Open science

Rationale and objectives

Information and communication technologies (ICTs) - new data storage infrastructure, broadband Internet, high speed computing and analytical software tools - are radically modifying the way science is conducted and the way the results of research are disseminated. Whilst openness has always been one of the accepted norms of scientific practice, a new paradigm of 'Open Science' is emerging. This encompasses a more collaborative scientific enterprise, open access to scientific data, open access to scientific journals and greater engagement of civil society - including industry. In parallel, the availability and scale of data that is available for, and produced by, science has massively increased as has our ability to interrogate and analyse that data. 'Big data' and data driven research is now ubiquitous across all scientific disciplines and is opening up exciting new possibilities for addressing previously inaccessible scientific challenges. Meanwhile, the ability to link data from different sources and fields is providing new insights into the complex global societal challenges.

In addition to enabling new scientific discoveries, there are a number of reasons why 'Open Science' is being actively promoted in most OECD countries (OECD 2015a). The traditional scientific journal publishing model has been severely criticised for limiting access to the outputs of publically-funded scientific research to an exclusive club of higher education and research institutions, many of which have themselves been vehemently protesting about the rising costs of journal subscriptions. In this context, open access publishing, which takes advantage of the very low costs of information dissemination on-line, presents an attractive alternative. There have been concerns also about the rigour and reproducibility of published scientific results that can be at least partially addressed by ensuring open access on line to the underpinning research data. Increased access to scientific information and data can make the research system more effective and efficient by reducing duplication; by allowing the same data to generate more research; and, by multiplying opportunities for domestic and global participation in the research process. Open access to scientific results and data should increase the knowledge spill-overs from public research and promote innovation. It can also play an important role in promoting citizens’ engagement and trust in science, making research more transparent and accountable and promoting citizen science.

Major aspects and instruments

Policy makers, including funders of public research, can play an important role by promoting access to, and re-use of, scientific research results. In particular, they can remove barriers to open science by setting appropriate funding and incentive mechanisms, developing the infrastructure necessary to make open science happen and, in some cases, adopting mandatory rules for the open disclosure of publicly funded research results.

Two main publishing models have emerged to promote open access to scientific articles. *Green open access* refers to the “self-archiving” of a published article or the final peer-reviewed manuscript by a researcher after or alongside its publication in a scholarly journal. Public access to such an article can be delayed by a stipulated period of embargo. *Gold open access* or “author pays publishing” refers to a model in which a publication is immediately provided in an open access mode online by the scientific publisher. In this case, the associated costs are shifted from the reader to the author or the university or research institute to which the author is affiliated. The agencies sponsoring the research may also make provision for the costs of open access.

Whilst science is collaborative it is also intensely competitive. Individual scientists and their institutions are to a very large extent judged by their publication outputs, often using standardised journal bibliometric measures. They therefore have little incentive to share data and experimental material. Mechanisms that accredit the publication of datasets and other collaborative efforts, including citizen and industry engagement, are essential for promoting Open Science. New measures and indicators are required to monitor the implementation and impacts of open science.

Enabling open science requires the development of sustainable infrastructure for organising and sharing research results and data, as well as the development of standards and services to make these resources readily usable. This may involve the creation of publication and/or data repositories, the development and promotion of metadata standards and inter-operability across countries and disciplines. Data management plans for research projects need to be connected to the provision of this infrastructure.

Dedicated data infrastructures are only effective if they are operated dedicated data professionals. Data stewardship requires specialised skills, which are not always recognised and valued in the academic system. Both the number and status of data scientists need to be addressed for Open Science to be a success. At the same time, the general level of data literacy, computing and statistical skills in many scientific fields needs to be raised. And there may be a need for a new cadre of data analysts in some areas.

A legitimate right of first usage for the scientist creating the data, intellectual property rights, privacy and ethical concerns dictate justifiable limits on openness for certain types of data and establishing consensus on what sensible limits are will be an important determinant of how quickly open science advances in different research areas. Personal data, including health records and on-line social networking data, present a particular challenge. New mechanisms for ensuring anonymisation and informed consent are required and public engagement and trust need to be ensured.

Recent policy trends

Different countries are at different stages of thinking and development with regards to Open Science. Most European countries and the USA have been promoting open access to both publications and data for several years. Japan has also been an advocate of open access publishing and is now reviewing its position in relation to data following a report from a national expert panel on Open Science in 2015. National visions and priorities for open science understandably differ and to some extent reflect scientific capacity and economic development. For example, the National Open Access to Knowledge initiative in Colombia does not focus on international leadership but specifically targets the integrated development of policies and infrastructure to promote open access to locally produced scientific knowledge.

Despite their differences, most OECD and non-member countries are developing frameworks, guidelines and initiatives to encourage greater openness in science. Some, such as the UK, have begun to assess the impact of earlier policy initiatives. Most of the respondent countries to the EC/OECD STI Policy questionnaire 2016 highlighted changes in their policy framework for open science (Figure 1).

It is notable that there are different levels and scales of policy action and these tend to either explicitly or implicitly reinforce each-other. For example, the European Commission (EC) has been very actively promoting Open Science as part of the European Research Area and many European countries and/or federal regions have mirrored its position on mandating open access publications. EC funds have also catalysed national and institutional investment in data infrastructures. In the USA, the Office of Science and Technology Policy (OSTP) has mandated open access publishing and sharing of data for all federally funded research and stimulated funding agencies and research institutions to review their policies. Private foundations, charities and philanthropies are also strong advocates for open access in a number of countries, which can have a significant influence on the

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- Recent policy actions to promote Open Science include: A wide variety of distributed institutional repositories, digital libraries and platforms continue to be supported with public funds in most countries. Public-private partnerships are also being encouraged, for example in the USA. There is a growing trend towards linking the information on research inputs (project databases and individual cvs) with outputs (publications and data) either within single repositories or across repositories. For example, Iceland, is building a national current research information system (CRIS) similar to the Research Gate system in the UK. Flanders is building an equivalent Research Information Space. At the European level, the openAIRE initiative is aggregating different types of scientific data and information at the continental level and linking many national repository networks.
- The number of countries with mandatory open access provisions is expanding. Most of these mandate open access to science publications via either Green or Gold pathways, with greater access to research data being encouraged rather than fully mandated. In most cases the lead is being taken by research funding agencies, who also frequently make a provision for funding to cover the 'author pays' costs of open access publishing. In some countries these mandates are also embedded in national (e.g. Mexico) or federal state (e.g. Germany) legislation and universities may be asked to allocate funding to support open access publishing. The Netherlands has set a target to have 60% of its published scientific articles being made accessible for free on line within five years.
- Austria is one of several countries that have recently introduced modifications to national copyright legislation to promote Open Science. Germany has amended its copyright legislation, and the United Kingdom passed a series of amendments to its copyright legal framework that came into force in 2014 (OECD 2015b). These changes include greater freedom in the dissemination and re-use of copied or recorded material for educational and non-commercial research purposes. For example, the recent changes in Austria, as in Germany, specifically enable secondary publication and thus remove an obstacle to deposition of scientific articles by authors in open access repositories. The UK has introduced a text and data-mining (TDM) copyright exemption for non-commercial research purposes.
- Data is now increasingly recognised as part of the essential infrastructure underpinning science. Nevertheless, science budgets are limited and have to meet many demands. The planning and funding for major e-infrastructures are increasingly being embedded in broader national (and European) research infrastructure mapping and funding processes. Norway and Belgium are recent examples in this regard. At the same time, new dedicated funding initiatives for improving open science infrastructures are being implemented in many countries. The Open Finland Challenge is a novel example of a targeted programme that supports the best ideas and new digital applications from commercial developers and academia for improving data openness.
- Some countries have begun to address the scarcity of skills related to open science by promoting dedicated training and guidelines for researchers. The Finnish Ministry of Education and Culture released a Data Management Guide for researchers; the Guide covers issues related to data management and describes existing services for data management available in the country. The development of skills for data analytics is one of the four main pillars of the Knowledge initiative of the US National Institute of Health. This initiative aims to develop skills in the science of big data, and data usage and analysis in the biomedical field. In 2013 the UK released a Data Capability Strategy focuses on (among other issues) human

capital and skill development for data analytics as well as data accessibility and data-sharing skills in consumers, business and academia. In addition, the creation of centres for doctoral training on big data has been announced in several universities and higher education institutions in the country. With similar goals, the Open Data Institute has been recently established in London, United Kingdom.

Table 1. Open science: typology of national policy initiatives and country examples

Strategic objectives	Policy instruments		Selected country examples
Strengthening public research capacity			
Opening science	Reform and regulation	Mandatory provisions in legal framework and public research funding mechanisms	Croatia (Law on science and higher education), Belgium (OA mandate), Denmark (OA policy), Greece (Law 4310/2014 on OA), Iceland (Act on public support for research), Italy (2013/14 Acts for OA), Lithuania (Law on Higher Education and Research), Netherlands (NOW OA Policy, 60% free online target), Norway (RCN), Slovenia (Slovenian Research Agency), Spain (STI Act), Sweden (Research Council), UK (OA policy), US (OSTP mandate, OD Executive Order).
		Standards	Chile (Institutional Policy on Management of Research Data and Scientific Information), Germany (Priority Initiative "Digital Information"), Norway (Norwegian Licence for Public Data).
	Multi-level contracts	Performance agreements with agencies and universities	Austria.
	Financial support	Provision for OA/OD costs	Germany (DFG OA Policy), Netherlands (collective agreements), Norway (STIM-OA programme), Turkey (Incentive Program UBYT).
	Non-financial support	Services (guidelines, awareness campaigns, (information and training, networking support)	Austria (OA Network Austria - OANA), Germany (OA platform), France (Digital Scientific Library, Couperin Consortium, EPRIST), Greece (GR_Net), Ireland (Open Access Ireland website), Lithuania (Lituanistika database), Netherlands (NWO Incentive Fund Open Access), Norway (web one-stop shop), Portugal (RCTS Network), Sweden (national guidelines for OA), US (Project Open Data).
		Recognition and visibility (e.g. awards)	Finland (Open Finland Challenge)
Improving policy governance			
Direction setting	Guiding documents and policy statements	At national level	Belgium (Fl.) (Blueprint for OD), Brussels (Brussels Declaration on OA), Czech Rep. (R&D Council's recommendation, OP RD and Education), Ireland (National OA Statement), Italy (National Agenda for the Enhancement of Public Data), Mexico (Open Government Partnerhsip Action Plan), Netherlands (Letter to the Parliament on OA), Norway (RCN policy on open data), Portugal (FCT policy statement), Slovenia (National Strategy on OA/OD), Spain (Alhambra Declaration), Turkey (Final Declarations of the Workshops on OS and OA).
		At state/regional level	Belgium (Fl.), Germany, Spain.
		At institutional level	Belgium (universities, PRIs), France (CNRS, INRA data management scheme), Germany (major PRIs), Netherlands (universities), Norway (universities), Slovenia (universities), Spain (universities).
	Roadmaps and action plans		Finland (Strategy and Roadmap for Research Infrastructures), Slovenia (Action Plan for the establishment of a OD system).
Intra-governmental coordination and multi-stakeholders' participation	Regulation		Italy (collective agreement for OA), Mexico (Open Data Law).
	Networking infrastructures		Austria (Network of funding agencies and research providers), Colombia (RENATA Network), Finland (APPS4FINLAND), Germany (Priority Initiative 'Digital Information'), Greece (National Documentation Centre EKT), Japan (Expert Panel on Open Science), Mexico (Open Government Partnership Action Plan), Slovenia (National Point of Reference), Slovak Rep. (SCSTI), Turkey (National Open Access Committee), UK (Open Access Coordination group and Open Data Research Forum, Gateway for Higher Education).
	Public-private partnerships		Colombia (National Open Access to Knowledge System), Italy (Open Government Partnership).
Monitoring and evaluation	Meta-instruments (indicators etc.)		Spain (Recolecta platform)

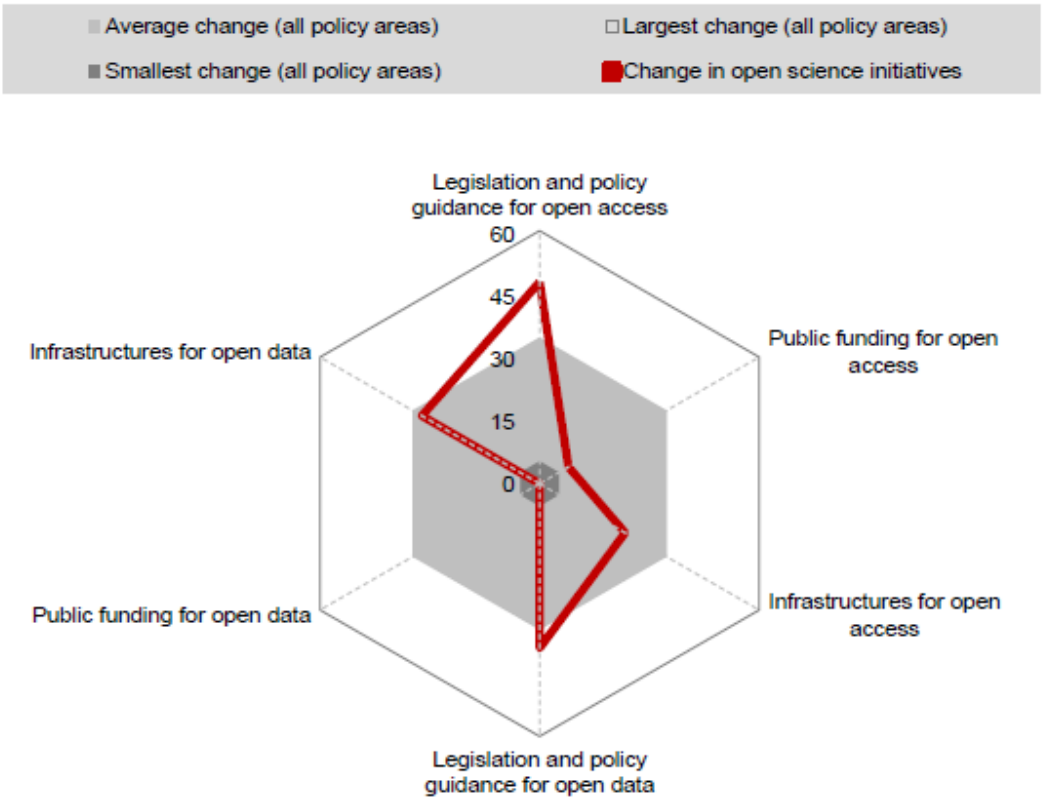
Improving actors' interaction			
Platforms, networks and infrastructures	**Physical and networking infrastructures**	Digitalisation of research results, archives and repositories	Austria (Austrian centre for Digital Humanities, e-Infrastructures Austria), Belgium (Biodiversity Platform, INBO, VLIZ), Brazil (FINEP Innovation Portal), Chile (Programme of Management of Research Data and Scientific Information), Colombia (Network of Repositories and Digital Libraries BDCOL), Croatia (DABAR), France (ISTEX or HAL platforms, CINES computing centre), Finland (National Digital Library), Iceland (CRIS), Ireland (Rian), Italy (National Register of public administration databases), Latvia (Academic network), Lithuania (Lituanistika database), Mexico (REMERI), Netherlands (DANS), Norway (CRIStin), Peru (Alicia/Renare), Poland (Virtual Library of Science), Portugal (RCAAP portal), Slovenia (OA repositories, NIO portal), Slovak Rep. (Data Centre for R&D), US (data.gov), EU (OpenAIRE2020).
		Databases of research resources (projects, tenders, personnel, institutions)	Argentina (SICYTAR), Belgium (iMinds pilot), Brazil (FINEP Innovation Portal), Croatia (CROSBI), Czech Rep. (R&D&I Information System), Norway (CRIStin), Russian Fed. (Russian Science Map), UK (Gateway to Research).
		Interoperability of systems and platforms	Colombia (National Open Access to Knowledge System), France (ISIDORE), Slovak Rep. (Central Information Portal for R&D and Innovation).
	Public-private partnerships		Colombia (National Open Access to Knowledge System), US (Office of S&T Policy).
	Non-financial support	Services (guidelines, information, expertise)	Mexico (general and technical guidelines to create national and institutional repositories).
Intellectual Property Rights	**Reform and regulation**		Austria (amended Copyright Law), Germany (amended Copyright Law).
Globalisation and international	**Guiding documents**		Germany (Priority Initiative 'Digital Information'), EU (Berlin Declaration on Open Access).
cooperation	**Platforms and infrastructures**	Interoperability of cyberinfrastructures	France (ISIDORE), Portugal (Scientific Open Access Repository of Portugal — RCAAP), South Africa (SANReN), EU (OpenAIRE2020).
Strengthening skills for innovation			
Education	**Reform and regulation**	Revised curricula and teaching methods for general data literacy	Austria (Efit21),Croatia (work Srce), Slovenia (Opening Up Slovenia).
	Platforms and infrastructures		Slovenia (Open by Default Service Standard, VideoLectures.NET)
Innovation culture	**Guiding documents**		Italy (National Plan for Culture, Education and Digital Skills)
	Platforms and infrastructures	Trust and public engagement	Slovenia (VideoLectures.NET), UK (MiData).

Note: OA = Open Access and OD = Open Data. This table draws upon recent analytical works on the innovation policy mix carried out for the OECD STI Outlook under the aegis of the OECD Committee for Scientific and Technological Policy. Country information is drawn from the EC/OECD International Science, Technology and Innovation Policy (STIP) Database, edition 2016, https://www.innovationpolicyplatform.org/topic-menu/sti-policy-database, OECD (2015), Making Open Science a Reality, www.innovationpolicyplatform.org/content/open-science and OECD (2015b), Inquiries into Intellectual Property's Economic Impact, OECD Publishing, Paris.

Source: Based on EC/OECD (forthcoming) and Kergroach *et al.* (forthcoming-a)..

Figure 1. Open science initiatives among other areas of STI policy change, 2014-16

Percentage of policy initiatives that have been newly introduced, revised or repealed over the period



Note: The EC/OECD STI Policy survey 2016 aims to review major changes in national policy portfolio and governance arrangements for STI. The survey builds on the conceptual work carried on under the aegis of the OECD Committee for Scientific and Technological Policy (CSTP) for mapping the policy mix for innovation and therefore covers a broad range of policy areas (Kergroach et al., forthcoming-a). 52 economies participated in 2016, including OECD countries, key emerging economies (e.g. Argentina, Brazil, the People's Republic of China, Colombia, Costa Rica, Egypt, Indonesia, Malaysia, Peru, the Russian Federation, South Africa and Thailand), non-OECD EU Member States, and the European Commission. Taken together, the countries covered in the STIP survey 2016 account for an estimated 98% of global R&D. The responses are provided by CSTP Delegates and European Research and Innovation Committee (ERAC) Delegates for EU non-OECD countries.

This is an experimental indicator that accounts for the number of major policy initiatives implemented, repealed or substantially revised during 2014-16 as a share of total policy initiatives active at the beginning of the period. Although simple counts do not account for the magnitude and impact of policy changes, this ratio reflects STI policy focus and activity in specific policy areas and over specific periods of time. The chart above shows the intensity of changes in the policy area(s) under review as compared to the whole policy mix for innovation. Changes in the whole mapping are represented by the smallest, the largest and the average changes observed in all policy areas taken together.

Source: Based on EC/OECD (forthcoming), *International Database on STI Policies (STIP)*; and Kergroach *et al.* (forthcoming-b).

StatLink http://dx.doi.org/10.1787/888933445165

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OECD Directorate for Science, Technology and Innovation.

* Based on the work carried out by the Global Science Forum.
** Based on the work carried out by the OECD Committee for Scientific and Technological Policy and its Working Party of Innovation and Technology Policy.
Please cite as: OECD (2016), "Open science" in *OECD Science, Technology and Innovation Outlook 2016*, OECD Publishing, Paris,
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Links
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