning Science Across Parkinson's (ASAP, 2021) is an example of the more forward-looking funder policies.

OS monitoring is still a relatively new and developing aspect of the research community where organisations like CoARA and UNESCO are guiding these conversations. However, it is difficult for funders to track these conversations, and it is important for these groups to engage funders, where reasonable (e.g., Centre & ReSA, 2024). For instance, to develop a common framework and schema where policy recommendations and requirements can be aligned. These communities, for the funders sake, should also work towards ensuring that the underlying sources and workflows used to provide information for monitoring and assessment are clear. Funders are limited in how they can interface with OS infrastructure, so it is important for infrastructure providers to take a simple approach to how they need funders to provide them with information (for instance, asking funders to interact with APIs or use XML vs CSV). The support of funders like Arcadia for projects such as OpenAlex (Portenoy, 2024) underscores the importance of investing in collaborative, open scholarly infrastructure to be used as sources for OS monitoring. This commitment is shared by other funders, such as the Bill & Melinda Gates Foundation and the French National Research Agency, who have demonstrated their support by signing the 2024 Barcelona Declaration of Open Research Information.

Initiatives like the national PID strategies out of RDA (Brown, Simons, Bangert, & Sadler, 2022) are helpful to funders as they outline the required infrastructure components they need to enable OS. An example is RAiD (Research Activity Identifier) which allows funders to interlink outputs and resources, but also better understand (interdisciplinary) collaboration in the projects they fund. Not every funder has the capability to implement a data management plan workflow but an output-based approach is an alternative to monitoring and assessment. In line with PIDs that make researchers outputs searchable and discoverable and guarantee their long-term accessibility and tracing, it is worth mentioning emerging decentralised PID approaches such as dPIDs (Hill, Koellinger, & Van Winkle, 2024) and dARK (Matas, Segundo, Nobrega, Filho, & Mena-Chalco, 2023), as new potential monitoring systems to be explored.

New approaches to funding OS need to be explored and implemented, where funding is

allocated to support policies. These can be prizes celebrating OS aspects such as the 'DataWorks! Prize', developing 'OS champions', for instance, at Michael J. Fox Foundation (in the US), encouraging and allocating support for DMPs and data publishing like ANII (in Uruguay). Also, coordination is key as a number of funders are limited by how much they can allocate to OS versus some of the funders that are allocating more towards big initiatives and infrastructure projects. The decision regarding what to fund in OS is more often dependent on the funder's vision, mission, goals, and values.

Supporting OS requires certain commitments from funders beyond just infrastructure. Diversity, Equity, Inclusion, and Accessibility (DEIA) should be integrated into programs together with fostering team science, collaboration, and greater transparency, in line with the CARE principles (Russo Carroll, Garba, & Figueroa-Rodriguez, 2020). These are key tenets of OS, but it is also important that funders look at which principles and values are important to them and how they align with OS (e.g., supporting preprints and open access for the public good). These principles and values can be used as a compass to help with guiding funders through a dynamic OS landscape. Funders should look internally too on how they dedicate staff time and resources to support OS (e.g., setting up teams and roles).

Table 3.2: Recommendations to Funders

Table 3.2

Recommendation scope	Recommended action	Examples
Engaging with OS communities	Be part of the OS conversation by joining relevant communities, such as the Research Data Alliance	List of OS communities of practice
		RDA's Research Funders and Stakeholders on Open Research IG
		RDA's National PID Strategies WG
Adopting formal OS policies	Adopt and publish formal policies requiring/strongly encouraging OS activities	
	* Be specific whether it is a requirement or a recommendation (e.g., require vs encourage preprints)	
OS evaluation	Align OS outputs with traditional ones	
	* Recognise well-documented, FAIR and open digital outputs as first-class contributions during the project lifecycle and in the research assessment framework	NOR-CAM Assessment Framework
		EC's OS Career Assessment Matrix (OS-CAM)
Monitoring OS outputs	Monitor compliance in OS implementation and make it transparent to relevant stakeholders	
	* Share funded OS activities with open scholarly infrastructure, academic databases and search engines	Transition of Open Funder Registry into Research Organisation Registry
		OpenAlex: open bibliographic database
		Funders' support of the Barcelona Declaration on Open Research Information
	* Share/credit the array of research outcomes from funded projects and explore project identifiers like the RAiD as an opportunity to link the project outcomes	RAiD

		Korean NTIS platform (linkage of outputs based on national R&D project number)
OS Funding	Create calls financing OS-driven activities	
	* Calls financing data sharing and re-use and support for software that is critical to research	DataWorks! Prize
		Essential Open Source Software for Science
	* Short-term funding for early career researchers to improve OS sharing	
	For all research projects, systematically allocate a portion of the proposal budget to OS activities, such as data management and sharing	A pilot incentive programme from the Uruguayan ANII research funding agency, offering a 10% increase in fund amounts to those who present a DMP
	Ensure that enough funding is dedicated to appropriate resources for staff and OS infrastructure devoted to the development of shared data platforms (i.e., with standardisation, quality control and analysis tools services that will enable real-time use of data within a project collaboration and future reuse by all)	Life watch services

3.3 To publishers

Piwowar & Chapman (2008) investigated the data sharing policies of 70 journals and found that researchers more frequently share data when journals have such a policy, and that the probability of sharing data correlates positively with the strength of the policy (Mongeon, Robinson-Garcia, Jeng, & Costas, 2017). Publishers' policies are therefore key for OS implementation. Over time many have established sharing policies in line with recommendations to research funders and institutions, yet there is a need for journals to provide clearer instructions to authors, reviewers and staff to encourage OS and foster rewarding schemes for it.

Journals should facilitate researcher-authors' compliance with good OS practices as a prerequisite to credit. This entails implementing a number of connected measures: first, establishing a clear mandate to use unique PIDs for both individuals and their research outputs to enable their digital connectivity to the scholarly record and the attribution of their work; second, making a clear request that all data and software related to a published manuscript adhere to the FAIR principles, along with providing guidance on how to do so and where to deposit these resources to enable reuse; third, providing support for preprints would also help facilitate open access; and fourth, requiring the full and proper citation of all data and software, whether created, used or reused from others' research, in all publications, as it is indispensable for receiving credit.

Requesting FAIR data and software implies that editorial staff and reviewers are able to verify proper citation of data and software and ensure that all supplementary resources are openly available, free of charge, even if the article is not. For this, journals should assign specific editors, such as 'data editors', to assess the quality and FAIRness of data and software (e.g., The American Naturalist). By supporting the FAIR principles in their policies, in combination with clear instructions on how authors should comply, will aid the journals in making strides towards more automated reviews.

The peer-reviewing activity is essential to the scientific method, and publishers should endeavour to recognise its importance and promote transparency through open peer-reviewing models (with or without reviewers anonymity). This can be an additional way to expand OS and improve responsible research assessment. Journals should systematically implement existing tools, such as the CRediT taxonomy, to enable clarifying one's contribution/roles in research works, and systematically use existing guidelines such as the TOP Factor, which can assess their openness and transparency.

Finally, to foster greater inclusivity it is crucial to reconsider the current calibration of OA publishing fees, which are based solely on a country's GDP for Low- and Middle-Income Countries (LMICs). This approach unfairly impacts countries like for instance Uruguay, where GDP is not considered to be low while their R&D funding is; In such cases, it is

imperative to employ more meaningful economic indicators to mitigate the exacerbation of disparities in global knowledge access and to calibrate more equitable costs. Programs such as Research4Life provide one mechanism for use by publishers to try to calibrate costs. More concrete examples are provided in Table 3.3.

Table 3.3: Recommendations to Publishers

Table 3.3

Recommendation scope	Recommended action	Examples
Unambiguous identification	Make use of ORCIDs mandatory in all research outputs (as it is the only universal and free identifier)	Getting started with your ORCID record
	* Make the ORCID search easier in the manuscript submission system	
Findable data & software citation	Require that authors cite data & software they produce and/or reuse in the method/reference section or in a data/software availability statement	AGU's Data & Software Availability Statement
Pre-printing	Provide support for preprints to facilitate open access and open peer-review	eLife's New Model
		Peer Community in
Open peer-review	Foster discussion on the implementation of open peer-review models and the recognition of expert efforts in open peer-review	Open Research Europe: Open Peer-Review Publishing Model
Recognising contributorship	Adopt the CRediT taxonomy to enable the mention of OS activities as part of the contributors' research outputs	Implementing CRediT
		ESIP Research Artefact Citation (see Activities / Large Spreadsheet of Research Artefacts)
Encouraging OS activities	Adopt the OS badges initiative to award badges based on preregistration/open data/open materials	CoS Badges initiative
	Encourage OA publishing in all LMICs by revising the criteria for publishing fees and adjusting them based on meaningful indicators (for instance, to the national Gross domestic expenditure on R&D/GERD and not only to the country GDP)	Research and Development Expenditure (% of GDP)
		Research4Life
Assessing openness	Assess journals for transparency and openness	
	* Start with assessing OA and use the TOP factor for more advanced assessment	TOP factor
	Establish data and software review mechanisms where relevant	

	* Establish data editors that work with the publication stakeholders to assess quality and FAIRness of data/software	Role of data editors in astronomy

3.4 To government policy makers

The governments' adoption and promotion of a national OS policy are an important driver for its implementation. It demonstrates political willingness and helps facilitate the harmonisation of practices across a variety of institutions and disciplines: giving common guidelines and a roadmap to all universities and research institutes facilitates a consistent uptake of OS across territory, institutes and disciplines. Some countries have been early in setting up a national OS strategy (Sveinsdottir, Davidson, & Proudman, 2021), and a few of them have included rewarding mechanisms such as France (MESR, 2021) and the Netherlands (NPOS, 2022). In the French national OS plan, a number of measures are mentioned to make OS practices sustainable, among them the requirement for changes in the evaluation system. In the Dutch national OS strategy, a requirement for realising OS is to 'Make OS rewarding through incentives (Recognition & Rewards)'.

It is important to recognise that international reference texts such as the UNESCO Recommendation on OS (UNESCO, 2021) have stimulated such national strategies and policies. By the end of 2023, eleven countries had national policies stemming from UNESCO's OS recommendations (Austria, Colombia, Cyprus, Ireland, Italy, Latvia, Lesotho, Romania, South Africa, Spain and Ukraine), so the number of countries having such national policies had doubled since the recommendation. Four countries included OS principles in their national Science Technology and Innovation policies (Estonia, Ghana, Sierra Leone and Slovenia); eleven countries (Botswana, Côte d'Ivoire, Croatia, Kenya, Mozambique, Namibia, Nigeria, Somalia, United Republic of Tanzania, Uganda and Venezuela) are currently developing OS policies taking into account the UNESCO recommendation though not specifically mentioning rewarding and crediting measures (UNESCO, 2023).

Our overarching recommendation is for governments to develop national OS policies. Table 3.4 gives examples of such national strategies in various countries that policymakers can adapt to their own contexts. Considering such policies, a number of specific elements need attention.

First, incorporating effective reward mechanisms into national OS policies is important. Providing clear incentives is needed, as opposed to framing OS activities as burdensome requirements. These incentives are vital for fostering the acceptance and successful implementation of OS policies within the scientific community.

Second, compiling and documenting use cases via dedicated websites would highlight real-life mechanisms that have been implemented or piloted. Given the substantial diversity among institutions and policies across various domains and contexts, it is clear that rewarding different scientific activities is not a 'one size fits all' effort. Showcasing use cases would accelerate the implementation of systems that work effectively across most domains. At

the same time, it would accommodate specific mechanisms where necessary. Additionally, it would help avoid repeating mistakes or duplicating efforts.

Third, systematic and rigorous approaches to analyse OS activities, particularly reward mechanisms, are needed. The French national OS plan, for example, has launched a specific call for research proposals in 2023 to study OS activities, including reward systems. To achieve a comprehensive understanding, we recommend prioritising and encouraging funding for projects dedicated to the in-depth analysis of these mechanisms or providing direct funding for such research initiatives.

Finally, it is often the case that various practices are established and tools or mechanisms are tested, but this is frequently done in silos, without coordination between institutions. At the national level, such coordination can be organised and highlighted. Thus, facilitating networking and sharing of practices across institutions at the national level is highly recommended. Further, despite international initiatives such as RDA and CoARA that are pivotal for harmonising assessment methods and mechanisms, there is still a notable lack of dedicated efforts to standardise the assessment of rewards for OS activities at the national level across various institutions and disciplines. Addressing this gap should be a priority to advance OS on a global scale.

Table 3.4: Recommendations to Government-policy-makers

Table 3.4

Recommendation scope	Recommended action	Examples
Promoting national overarching policies on OS	Develop overarching policies requiring/strongly encouraging OS activities at all levels, including an increase in OS awareness among decision-makers	Table B.1 OS Policies
	Ensure that the national policies will allow to:	
	* Harmonise practices	
	* Provide a budget	
	* Monitor implementation across disciplines and institutions	
	* Include rewarding mechanisms as key elements of OS policies (positive aspects rather than a 'burden' and requirements only)	
	- Create observatories of practices that showcase the rewarding mechanisms in place or being piloted in real life;	
	- Provide funding to compare/value and harmonise mechanisms and to study deeply such mechanisms;	
	- Facilitate networking and sharing of practices across institutions at the national level;	
	- Harmonise the way mechanisms are assessed;	
	- Participate in international comparisons and organise involvement in international initiatives (e.g. SCOSS, CoARA, RDA);	
	- Facilitate the implementation of evaluation criteria, considering all aspects of OS (i.e., not only open publications and open data, but also actual reuse of existing data and citizen science activities engaging the public in the scientific process)	

3.5 To researchers

At the individual level and in the current research ecosystem, getting some kind of reward from OS activities will result from several distinct mechanisms that people must be aware of.

First, the normative context framing one's research activity, e.g. in particular national and institutional ones if existent, sets the tone for what must, can or should be done, and sometimes describes how. It is then imperative that everyone is aware of the policies and regulations in place and of the possible means accompanying their implementation. More and more, OS frameworks are endorsed over time worldwide and may provide opportunities to get/apply for various kinds of training and support (material, financial, human). For instance, through specific funds, prizes or awards (see SHARC's OS Awards/Prizes B.2 and OS Funds B.3), or by anticipating an OS budget in the funding applications. Researchers need to watch over this evolving context to anticipate assignments and seize opportunities.

Second, a number of actions are necessary to maximise one's digital presence and visibility on the basis of crediting processes in research (detailed in Stall, Specht, Amato, & al., 2023). The prerequisite for crediting is an identification scheme for researchers and their work's outputs that is unambiguous, persistent and embedded in the scholarly digital ecosystem. The attribution of a PID with associated rich metadata to a research object, makes it searchable and discoverable and guarantees its long-term accessibility and tracing. This is easily achievable for datasets or databases that are numerical by nature. Regarding physical/material resources, it requires first that their description is somehow digitised and accessible on the web (e.g., via metadata-only datasets, data papers or landing pages). Identification through PIDs is now supported by robust organisations, especially DataCite operating DOIs for numerical objects and ORCID for individual researchers. Making visible those identified elements is the next step to getting or giving credit. It is essential that researchers refer systematically to all their own OS-identified outputs wherever relevant through citation and/or acknowledgement, notably in papers, CVs and reporting activities. It is equally essential that researchers cite or acknowledge other's outputs they reuse in their own research. This is also intrinsically linked with how co-authorship is managed within projects/teams. It is important to consider the diverse contributor roles and it is advised to establish how to handle co-authorships from the beginning of a project to ensure that everyone's contribution (including e.g., technicians or data collectors) is included.

Thirdly, obtaining symbolic rewards such as OS badges and certificates or OS ambassador roles can serve as a form of recognition for researchers who engage in OS practices (e.g., Open Science Badges of the Center for Open Science). These recognition schemes can help build trust in the researchers' work and enhance their credibility as researchers (Schneider, Rosman, Kelava, & Merk, 2022). By earning badges, researchers demonstrate their

commitment to OS and become visible in their community for that. Having digital badges incorporated into an author's record as a contribution to overall metrics is to be explored and implemented in research scholarly infrastructures. More practical information is provided in Table 3.4.

Finally, credit/recognition can also be obtained for research outputs that have a commercial perspective through patents that may have been obtained based on the results. Obtaining patents means that researchers or their employer legally own intellectual property rights. Researchers should be aware that patenting and OS practices are compatible (EC Innovation Council and SMEs Executive Agency, 2023), i.e. open sharing of findings can be done as soon as a patent application is filed or prior to the filing in certain jurisdictions such as the US and South Korea which provide 'grace periods' (Nuechterlein, Rotenberg, LeDue, Pavlidis, & Illes, 2023). In such cases, advice should be given to the applicant that they should encourage the 'free non-commercial use by [other] researchers of knowledge disclosed in patents'. Given that large, detailed and consistent datasets are an asset not only for researchers but also for companies, monetary reward opportunities can arise to provide incentives for data sharing (ALLEA, 2022).

For examples on national and institutional OS plans, OS and FAIR awards, dedicated funds for OS, and training initiatives, please refer to our Rewarding tools B (OS Awards/Prizes, OS Funds, OS Badges/Certificates/Tokens, OS Champions).

Table 3.5: Recommendations to Researchers

Table 3.5

Recommendation scope	Recommended action	Examples
Raising awareness of OS policies	Be aware of the existing and relevant institutional, countrywide, regional, and community research policies, including laws, regulations and agreements	OS Policies Table B.1
Raising awareness of OS training	Be aware of OS training sessions and resources provided by institutions or communities	UNESCO OS Capacity Building Index
		OS Loterre Thesaurus
OS Capacity building	Maximise as much as possible digital presence using PID for individuals and for all outputs (e.g., ORCID, DOI or other identifier for open access publications / open access datasets / open source software)	Parsec Digital Presence checklist
		PLOS Handbook/Guide
	* Include citation elements for research data/software created in the References section of a paper. To support indexing and reuse:	AGU's Data and Software Availability and Citation Checklist & Templates
	- Use American Psychological Association (APA) style;	
	- Include a persistent identifier (DOI), preferred, or URL;	
	- Use labels/bracketed descriptions (e.g., [Dataset], [Software], [Collection], [ComputationalNotebook])	
	* Include a data/software availability statement in any paper that describes where and how data are available, and how to cite them if possible.	
	Update CV & reporting information within OS activities	
Recognising contributorship	Acknowledge OS contributorship	
	* Specify all kind of contributorship early in the projects	The Turing Way project's Acknowledging Contributors
	* Use the CRediT taxonomy:	Implementing the CRediT Taxonomy

	- Allocate the terms appropriately to project contributorship and contributions to research outputs;	
	- Advocate for institutional acknowledgement and adoption of the taxonomy for research outputs	
	* Cite data and research outputs in Data Availability Statement and References sections of papers	
	* Acknowledge and cite OS tools used, e.g. with an identifier or 'How to cite' statement (if any)	
Raising awareness of OS costs	Be aware of how to include OS costs in all funding applications	Curation and Data Management Services
Raising awareness of OS financial rewarding	Solicit dedicated financial reward or support	OS Awards/Prizes Table B.1
	* Apply to specific funds for OS activities wherever relevant	
	* Apply to OS prize/awards if any	
Raising awareness of OS symbolic rewarding	Get symbolic reward	
	* Apply for OS certificates/OS ambassador/OS badge schemes	OS Champions Table B.5
	* Apply for training badges	OS Badges/Certificates/Tokens Table B.4
	* Join OS acknowledging opportunities to gain visibility/reputation	

4 Concluding remarks

Opening science today necessitates integrating transformative changes in research culture, workflows, governance structures and assessment mechanisms, and involves extending these changes across all scientific communities. Achieving this goal is not feasible through the efforts of an individual researcher without support from other stakeholders in the research ecosystem and global coordination of their collective actions. These stakeholders include research performing and funding organisations, publishers and government policy makers.

Given the historical organisation of science, the transition to OS can be challenging, burdensome, and costly for researchers who generate scientific outputs. Identifying mechanisms to facilitate and reward those at the forefront of this transition is essential for accelerating the entire process. This study has practical implications, providing actionable recommendations that embrace a holistic approach to guide the development and implementation of rewarding schemes at various levels - where they exist, or to assist in their creation where they are needed.

It is important to note that incentivising OS practices, such as data sharing, might lead some researchers to engage in strategic sharing to accumulate rewards, effectively 'gaming' the system rather than focusing on the production of new, high-quality knowledge. Therefore, to prevent a similar 'publish or perish' dynamic within OS practices - where rewards may drive efforts focused more on quantity than on substantive contributions - it is crucial that any OS reward and incentive schemes incorporate stringent eligibility criteria for rewards, based on rigorous quality assessments of outputs and governed by principles of research integrity and responsible conduct.

5 Acknowledgements

Thanks to the contributors to initial phases of the present work:

Romain David (ERINHA, FR), Alison Specht (University of Queensland, AU), Gabrielle Bertier (University Toulouse III, FR), Mohammed Yahia (INIST, FR), Louise Bezuidenhout (Data Archiving and Networked Services, DANS and Royal, Netherlands Academy of Arts and Sciences, NL), Michele de Rosa (2.-0 LCA consultants, DK), Laurent Dollé (Université Libre de Bruxelles, BE), Sofie Beckaert (University Gent, BE), and Elena Bravo (ISS, IT).

We also thank Anne-Sophie Archambeau, Jane Carpenter, Anna Cohen Nabeiro, Aurélie Delavaud, Fiona Murphy, Sophie Parmelon, Anne-Marie Tassé and Martina Zilioli for their inputs.

Finally, we wish to acknowledge the fruitful comments from all the members of the RDA-SHARC interest group and all the attendants to the various SHARC working sessions held at RDA plenaries.

6 Funding

This research received funding from the PARSEC Belmont Forum Collaborative Research Action on Science-Driven e-Infrastructures Innovation (SEI2018). Additionally, FG was funded by the European Union (ERC, BEAST, 101044740). HS received funding from the Korea Institute of Science and Technology Information (No. K-24-L01-C05-S01). ACT received funding from the European Union's Horizon 2020 research and innovation programme EOSC Future under grant agreement no 101017536 as domain ambassador.

Funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

References

ALLEA. (2022). *Aligning intellectual property rights with open science - ALLEA statement.* Retrieved from https://allea.org/wp-content/uploads/2022/04/ALLEA-Statement-Aligning-IPR-with-Open-Science.pdf

ALLEA. (2023). *The european code of conduct for research integrity -revised edition 2023.* Berlin. Retrieved from https://allea.org/code-of-conduct/

Arthur, P. L., Hearn, L., Montgomery, L., Craig, H., Arbuckle, A., & Siemens, R. (2021). Open scholarship in australia: A review of needs, barriers, and opportunities. *Digital Scholarship in the Humanities*, *36*(4), 795–812. https://doi.org/10.1093/llc/fqaa063

ASAP. (2021). *ASAP's open access policy.* Retrieved from https://parkinsonsroadmap.org/open-access-policy/#

Blume, S. S. (1974). *Toward a political sociology of science.* New York, Free Press.

BOAI. (2002). Budapest open access initiative. Retrieved January 18, 2024, from https://www.budapestopenaccessinitiative.org/read/

Bosman, J., Debackere, K., & Cawthorn, W. (2024). *Next generation metrics for scientific and scholarly research in europe.* https://doi.org/10.5281/zenodo.11123148

Brown, C., Simons, N., Bangert, D., & Sadler, S. (2022). Research data alliance - national PID strategies working group. Retrieved from https://www.rd-alliance.org/groups/national-pid-strategies-wg/members/all-members/

Centre, S. D., & ReSA. (2024). *2024 International Research Software Funders Workshop.* Retrieved from https://adore.software/2024-international-research-software-funders-workshop/

CLACSO. (2019). FOLEC. Retrieved January 18, 2024, from https://www.clacso.org/folec/

CNRS. (2019). *CNRS roadmap for open science.* Retrieved from https://www.science-ouverte.cnrs.fr/wp-content/uploads/2019/11/CNRS_Roadmap_Open_Science_18nov2019.pdf

cOAlition S. (2023). Plan s. Towards responsible publishing. Retrieved January 18, 2024, from https://www.coalition-s.org/towards-responsible-publishing/

CoARA. (2022). Coalition for advancing research assessment. Retrieved January 18, 2024, from https://coara.eu/

CODATA WG. (2024). *CODATA Working Groups.* Retrieved from https://codata.org/initiatives/working-groups/

Cole, N. L., Klebel, T., Apartis, S., & Ross-Hellauer, T. (2024). The societal impact of open science–a scoping review. Retrieved from https://osf.io/preprints/socarxiv/tqrwg

Czarnitzki, D., Grimpe, C., & Pellens, M. (2015). Access to research inputs: Open science versus the entrepreneurial university. *Journal of Technology Transfer*, *40*(6), 1050–1063. https://doi.org/10.1007/s10961-015-9392-0

Das, A. K. (2015). *Research evaluation metrics*. UNESCO. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000232210

Dasgupta, P., & David, P. A. (1994). Toward a new economics of science. *Research Policy*, *23*(5), 487–521. https://doi.org/10.1016/0048-7333(94)01002-1

Datacite. (2024). *Data-level metrics*. Retrieved from https://datacite.org/blog/tag/data-level-metrics/

David, R., Mabile, L., Specht, A., Stryeck, S., Mohamed, Y., Thomsen, M., … Interest Group, C. (SHARC). (2024). *Templates for FAIRness evaluation criteria - RDA-SHARC ig V1.4*. Zenodo. https://doi.org/10.5281/zenodo.11243918

Dijstelbloem, H., Huisman, F., Miedema, F., & Mijnhardt, W. (2013). *Why science does not work as it should and what to do about it*. Science in Transition. Retrieved from Science in Transition website: https://scienceintransition.nl/english

DORA. (2012). San francisco declaration on research assessment. Retrieved January 18, 2024, from https://sfdora.org/read/

EC DGRI. (2021). *European commission, directorate-general for research and innovation. European research area policy agenda – overview of actions for the period 2022-2024*. EU Publications Office. Retrieved from EU Publications Office website: https://data.europa.eu/doi/10.2777/52110

EC Innovation Council and SMEs Executive Agency. (2023). *European IP helpdesk bulletin. No. 7, december 2023, open science*. Retrieved from https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/943874e5-9fbc-11ee-b164-01aa75ed71a1

EU AGA. (2023, April 1). EU funding programmes 2021-2027. Annotated grant agreement. Retrieved January 18, 2024, from https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/aga_en.pdf

EU Council. (2022, June 10). Council conclusions on research assessment and implementation of open science. Retrieved January 18, 2024, from https://www.consilium.europa.eu/media/56958/st10126-en22.pdf

EU Horizon RIA GraspOS project. (2023). GraspOS: Next generation research assessment to promote open science. Retrieved January 18, 2024, from https://cordis.europa.eu/project/id/101095129

EU Parliament and Council. (2021, April 28). Regulation (EU) 2021/695 of the european parliament and of the council. Retrieved January 18, 2024, from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0695&qid=1705589817543

European Commission, Directorate-General for Research and Innovation, Cabello Valdes, C., Rentier, B., Kaunismaa, E., Metcalfe, J., Esposito, F., … O'Carroll, C. (2017).

Evaluation of research careers fully acknowledging open science practices – rewards, incentives and/or recognition for researchers practicing open science. EU Publications Office. Retrieved from https://data.europa.eu/doi/10.2777/75255

Finke, A., & Hensel, T. (2024). *Decentralized peer review in open science: A mechanism proposal*. https://doi.org/10.48550/arXiv.2404.18148

Grattarola, F., Shmagun, H., Erdmann, C., Cambon-Thomsen, A., Thomsen, M., & Mabile, L. (2024). Gaps between open science activities and actual recognition systems: Insights from an international survey. https://doi.org/10.31235/osf.io/hru2x

Haas, M. R., & Park, S. (2010). To share or not to share? Professional norms, reference groups, and information withholding among life scientists. *Organization Science*, *21*(4), 873–891. https://doi.org/10.1287/orsc.1090.0500

Hackett, E. J. (2008). *Research ethics. Science as a vocation in the 1990s. The changing organizational culture of academic science*. Taylor & Francis.

Haeussler, C., Jiang, L., Thursby, J., & Thursby, M. (2014). Specific and general information sharing among competing academic researchers. *Research Policy*, *43*(3), 465–475. https://doi.org/10.1016/j.respol.2013.08.017

Hicks, D. (2012). Performance-based university research funding systems. *Research Policy*, *41*(2), 251–261. https://doi.org/10.1016/j.respol.2011.09.007

Hicks, D., Wouters, P., Waltman, L., Rijcke, S. de, & Rafols, I. (2015). The leiden manifesto for research metrics. *Nature*, *520*(7548), 429–431. https://doi.org/10.1038/520429a

Hill, C., Koellinger, P., & Van Winkle, E. (2024, March 14). THE SCHOLARLY kitchen. Guest post — navigating the drift: Persistence challenges in the digital scientific record and the promise of dPIDs. Retrieved from https://scholarlykitchen.sspnet.org/2024/03/14/guest-post-navigating-the-drift-persistence-challenges-in-the-digital-scientific-record-and-the-promise-of-dpids/

Latour, B., & Woolgar, S. (1979). *Laboratory life: The construction of scientific facts*. Sage Publications, Beverly Hills.

Manco, A. (2022). A landscape of open science policies research. *Sage Open*, *12*(4), 21582440221140358. https://doi.org/10.1177/21582440221140358

Matas, L., Segundo, W., Nobrega, T., Filho, J. E. S., & Mena-Chalco, J. (2023, July 10). dARK: A decentralized blockchain implementation of ARK persistent identifiers. Open repositories 2023 (OR2023), stellenbosch, south africa. Presented at the Open repositories 2023 (OR2023). https://doi.org/10.5281/zenodo.8091668

Merton, R. K. (1942). *The normative structure of science* (Storer N.W.).

Merton, R. K. (1973). *Sociology of science*. University of Chicago Press, Chicago.

MESR. (2021). *Second french plan for open science: Generalising open science in france 2021-2024*. Retrieved from https://www.ouvrirlascience.fr/second-national-plan-for-open-science/

Mongeon, P., Robinson-Garcia, N., Jeng, W., & Costas, R. (2017). Incorporating data sharing to the reward system of science: Linking DataCite records to authors in the web of science. *Aslib Journal of Information Management*, *69*(5), 545–556. https:

//doi.org/10.1108/AJIM-01-2017-0024

Munafò, M. R., Nosek, B. A., Bishop, D. V. M., Button, K. S., Chambers, C. D., Percie Du Sert, N., … Ioannidis, J. P. A. (2017). A manifesto for reproducible science. *Nature Human Behaviour*, *1*(1), 0021. https://doi.org/10.1038/s41562-016-0021

Murray, F., & O'Mahony, S. (2007). Exploring the foundations of cumulative innovation: Implications for organization science. *Organization Science*, *18*(6), 1006–1021.

Nelson, A. J. (2016). How to share "a really good secret": Managing sharing/secrecy tensions around scientific knowledge disclosure. *Organization Science*, *27*(2), 265–285. https://doi.org/10.1287/orsc.2015.1040

Nosek, B. A., Alter, G., Banks, G. C., Borsboom, D., Bowman, S. D., Breckler, S. J., … al., et. (2023, September 27). Transparency and openness promotion (TOP) guidelines [OSF]. Retrieved January 18, 2024, from https://osf.io/9f6gx

NPOS. (2022). *Open science 2030 in the netherlands: NPOS2030 ambition document and rolling agenda (approved version)*. https://doi.org/10.5281/zenodo.7433767

Nuechterlein, A., Rotenberg, A., LeDue, J., Pavlidis, P., & Illes, J. (2023). Open science in play and in tension with patent protections. *Journal of Law and the Biosciences*, *10*(2), lsad016. https://doi.org/10.1093/jlb/lsad016

Open and Universal Science (OPUS) project. (2022). *EU - Open and Universal Science (OPUS) project*. Retrieved from https://opusproject.eu/

Piwowar, H. A., & Chapman, W. W. (2008). Identifying data sharing in biomedical literature. *AMIA Annual Symposium Proceedings*, *2008*, 596–600. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2655927/

Portenoy, J. (2024, March 13). OurResearch blog news from the OurResearch team. OurResearch receives $7.5M grant from arcadia to establish OpenAlex, a milestone development for open science. Retrieved from https://blog.ourresearch.org/ourresearch-receives-7-5m-grant-from-arcadia-to-establish-openalex-a-milestone-development-for-open-science/

RDA-EoR IG. (2023). *Research Data Alliance-Evaluation of Research Interest Group*. Retrieved from https://www.rd-alliance.org/groups/evaluation-research-ig/

RDA-SHARC IG. (2017). *Research Data Alliance - SHAring Rewards & Credit (SHARC) Interest Group*. Retrieved from https://www.rd-alliance.org/groups/sharing-rewards-and-credit-sharc-ig

Rijcke, S., Cosentino, C., Crewe, R., D'Ippoliti, C., Motala-Timol, S., Rahman, N. B. A., … Yupeng, Y. (2023). *The future of research evaluation: The synthesis of current debates and development. Discussion paper*. https://doi.org/10.24948/2023.06

Russo Carroll, S., Garba, I., & Figueroa-Rodriguez, O. L. (2020). The CARE principles for indigenous data governance. *Data Science Journal*, *19*(43), 1–12. https://doi.org/10.5334/dsj-2020-043

Schneider, J., Rosman, T., Kelava, A., & Merk, S. (2022). Do open-science badges increase trust in scientists among undergraduates, scientists, and the public? *Psychological Science*. https://doi.org/10.1177/09567976221097499

Second World Conference on Research Integrity. (2010). Singapore statement on research integrity. Retrieved January 18, 2024, from https://www.singaporestatement.org/guidance/singapore-statement

Shibayama, S., & Baba, Y. (2011). Sharing research tools in academia: The case of japan. *Science and Public Policy*, *38*(8), 649–659. https://doi.org/10.3152/030234211X13122939587699

Shibayama, S., & Lawson, C. (2021). The use of rewards in the sharing of research resources. *Research Policy*, *50*(7), 104260. https://doi.org/10.1016/j.respol.2021.104260

Stall, S., Specht, A., Amato, J. G., & al., et. (2023). *Parsec Digital Presence checklist*. https://doi.org/10.5281/zenodo.4706118

Sveinsdottir, T., Davidson, J., & Proudman, V. (2021). *An analysis of open science policies in europe*. SPARC Europe. Retrieved from SPARC Europe website: https://doi.org/10.5281/zenodo.4725817

Tenopir, C., Dalton, E. D., Allard, S., Frame, M., Pjesivac, I., Birch, B., … Dorsett, K. (2015). Changes in data sharing and data reuse practices and perceptions among scientists worldwide. *PLoS One*, *10*(8), e0134826. https://doi.org/10.1371/journal.pone.0134826

Ugwu Okechukwu, P.-C., Ugwu Jovita, N., Alum Esther, U., & Obeagu, E. I. (2023). *Redefining academic performance metrics: Evaluating the excellence of researchers, academics, and scholars*. *4*(1), 36–42. https://doi.org/10.59298/NIJSES/2023/10.5.1000

UHR Working Group. (2021). *NOR-CAM – a toolbox for recognition and rewards in academic careers. Available at:* Retrieved from https://www.uhr.no/en/_f/p3/i86e9ec84-3b3d-48ce-8167-bbae0f507ce8/nor-cam-a-tool-box-for-assessment-and-rewards.pdf

UNESCO. (2017). *UNESCO recommendation on science and scientific researchers*. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000263618

UNESCO. (2021). *UNESCO recommendation on open science*. Retrieved from https://doi.org/10.54677/MNMH8546

UNESCO. (2023). *Open science outlook 1: Status and trends around the world*. United Nations Educational, Scientific; Cultural Organization,. https://doi.org/10.54677/GIIC6829

VNSU, NFU, KNAW, NWO, & ZonMw. (2019). Recognition and rewards. Room for everyone's talent. Retrieved January 18, 2024, from https://recognitionrewards.nl/about/position-paper/

Wallis, J. C., Rolando, E., & Borgman, C. L. (2013). If we share data, will anyone use them? Data sharing and reuse in the long tail of science and technology. *PLoS One*, *8*(7), e67332. https://doi.org/10.1371/journal.pone.0067332

Walsh, J. P., Cohen, W. M., & Cho, C. (2007). Where excludability matters: Material versus intellectual property in academic biomedical research. *Research Policy*, *36*(8), 1184–1203. https://doi.org/10.1016/j.respol.2007.04.006

Wilkinson, M. D., Dumontier, M., Aalbersberg, Ij. J., Appleton, G., Axton, M., Baak, A.,

… Mons, B. (2016). The FAIR guiding principles for scientific data management and stewardship. *Scientific Data*, *3*(1), 160018. https://doi.org/10.1038/sdata.2016.18

Wilsdon, J., Allen, L., Belfiore, E., Campbell, P., Curry, S., Hill, S., … Johnson, B. (2015). *The metric tide: Report of the independent review of the role of metrics in research assessment and management wilsdon*. https://doi.org/10.13140/RG.2.1.4929.1363

Working group for responsible evaluation of a researcher. (2020). *Good practice in researcher evaluation. Recommendation for the responsible evaluation of a researcher in finland*. The Committee for Public Information (TJNK); Federation of Finnish Learned Societies (TSV). Retrieved from The Committee for Public Information (TJNK); Federation of Finnish Learned Societies (TSV) website: https://avointiede.fi/sites/default/files/2020-03/responsible-evalution.pdf

Wouters, P., Thelwall, M., Kousha, K., Waltman, L., Rijcke, S. de, Rushforth, A., & Franssen, T. (2015). *The metric tide: Literature review (supplementary report i to the independent review of the role of metrics in research assessment and management)*. Retrieved from 10.13140/RG.2.1.5066.3520

A Terminology

Table A.1 Types of rewards in Research

Table A.1

Type	Category	Term
Tangible	Open outputs-related	authorship (e.g., research article, data, software, objects),
		contributorship (e.g., editorship, consortium contribution, data management...)
		citation
		acknowledgement (e.g., peer-review activity)
	Open research evaluation-related	gained credits
		specific funding (research allocation/grant
		prize
		gratification
		money for authorship in publications
		badges, medals
	Career-related	career promotion / advancement (e.g., tenure)
		career development
		job hiring / recruitment
		salary (e.g., human resources dedicated to open science)
		financial reward
Intangible	Personal perceptions	getting recognition
		improving reputation
		increasing merit
		pleasure/satisfaction (e.g., contributing to the knowledge commons and public goods)

		increasing trust about your work
		mutual benefit
	Increased public visibility	having more impact
		through champion's portrait
		receiving public acknowledgment
	More research opportunities	expanding national & international of collaborations & network
		increasing number and diversity of partnerships
		favouring team work's efficiency

Table A.2 Mechanisms/tools to provide a reward for OS

Table A.2

Mechanism tool	Term	Description	Examples
Policies and guidelines	reward frameworks	Institutional schemes and programmes for OS rewards	Documentation for an OS award competition
	funding	Allocation of funds for OS-related rewards	OS grants or extra amounts assigned for OS within current grants; prizes for exemplary OS practices
	recommendati	Suggestions of rewarding mechanisms tailored to specific communities	Rules for OS reward eligibility and competition for applicants
	guidance best practices		
	sanctions	Negative incentives to avoid	Being penalised by non-compliance with data sharing policies and related terms of research grants (e.g., suspending a grant or rejecting future grant applications)
Support, training and capacity building	infrastructures	OS technological platforms or tools enabling the practical implementation of a rewarding scheme	Collaborative research platforms (e.g. ResearchHub)
	educational & training resources	On line and live modules addressing OS various facets and providing rewards upon completion	Certificate, badges, ideally connected to ORCID profiles; mentorship programmes
	support of networks	Support of cross-institutional collaborations in OS domains, OS oriented groups and initiatives across disciplines at various levels	Funds for working groups in OS and networking activities; recognition of such activities at institution level in evaluation.
	support from experts	Support from OS experts, network of OS delegates or officers	Data stewards per team/institution; helpdesk for OS activities

Research evaluation	metrics	For OS quality and impact of research	Data/software citation, usage, contributions, etc.
	criteria for OS outputs & activities	Criteria to assess OS activities as part of research performing	Requirement to report only open access publications for annual research evaluation; recognition of collaborations across disciplines, sectors and with public (e.g. citizen science engagement)

B Mapping tools

Table B.1 OS Policies

Table B.1

Country region international	Institution agency	Brief outline of the policy specifying the os activities	Remarks	Link to a page mentioning os rewards
France	Institut Pasteur	This is the 2019-2023 Strategic Plan of the institute, which includes a general commitment to open science. One of its strategic objectives is to promote open access to publications and research data.	In French	
France	Institut Pasteur	This Charter for Free Access to Publications sets the institute's objective of achieving 100% of annual publications being OA and being accessed via the institutional repository.		
France	Institut Pasteur	This policy sets the institute's detailed guidelines on the management and sharing of research data and software codes, according to the FAIR principles.		
France	CNRS	The CNRS Roadmap for Open Science sets a number of actions centered around the four main objectives: (1) Scholarly publications produced by CNRS researchers and financed mainly from public funds must be 100% accessible and reusable, copyright must not be transferred. (2) Data (raw data, source codes and software) produced by CNRS researchers or using resources implemented by the CNRS must, as far as possible, be made accessible and reusable, according to the FAIR principles. (3) Facilitate text and data mining by developing infrastructures, tools and skills to enable fully independent analysis capacities on scientific content. (4) Transform the individual assessment of researchers by making it compliant with the goals of open science together with taking their contributions to open science into account in assessments.		Financial support for researchers to participate in RDA meetings/initiatives (p. 14)

France	Ministry of Higher Education, Research and Innovation	The Second National Plan on Open Science, published by the French Ministry of Higher Education, Research and Innovation, aims to reach 100% of open access publications resulting from publicly funded research by 2030, particularly supporting the Diamond model. It also promotes data sharing through the creation of the Recherche Data Gouv platform as well as opening up source code from research. Its scope also includes several measures for sustainable transformation towards open science, such as the increase of the national fund for open science and the promotion of recognition of open science activities in research assessments.	Commitments to award an annual research data prize (p. 15), open source research software prize (p. 18) and open science thesis prize (p. 23)
Finland	Federation of Finnish Learned Societies / Secretariat for the National Open Science and Research Coordination	These are national open science policies in Finland, with the Federation of Finnish Learned Societies (TSV) funded by the Ministry of Education and Culture taking on a national coordinating role. These policies outline the strategic principles, objectives and action plans necessary to achieve the objectives set out in the Finnish Declaration for Open Science and Research 2020–2025. The policies are drafted for four areas: culture for open scholarship; open access to scholarly publications; open access of research data and methods; and open education and open access to educational resources.	
Finland	Federation of Finnish Learned Societies	The Finnish national recommendation for responsible evaluation and assessment states that researchers' activities to promote open access to research outputs should be considered as part of the evaluation and be recognised as in integral part of everyday research work.	

Finland	Finnish Meteorological Institute	This is the Open Access Publishing Policy, which applies to all publicly funded research activities that have as result publication of research literature. The institute requires the Green route, while the Golden immediate access is strongly encouraged when possible, the hybrid open aceess is acceptable in exceptional circumstances (only if the external funding contract permits it).	
Finland	Finnish Meteorological Institute	This is the Research Data Policy. It provides guidance on the management of the digital research data produced, used and edited in FMI's research projects and promotes the FAIR data principles.	
Finland	Finnish Meteorological Institute	This is the Open-Source Software Policy, which applies to all publicly funded research activities that have as result the development of software.	
Norway	NOR-CAM A national framework for recognition and rewards in academic careers.	A working group appointed by the Universities Norway (UHR) produced guiding principles for the assessment and evaluation of Norwegian research(ers) in light of the transition to open science. In other words, these principles call for recognition and rewards of all results, activities and competencies related to open science in the new framework of research assessment.	The whole document broadly encourages open science rewards
Scotland	University of Glasgow	The University of Glasgow's Academic Promotion Criteria include open access and open research practices as part of assessing excellence of research outputs.	

the Netherlands	National Initiative (Regieorgaan) Open Science led by Dutch Research Council NWO	This document includes the guiding principles that underlie shared endeavours for the years to come, the vision for open science in the year 2030, the strategic goals the Netherlands is working towards and cross-cutting requirements for all actions to be taken up. An open consultation in which 78 Dutch institutions, networks, communities and individuals gave their constructive feedback, was part of the process of defining shared ambitions in this document. The facilitating role of realising these commitments is taken up by the national initiative on open science led by Dutch Research Council (NWO), with the Ministry of Education, Culture and Science providing 20 million euros per year until 2032.	'Making open science rewarding through incentives (Recognition & Rewards)' is one of the essential requirements, for which some actions are planned (p. 14)
the Netherlands	the Dutch Research Council (NWO), Dutch Universities (VSNU) and the Royal Netherlands Academy of Arts and Sciences (KNAW)	The Strategy Evaluation Protocol (SEP) was drafted by a dedicated committee, set up jointly by the Dutch Research Council (NWO), Dutch Universities (VSNU) and the Royal Netherlands Academy of Arts and Sciences (KNAW). These organisations have undertaken to assess all research within their organisations in accordance with the SEP, which integrates open science practices into the assessment criteria.	Human Resource Policy will include a 'consideration of how the research unit ensures that researchers are properly evaluated, rewarded and incentivised.' (p. 10)
the Netherlands	Utrecht University	This vision document describes the Utrecht University's model for recognition and rewards ("TRIPLE" model), which embraces open science as one of its five guiding principles.	Recognize and reward openness in all domains (p. 6)

the Netherlands	TU Delft	This is the TU Delft Research Software Policy. The Policy: 1) facilitates best-practices on research software management and sharing, irrespective of whether the code is proprietary or open source; 2) emphasises the value of research software as a standalone research output and facilitates proper recognition of the contribution of TU Delft researchers to software; 3) sets out some high-level requirements for how software should be managed, the responsibilities of the different stakeholders involved in software development and describes the global workflows that facilitate sharing software openly. This policy is accompanied by the document "TU Delft Guidelines on Research Software: Licensing, Registration and Commercialisation".		
Italy	National Institute of Geophysics and Volcanology (INGV)	This is the Data Policy of the institute, which specifies the principles for the management of data produced in the context of research activities financed with public funds.	In Italian	
Italy	Ministry of University and Research	National Plan for Open Science by the Italian Ministry of University and Research sets objectives and priorities on five axes of intervention: open access to scientific publications; research data; research evaluation; engagement and coordination activities among communities and actors involved in open science; and opening up research data on SARS-COV-2 AND COVID-19 and exploration of innovative open data models on public health.		One of the actions planned is 'to acknowledge and reward open science good practices as evaluation criteria…' (p. 13)
Italy	Institute of Information Science and Technologies of the National Research Council of Pisa	The provided link is a catalogue that lists open access policies of several Italian institutes. It is a project developed by the Institute of Information Science and Technologies of the National Research Council of Pisa to promote and study open science topics.		

UK	UKRI	The UKRI Open Access Policy requires that all peer-reviewed research articles (including conference proceedings) that acknowledge funding from UKRI be made open access immediately upon publication, without embargo, under a CC-BY licence. Additionally it requires that long-form publications such as monographs be made open access within 12 months of publication.	
Ireland	Ireland's National Open Research Forum, supported by the Department of Further and Higher Education, Research, Innovation and Science	The action plan serves as a roadmap for the implementation of open research across Ireland, outlining national goals and coordinated actions that will assist the research system as a whole to better support open research practices. It is structured according to three themes: establishing a culture of open research at every level of the Irish research system; achieving 100% open access to research publications; and enabling FAIRness of research data and other outputs such as software code. The process of developing the action plan was supported by the The Department of Further and Higher Education, Research, Innovation and Science and led by Ireland's National Open Research Forum (NORF), a broad group that combines the expertise of representatives from policy, research funding organisations, research performing organisations, the library sector, research infrastructures, enterprise and other key stakeholders in the research system across Ireland.	Action 3.2 (p. 10): 'Strengthen the system-wide recognition and reward of open research practices.'

Ukraine	The Government of Ukraine	The plan, approved by the Government of Ukraine, includes integration of open science into national science, research, education, innovation policies and strategies and stipulates working in collaboration with EOSC and Horizon Europe partnerships. The plan sets six main objectives and corresponding activities to be conducted by 2030 by several stakeholders such as the Ministry of Education and Science, Ministry of Digital Transformation, Ministry of Health, National Academy of Sciences, with the leading role of the Ministry of Education and Science and the National Academy of Sciences. These six objectives are as follows: ensuring open access to research results and scientific information; ensuring open access to research infrastructure; creating the conditions for effective work with open scientific information and research infrastructures (e.g., aligning legislation with the EU standards regarding the FAIR research data); popularisation of science and encouraging citizens to participate in scientific activities; improving research assessment; and awareness raising and capacity building on open science skills and competencies.
Europe	European Commission	This is the European Commmission's Communication 'A new European Research Area (ERA) for Research and Innovation', where theopen science paradigm, including the EOSC initiative, is directly linked to the new ERA's objectives and is recognised as an ERA's means to enhance 'access to open, free of charge, re-usable scientific information'. The three commitments associated with open science are expressed in Section 2.4.

Europe	All European Academies	As a longstanding proponent of open science, ALLEA has accumulated decades of experience and expertise on fundamental aspects of open science such as legal and ethical considerations, data management in the humanities, and digital research infrastructures. It works together with Member Academies to amplify their voice considering the role of Europe in this global debate. Jointly with them, it gathers evidence and data, foster knowledge, and practices exchange, and formulate common positions in a coherent and timely manner through multiple initiatives.
US	NASA	This a formal policy of the the NASA's Science Mission Directorate (SMD), which sets mandatory requirements for opening up of publications, research data and software produced as part of SMD-funded research activities.This policy has received a remarkable support for its implementation through the Transform to Open Science (TOPS), a $40 million 5-year programme included in the NASA SMD's Open-Source Science Initiative.
US	White House Office for Science and Technology Policy (OSTP)	The 2022 memorandum of of the White House Office for Science and Technology Policy (OSTP) provides policy guidance to all federal agencies with research and development expenditures on updating their public access policies in accordance with the following: update their public access policies to make publications and their supporting data resulting from federally funded research publicly accessible without an embargo on their free and public release; establish transparent procedures that ensure scientific and research integrity is maintained in public access policies; and coordinate with OSTP to ensure equitable delivery of federally funded research results and data.

US	Massachusetts Institute of Technology (MIT)	This is the MIT Faculty OA Policy, which, through an opt-in licence to MIT, allows authors to legally make their final, peer-reviewed manuscripts freely accessible through the open access repository DSpace@MIT and other venues. The policy allows MIT authors to retain control of the copyright.
US	SPARC	It is a resource for tracking the U.S. federal agencies' public access plans for articles and data sharing requirements.
Argentina	National Congress of Argentina	This is Law No 26.899 'Open Access Institutional Digital Repositories'. The law mandates institutions that receive government funds for conducting research to develop interoperable institutional open access repositories, and researchers are required to deposit their research results and data (with maximum embargo of 6 months for publications and 5 years for data). The law also requests a Data Management Plan for projects, which expect to generate research data.
Brazil	Fifth Action Plan for the Open Government of Brazil	This is Brazil's latest National Action Plan on Open Government (2021-2023). It establishes Commitment 8 to 'Develop an assessment model to promote Open Science'. The public problems this commitment will address are the lack of basic OS guidelines for funding agencies, lack of metrics for OS actions/practices, and low interoperability of platforms related to science activity. This commitment emerged from the fulfilment of Commitment 3 of Brazil's Fourth Action Plan, which consisted of establishing scientific data governance mechanisms for the advancement of OS in Brazil.

Colombia	Ministry of Science, Technology and Innovation of Colombia	This is the National Open Science Policy 2022-2031. It comprises five sections: an introduction contextualising the policy nationally and internationally, followed by its justification as a tool for knowledge inclusion; a theoretical overview; a diagnosis of open science in Colombia; and proposals for policy objectives and actions, such as creating a system of metrics and incentives to encourage, value and recognise OS practices. The document integrates input from citizens, institutions, and diverse sectors nationwide.	In Spanish	Specific objective 3 (p. 51): 'Institute a system of metrics and incentives to promote, value and recognise the Open Science practices, processes and results of the Colombian scientific community and integrate it into the existing models and systems of metrics and incentives of the country's existing STI activities.'
Chile	Chilean National Agency for Research and Development (Agencia Nacional de Investigación y Desarrollo de Chile) under the Ministry of Science, Technology, Knowledge and Innovation	The policy of the Chilean National Agency for Research and Development (ANID) covers such aspects as international context, policy justification focusing on knowledge democratisation, theoretical foundations, and a diagnostic of the country's open science landscape. Additionally, it proposes specific objectives and actions for advancing open science, incorporating citizen input through workshops and focus groups nationwide.	In Spanish	

Ecuador	Ministry of Higher Education, Science, Technology and Innovation of Ecuador (Secretaría de Educación Superior, Ciencia, Tecnología e Innovación, Senescyt)	The section "Co-creation of the national open science and strategic research policy" outlines Ecuador's commitment to reforming its scientific knowledge creation model. The initiative, spearheaded by the Ministry of Higher Education, Science, Technology and Innovation (Secretaría de Educación Superior, Ciencia, Tecnología e Innovación, Senescyt), aims to address inefficiencies in scientific production and disconnection from societal needs. Through a multi-stakeholder approach, the commitment seeks to develop a national open science policy aligned with UNESCO's recommendations. Short-term objectives include raising awareness, while medium-term goals focus on fostering research and community engagement. This initiative reflects the Open Government Partnership's values by promoting transparency, accountability, and participation in scientific endeavours, contributing to national and international development agendas.	
El Salvador	Consortium of University Libraries of El Salvador (CBUES)	Through their Open Access Policy, CBUES, the Consortium of University Libraries, offers universities, scientific and cultural institutions, researchers, teachers and students the Digital Repository of Science and Culture of El Salvador (REDICCES), so that they can deposit a copy of their documents in it, as long as the documents have a scientific, academic, historical or cultural character in order to achieve greater dissemination, visibility, promotion and recognition.	In Spanish
Mexico	General Congress of the United Mexican States	Decree amending and adding various provisions to the Law on Science and Technology, including articles that establish the State policy concerning Open Access, Access to Scientific, Technological and Innovation Information and the National Repository.	In Spanish

Peru	Congress of Peru	Law creating and regulating the National Open Access Digital Repository of Science, Technology and Innovation. The law establishes the mandatory application of conservation, preservation and open access to the intellectual heritage financed with state resources in the areas of science, technology and innovation. It also supports the development of a national repository of scientific productions and assigns the National Council for Science, Technology and Technological Innovation (Concytec) to be the administrator of the national repository.	In Spanish
South Korea	Korea Institute of Science and Technology Information (KISTI)	It is an institutional Open Access Policy, in accordance with which KISTI researchers are required to deposit an electronic copy of either the published version or the AAM of journal articles in the KISTI OA repository with a CC BY-NC licence. The policy permits exceptions and an embargo period.	
South Korea	South Korea's Ministry of Science and ICT	The National R&D Information Standard, enforced by the Ministry of Science and ICT, includes several sections relevant to open science. Article 23 contains provisions on research data management and Data Management Plan in relation to national R&D projects. In addition, Appendix 1 prescribes 411 metadata elements associated with national R&D projects and their outputs, which must be opened to the public through the NTIS (National Science & Technology Information Service) digital platform.	In Korean

South Korea	National Research Foundation of Korea (NRF)	This document is the NRF's Data Management Plan (DMP) Guideline, which applies only to national R&D projects for which a DMP is deemed necessary (according to the national standard outlined in the previous row, central administrative agencies such as ministries have the discretion to decide which national R&D projects they fund will require a DMP). For such projects, NRF requires researchers to submit a DMP as part of application for R&D project funding. The research data arising from the NRF funding are expected to be managed by a relevant R&D-performing organisation and be shared via a public repository, in accordance with a DMP.	In Korean
Japan	Cabinet Office (Government of Japan)	The 6th Basic Plan of the Government of Japan aims to build a new research system based on the promotion of open science and data-driven research (see Section 2.2 in Chapter 2). Among the concrete measures planned is the development/improvement of a national digital infrastructure for the management and utilisation of research data and the promotion of data policies across institutions.	
Japan	Cabinet Office (Government of Japan)	The Integrated Innovation Strategy of the Government of Japan includes, among other STI-related objectives, promotion of open access to scholarly publications and scientific data. According to the strategy, the government will develop a national policy to promote immediate open access to scholarly publications and scientific data for which competitive research funds are used, starting from application in FY2025. This decision is based on the commitment made during the G7 Hiroshima Leaders' Communiqué and the G7 Science and Technology Ministers' Communiqué in May in 2023.	

Japan	Japan Science and Technology Agency (JST)	This is the 2017 JST Policy on Open Access to Research Publications and Research Data Management. In particular, it specifies that research publications should be made openly available within 12 months of publication (Green OA is recommended). Additionally, it requires to develop a DMP, which should be submitted to JST before the research project begins at the latest. Research data underlying publication should be made openly available, in accordance with DMP.	
International	UNESCO	This is the UNESCO Recommendation on Open Science adopted by the General Conference of UNESCO at its 41st session in 2021. This instrument attempts to set a harmonised understanding of open science by providing a definition of open science, defining its core values and guiding principles and proposing seven areas of actions for its operationalisation.	p. 27 – Action V: Fostering a culture of open science and aligning incentives for open science
International	Research Software Alliance, Netherlands eScience Center	The Amsterdam Declaration on Funding Research Software Sustainability (2023) is a first step towards formalising, on a global level, the basic principles and recommendations related to funding the sustainability of research software, including the people needed to achieve this goal.	'Funders should consider the value and impact of research software as a research output in its own right, to facilitate appropriate reward and recognition measures that enable career progression for all people involved.' (p. 4)
International	Coalition for Advancing Research Assessment (CoARA)	The COARA Agreement on Reforming Research Assessment promotes recognition and valorisation of the diversity of research activities and outputs and rewarding behaviour underpinning open science practices, such as early knowledge sharing and open collaboration.	'Recognise the diversity of research activities and practices, with a diversity of outputs, and reward early sharing and open collaboration…' (p. 4)

Rewarding tools

Table B.2 OS Awards/Prizes

Table B.2

Initiative or tool related to an academic os rewarding mechanism	Brief outline of os activities rewarded	For whom	Type of rewarding	Notes (N/S = not specified)
AGU OS recognition prize	Recognition of an outstanding work in advancing Open Science related to Earth and Space Sciences and its impact globally; Three awards for either individuals or teams	Earth & Space Science researchers (from any affiliation)	financial	annually
The University of Helsinki's Open Science Award	Recognition of various Open Science activities (irrelevant of discipline)	University of Helsinki's researchers	financial	annually
Aston University's Open Research Awards	Recognition of all Open Science activities (irrelevant of discipline)	Aston University's researchers	N/S	not planned in 2024 but probably in 2025
The Leo Waaijers Award for Open Science initiative	Recognition of innovative and/or impactful initiative in the field of Open Science (irrelevant of discipline)	initiative (at least partly) of Dutch origin	financial	annually
NIH/FASEB 'DataWorks! Challenge'	Recognition of new and innovative approaches to data sharing and reuse in biological and biomedical research	biological and biomedical researchers (citizen or permanent resident of the United States); non-U.S. citizens and non-permanent residents can participate as a member of a team but are not eligible to win a monetary prize	financial	annually
Jean-Pierre Demailly Open Science Prize in mathematics	Recognition of a project that contributes to Open Science in mathematics, whether in scientific publishing, collaboration between mathematicians, or free software in mathematics	Mathematics scientists	N/S	biennially

"Pedro Lagomarsino de Leon Roig" Doctoral Prize in Neuroscience	Recognition of a PhD thesis in Neuroscience and related subjects in Italy that best combines excellent scientific results with excellent methods for data analysis, data management, and open science. Pedro Lagomarsino de Leon Roig was a staunch supporter of Open Science.	PhD students in Neuroscience and related subjects in Italy	financial	N/S
The QUEST 1,000 € Open Data Reuse Award (BIH-Charité)	Recognition of publications which made use of publicly available datasets; the goal is to raise awareness for the importance of data as first-class research outcomes and the potential that data reuse has for contributing to innovation, interdisciplinarity and scientific progress	first/last/corresponding BIH or Charité authors (and employees)	financial	annually
White House Office of Science & Technology Policy Open Science Recognition Challenge	Recognition of stories and teams behind projects that have addressed a particular challenge or advanced a solution, while embodying Open Science principles and practices (e.g., OS to advance education, innovation, interdisciplinary collaboration)	project leads must live and works in the United States, including Puerto Rico, the U.S. Virgin Islands, Guam, the Commonwealth of the Northern Marianas, American Samoa, Palau, the Federated States of Micronesia, or the Republic of the Marshall Islands	symbolic / reputational	one-time prize devoted to a Year of Open Science (2023)
Open Scholarship Seed Award program sponsored by the Open Research Funders Group	Support of a variety of Open Science activities through awareness building and community events (hackathons, seminars, and discussions on reform strategies); capacity building (summer schools, metadata seminars, open data training, and communicating research results to non-technical audiences) and infrastructure (development of technology, services, protocols, standards, code, or software); the award does not provide funding for any charges related to processing articles (APCs)	researchers around the world	financial	N/S

ACLS Open Book Prize + Arcadia Open Access Publishing Award	Published OA monographs (eligible categories in 2023: History; Multimodal, born-digital works)	Authors and publishers of OA monographs (from any country; publications must be in English)	financial	annually
Singapore Open Research Awards	Recognition of various Open Science activities (irrelevant of discipline)	Principal investigators, post-doc research staff and PhD students affiliated with domestic universities (NTU, NUS, SMU, SUTD, SUSS and SIT)	financial	biannually (part of the Singapore Open Research Conference)
The Sarah Jones Award for exceptional contribution to fostering collaboration in Open Science	Recognition of exceptional contribution to fostering collaboration in Open Science (including but not limited to education & training, research data management & FAIR data) that has had positive change and impact as a result of this work; this impact can be on an organisational, community or individual level.	This award is open to all nominees and not restricted to members of the RDA community, however a demonstration of contribution within the RDA community is of great importance.	financial	

Table B.3 OS Funds

Table B.3

Initiative or tool related to an academic os rewarding mechanism	Brief outline of os activities rewarded	For whom	Type of rewarding	Notes (N/S = not specified)
Wellcome Trust Open Access block grant funding	Support of reasonable open access publishing costs for research papers (costs of open access publishing in subscription journals are not covered)	several UK universities	financial	Funding of APCs in fully open access journals or platforms and until 31 December 2024 in cOAlition S approved transformative journals.
UKRI's Open Access Funds	Support of open access publication costs for research articles and long-form publications like monographs	UK research organisations	financial	
NASA Open Science funding opportunities	Focus on open source tools/software	NASA researchers	financial	
French National Fund for Open Science	Various OS acitivites (each call for projects specifies priorities)	French institutions or foreign actors having a significant impact on the French open science landscape and whose governance is based on a significant French contribution	financial	

Ireland's National Open Research Forum (NORF) Open Research Fund	Supports of various OS activities (each call for projects specifies priorities)	Irish organisation/institution/entity as the Lead Institution; other organisations can participate as Partner Institutions (there is no limit on the number of Partner Institutions)	financial	
NWO Open Science Fund (The Netherlands)	Support of various Open Science activities. Particularly encouraged are projects that: improve how good open science practice is recognised and rewarded, transform the way researchers publish, further the adoption of citizen science approaches etc.	All researchers (not clear)	financial	
Netherlands eScience center Fellowship Programme	Promotes the visibility and best practices in open research software (irrelevant of discipline)	Applicants should be based in the Netherlands	financial	
Performance-oriented funding at the Charité (Germany)	Starting from 2019, Charité researchers receive additional performance-oriented funding if they openly shared the data underlying their article publications. At the Charité, this funding is distributed as part of the LoM (Leistungsorientierte Mittelvergabe).	Charité researchers	N/S	Section "How will I be recognized for sharing data?"

Table B.4 OS Badges/Certificates/Tokens

Table B.4

Initiative or tool related to an academic os rewarding mechanism	Brief outline of os activities rewarded	For whom	Type of rewarding	Notes (N/S = not specified)
NASA Open Science Digital Badge	Recognition of completion of all five modules of the NASA's 'Open Science 101' course on various Open Science aspects and practices (badge is linked to an ORCID account)	The course is for all researchers, students etc. interested in Open Science.	symbolic / reputational	
Univ Paris Cité's Open Science certification	Recognition of completion of the five modules of the Open Science course on various Open Science aspects and practices and participation in other mandatory activities (e.g., being part of an interdisciplinary Open Science community)	Univ Paris Cité's PhD students	symbolic / reputational	Certification programme is suspended for the year 2023-2024.
EASYDAB seal for FAIR and open Earth System Science data	Indication that the archived data in a repository have an open license, are published with a DataCite DOI, allign with the FAIR Data Principles, have been checked by the data repository for compliance with an approved metadata standard	All researchers who published Earth System Science data in repository who signed a contract with the German National Library of Science and Technology (TIB) and comply with the EASYDAB Guideline.	symbolic / reputational	
Open Science Badges of the Center for Open Science (COS)	Recognition of publications which have preregistered their study, or made underlying data and materials openly available	Authors in journals which issue the COS Open Science Badges	symbolic / reputational	

NISO CRediT (Contributor Roles Taxonomy)	Recognition of individual open research contribution to a scholarly publication using 14 contributor roles	All researchers can allocate terms and advocate that their institution and any publications they are submitting to acknowledge and adopt the taxonomy.	symbolic / reputational	
Rescognito	Recognition of individual open research contribution to a scholarly publication (based on the NISO CRediT)	All researchers with an ORCID can assert contribution terms for any publication with a DOI listed in their ORCID record	symbolic / reputational	CRediT can even be claimed for previously published manuscripts or preprints.
ACM (Association for Computing Machinery) Badging Initiative	Artifacts Evaluated, Artifacts Available and Results Validated Badges may be applied to recognise the evaluation of artifacts related to research articles (artifact can be software, input datasets or scripts used to analyze results…)	Authors of ACM publications	symbolic / reputational	
ResearchHub	The goal of the platform is to make a modern mobile and web application where people can collaborate on scientific research in a more efficient way, similar to what GitHub has done for software engineering. To incentivize users, ResearchHub issues tokens that users can earn and transfer to one another by sharing, curating, and discussing topics within the platform. Users can also transfer tokens to one another on the platform by creating "bounties" to incentivize other users to engage with their post. Rewards for contributions are proportionate to how valuable the community perceives the actions to be - as measured by upvotes.	All researchers	reputational	

Table B.5 OS Champions

Table B.5

Initiative or tool related to an academic os rewarding mechanism	Brief outline of os activities rewarded	For whom	Type of rewarding	Notes (N/S = not specified)
eLife Open Science Champions Network	Recognition of various OS activities	eLife community researchers	symbolic / reputational	access to select training resources developed alongside the eLife Ambassadors, our other projects such as Sciety, and our partner organisations involved in the Ambassadors training programme
GBIF Open Data Ambassador	Recognition of OS activities in relation to open biodiversity data	Anyone who has shared biodiversity data through GBIF, used GBIF-mediated data and/or advocated open data in a professional capacity at least once	symbolic / reputational	access to specific GBIF resources
Charles University's Open Science Champions (Czech Republic)	Recognition of various Open Science activities (irrelevant of discipline)	Charles University's researchers practising Open Science	symbolic / reputational	
SPARC Europe's Open Champions	Recognition of Open Access, Open Education and Open Data related activities	Research administrators, rectors, senior researchers, PhD students or young researchers nominated by SPARC Europe members	symbolic / reputational	

C Abbreviations

Abbreviation	Definition
AGA	Annotated Grant Agreement
AGU	American Geophysical Union
ALLEA	All European Academies
ANR	Agence Nationale de Recherche (French National Research Agency)
BoF	Birds of a Feather
CARE	Collective benefit, Authority to control, Responsibility, Ethics
ChatGPT	Chat Generative Pre-trained Transformer
CLACSO	Consejo Latinoamericano de Ciencias Sociales
CoARA	Coalition for Advancing Research Assessment
CODATA	Committee On Data
CRediT	Contributor Roles Taxonomy
CUDOS	Communality, Universalism, Disinterestedness and Organised Scepticism
DDOR	Direction des données ouvertes de la recherche (DDOR) du CNRS
DMP	Data Management Plan
DEIA	Diversity, Equity, Inclusion, and Accessibility
DOI	Digital Object Identifier
DORA	Declaration On Research Assessment
FAIR	Findable, Accessible, Interoperable, Reusable
GERD	Gross domestic Expenditure on R&D
LMIC	Low- or Middle-Income Country
NIH	National Institutes of Health
OA	Open Access
ORCID	Open Researcher and Contributor ID
OS	Open Science
OS-CAM	Open Science Career Assessment Matrix
OSTP	Office of Science and Technology Policy
PID	Persistent IDentifier
RAiD	Research Activity Identifier

Abbreviation	Definition
RDA	Research Data Alliance
RRA	Responsible Research Assessment
SciELO	Scientific Electronic Library Online
SCOSS	Sustainability Coalition for Open Science Services
SHARC	SHAring Rewards and Credit
TOP	Transparency Openness Promotion
UKRN	UK Reproducibility Network
UNESCO	United Nations Educational, Scientific and Cultural Organisation