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Mutual Learning Exercise: Open Science – Altmetrics and Rewards

Incentives and Rewards to engage in Open Science Activities

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MLE on Open Science: Altmetrics and Rewards – Incentives and Rewards to Engage in Open Science Activities

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1 INTRODUCTION

This report has been produced following the 3rd working meeting of the participants in the Mutual Learning Exercise (MLE) on Open Science, which was hosted by Croatia in Dubrovnik on 12 and 13 September 2017. It provides an overview and assessment of the various practices currently being used and/or investigated to incentivise and reward researchers and their institutions for engaging in open science activities.

The report starts with a section (section 2) outlining the Open Science agenda and aims and its role within the broader research and science policy landscape. Section 3 outlines the advantages and challenges underpinning the implementation of Open Science, thereby providing the necessary background to the discussion on incentives and rewards which can foster such activities. Section 4 reports on the discussions emerging from the MLE participants and outlines key concerns and feedback gathered by Member States on how Open Science can and should be fostered. Sections 4, 5 and 6 detail the incentives and rewards that could be provided, or in some cases have already been implemented, by three groups of key stakeholders: researchers themselves; research-performing institutions and funding bodies; and national governments. In conclusion, a summary is made of the main advantages and disadvantages of each type of incentive, with suggestions as to who is mainly responsible for managing its implementation.

The report is based on a review of relevant background academic literature and policy documents, discussions at previous MLE meetings (particularly the one on alternative metrics for Open Science, which took place in May 2017 in Helsinki), and on answers to open-ended questions sent to the MLE participants ahead of the meeting. Data have also been sourced from the European Open Science Monitor which, at the time of writing, is the most comprehensive source of information on Open Science implementation policies across European Member States (http://ec.europa.eu/research/openscience).

2 BACKGROUND

The revolutionary potential of Open Science to enhance research quality, reliability, integrity and societal impact has been widely discussed in academia and policy (Hey et al. 2009, Royal Society 2012, Kitchin 2014, Leonelli 2016, McKiernan et al. 2016). In the book "Open Innovation, Open Science, Open to the World", which was published in 2015 and outlines the European Commission's commitment to Open Science and its vision for its development and impact, Open Science is defined as:

> "a new approach to the scientific process based on cooperative work and new ways of diffusing knowledge by using digital technologies and new collaborative tools. The idea captures a systemic change to the way science and research have been carried out for the last fifty years: shifting from the standard practices of publishing research results in scientific publications towards sharing and using all available knowledge at an earlier stage in the research process." (p. 33)

The movement towards Open Science runs parallel with a broad international debate about the current state and social function of research. It has been widely recognised that research, particularly as institutionalised within academia, has developed into a social system dominated by systemic drivers that cause it to be self-referential in the incentives applied to researchers' academic career advancement and institutional reputation. This has generated hypercompetitive research behaviours, a systematic devaluation of the quality and reproducibility of research outputs in favour of high volume and prestige, and the dominance of publication in high-impact-factor-s journals over other, more desirable research goals (such as addressing socially relevant topics, undertaking high-risk and innovative projects, and enacting a research agenda aligned with the values and goals of democratic societies). The current system of research assessment and institutionalisation has encouraged a disconnection between knowledge production and the role research can and should play to help achieve key societal aims (Kleinman 2000, Radder 2010, Nordmann et al. 2011, Miedema 2012, Wilsdon et al. 2015). Open Science, with its recognition of the importance of societal engagement (for instance, in the form of citizen science involvement in the design and ongoing development of projects) and of the diversity of outputs and resources developed by any one research group (including models, data, code, workflows and non-academic writings, all of which can be made available for repurposing by other groups around the globe), provides an important opportunity as well as an effective strategy to remedy this situation.

There is ongoing debate on whether Open Science is better defined by the use of new digital tools, a specific set of values, and/or practices of collaboration and sharing (Grubb and Easterbook 2011, Royal Society 2012, Mauthner and Parry 2013, Fecher and Friesike 2014, Levin and Leonelli 2016). This report does not commit to any one of these definitions, all of which capture important aspects of the movement towards Open Science. What matters is that the very existence of a debate around what Open Science can be provides policymakers, research institutions, funding bodies and researchers themselves with an opportunity to critically consider:

- what does and should count as high-quality research;
- what goals researchers should pursue;
- how research results should be evaluated and disseminated; and
- how research should be supported and embedded within society (Leonelli 2016).

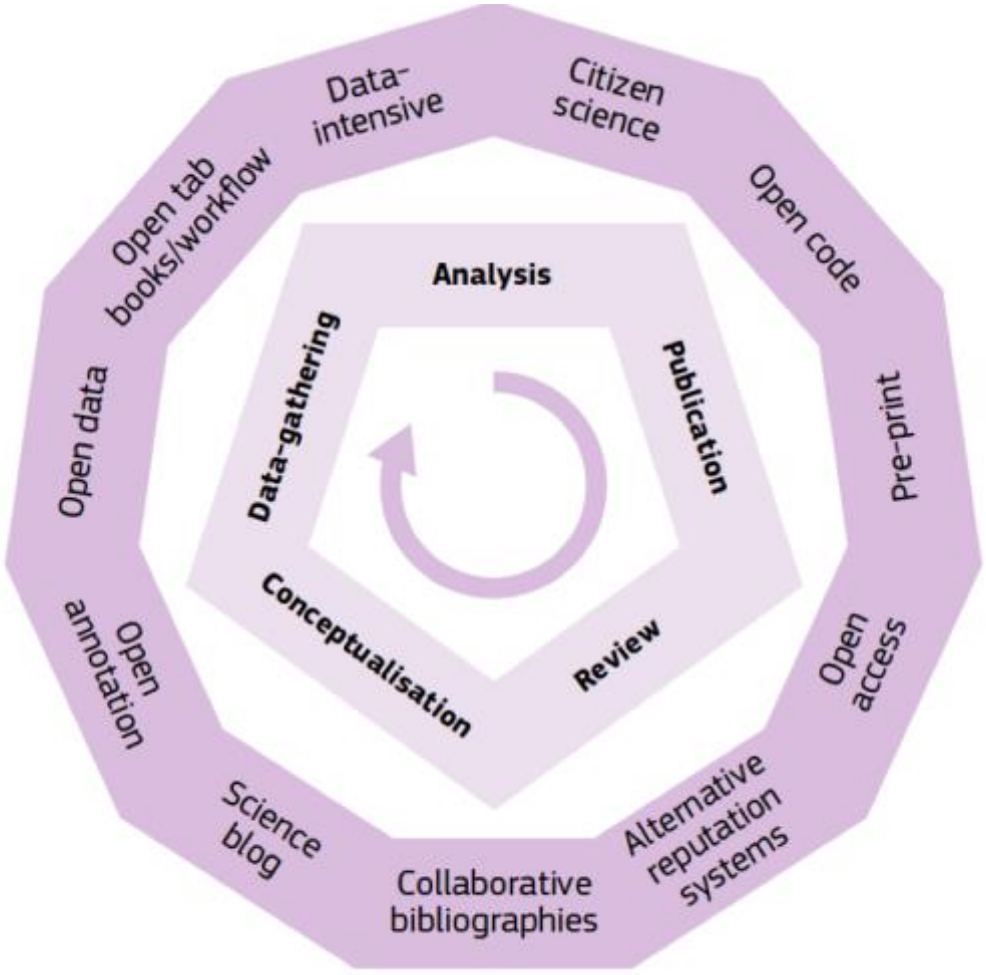
At the same time, there are three crucial points of consensus among Open Science experts, practitioners and policymakers:

(1) Open Science involves a systemic shift in current practices of research, publishing and evaluation;

(2) Open Science affects all stages of the research process, including data gathering, analysis, review and conceptualisation (figure 1), and its implementation involves a wide set of governance structures ranging from technical mechanisms of review to broad policy guidelines (figure 2).

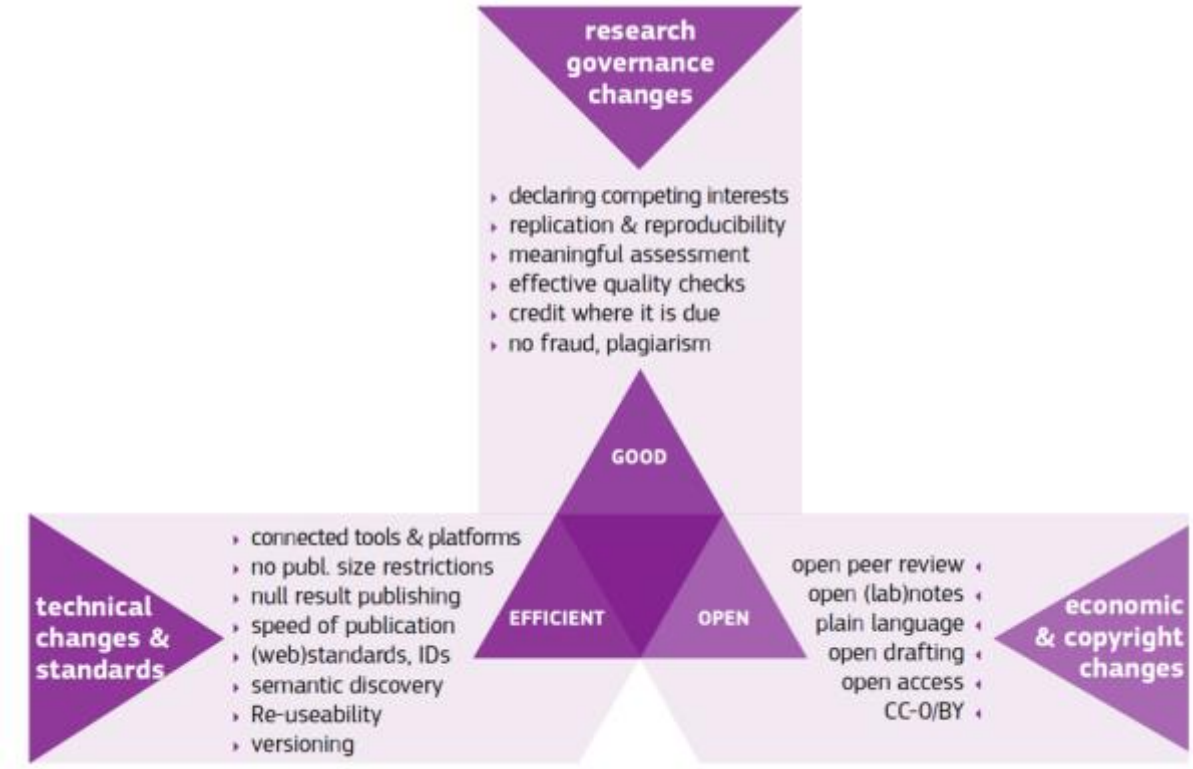
(3) The implications of Open Science for any one research system (at the international, national, regional and local levels, as well as across disciplinary domains and otherwise defined areas of research interest) need to be considered with reference to its specific characteristics; thus, the mechanisms through which Open Science is implemented are likely to vary.

Figure 1: Open Science components and their role in the research process



Source: http://ec.europa.eu/research/consultations/science-2.0/background.pdf

Figure 2: Components of good, efficient and open science



Source: http://blogs.lse.ac.uk/impactofsocialsciences/2015/11/11/101-innovations-in-scholarly-communication/)

There is clear evidence that open research practices can bring considerable benefits to the quality, transparency, efficiency and social role of research. These benefits include improvements in:

- the pathways to and quality of discoveries, including the efficient use of data science and big-data mining (for example, by making it possible to link datasets documenting different aspects of the same phenomenon, thus producing knowledge with a stronger evidence base and broader scope – as in current efforts to integrate available information on the physiological, genetic, behavioural and environmental factors involved in mental health);

- the uptake of new technologies towards better communication, engagement and teaching of research methods and outputs (most blatantly exemplified by the use of the internet and social media to foster debate and analysis across large networks of researchers and relevant stakeholders);

- the evaluation of research efforts (for instance, by employing assessment methods that move beyond the current 'publish or perish' ethos and encouraging the development of high-quality outputs that are sustainable and robust in the long term – see below);

- the transparency of the methods and criteria through which research is conducted, assessed and supported;

- collaborative efforts across disciplines, nations and expertise, resulting in more efficient investments and faster results, as well as better communication and working relations;

- the reliability and timeliness of research in tacking social challenges;

- the fight against fraud, lack of integrity and duplication of efforts;

- public engagement and the involvement of a broad range of stakeholders in the design and evaluation of research;

- the social, ethical and political legitimacy of science, resulting in an increase in public trust and participation in research, thereby countering current trends towards "alternative facts" and "fake news".

Thus, implementation of Open Science principles and methods provides a way to increase the scientific, economic and social value of research, whilst reducing the waste of resources created by narrow-minded competition and by the lack of sharing of data, models, methods and materials.

3 ADVANTAGES AND CHALLENGES OF MAKING RESEARCH OPEN

Considering openness as a key norm for the conduct of science is by no means a novel idea. Since at least the scientific revolution, the principles of public scrutiny, transparency and the reproducibility of results have been employed to demarcate science from other knowledge-making activities and to define how research should be conducted and what counts as an output (Merton 1942, Popper 1945, Longino 2002, Kitcher 2011). Some research communities (including in fields such as astronomy, meteorology, natural history, demography and, more recently, genomics) have long advocated the open sharing of data and ideas, grounded in the belief that collaboration and public debate can and do engender reliable and insightful knowledge. This raises the question of why this approach has not taken hold in contemporary mainstream research. As argued above, the practice of science has undergone critical developments over the last century which have limited researchers' ability to enact openness in their daily decision-making. Open Science is therefore defined by the European Commission as a radical departure from the ways in which research is normally conducted and assessed.

It is the main contention of this report that the primary explanation for the current lack of uptake lies in the lack of incentives and rewards for Open Science practices. This section discusses eight areas in which contemporary modes of research support, publication and assessment pose obstacles and disincentives to making research open: (1) evaluation and credit systems; (2) diversity in research cultures; (3) costs and accountability; (4) skills and training; (5) intellectual property regimes; (6) semantic ambiguity; (7) ethical and social concerns; and (8) a high resource bias. Understanding this landscape is a crucial precondition to the remaining sections in the report, which examine the incentives and rewards that could counter this trend and stimulate the adoption and implementation of Open Science among different stakeholders.

3.1 Evaluation and credit systems

Openness is strongly constrained by the evaluation measures used to assess research outputs, which typically rely on quantitative measures of the number of articles produced, where they are published, and the number of citations garnered. As indicated by previous MLE reports, these measures do not take account of efforts made by researchers to share their work, propose highly creative and innovative solutions and tackle real world problems. Consequently, researchers who engage in Open Science are placed at a significant disadvantage to their colleagues who only care about publishing papers in top-ranking journals (Benedictus et al. 2016). This leads to a risk-averse mentality and reinforces a publish or perish model of academic success. The situation is made worse by the fierce competition for limited jobs and resources which characterises most research fields, leading researchers to prioritise speed over quality of discoveries, which acts as a strong disincentive to sharing results and methods. The pressure to publish leads to information control, whereby only a small number of results are disclosed to a relatively select audience, and to a strong bias against sharing negative results. Within such a climate, "increasing transparency in research practices can have unintended consequences. Anything that is open to public scrutiny can be used to assess the practices in question, which may be premature for ongoing projects that need time to yield clear and widely intelligible results. It may also compound researchers' fears of being 'scooped'. It is not hard to imagine that researchers forced to render lab or field notes, protocols or software freely accessible to others will feel the need to create shadow procedures and infrastructures for those parts of their practice that they do not want, or cannot share" (Leonelli et al. 2015, 12; see also Tenopir et al. 2011 and 2015; Poline et al. 2012; Schäfer et al. 2011). The Open Science practice that is perhaps worst affected is Open Data sharing, given the considerable work involved in preparing data for donation to a public repository, the risks that researchers associate with the procedure of data cleaning, standardisation and curation involved, and the complete lack of rewards associated with data publication (Edwards et al 2011).

This situation has a strong impact on the choices and behaviours of junior researchers, who are most vulnerable to assessment requirements upon which their employment and

research directions depend entirely. Conservatism in assessment is partly driven by the metrics and evaluation criteria endorsed by research-performing institutions and funding bodies, as detailed in the previous MLE report. Conservatism is typically also supported by senior academics who inform promotion decisions and the allocation of funding. These individuals often reproduce the assessment cultures through which they have proved successful. It is therefore crucial to provide incentives for senior academics to embrace and reward Open Science activities in their evaluation work. With Open Science being incorporated into incentive and reward structures, including institutional hiring policies, young researchers can establish and adapt themselves to new systems of merit and recognition. It is thus particularly important to regard Open Science as part of a more comprehensive systemic change in research processes, management, administration and evaluation, so as to engender the cultural and structural changes necessary to enable Open Science.

3.2 Diversity in research cultures and quality assurance criteria

Different disciplines have very different criteria for assessing research excellence and quality, which are rooted in the history of each field, their subject matter and methods, and their role in society. This diversity is most pronounced between the humanities and qualitative social sciences, and more quantitative fields in the social and natural sciences. At the same time, attitudes towards openness also vary enormously *within* disciplines and epistemic communities (Fecher et al. 2015, Levin et al. 2016). Different branches of biology, for instance, have completely different attitudes to competition and sharing, with fields such as animal biology remaining fiercely competitive while genomics and model organism biology have endorsed what they call a "share and survive" ethos (Rhee 2004). Fields more heavily invested in commercial partnerships and applications (such as pharmacology and biomedicine) also tend to share less than those focused primarily on fundamental research.

Perhaps the most variable yet most important methodological concern for researchers looking to share results is the interpretation of research quality, controls and validation criteria. Since these are closely tuned to the specific methods and materials used in each research group, it is no surprise that there is such high variability among the criteria used to assess the reliability of outputs. It is impossible to establish detailed benchmarks for what counts as 'good-quality' data and metadata for each research field and objective as these depend on the nature of the questions, phenomena and methods at hand. This has significant consequences for the implementation of Open Science.

Worries around quality assurance regularly feature among the greatest source of concern for natural science researchers in relation to Open Science (Borgman 2012, EU Survey on Science 2.0, Digital Science Report 2016, Fecher et al. 2016). For instance, researchers are concerned about the reliability of data shared via digital repositories, particularly given that many such data have not undergone peer review. By the same token, many researchers are reluctant to share data and materials that they themselves consider to be of lower quality. In the humanities and social sciences, similar concerns are raised about quality controls concerning the publication of articles and monographs, since the reputation and reviewing mechanisms used by particular publishers plays a significant role in quality assurance, and Open Access publications are still perceived as of being of lower quality (Laakso et al. 2011). The extent to which researchers trust each other's work matters enormously to the success of large research projects and to the efficient repurposing of available research outputs. Fostering such trust requires relevant training and skills and must be underpinned by credible quality-assessment mechanisms.

3.3 Cost, accountability and long-term sustainability

The set-up of infrastructures, assessment mechanisms and publication outlets that serve Open Science is neither quick nor cheap, but must be implemented in a coordinated way by a large group of stakeholders. Those benefitting from Open Science tools range from researchers to research institutions, funders, industrial partners and society at large. This makes it very hard to decide how to divide up the resources and who should take financial

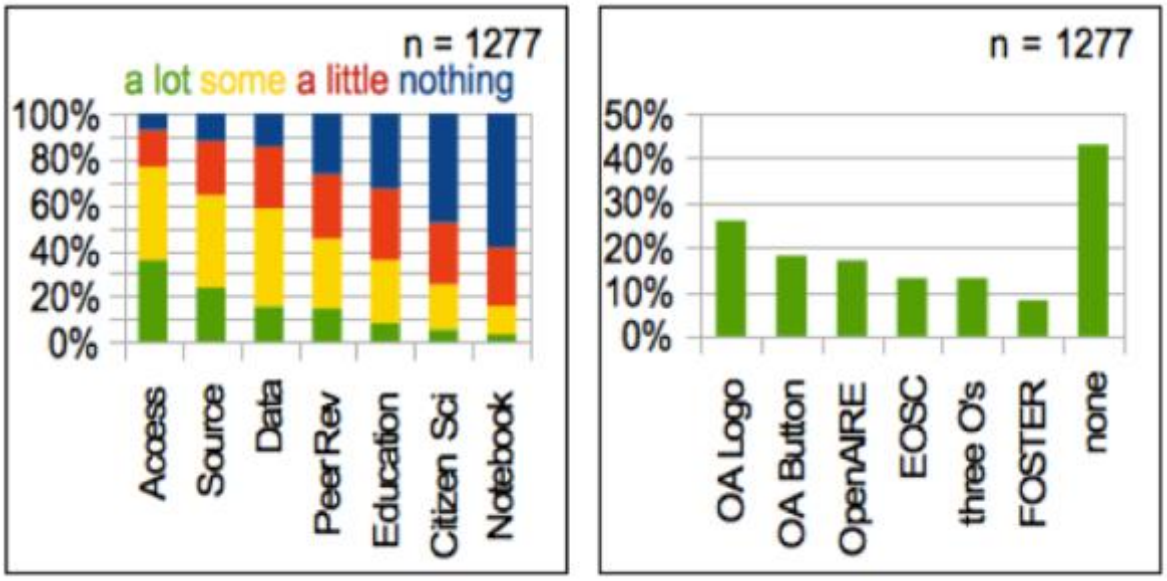
responsibility for supporting their development and maintenance. To make matters even more complex, Open Science is an international phenomenon that requires coordination among nation states and different systems of research evaluation, funding and support. Given the complexities of allocating accountability and coordinating roles in this complex landscape, the business models and long-term funding strategies underpinning many Open Science initiatives remain unclear. There is major uncertainty surrounding the short-term nature of current funding of archives and data infrastructures and deciding who should be responsible for supporting, developing and updating these tools in the future. This is a particularly burdensome task given the constant shifts in related technology and knowledge base (Nelson 2009, Bastow and Leonelli 2010, Royal Society 2012, Eschenfelder and Shankar 2016). Many researchers view this uncertainty as risking the integrity and accessibility of material placed in digital repositories, and thus as a major disincentive to engage in Open Science practices (Tenopir 2011 and 2015, Borgman 2012, Leonelli et al. 2016, Digital Science 2016). Trust remains low in the reliability of archival services for pre-prints and data, for instance, particularly when they are funded by individual institutions (which may decide to interrupt the service) or short-term projects (after which further funding may not be found).

3.4 Skills and training

There is considerable confusion among researchers about what openness means in practice, what options are available to implement it, what is legal, what is recommended by funders, learned societies, publishers, research institutions and governmental bodies, and whether such recommendations are compatible with one another. As illustrated by several recent surveys and highlighted by MLE participants, many researchers know very little about the variety of Open Science formats and practices, how to choose and implement them, and what they could contribute to their work. A survey carried out for a recent report of the EU Working Group on Education and Skills under Open Science (2017) highlights that while European researchers have some understanding of Open Access, Open Source and Open Data activities, they are less aware of Open Peer Review, Open Education, Citizen Science and Open Notebooks. Over 40 % of respondents reported being unaware of any of the current international initiatives and policies supporting Open Science, such as OpenAIRE, the European Open Science Cloud (EOSC) and the OA Button (see figure 3)[1].

[1] OpenAIRE is a European project aiming to promote Open Science practices and related tools (https://www.openaire.eu/); the European Open Science Cloud is the infrastructure coordinated at European level to serve open research and innovation (https://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud); and the OA Button is an initiative supporting legal access to publications and data beyond paywalls (https://openaccessbutton.org/).

Figure 3: Researchers' awareness of Open Access activities and related mandates, as measured through a survey conducted in 2016-2017 by the EU Working Group on Education and Skills under Open Science (2017)



N refers to the number of respondents in the survey. In the first figure, researchers were asked to rate their level of awareness of the key Open Science components. In the second figure, researchers were asked whether they were acquainted with specific Open Science projects and tools.

Source: EU Working Group on Training and Skills under Open Science (2017)

The report concludes that "researchers are largely unaware of Open Science policies and practices, require more skills training and support to practise Open Science, and need to be incentivised to begin, and continue to practise, Open Science." This is striking given the complex and sophisticated practices and skills involved in disseminating and reproducing data, software, techniques, methods, protocols and materials, vis-à-vis research articles. These practices are typically different depending on the field of study, and need to be aligned with existing methods and instruments used by researchers in their everyday work. At the same time, minimal standards must be agreed and implemented internationally to guarantee interoperability and effective linkages among local resources (Sansone et al. 2012)[2]. See, for example, table 1 which lists the many types of tools required to successfully manage and openly share data, and the variety of resources available to researchers in specific fields (in this case, plant science) to cope with such demands. To deal with this new source of complexity, researchers are in desperate need of Open Science training and expert assistance, a point which will be expanded upon below.

[2] GO FAIR is one of the concrete projects related to data sharing which aims to standardise and make available a tool box for researchers showing how to make data ready for sharing (https://www.dtls.nl/fair-data/go-fair/).

Table 1: Typology of the various tools developed to support sustainable and internationally coordinated data management, with specific examples relating to plant science

Table 1 | General tools for data management.

Type of tool	Function	Examples of relevance to the plant community
Open lab books	Digital and shareable version of traditional lab books	RSpace (http://www.researchspace.com)
Generic open data repositories	General storage for many different data types	Figshare (http://www.figshare.com) DataVerse (http://www.dataverse.org)
Specific databases	Fine-grained datasets that require subject-specific metadata	The Arabidopsis Information Resource (http://www.arabidopsis.org) The Bio-Analytic Resource for Plant Biology (http://www.bar.utoronto.ca) iHub (http://www.ionomicshub.org/home/PiiMS)
Data portals	Aggregating and providing visibility for various databases and resources	Araport (http://www.araport.org) Biosharing (http://www.biosharing.org) Agroportal[22]
Bio-ontologies	Keywords for the annotation, ordering and retrieval of data	Plant Ontology[25] Crop Ontology[26]
Metadata standards	Standardization of experimental data collection	Minimal Information on Biological and Biomedical Investigations (http://www.biosharing.org/standards) Minimal Information about a Microarray Experiment[27] Minimal Information about Plant Phenotyping Experiments (http://www.cropnet.pl/phenotypes/?page_id=15)
Identifiers for research materials	Annotation and retrieval of research materials on which experiments were originally performed	Germplasm Resource Information Network – Global (http://www.grin-global.org/) Multi-Crop Passport Descriptors (http://www.bioversityinternational.org/e-library/publications/detail/faobioversity-multi-crop-passport-descriptors-v2-mcpd-v2) Genesys (http://www.genesys-pgr.org)
Informatics standards	Software tools helping to format, store and visualize data	Breeding API (http://www.docs.brapi.apiary.io/) InterMINE (http://www.intermine.org)
Data annotation pipelines	Annotation of data from generation to reuse	Integrated Breeding Platform (http://www.integratedbreeding.net/) CropStore (http://www.cropstoredb.org/description.php) eDal (http://www.edal.ipk-gatersleben.de)
Guidelines of good practice	Articulation of data management principles and actions fostering data reuse	FAIR Data (http://www.force11.org/group/fairgroup/fairprinciples) Wheat Data Interoperability Guidelines[31]

Source: Leonelli et al. 2017

3.5 Intellectual property concerns

While there is evidence of the advantages Open Science could yield for translational research and commercial applications, the push towards the free sharing of research outputs is not easily aligned with the multiple intellectual property regimes currently underpinning the production and application of knowledge in both public and private research organisations (Evans 2010, Haeussler 2011, Holmes 2016, Minssen and Pierce 2017). Researchers are generally confused about which modes of intellectual property apply to their outputs (Borgman 2012, Levin et al. 2016). Such confusion is compounded by the multiple layers of accountability to which any individual researcher is exposed, ranging from accountability to research groups, home institutions, research sponsors, research partners, governmental agencies and assessment exercises. Given the international nature of research and funding networks, any one project (and related outputs) can also be liable to various national legislation, and thus to different and sometimes contradictory licensing terms. In its Open Science Agenda, the European Commission has pledged to address the issue through "better taking into account of public benefits, social interest and the situation of academics and innovative industries when reviewing the European copyright legislation" (Directorate-General for Research and Innovation, 2016). This promise is proving difficult to align with the evolving legal framework around copyright, as expressed for instance in the Directive on Copyright in the Digital Single Market, which in its September 2017 formulation, may prevent researchers from freely text and data mining the content of internet sites.

Another set of concerns around intellectual property emerges in relation to the publication of written outputs. First, there are issues with adjudicating authorship claims and with distinguishing authors from other types of contributors. This is particularly difficult in cases where much of the intellectual work underpinning a publication has been done by emerging professionals, such as data scientists and data curators, whose contributions are not always

adequately recognised. Similarly, where published claims are heavily based on data, techniques or materials openly shared by other research groups, this is prompting questions around whether acknowledgement should come in the form of authorship, citation, or in other ways. Secondly, there are issues with understanding licensing conditions associated with publication. Despite the availability of clear and legible licensing models (such as the Creative Commons, https://creativecommons.org/), many publishing companies rely on customised contracts whose implications for Open Science dissemination are not straightforward or easy for authors to understand – and to which authors do not have access when choosing their publication outlet. In an attempt to address this issue, the Working Group on Open Science Publishing of the Open Science Policy Platform has recently recommended that "it is essential that sufficient information about OA requirements, mandates and modalities of compliance are made available by publishing outlets, in a clear and intelligible manner, to researchers and research institutions needing to take decisions around how to disseminate their outputs" (2017).

3.6 Semantic ambiguity

Openness can mean different things to different stakeholders, and is associated with ideas as different as "free of license", "free of ownership", "under CC-BY license", "common good", "good enough to share", "unrestricted access and/or use", or "accessible without payment", to name but a few existing interpretations (Grubb and Easterbrook 2011). This is true even of researchers working within the same institution and discipline (Levin et al. 2016). Alongside the above-mentioned confusion surrounding intellectual property regimes relevant to Open Science, most researchers also lack an understanding of whether and how Open Science policies align with existing metrics of excellence and impact deployed by research institutions, research funders and governmental agencies. In the UK, for instance, impact is often associated with public-private research partnerships operating under closed intellectual property regimes, an arrangement strongly encouraged both by individual universities and by the government (Research Council UK 2014). At the same time, the UK Higher Education Authority has strongly endorsed Open Science guidelines, including mandatory Open Access for all publicly funded research and a commitment, in principle, to Open Data (HEFCE 2014). As documented by historians of science, secrecy has long played a strategic role in various branches of research, particularly when dealing with projects of considerable military, commercial or ethical sensitivity, such as the development of widely applicable surveillance systems or techniques that could be used to create weapons (for example, Rappert 2007, Royal Society 2012, Balmer 2015). This makes decisions around what to keep closed or to make open particularly delicate, and provides a disincentive to researchers and institutions unsure about how to assess the advantages of Open Science and how to apply Open Science guidelines to their specific case. Well-informed decision-making around these issues is crucial to develop rationales for which parts of the research cycle can and should be made open, and which should be kept closed (as emphasised, for instance, by Guidelines on FAIR data management within Horizon 2020, which state that data should be "as open as possible, as closed as necessary"; EU Directorate-General for Research and Innovation 2016).

3.7 Ethical and societal concerns

It is important to think broadly about who the relevant stakeholders are for Open Science, and how Open Science practices can help address the tensions which characterise the role and perception of scientific expertise within Western media and society. Scholars in science and technology studies have lamented the large discrepancy between the evaluation criteria used to assess scientific excellence and assessment of the social, cultural and economic functions of science (a phenomenon that Paul Wouters has called "e/valuation gap", Wouters 2017).

Many ethical issues are emerging specifically in relation to Open Science implementation. For instance, there are concerns over privacy and data ownership, which are particularly evident in the case of personal data used in biomedical or social science research (Nuffield Council of Bioethics 2015, Mittelstadt and Floridi 2016, Prainsack and Buyx 2016). The European Commission has listed the relationship between data protection regulations and

open data policies as an urgent issue to be tackled within the Open Science Agenda (Directorate-General for Research and Innovation, 2016). There are also ethical and social concerns around big-data mining and the social functions and uses of surveillance technologies and artificial intelligence built on access to publicly available research data. A recent report by the Royal Society and the British Academy has highlighted the importance of data governance structures supporting human flourishing and wellbeing, and the relationship between such governance and implementation of Open Science policies (Royal Society and British Academy 2017).

3.8 High resource bias

Open Science has the potential to improve access to research tools and outputs for researchers working in low-resourced situations. However, Open Science implementation tends to focus on high-resource, internationally well-recognised research environments. For example, Open Data repositories mainly display output from English-speaking labs in prominent research institutions, which have: funds to curate contents and participate in the adoption and development of expensive equipment and software; visibility to determine dissemination formats/procedures; and resources and confidence to build on data donated by others (Science International 2015, Bezuidenhout et al. 2017). Low-resource research environments, defined as having access to fewer technological, organisational and human resources with respect to their needs, tend to invest much less effort in developing and implementing Open Science tools. Furthermore, few provisions have hitherto been made for situations of *systematic disadvantage* (where researchers lack infrastructures and online access) and *vulnerability* (where access to a particular source of material or data type is what provides a competitive edge, as in archaeology and botany). This results in researchers fearing that sharing their results will undermine rather than enhance their international credibility, and increase their disadvantage compared to better-resourced colleagues (Bezuidenout et al. 2017). Thus, there is a risk that the implementation of Open Science practices will result in a greater digital divide between research conducted in well-established research institutions and research carried out by small institutions, citizen scientists or small enterprises.

4 KEY CONCERNS AROUND OPEN SCIENCE IMPLEMENTATION FOR MEMBER STATES

Participants at the MLE were invited to respond to a questionnaire, distributed in May 2017, which included 13 open-ended questions relevant to this report. These questions were grouped under three themes: the **current situation** of Open Science implementation in each country (four questions); issues of specific relevance to **incentives and rewards** (four questions); and perspectives on **future developments** in this area (five questions). The questions and an edited version of the responses are provided in the appendix to this report. Seventeen MLE participants responded to the questionnaire, representing 10 Member States (Belgium, Switzerland, Armenia, Moldova, Sweden, Austria, Croatia, Lithuania, Portugal and Slovenia).

From an analysis of the participants' responses to the questionnaire, as well as feedback received during discussions at MLE meetings, it is clear that Member States vary considerably in their approach to Open Science and how far they have adopted Open Science activities, incentives and assessment procedures. Depending on the national context, governments, individual funders and research institutions assume different levels of responsibility and display varying levels of commitment to the Open Science agenda. Nevertheless, there are eight points on which consensus emerged from the vast majority of participants, and which thus signal widespread concern among Member States regarding Open Science:

1. Many governmental agencies, research institutions and funders have put incentives in place for the Open Access archival of research articles, research institutions and funders, and indeed most of the 'success stories' in responses to the questionnaire given to delegates (see appendix) concern Open Access initiatives.

2. Very few Member States have made provisions for research components other than publications (such as Open Data or Education).

3. Incorporation of Open Science goals in research evaluation and assessment lags far behind, with a majority of countries relying heavily on quantitative assessments of publications, including impact factors. Although this is due to the cost-effectiveness and simplicity of quantitative assessment, it runs counter to the consensus among experts that multiple indicators, including both qualitative and quantitative measures, are the most reliable way to evaluate research.

4. Even for those Member States that have accepted to be part of the MLE, it is not always clear who is responsible for discussing and implementing Open Science policies at the national level. This makes it difficult to foster decision-making on how to implement Open Science mandates, particularly given: (1) the transformative nature of the cultural, evaluative and administrative changes required; and (2) the amount of investment needed to support related infrastructures and services. There is an urgent need for opportunities and venues to deliberate on Open Science implementation and investment at the national level.

5. Given the international nature of Open Science provisions and standards, Member States expect much of the support, coordination and infrastructural facilities required for Open Science implementation to come from the ERA and related European agencies.

6. Researchers and research organisations (including both learned societies and research-performing institutions) are seen as crucial participants in any decision-making process mapping future Open Science implementation and related training, so as to ensure successful and effective uptake by the research community.

7. However, there is widespread concern around the conservatism characterising particularly senior academic circles, which are typically responsible for research evaluation in the form of the peer review of funding proposals and publications. It

is imperative to provide training and incentives for senior academics to value Open Science activities and support the careers and outputs of junior researchers who operate in this way.

8. The transition towards assessment procedures in line with Open Science is likely to yield temporary setbacks and difficulties for some research initiatives and communities, particularly given the different types and levels of uptake of Open Science ethos across research fields. Therefore, the transition must be closely monitored and documented, with clear points of contact within each Member State to address and resolve emerging challenges.

5 INCENTIVES AND REWARDS FOR OPEN SCIENCE: RESEARCHERS

A recent review of existing research on how open research activities may benefit researchers concludes that "open research is associated with increases in citations, media attention, potential collaborators, job opportunities, and funding opportunities" (Morey et al. 2016). However, the vast majority of researchers are subject to requirements made by their peers, disciplinary communities, home institutions and funding bodies, which act as barriers to the adoption and implementation of Open Science behaviour. Furthermore, the highly competitive nature of contemporary academia makes many researchers nervous about sharing their data and materials, for fear of being 'scooped' and losing their competitive advantage. Shifting these perceptions, moving away from the current 'publish or perish' culture and making sure that researchers are rewarded for Open Science behaviour are among the most important goals of Open Science policies. A truly Open Science landscape can only emerge through the participation and input of those who carry out research activities (Neylon 2012).

In position statements, such as the Bratislava Declaration of Young Researchers (2016) and the Position Statements on Open Access and Open Data of the European and Global Young Academies (2016), junior and mid-career researchers have signalled their willingness to engage in Open Science activities. They have also pointed out the obstacles that stand in their way, which include publication-oriented systems of assessment as well as conservatism among senior members in their research communities. Taking this feedback on board, the EU Report of the Working Group on Skills for Open Science proposed a distinction between the roles played by researchers at different career stages in Open Science implementation. Researchers at early career and employment stages are encouraged to recognise "the need for [Open Science] skills as part of their learning process as well as the need to link to recognition/rewards and the impact of acquiring and using OS skills". Senior researchers in established positions are invited to recognise "the need to take leadership and ensure that their mentees acquire the skills as well as the need to demonstrate to them the positive effects of sharing data and information". This section discusses some of the main incentives and rewards that could be used to foster engagement in Open Science activities by researchers at all levels of career development, taking into account the role played by senior researchers in research evaluation and the allocation of rewards.

5.1 Assessment and promotion criteria

The survey carried out by the EU Report on Rewards (2017) made it clear that "evaluation criteria are still most often based on scholarly publications and their number is the most widespread indicator of performance. Other criteria such as measuring the impact of the scientific production on the academic community (citations, h index, etc.) are much less assessed and the least used are the purely qualitative evaluations that require critical reading of the publications and assessment of other achievements than scientific production such as openness, sharing, support to the community, team spirit, participation in citizen science and information of the lay public." Conversely, the San Francisco Declaration on Research Assessment (http://am.ascb.org/dora/), the Metric Tide report (Wilsdon et al. 2015), the Leiden Manifesto (Hicks et al. 2015) and the EU Expert Report on Alternative Research Metrics (2017) have recommended the use of multiple indicators, including both quantitative and qualitative metrics, to assess and support the multiplicity of career paths across the research system. This involves a shift in citation cultures, and a move away from prestige-led assessment based on the reputation of the publication in which articles appear or the research location where the work is being conducted.

It is crucial to avoid assessment mechanisms that regard Open Access publishing and Open Science practices such as data sharing as "academic career suicide". Open Science behaviour is time-consuming and resource-intensive (Tenopir et al. 2011 and 2015, Borgman 2012, Acord and Hartley 2013, Wallis et al. 2013, Ankeny and Leonelli 2015), and must be rewarded by both funding bodies and research institutions (Fecher et al. 2015). Open Access publication needs to be encouraged by research communities and learned societies (thereby countering the widespread belief that Open Access publishing is

damaging to researchers' credibility and constitutes an indicator of low-quality research). Furthermore, it is crucial that assessment encompasses all levels of seniority, and takes account of the diverse backgrounds and competencies of individual researchers. Because of such complexity and sensitivity in this context, the EU Expert Group Report on next-generation metrics concluded that: "Evaluating a researcher cannot be reduced to a number because their merits, achievements, usefulness are a complex set of different variables, impossible to be summarised by a single figure" (Wilsdon et al. 2017).

The Open Science Career Assessment Matrix (OS-CAM) has been proposed by the EU Working Group on Open Science Rewards as a platform for a fair and transparent assessment system for all researchers, regardless of where they come from, work or publish (table 2)[3]. This work was presented to and discussed by MLE participants during the country visits to Croatia in September 2017.

Table 2: Open Science Career Assessment Matrix scheme from EU High Level Report (September 2017)

Open Science Career Assessment Matrix (OS-CAM)	
Open Science activities	*Possible evaluation criteria*
RESEARCH OUTPUT	
Research activity	Pushing forward the boundaries of open science as a research topic
Publications	Publishing in open access journals Self-archiving in open access repositories
Datasets and research results	Using the FAIR data principles Adopting quality standards in open data management and open datasets Making use of open data from other researchers
Open source	Using open source software and other open tools Developing new software and tools that are open to other users
Funding	Securing funding for open science activities
RESEARCH PROCESS	
Stakeholder engagement / citizen science	Actively engaging society and research users in the research process Sharing provisional research results with stakeholders through open platforms (e.g. Arxiv, Figshare) Involving stakeholders in peer review processes
Collaboration and Interdisciplinarity	Widening participation in research through open collaborative projects Engaging in team science through diverse cross-disciplinary teams
Research integrity	Being aware of the ethical and legal issues relating to data sharing, confidentiality, attribution and environmental impact of open science activities Fully recognizing the contribution of others in research projects, including collaborators, co-authors, citizens, open data providers
Risk management	Taking account of the risks involved in open science
SERVICE AND LEADERSHIP	
Leadership	Developing a vision and strategy on how to integrate OS practices in the normal practice of doing research Driving policy and practice in open science Being a role model in practicing open science
Academic standing	Developing an international or national profile for open science activities Contributing as editor or advisor for open science journals or bodies
Peer review	Contributing to open peer review processes Examining or assessing open research
Networking	Participating in national and international networks relating to open science

[3] This work builds on the outputs of ACUMEN, a large-scale collaboration across nine European research institutes to investigate alternative research assessment practices (http://research-acumen.eu/).

RESEARCH IMPACT	
Communication and Dissemination	Participating in public engagement activities Sharing research results through non-academic dissemination channels Translating research into a language suitable for public understanding
IP (patents, licenses)	Being knowledgeable on the legal and ethical issues relating to IPR Transferring IP to the wider economy
Societal impact	Evidence of use of research by societal groups Recognition from societal groups or for societal activities
Knowledge exchange	Engaging in open innovation with partners beyond academia
TEACHING AND SUPERVISION	
Teaching	Training other researchers in open science principles and methods Developing curricula and programs in open science methods, including open science data management Raising awareness and understanding in open science in undergraduate and masters' programs
Mentoring	Mentoring and encouraging others in developing their open science capabilities
Supervision	Supporting early stage researchers to adopt an open science approach
PROFESSIONAL EXPERIENCE	
Continuing professional development	Investing in own professional development to build open science capabilities
Project management	Successfully delivering open science projects involving diverse research teams
Personal qualities	Demonstrating the personal qualities to engage society and research users with open science Showing the flexibility and perseverance to respond to the challenges of conducting open science

Source: https://ec.europa.eu/research/openscience/pdf/os_rewards_wgreport_final.pdf

Implementation of the OS-CAM system aims to acknowledge the invisible labour carried out as part of research, particularly the efforts involved in teamwork, management, public engagement and professional service such as refereeing, teaching and data management. This system encompasses researchers at all career levels, ranging from early career to established senior researchers. In particular, it benefits young researchers, since it encourages them to acquire professional skills and experience in several aspects of research work, and not to sacrifice research quality and public engagement activities in the name of producing more publications. Thus, the system is geared to valuing the content and reach of research activities. It also has the potential to facilitate the movement of researchers between academia and other sectors, as early-career researchers are explicitly assessed in the exercise of skills that are also valued outside academia. The EU Report notes that the OS-CAM is compatible with the European Charter for Researchers and Code of Conduct for their Recruitment (which was published in 2005) and can also be used as a reference point to take a more explicit account of the roles, responsibilities and entitlements of researchers, employers and those funding researchers.

5.2 Training on Open Access guidelines and implementation tools

Research institutions should provide systematic training for scientific researchers on practices such as self-archiving, on different formats of data sharing and its advantages and potential downsides, and on how to make information intelligible for specific user groups. Moreover, as an increasing number of institutions run research or teaching initiatives around 'big data', it is important that these are not narrowly focused on technical skills such as predictive analytics or data cleaning, but that they deal with big data comprehensively, including its societal, ethical, philosophical and regulatory aspects. This will lead to higher levels of awareness of the potential benefits and drawbacks of Open Science among both scientific researchers and wider publics, which in turn facilitates more meaningful and targeted support for Open Science.

The Report of the EU Working Group on Skills for Open Science identifies four broad categories of Open Science skills and expertise, which include: (1) those necessary for Open Access publishing, such as how to choose a publishing venue and related licensing; (2) those that concern data sharing and reuse, including standards for the formatting and curation of data and metadata; (3) those that ground participation in and beyond one's scholarly community, such as is needed to manage research to preserve its integrity and abide with the law (a difficult challenge given the potential tensions between Open Data

directives and data protection legislation); and (4) those needed to engage the general public in research planning and activities (so-called 'citizen science skills') (EU Report 2017). Besides greater visibility and career progression, the acquisition of these skills can constitute an incentive for researchers who are interested in learning to work in this way but do not have the resources or ability to do so.

At the same time, it must be stressed that, no matter how many incentives they receive to implement Open Science guidelines, individual researchers (and even research groups) are typically not in a position to acquire and use all the skills required to be able to work in this way, particularly given the multiple administrative and managerial tasks they are already responsible for. External support – in the form of access to relevant infrastructures and expert advice from libraries, administrators and information management professionals – is essential and highly motivating for researchers who are already working to deliver research results under considerable pressures and with limited resources. It is therefore important to provide Open Science training across both academic and professional services (including administrators and research officers). A useful resource for researchers and support staff is the FOSTER portal (www.fosteropenscience.eu) which provides access to tools and training resources for Open Science skills. The EU Report lists several other relevant initiatives.

5.3 Citation and authorship cultures

Innovative models of authorship and citation are required as incentives for researchers to engage in the work involved in all stages of Open Science, and for funders and research institutions to be able to measure and assess such work. Many scientific journals have launched new policies about what kinds of contributions count as authorship, and require authors to provide explicit and detailed descriptions of their contributions.

Several initiatives are also under way to facilitate the publication and citation of datasets. For instance, Open Access repositories such as Figshare and Zenodo provide unique digital object identifiers for each dataset, making it possible to cite them and attach them to ORCID researcher profiles. Data journals such as GigaScience and F1000 enable the refereeing and publication of data and related methods in a similar format to a traditional article. There is evidence that Open Access to publications and datasets spurs the reuse (and related citations) of the research in question (Gaule and Maystre 2011, Piwowar 2013, Fecher et al. 2015, McKiernan et al. 2016). This finding represents a significant incentive for researchers keen to increase the visibility of their work.

The OS-CAM system of assessment detailed above also takes account of authorship of work that does not necessarily undergo traditional peer review, and yet has an impact on the extent to which a researcher engages with a wide variety of stakeholders and garners feedback for his or her work beyond the boundaries of academia. Examples of such work include contributions to traditional and social media, policy reports and educational aids for teaching.

Furthermore, there is a push to recognise and reward the authorship of peer reviews and evaluation reports carried out for publishing outlets and funding bodies. These time-consuming contributions are indispensable to the functioning of the scientific system, and it has been argued that making such work visible and recognised will enhance both the quality and fairness of the peer-review system (which has been extensively critiqued for its exploitative and potentially unjust nature), thereby offering an important incentive to Open Science activities (Morey et al. 2016).

5.4 Guarantees of the international and sustainable nature of Open Science initiatives and related infrastructures

In response to the high level of concern over the maintenance of Open Science resources for long-term use, over the last decade, the European Commission has taken important steps to ensure the sustainability of Open Science infrastructures. Most recently, this includes the launch of the EOSC, which aims to federate key data infrastructures in Europe to guarantee their functioning over the long term. Individual Member States, research institutions and research funders need to support this effort by taking steps towards ensuring financial support for Open Science implementation in their own domains. This should include support for training in Open Science skills for researchers, research administrators and institutions, as well as administrative and systemic changes in research assessment. It is imperative that a balance is struck between top-down efforts to incentivise activities at the international, national and regional levels, and bottom-up tools devised by specific groups to take account of the needs, expectations and background knowledge of users on the ground (Leonelli et al. 2015). The work of platforms and organisations aiming to link up international initiatives (such as ELIXIR, OpenAIRE and the EOSC) is particularly significant insofar as it supports both long-term sustainability and the visibility/accessibility of Open Science tools to the international research community. Finally, it is crucial for funding bodies to emphasise Open Science activities in all funding calls, again providing researchers with immediate evidence of the available pathways towards benefiting from Open Science and improving and expanding their work accordingly.

5.5 Open Science prizes and funding streams: establishing champions and role models

Providing visibility and rewards to champions of Open Science can incentivise Open Science implementation in at least three ways:

- by providing evidence of the international recognition accorded to contributions in this area;
- by attracting attention to initiatives that can act as role models within specific fields and in relation to specific practices; and
- perhaps most importantly, by demonstrating the scientific value of Open Science practices by showing how activities such as data sharing can enhance the quality and reproducibility of research (thus providing concrete counter-examples to researchers' fears that Open Science may result in outputs of low quality and reliability).

One example is the establishment of funding formats dedicated specifically to Open Science initiatives, such as, for instance, 'data challenges' dedicated to the reuse of data and the development of better tools for data management (like the work currently funded through the EOSC pilot project). Another example is the Open Science Prize (www.opensciencеprize.org) and the prizes given by the Research Data Alliance. It would be useful for learned societies in all fields to consider awarding similar prizes, so as to stimulate awareness of the advantages of Open Science activities (and the forms they can take) within each area of research. This would be particularly useful to familiarise individuals who are not already involved in Open Science debates with the advantages of this manner of working, alleviate fears relating to burdens and risks associated with sharing research outputs, and illustrate ways in which openness can be integrated into research design and everyday activities characteristic of specific research communities.

6 INCENTIVES AND REWARDS FOR OPEN SCIENCE: RESEARCH ORGANISATIONS AND FUNDING BODIES

Higher education institutes (HEIs) and other research-performing organisations play a crucial role in implementing and enabling Open Science activities through the right incentives and evaluation mechanisms. Funding bodies also provide significant incentives to both institutions and researchers by establishing criteria for resource allocation. Furthermore, these stakeholders are at the front line in terms of complying with the EU Open Science mandate by 2020, particularly in countries such as Switzerland and France where individual HEIs operate with a large degree of autonomy from central government.

The transition to Open Science is complex and multifaceted, which means it is unlikely to be immediate and will require substantive resources and decision-making by all stakeholders involved in supporting, performing and using research. Research institutions and funders must establish clear ways not only to foster but also to monitor the transition to Open Science. Problems are likely to emerge from the differential implementation of Open Science measures, for instance in cases of researchers moving from an institution where Open Science is rewarded to one in which it is penalised. It is also possible for funding agencies and research institutes to endorse contradictory policies concerning Open Science (for instance, where a research institute retains ownership of the data produced by researchers but the funding body supporting the project requires data to be made openly available). Such situations have the potential to damage both the careers of researchers involved and the quality of their outputs, and thus must be identified and resolved as quickly and effectively as possible. This requires creating venues and resources for debate and dialogue between funders and research institutions, as well as incentives for these organisations to work together effectively.

To date, most funders' policy mandates of relevance to Open Science activities have focused on the implementation of Open Access, and specifically on mandating Open Access archiving (the so-called "Green Open Access" model; see figure 4). In countries such as the UK, the Netherlands and Moldova, open archiving has become compulsory for publications to be counted as part of governmental assessment exercises, resulting in most universities developing in-house archival services.

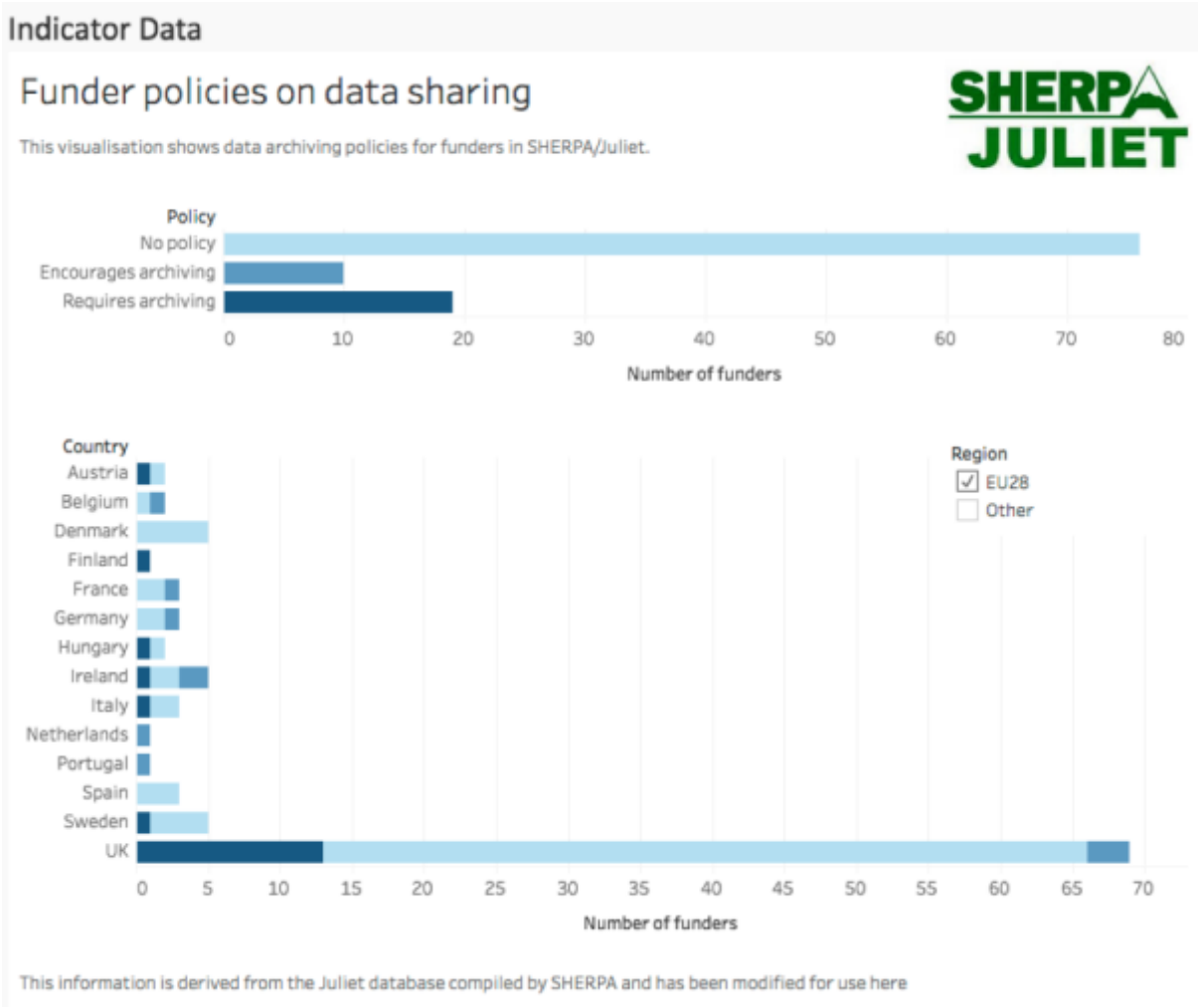
Figure 4: European funders' policies on Open Access

Source: European Open Science Monitor, accessed August 2017

As is also evident from figure 4, European funders have been more reluctant to mandate Open Access publishing, a situation that is at least partly explained by unresolved issues around who bears responsibility for the associated costs, and by ongoing disputes with publishers, learned societies and universities over Open Access publishing models and related metrics. The situation on Open Data is even more striking, with few funders in Austria, Finland, Hungary, Ireland, Italy and Sweden so far committing to mandating data sharing, while the vast majority of funders remain neutral as regards what researchers should be doing (figure 5). The reasons for such reluctance include difficulties in tackling the diversity of data types and uses, researchers' own reluctance to share their data, as well as the lack of rewards associated with this highly laborious practice. Making sure that data production is documented and visualised with enough detail for others to be able to replicate it, and formatting data and related metadata in ways that comply with international standards for data curation, are activities that require considerable time and

expertise, and which therefore reduce the time available to researchers for other activities. These issues can only be resolved with extensive and careful debate among stakeholders, as is exemplified by the Open Science Policy Platform. Below are some of the incentives and potential rewards for European research-performing institutions and funding bodies to support Open Science activities.

Figure 5: European funders' policies on data sharing



Source: European Open Science Monitor, accessed August 2017

6.1 Fostering interdisciplinary and translation research

HEIs have long been caught in a bind between their impact and engagement goals, and their ambitions for scientific excellence. Open Science activities and related assessment can help foster socially relevant interdisciplinary and translational research programmes. Open Science has the potential to provide a link between high-quality and commercially attractive research, enabling institutions to incentivise both excellent and impactful science, thereby narrowing the gulf between academia and society. This can happen, for instance, by involving industry stakeholders in the process of designing publicly funded research, or by establishing pathways between data production sites and those of analysis and interpretation. For such links to work, it is imperative that commercial and private research funders support Open Science guidelines and practices as strongly as public funders. This will guarantee reciprocity in data-sharing and interpretation activities, promote trust between the relevant stakeholders, and ensure that privately funded research is subject to the same checks for quality, reliability, ethics and social relevance as publicly funded research.

Furthermore, Open Science assessment procedures make it easier to identify and reward academic service and good citizenship, thus facilitating collaboration among colleagues within the same institution, as well as co-operation and exchanges with other institutions worldwide. More broadly, Open Science can help to enhance the effectiveness and speed of delivering research solutions to societal problems. The successful way in which the Ebola and Zika epidemics have been identified and tackled is a good example of this. These enormous research efforts, involving researchers from all over the world, were based on an agreement among participants to share results and progress in an open way – an agreement endorsed by funders such as the EU and the World Health Organization. The implications of this choice cannot be measured using traditional metrics looking at academic output in terms of citations and impacts (which for those researchers involved meant having to make a choice between contributing to tackling an emergency and fostering their own academic career). The adoption of assessment measures that reward Open Science behaviour will further incentivise and reward the international and interdisciplinary cooperation required to tackle urgent global challenges.

6.2 Promoting social engagement and responsible innovation

Open Science fosters the involvement of a broad range of stakeholders in the planning and conduct of research, thereby avoiding notoriously simplistic and unsuccessful linear models of innovation and public understanding (within which the general public figures as the passive recipient of research outputs). It is crucial for research organisations and funding bodies to provide incentives and rewards for productive, ongoing interactions between researchers and the wide range of stakeholders (including the public at large) which may be affected by research outputs. For instance, such incentives may involve systems for the collection and analysis of data from a wide variety of sources in order to document and reward diverse social interactions (Wolf et al. 2013). Such mechanisms would also facilitate critical debate around the ethical aspects and implications of any given research project, which in turn enables implementation of responsible approaches to innovation (Stilgoe et al. 2013, Vayena and Tasioulas 2016).

The Open Science agenda and related assessment procedures provide an opportunity for research institutions to move away from blind acceptance of metrics such as impact factors as the only well-established way to evaluate the impact of research. By identifying and using metrics that capture public engagement and contributions to society, universities and research institutes can take ownership of the kind of impact and social profile they wish to achieve while providing clear incentives for staff to operate accordingly.

6.3 Enhancing educational resources

Research-performing organisations, and particularly universities, have a strong interest in linking scholarly activities with the provision of education, and in making their educational offering as innovative, attractive and research-led as possible. Open Education tools building on Open Science practices have a strong potential to engender novel approaches to teaching, as well as to build social engagement and problem-based reasoning into modules and seminars. Open Science tools can also enhance online learning and the use of digital resources for effective teaching; help with employability and with the wider recognition of student achievement; and enhance how educational impact is tracked and documented, thereby increasing visibility and recognition of the quality of teaching programmes and related research. Among the several resources developed by European projects to foster Open Education, it is worth highlighting the activities of SPARC (SPARC Europe 2016), a global coalition of academic and research libraries committed to making Open Science the default for research and education, and specially to promoting Open Education resources. The LERU Roadmap and Toolkit for Open Science (2014, 2017) also includes useful suggestions for the effective use of Open Science activities to foster Open Education.

6.4 Improving management practice

Research institutions can use Open Science tools and practices to improve the management of their staff and resources, by using Open Science metrics to measure university research performance (Moed et al. 1995). For example, although many institutions encourage the use of repositories, there is still no consensus on how to use them as part of metrics and incentives. Universities in the Netherlands, Finland and Belgium are leading important initiatives in this area. University College London and the University of Helsinki provide their employees with detailed guidelines and dedicated infrastructures to publish Open Access. Since 2010, the University of Ghent has implemented a mandatory archiving system for all staff publications. Such systems can be used to assess trends in published work and to help assess the outputs of researchers, research groups, faculties and the institution as a whole. At the University of Liège, for example, the evaluation of individual researchers is based exclusively on what they submit to their institutional repository. This policy has swiftly transformed Open Access into a requirement for career progression.

Traditional research metrics, such as impact factors, are focused on a researcher's track record and past achievements. In contrast, evaluations based on data gathered about Open Science activities can also help to assess prospective research and its future potential, by examining the efforts made by individuals or groups towards data collection, international networking or public engagement, for instance. Such information is relevant for funding allocation and hiring decisions. Furthermore, by focusing on all components of science rather than solely on 'top' written outputs, these metrics can help to identify and highlight different strengths and skills among staff, which in turn helps to diversify talent management and produce a workforce that is robust and resilient in the face of ongoing changes in technologies, knowledge and societal challenges.

In addition, the implementation of Open Science and related assessment measures promotes (and helps to provide evidence for) compliance with the Human Resources Strategy for Researchers currently recommended for all H2020 contracts. It should be noted that, as recommended by the recent report by the EU Working Group on Skills and Education under Open Science, the Human Resources Strategy for Researchers and related guidance for doctoral students and support staff at the European level may soon be revised to align more explicitly with the Open Science agenda. ("There should be a review of ERA policies, ERA roadmaps and National Action Plans through the lens of Open Science. If necessary, policies must be updated in order to ensure compatibility with Open Science.")

To promote the efficient and swift implementation of the Open Science agenda, research and funding institutions must commit to the provision of relevant training for their research and professional staff as well as to creating new professional roles which must be adequately rewarded and given the capacity to effect changes within the organisation. Such roles include data curators and information managers. One way to address this requirement within universities is to incentivise and reward assistance from libraries, which are ideally positioned as a key support and training point for research staff. However, as repeatedly noted by LIBER (the Association of European Research Libraries, libereurope.eu), this involves a considerable shift in the role and status of libraries within research institutions, as well as the setting up of dedicated training for library staff to learn Open Science skills and related management practices.

6.5 Improving transparency and external accountability

The implementation of the OS-CAM assessment of research activities detailed above not only constitutes a fair way to reward Open Access behaviour among researchers, but also provides institutions with rich data documenting the wide-ranging impact and value of research outputs in society. Access to and analysis of such data would facilitate the process of documenting the returns yielded by investment in research, thereby helping research institutions and funding bodies to account for their decisions on resource allocation to sponsors, partners, peers and taxpayers.

Furthermore, such data would help institutions and funding bodies to document their transition to an Open Science system, and to swiftly identify and address any problems or concerns that may emerge during this complex process. In this respect, a useful Open Science innovation is the Open Peer Review (Morey et al. 2016) which, when applied to the process of grant evaluation and allocation of funding, would provide a transparent, publicly accessible rationale for decisions made about the allocation of resources. There are justified concerns around the widespread adoption of Open Peer Review, given the substantial inequalities in power, seniority and resources which characterise the current research environment. For instance, a junior researcher openly critiquing a senior figure, or a researcher from a small university assessing the work of a top-ranking institution, provide easy targets for subsequent discrimination by those they attack, no matter how well justified. Specific institutional and assessment mechanism must be put in place to avoid such discrimination, with learned societies playing a particularly important role in monitoring local disputes and encouraging each community to behave fairly and equitably. In this sense, the adoption of Open Peer Review is a good example of the extent of cultural change required to implement Open Science.

Data gathered in this way becomes even more relevant in situations where traditional metrics do not easily apply: for instance, humanities research conducted in languages other than English, or research that is only relevant to a specific locality and is therefore unlikely to be widely cited. Armenia, for example, is looking to establish a database for all Armenian-based journals, and implementing an Open Access mandate for these publications as an incentive to their visibility, accessibility and quality. A similar initiative has already been implemented in Finland (https://journal.fl/index/index), bringing greater visibility to research published locally, and making it easier for government and research institutions to evaluate.

Ethical scrutiny of research practices is also fostered through Open Research practices, for instance through data management plans and statements around the research's social engagement and implications.

Another section of research and funding institutions that is strongly affected by the Open Science agenda concerns technology transfer offices and legal departments responsible for handling intellectual property issues. Open Science provides an opportunity for research organisations to rethink and adapt their intellectual property regimes to the demands of 21st century research.

6.6 Enhancing international visibility and reputation

Given the evidence that openly shared research results in more visibility and citations (Morey et al. 2016) and the increasing tendency for research assessment to take Open Science behaviour into account, Open Science activities can be expected to foster the performance of research institutions within research and university rankings. More broadly and more significantly, given the current dependence of such rankings on traditional assessments such as impact factors, Open Science activities foster greater collaboration within and beyond each institution, and create a rich landscape of outputs which research institutions can claim as their own. Such activities also enhance the ability of institutions to track who adopts and repurposes the knowledge and tools they create, and to what end.

Furthermore, the implementation of the OS-CAM assessment can enhance the reputation of research institutions among prospective employees, thus helping to attract and retain talent and increasing the international visibility of research efforts and investments.

7 INCENTIVES AND REWARDS FOR OPEN SCIENCE: NATIONAL GOVERNMENTS

While it is widely acknowledged that Open Science initiatives and practices must emerge 'bottom-up', thus aligning with researchers' experiences and needs, top-down legislation serves a crucial role as a framework within which incentives can be positioned and motivated. National governments need to take responsibility for fostering Open Science activities and for making it as easy as possible for researchers and research institutions to implement the required changes. From the discussions held during the course of the MLE, it is clear that the vast majority of researchers and research institutions expect national governments to explicitly endorse Open Science policy and provide resources and funding to support and coordinate its implementation across all relevant stakeholders. MLE participants perceive this as a key incentive for the uptake of Open Science activities at the national level, since it signals that the country is prepared to recognise and reward those willing to challenge traditional approaches to research and publishing.

7.1 Improving transparency and external accountability

A survey among participants at this MLE (details below) revealed a strong interest in Open Science activities and policies from several Member States, but a lack of monitoring and enforcement regarding Open Science guidelines. Investments made towards facilitating Open Science activities are likely to yield high returns in terms of a more transparent research labour market, better and more reliable research outputs, and a more effective translation of fundamental research into innovative solutions to societal challenges. The role of government in providing incentives for Open Science is particularly significant in countries such as Moldova, Italy, Croatia and Slovenia where universities have a limited degree of autonomy, and most decisions concerning evaluation and resources are made at the governmental level. In such cases, the relevant ministries bear a greater responsibility for setting a clear and rigorous agenda to promote Open Science activities.

The Netherlands, Finland, the UK and Moldova are providing useful models for how Open Science can be incentivised by national governments. For instance, the Netherlands implemented a National Plan Open Science which is responsible for gathering and implementing the relevant training. The UK has made Open Access archiving mandatory for all research output considered for the Research Excellence Framework, its national research assessment exercise (HEFCE 2014). In Moldova, journals are only recognised by governmental assessment if they have Open Access status, a measure widely seen as a very effective incentive. Other countries have started to build national infrastructure to support the move to Open Access publishing. Croatia has established a national platform of almost 400 Diamond Open Access journals, subsidised by the Ministry of Education. It has also created a Croatian scientific bibliography CRSOSBI (https://bib.irb.hr/) which contains more than 450 000 bibliographic records, enabling scientists to easily archive full-text articles in Open Access. In Slovenia, the COBISS/SciMet (http://scimet.izum.si/) collects research outputs centrally and the personal bibliographies of researchers are stored and visible within the same service, enabling researchers to monitor the performance of their publications by using alternative metrics and more traditional metrics.

7.2 Promoting social engagement and responsible innovation

Open Science practices promote an effective translation and engagement between science, policy and society. They foster a better circulation of researchers between academia and industry; provide the opportunity to address the 'citation gap' separating blue-skies research and applications; and incentivise the involvement of a broad range of stakeholders in designing and evaluating research.

Governmental policy is crucial to the implementation of Open Science and needs to be accompanied by public debate and 'bottom-up' support, thereby engaging with stakeholders from all sectors to illustrate the advantages of Open Research practices and garnering feedback as to its implications for specific users. The Royal Society and British Academy 2017 Report on Data Governance (2017) warns against mismanaging public perceptions and recommends multiple opportunities for the public to engage in Open Research and to participate in shaping both the policies and the specific tools implemented

under the Open Science agenda. As part of this mandate, governmental agencies, funding bodies and research institutions can also play a pivotal role in shaping publishers' attitudes and services relating to Open Science.

Crucially, Open Science activities promote trust and reciprocity of engagement among private and public stakeholders, so that more transparency is attached to data sharing and analysis for the purposes of innovation. Further, they ensure responsible and engaged practices are employed for the development of new technology (note that for this to work, governments must require private funders to follow Open Science guidelines in the same way as publicly funded bodies do).

7.3 Economic growth

This also means better and more efficient documentation of impact and value production, illustrating the returns that investment in research can yield at the national level. An example of the successful use of this strategy is provided by the European Bioinformatics Institute (EBI), whose Open Science activities have been assessed by an independent consultancy in order to estimate the impact the data and services freely provided by EBI has had on its users. The report concluded that: "Users reported that EMBL-EBI data and services made their research significantly more efficient. This benefit to users and their funders is estimated, at a minimum, to be worth £1 billion per annum worldwide – equivalent to more than 20 times the direct operational cost. In terms of return on investment in R&D: during the last year the use of EMBL-EBI services contributed to the wider realisation of future research impacts conservatively estimated to be worth some £920 million annually, or £6.9 billion over 30 years in net present value" (Beagrie et al. 2016). The report makes it clear that such a high return on investment is largely due to the Open Access policies enforced by the EBI, and that Open Research practices also made it possible to track and document the impact of Open Science policy.

7.4 Enhancing international relations

Open Science serves as a motor for economic growth, public engagement and social prosperity across Europe, taking advantage of both the Common Market and the ERA agreements for international collaboration. Open Science agreements and work towards common standards also have the potential to foster networking and communication among Member States as well as with global partners, thus promoting diplomatic relations across institutions and countries and increasing the global visibility of European achievements in research and innovation. By working together, European Member States have an opportunity to lead the world in developing best practice for Open Science, improving the channels through which researchers can help address global challenges, and providing future generations with ways to actively shape and engage with scientific and technological innovation.

The role played by Open Science in fostering science diplomacy brings the science policy agenda at the regional, national and European levels into close alignment with foreign policy goals and procedures. European Commissioner Moedas highlighted the link between the Open Science Agenda promoted by his Directorate-General and the EU's overarching diplomatic mission as follows: "… for today's EU, European research is an important resource for exercising its collective responsibility in a spirit of international solidarity, as part of its efforts to work with international partners to solve common and complex global challenges. EU science diplomacy is therefore becoming an increasingly visible part of the Union's foreign policy, one taken into account more often and with deeper commitment than ever before" (Moedas 2016). Operating in this way requires each government to establish clear contact points, communication channels and venues to debate Open Science implementation at the national level, and to engage with international debates in this area.

8 CONCLUSIONS

The development and implementation of incentives and rewards for Open Science practices encompass several different measures whose application depends on the stakeholders involved as well as the specific field, community and location in question. Given the highly international nature of research networks, international coordination is crucial for the effective implementation of comparable measures. At the same time, each Member State, research funder and research-performing organisation must review the extent to which specific incentives will work in its specific context, and adapt the requirements discussed in this report accordingly.

In conclusion, two tables have been used to summarise the report's key messages. Table 3 gives an overview of the main findings from the literature and discussions among MLE participants. Table 4 provides a synoptic view of the approaches to incentivising and rewarding Open Science activities that have been identified and discussed in this report, the conditions under which they are most likely to operate effectively, their potential advantages and disadvantages, and the main stakeholders responsible for their implementation. In the next report for this MLE, specific examples, strategies and roadmaps for the successful implementation of Open Science practices will be considered and discussed.

Table 3: Overview of key findings concerning Open Science implementation

Challenges of Open Science implementation	• Shift to a new evaluation system for research • Attention to local research cultures and methods • Costs and infrastructures required to guarantee long-term sustainability • Need to provide new skills for researchers and new forms of support in data management • Clarification of legal frameworks and accountability relating to Open Science • Incorporation of ethical and social concerns into the implementation of Open Science • Methods to counter the high resource bias characterising many current Open Science activities
Concerns for Member States	• Go beyond Open Access support and take advantage of other aspects of Open Science (including Open Data and Education) • Shift to multiple indicators for research assessment, which are more effective but also more expensive to implement • Establish clear points of contact and accountability for the national implementation and monitoring of Open Science policy • Rely on well-coordinated and clearly formulated Open Science policies, infrastructures and role models at the European level • Involve researchers and research organisations in all aspects of Open Science implementation • Monitor the transition to Open Science and address emerging concerns in a timely and efficient manner
Incentives and rewards for researchers	• Fairer assessment of research efforts, resulting in incentives to produce better and more rigorous science • Better training and support for research dissemination and data curation • Fairer distribution of authorship claims and citation cultures • Reliable Open Science infrastructures, with guarantees that they can support researchers' work in the long term • Visible recognition of Open Science activities which are widely acknowledged as enhancing the reputation and credibility of researchers
Incentives and rewards for funding bodies and research institutions	• Improved translation of research efforts into societal outcomes • Promotion of interdisciplinary, problem-driven research culture • Promotion of responsible innovation • Improved educational resources and public engagement in research • Improved management practices • Improved transparency and external accountability • Enhanced international visibility and reputation
Incentives and rewards for national governments	• Stronger economy effectively building on investments in research and development • Improved transparency for citizens and international partners • Improved public engagement with national activities and publicly funded projects • Enhanced international and diplomatic relations

Table 4: Synoptic view of the approaches to incentivising and rewarding Open Science activities that have been discussed in this document

	OS-CAM Research Evaluation	OS Training Provision & Education Resources	Shifts in Citation & Authorship	Long-term Sustainability	Open Science Role Models	Responsible Innovation & Public Engagement	Transparency & Accountability	International Coordination & Science Diplomacy
Required conditions	Overhaul of evaluation procedures in research institutions and funding bodies	Resources and personnel to provide training locally and nationally	Overhaul of evaluation procedures and publishing formats	Complex coordination among stakeholders and long-term commitment	Establishment of criteria for successful Open Science in each field; buy-in from learned societies and academies	Rewards for social interaction and non-traditional outputs; co-design of research with relevant stakeholders	Systems for tracking, visualising and discussing the organisation, outputs and funding of research	Clear points of contact and communication channels/venues to debate Open Science implementation
Pros	Most important set of incentives and rewards for researchers	Enables researchers to practice Open Science effectively; produces innovative education tools	Recognition of currently invisible efforts to support Open Science	Crucial incentive for researchers; ensures the long-term fruitfulness of current investments	Exemplifying advantages of Open Science, and paths to implementation; enhance international status of research institutions; inexpensive	Embedding of research in society, towards devising ethical and responsible solutions to global challenges	Improved documentation and scrutiny of research processes and resources; greater reproducibility of results and evaluation of accountabilities	Enhanced international visibility, networking and diplomatic relations across institutions and nation states
Cons	Time-intensive evaluation procedures	Investment in training provision and related staff; must be included in researchers' workload	Requires new policies tailored to each publication output	Complex coordination among stakeholders and long-term financial support	Mobilise learned societies and science academies to actively promote Open Science	Risk of less investment in fundamental research; greater accountability for all research activities	Increased administration and more investment in data analysis and qualitative assessments	Increased national research budgets; need for coordination between science and foreign policy
Challenges	Administrative, cultural and financial	Administrative, financial and cultural	Cultural and logistical	Logistical and financial	Logistical	Cultural, administrative, logistical, financial	Administrative, cultural, logistical	Administrative, logistical, political
Who implements this? (note: researchers are always involved)	Research institutions, funding bodies, researchers	Funding bodies, libraries	Research institutions, funding bodies, editors, publishers	EU, national governments, research institutions, libraries	National governments, funding bodies, learned societies	Funding bodies, research institutions, EU, national governments	Funding bodies, research institutions, EU, national governments	National governments, policymakers, research managers

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APPENDIX: OVERVIEW OF MLE QUESTIONNAIRE RESPONSES

Current situation in your country:

- **What Open Science requirements or provisions, if any, have been adopted by the main research funders in your country?**

SLOVENIA: Resolution on Research and Innovation Strategy of Slovenia 2011-2020 (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Strategije/01.06._RISSdz_ENG.pdf), Chapter 4.5, Action 55 (Preparation of action plan for free access to data from publicly funded research); National strategy of open access to scientific publications and research data in Slovenia 2015-2020 (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Zakonodaja/Strategije/National_strategy_for_open_access_21._9._2015.pdf); Slovenian strategy for strengthening the European Research Area 2016-2020 (ERA Roadmap) (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Zakonodaja/Strategije/SI_ERA_Roadmap.pdf); Research Infrastructure Roadmap 2011-2020, Revision 2016 (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Strategije/NRRI_2016_ENG.pdf). Financial support to universities and research institutes for performance-related projects and setting up required infrastructure.
SWITZERLAND: Open Access policy http://www.snf.ch/en/theSNSF/research-policies/open-access/
SWEDEN: Three out of the four largest Swedish funders have mandates on Open Access www.vr.se; www.formas.se; www.forte.se – as well as some foundations: www.rj.se; www.ostersjostiftelsen.se; www.wallenberg.com.
BELGIUM: Federal government-funded researchers are invited to deposit publications in a repository and to publish in Open Access. An elaborate OA policy, including 6/12-month embargoes, quality exigencies, caps on APC and the Liège Model has been drafted but has been unsuccessful in being accepted at a higher level. For Open Data, no action has been taken yet, as agreed in consultation between the Federal, Flemish- and French-speaking administrations. Universities were the first to adopt OA mandates, following the trend launched by the University of Liège and its IDOA approach (Immediate Deposit Optional Access): https://www.ulg.ac.be/cms/c_17700/en/open-access FRS-FNRS has since adopted a similar mandate : http://www.fnrs.be/docs/Reglement_OPEN_ACCESS_EN.pdf. A decree is currently being prepared to extend this kind of mandate to all public funding within the Wallonia-Brussels Federation: http://marcourt.wallonie.be/le-libre-acces-aux-publications-scientifiques-en-federation/
CROATIA: Croatian Law on Science and Higher Education mandates that all higher education theses should be available in OA in a corresponding university library repository. To this author's knowledge, the Croatian Science Foundation has yet to adopt any Open Science requirements or provisions.
LITUANIA: The main outline for the policy concerning Open Access is set out in Article 51 of the Law on Higher Education and Research according to which "the results of all research works carried out in state higher education and research institutions must be communicated to the public (in the internet or in any other way), to the extent that this kind of communication is in compliance with the legal acts regulating the protection of intellectual property, commercial or state secrets." The Resolution regarding the approval of The Guidelines on Open Access to Scientific Publications and Data adopted by Research Council of Lithuania (the document: http://www.lmt.lt/lt/nuorodos/atvirosios_prieigos_dokumentai.html click pdf 'Lietuvos

mokslo tarybos nutarimas dėl atvirosios prieigos prie mokslo publikacijų ir duomenų gairių patvirtinimo, 2016 m. vasaris (anglų kalba)'.

PORTUGAL: For FCT, IP, Open Science has been high on its strategic agenda for a number of years. This has been reflected in FCT's continuous investment and support to the deployment of an Open Science e-infrastructure in the form of Repositório Científico de Acesso Aberto de Portugal (RCAAP) – Portugal's Open Access Scientific Repository – which is central to the national Open Science strategy; in FCT's policy on Open Access to publications arising from FCT-funded research (which is mandatory); and in FCT's policy on management and sharing of data and other results arising from FCT-funded research (policy statement, non-mandatory). RCAAP offers a range of services to the research community (mainly around the SaaS – software as a service – concept) such as the hosting of institutional open access repositories to applicant institutions; the hosting of scientific open access journals to applicant publishers, journals or editorial boards; the RCAAP portal, which is a single point of search, discovery, location and access to the publications deposited in its network of repositories and in the Brazilian repositories aggregated in OASIS.br; a pilot Scientific Data Hosting Service; and communication, dissemination and training services, providing training for the local managers who will be responsible for the services at the institutions. The main requirement in FCT's Open Access policy is to deposit in one of RCAAP's repositories and make available in Open Access the final peer-reviewed version of the publication that results from research funded by FCT (maybe the author's final peer-reviewed version, and not necessarily the journal's published .pdf version, as long as the content is the same). At this stage, FCT and its partners (institutions, participants of the RCAAP network of repositories) are implementing technical measures for making the network of RCAAP's integrated institutional repositories interoperable and able to communicate with FCT's internal research project and scholarships management and evaluation systems, so as to automatically extract information regarding published research resulting from FCT funding from the publications deposited in RCAAP into FCT's databases for evaluation. The objective is that every publication deposited in RCAAP associated with a specific FCT-funded project will automatically appear in FCT's internal systems and be reflected in the project's mid-term and final project reports. After guaranteeing that this work as it should, the next step will be for FCT to only accept such publications for reporting – i.e. no non-deposited publication will be allowed to be reported for project evaluation purposes, and technically there will be no way for researchers to report publications other than depositing them in RCAAP and expecting them to be automatically harvested into FCT's project management systems (and reporting templates). FCT expects that this method will guarantee maximum compliance with the Open Access policy and will also assist its monitoring, in a natural way. Simultaneously, it is also expected to substantially improve its current manual, reporting systems, making them much more user-friendly, fast, efficient and helpful to the researchers. It must be mentioned that this tight integration of the repository network and FCT's internal research management systems are part of an ongoing effort to develop a national CRIS under the project PT-CRIS which intends to connect all national research infrastructures and entities, through the use of unique identifiers and the establishment of interoperability frameworks, so that maximum benefit and usability may be derived in favour of researchers, funders and institutions alike. The PT-CRIS motto is: input once, reuse multiple.

RCAAP project: http://projecto.rcaap.pt/index.php/lang-en/sobre-o-rcaap/servicos

Policy on open access to publications arising from FCT-funded research (in Portuguese only): http://www.fct.pt/documentos/PoliticaAcessoAberto_Publicacoes.pdf

Policy on management and sharing of data and other results arising from FCT-funded research (in Portuguese only): http://www.fct.pt/documentos/PoliticaAcessoAberto_Dados.pdf

PT-CRIS: https://ptcris.pt/en/hub-ptcris-en/

AUSTRIA: FWF's Open Access policy: https://www.fwf.ac.at/en/research-funding/open-access-policy/ - Adapting Science Europe's Principles on Open Access to Research Publications - Signatory of the Berlin Declaration (2003): https://openaccess.mpg.de/Berlin-Declaration - Signatory of OA2020 (2016) - Expression of Interest in the Large-scale Implementation of Open Access to Scholarly Journals: https://oa2020.org/mission/ - Supporter of the Open Access recommendations by the Open Access Network Austria (OANA): https://zenodo.org/record/51799#.WQRItR5Qh2M

- **What Open Science requirements or provisions, if any, have been adopted by research institutions and governmental agencies in your country?**

SLOVENIA: Portal OpenAccess Slovenia (http://www.openaccess.si/), built by Slovenian universities and research institutions (supported by the ministry and research agency); Portal Open Science Slovenia (http://openscience.si), built by Slovenian universities (supported by the ministry and research agency); Open Access repositories are built up at several universities and research institutes (University of Ljubljana, University of Maribor, University of Primorska, University of Nova Gorica, digital repositories of the Slovenian public research institutes: refer to http://openscience.si); active participation in OpenAIRE (https://www.openaire.eu/). Formal requirements regarding Open Access publishing or other Open Science requirements have not yet been adopted by the universities or research institutions.

BELGIUM: Publications are required to be deposited in a compatible Open Access repository with only one research intuition at the federal level: the Belgian Health Care Knowledge Center (KCE). Universities were the first to adopt OA mandates, following the trend launched by the University of Liège and its IDOA approach (Immediate Deposit Optional Access): https://www.ulg.ac.be/cms/c_17700/en/open-access

MOLDOVA: http://idsi.md/en/academica – the academic network is probably a sample of requirements adopted by the Moldovan Academy of Sciences.

SWITZERLAND: The country has set in place specific regulations that mandate research funding and performing institutions to ensure public access to research results, in accordance with the legal provisions. The Federal Act on Promotion of Research and Innovation (RIPA) sets the legal basis for the transfer of knowledge and technology from publicly funded institutions and for Open Access to research data and results. Article 50 of the Federal Act on Promotion of Research and Innovation requires: "that the results of research are available to the public in accordance with the legal provisions". In 2015, the SERI mandated local universities and the SNSF to develop a national strategy on Open Access and to analyse its financial flow (see swissuniversities' and SNSF answer for further information). At the organisational level, there are specialised repositories where universities and other research organisations have made their institutional policies available on Open Access – for example, the Registry of Open Access Repositories Mandatory Archiving Policies (ROARMAP) and the OpenAIRE's website. In moving forward, a national study has identified the need to improve infrastructure for research data, while an ongoing study is exploring different measures to promote Open Access and research data existing at Swiss universities. The latter study will inform a system "to access, process and storage science-related digital content" by 2020 (see swissuniversities' answer for further information). At the governmental level, which is indirectly related to Open Science, the federal administration is legally required to open government. According to the Freedom of Information Act from 2004, everyone must in principle be given access to any information or document from the federal administration as long as the privacy of other individuals or the national security are not affected. Currently, different universities follow various policies on Open Access. Some universities

require their researchers to deposit their issued publications on an institutional repository – as long as there is no legal obstacle. Other institutions are less strict but recommend it. Some examples of institutional policies: http://www.unibe.ch/universitaet/dienstleistungen/universitaetsbibliothek/service/elektronisch_publizieren/open_access/open_access_policy_der_universitaet_bern/index_ger.html http://www.library.ethz.ch/ms/Open-Access-an-der-ETH-Zuerich/Open-Access-Policy-der-ETH-Zuerich http://www.ub.unibas.ch/ub-hauptbibliothek/dienstleistungen/publizieren/open-access/open-access-policy/. Since 2017, Switzerland has a national Open Access strategy. Its vision is that by 2024,"all scholarly publication activity in Switzerland should be OA, all scholarly publications funded by public money must be freely accessible on the internet. The OA landscape will consist of a mix of OA models." https://www.swissuniversities.ch/fileadmin/swissuniversities/Dokumente/Hochschulpolitik/Open_Access/P06_7.01-01_Open_Access_strategy_EN.pdf

CROATIA: Croatian Law on Science and Higher Education mandates that all higher education theses should be available in Open Access in a corresponding university library repository. There is no similar mandate at the national level for other types of publications, but the Ruđer Bošković Institute has declared the first Croatian institutional self-archiving mandate which mandates Open Access for all publications according to the publisher's copyright (Decision on the obligation to store scientific, professional and popular papers at the Ruđer Bošković Institute Repository - FULIR). The mandate was followed by the University of Zagreb's Faculty of Mechanical Engineering and Naval Architecture and the Physics Department in the Faculty of Science. The University Computing Centre (Srce) at the University of Zagreb has fully supported the principles and objectives of the Croatian Declaration on Open Access since 2012. Through its annual work, Srce incorporates the idea of Open Access to scientific information and educational materials in the area of construction and maintenance of open and sustainable national infrastructure and promotes Open Access and the systematic care of data and keeping them reliably. The work of Srce is based on two fundamental principles present in the Croatia Declaration on Open Access, as well as in other international documents related to Open Access and Open Educational content: 1. open access is of public interest, since it has abolished barriers and inequality, improved transparency and the quality of public actions, offers wider opportunities for access to knowledge and increases opportunities, competitiveness and the capacity of society as a whole; 2. results of the activities financed by public funds, especially in the field of education and science, should be made available in Open Access.

LITHUANIA: Almost all of Lithuania's largest state universities declare on their web pages support to EU policy on Open Access to research information, and some of them have adopted internal documents such as guidelines on Open Access to scientific publications and data. Some links: https://www.mruni.eu/mru_lt_dokumentai/biblioteka/pdf/Atvira_prieiga.pdf http://www.lsmuni.lt/lt/biblioteka/informacija-vartotojams/elektronine-lsmu-publikaciju-ir-e-dokumentu--registravimo-forma/lsmu-atviros-prieigos-mandatas/ http://www.vgtu.lt/mokslas-ir-inovacijos/mokslo-publikacijos/atviroji-prieiga/274301 http://www.vu.lt/site_files/Senatas_Taryba/S-2016-9/vu_mtdv_gaires_Senatui.pdf http://ktu.edu/uploads/files/Bibliotekos/KTU_AP_nuostatai.pdf

PORTUGAL: Research institutions, strongly connected to universities in Portugal, have been investing in Open Science, especially Open Access, from some time, mainly motivated by the emergence and spread of research information digital repositories promoted and supported by the aforementioned RCAAP project. Almost every public research institution and university has an Open Access repository (as well as several private institutions), and at least 21 institutions, including most of the major universities, have published and implemented Open Access policies, requiring their researchers or faculty to deposit and make freely available their research publications in the respective repositories. At the same time, the number of Open Access journals under institutional publishing initiatives has also been growing. An increase in the number of full Open

Access journals and other types of Open Research publications, ranging from books to individual articles, is strongly tied to the support to such initiatives provided by RCAAP's hosting of scientific open access journals service (SARC), by the Portuguese branch of the SciELO project – SciELO Portugal – which is run by a department of the Ministry of Education, and also to isolated institutional initiatives, such as LusOpenEdition – the Portuguese branch of the OpenEdition project – fostered by ISCTE-IUL, and UC Digitalis, developed by the University of Coimbra. Finally, there is an incipient, but far from generalised, institutional interest and concern in research data management, including its sharing, such as that demonstrated in the project TAIL and Dendro led by the University of Porto, as well as in citizen science, reflected in initiatives like the Invasoras.pt project.

However, these concerns generally manifest themselves through researcher-led project-based initiatives supported by institutions rather than within the framework of institutional strategies.

RCAAP's directory of harvested resources, including networked repositories and open access journals: https://www.rcaap.pt/directory.jsp?locale=en

Institutional Open Access policies in Portugal (including both universities and research institutions): http://roarmap.eprints.org/cgi/search/archive/advanced?exp=0%7C1%7Cpolicymaker_name%7Carchive%7C-%7Ccountry%3Acountry%3AANY%3AEQ%3A620%7Cpolicymaker_type%3Apolicymaker_type%3AANY%3AEQ%3Aresearch_org+multiple_research_orgs+research_org_subunit%7C-%7Ceprint_status%3Aeprint_status%3AANY%3AEQ%3Aarchive%7Cmetadata_visibility%3Ametadata_visibility%3AANY%3AEQ%3Ashow&_action_search=1&order=policymaker_name&screen=Search&cache=52061&search_offset=0

SciELO Portugal: http://www.scielo.mec.pt/scielo.php?script=sci_home&lng=en&nrm=iso

SciELO Portugal directory of Open Access journals: http://www.scielo.mec.pt/scielo.php?script=sci_alphabetic&lng=en&nrm=iso

LusOpenEdition (only in Portuguese): http://lusopenedition.org/aceraca

UC Digitalis: https://digitalis.uc.pt/en/content/uc_digitalis

UC Impactum (directory of periodicals made available under UC Digitals): https://digitalis.uc.pt/en/content/uc_impactum

Project TAIL: http://confdados.rcaap.pt/wp-content/uploads/2016/09/ConfDados_Cristina_Ribeiro.pdf

Project Dendro: http://dendro.fe.up.pt/blog/index.php/dendro/

Project Invasoras.pt: http://invasoras.pt/en/; http://invasoras.pt/en/the-project/ ; http://confdados.rcaap.pt/wp-content/uploads/2016/09/ConfDados_Elia_Marchante.pdf

- **What are the main challenges in your country towards the implementation of Open Science?**

Several respondents mentioned the lack of knowledge, interest and initiative at the governmental level, and a lack of commitment towards introducing a national Open Science agenda. In cases where the government has made relevant commitments, respondents mentioned the lack of appropriate financing and resources for the required infrastructure and systemic changes in administration and evaluation procedures. For instance, Slovenia mentioned the fact that while a governmental agenda is in place (the Action plan for Open Access to Scientific Publications and Research Data in Slovenia 2016-2020), it is not yet clear who will be responsible for developing and monitoring the concrete measures and resources necessary to implement it.

Three respondents mentioned academic culture, and particularly the reluctance in some research fields to publish in Open Access journals (which typically have less of a reputation than top, closed journals) and spend time in archiving articles in Open Access repositories.

Switzerland emphasised the tension between the public support expected for the implementation of Open Science and the fact that "about two-thirds of the funding for R&D as well as two-thirds of the R&D personnel in Switzerland come from the private sector (Federal Statistical Office). Private-sector research is thus very dominant and given its larger interest in intellectual property and industrial secret than public research institutions, this poses a major challenge for Open Science."

The publication of monographs in the humanities and social sciences was highlighted as particularly problematic. In addition, one respondent mentioned the lack of agreed standards as a considerable obstacle, and another highlighted publishers' policies.

- **Is the legal and institutional system in your country, including norms and regulations over intellectual property, conducive to the implementation of Open Science? If so, how? If not, how not?**

Some respondents signalled that such a system did not yet exist in their countries, but would be needed to establish a balance between protected data and Open Access to information. Other respondents mentioned that their own country aimed to harmonise their policies with EU practice, although this may present problems when no specific provisions are made for research vis-à-vis other types of activities.

Potential confusion between legislations instantiated by different ministries was mentioned as a barrier (for instance, when one ministry establishes intellectual property protection for the results of applied research, while another prioritises Open Science licensing for all products of publicly funded research).

Furthermore, the following countries offered specifics within their own situations:

SLOVENIA: Although the current legal and institutional system, including norms and regulations on intellectual property, is not preventing Open Science, it is not very conducive to it. The basic provisions (as an instruction measures) are already embedded into the existing Act on research and innovation activities in Slovenia. Nevertheless, the present legal and institutional system in Slovenia is not supportive enough in terms of addressing and regulating the essential attributes of Open Science and/or promoting its values. This is now the challenge of the Action plan for Open Access to Scientific Publications and Research Data in Slovenia 2016-2020, which has been prepared by the Ministry of Education, Science and Sport and is ready to be submitted for the approval of the Government of the Republic of Slovenia.
BELGIUM: At the federal level, all authors' rights will soon be ceded to the state by Royal Arrest. Should the federal level choose to make the research it funds open, it could. Moreover, the Belgian law on legal deposit will soon be extended to online digital content so no mandate furthering deposit will be needed. This is currently being examined in the context of the draft decree on Open Access in the Wallonia-Brussels Federation.
MOLDOVA: http://agepi.gov.md/en/legislatie/nationale; the State Agency for Intellectual Property has regulations including recommendations for the implementation of Open Science.
LITHUANIA: The Lithuanian legal and institutional system is favourable but not mandatory for the implementation of Open Science policy.

PORTUGAL: The Decree-Law 115/2013, published in 2013, mandates in its Article 50 the legal deposit of a print copy of every national master's degree dissertation and doctoral theses at the National Library and, simultaneously, the deposit of a digital copy in one of RCAAP's network repositories, the aim being to provide for Open Access to and long-term preservation of scientific information. This has been seen as a huge step towards promoting the dissemination of scientific information since every HEI is now legally obliged to comply with this requirement in relation to the dissertations and theses they issue. Decree-Law 115/2013 (only in PT): https://dre.pt/web/guest/pesquisa/-/search/498487/details/maximized

As for the intellectual property legislative framework, serious doubts remain among authors and institutions about their contractual positions with academic publishers and their own Open Access intentions and duties. More information is needed for researchers and authors in this domain, and it is possible that even legislative actions could be useful to clarify the rights and duties on all sides. This situation is certainly severely inhibiting the full acceptance and ownership of Open Science principles and practices. This has been acknowledged by the Open Science National Policy working subgroup on Open access and Data and may become the subject of a specific recommendation for the Open Science National Policy.

Incentives and rewards

- **Are there any types of incentive or reward in place to support Open Science activities in your country? If so, which ones, and who is implementing and monitoring them?**

Three respondents answered "no" or "very few". In addition:

SLOVENIA: Research data, deposited into data archives and catalogued for the national CRIS (SICRIS – Slovenian Current Research Information System) are rewarded with points. Furthermore, the ministry responsible for science is financing repositories for Open Access in the country.

BELGIUM: In the University of Liège, only what has been archived in the Green OA repository ('ORBI') counts in the evaluation. This is a strong stick/carrot kind of incentive. There is also a general feeling that engaging in citizen science although important, is not well rewarded. Researchers are cautious, too, about publishing in new OA journals, since the 'impact factor' cult is very present and hard to circumvent.

SWEDEN: Swedish research funders give grants to researchers for Open Access publishing. Some institutions do have publishing funds which support researchers to pay APC:
https://www.unisg.ch/en/forschung/foerderung/wissenschaftskommunikation/publikationsfonds http://www.oai.uzh.ch/en/at-the-uzh/funding/publishing-fund

CROATIA: Practical examples of incentives or rewards in place to support Open Science activities are very rare. One example is the Ruđer Bošković Institute (IRB) – one of the criteria for the awards for the best scientific papers in a given year is presented on the basis that these works are stored in our institutional repository (FULIR) and if available in Open Access. This is a very good example of how scientists are willing to store their work in a digital repository if this commitment is linked to some other processes (rewards, advancement in scientific professions, recruitment, etc.).

LITHUANIA: The Guidelines on Open Access to Scientific Publications and Data adopted by the Lithuania's Research Council states: "Research Council of Lithuania ... establishes the transitional period for the implementation of the Guidelines by 31 December 2020.

In case during the transitional period any infringements of the Guidelines are established, apply warnings only." The Council monitors the implementation of the Guidelines.

PORTUGAL: Incentives are in the form of infrastructure-related services and facilities, as well as training, given to research stakeholders by our national research and education network provider/manager, FCCN, which is one of the FCT's departments. These comprise mainly platform and software-providing services and training given by the RCAAP project to institutions which want to create an institutional Open Access repository and to journals, editorial boards and publishers that want to initiate a digital version of their academic journals. All these services are provided for free to applicant stakeholders. The aforementioned hosting of institutional repositories (SARI) is supplied under SaaS, i.e. based on RCAAP infrastructure (hardware, hosting, connectivity, OS, applications, security perimeter, service, back-ups, monitoring and alarms) whose management and operation is carried out by the RCAAP project team. However, the operation and administration of each institutional repository is the responsibility of member institutions. Similarly, the Scientific Journal Hosting Service (SARC), developed to facilitate scientific journal management and to support best practices, is supplied under SaaS (Software as a Service) based on the OJS – Open Journal System platform. To facilitate all these tasks, the RCAAP project team offers support for the initial set-up of managerial and operational applications for publishing the journals (applications which will be run by the publishers themselves in the later phases), a helpdesk support system and training sessions directed at journal managers and administrators but excluding all editorial content- and design-related tasks. Publishers of existing online and offline journals wishing to join the programme, whether to start publishing online (for exclusively offline journals) or simply to benefit from the advantages – technical facilities, indexing and support – provided by RCAAP (when a journal is already being published online), make an application to an (usually) annual call, making sure that the journal meets all the eligibility requirements. The publisher, not RCAAP, always has sole responsibility for all the journal's editorial process (organising the peer-review process and ensuring its results, editorial content, journal design, language and copy editing). Once the journal is up and running, the publisher is also responsible for managing and operating the publishing application software. There are no APC charges for authors who submit their work to journals published under the SARC service.

Apart from this, there are two institutions which have a strong requirement for making the scientific output of their researchers and faculty Open Access. The Instituto Politécnico de Bragança and the University of Minho, in their assessment regulations, determine that only those researchers' publications which are deposited and made available in the institutions' respective Open Access repositories will be considered in their assessment and career-progression processes. Likewise, the University of Porto assessment regulation for faculty staff determines that the deposit of a publication in the institution's own CRIS, SIGARRA, is mandatory. This may not be such a 'positive' incentive, like prizes, bonus points in evaluation processes or consideration of the researcher's proven track record of the uptake of Open Science practices as tiebreakers in application processes, but nevertheless it is a really effective incentive measure for researchers to make their work Open Access. This has been proven by results from the Minho and Bragança institutions of having their output in Open Access. According to the Pasteur4OA project report OPEN ACCESS POLICY:NUMBERS, ANALYSIS, EFFECTIVENESS, this puts them in second and fifth place, respectively, among all the research institutions in the world in terms of volume of repository content. The results achieved by the IP Bragança are particularly impressive, since they have a full-text article deposit rate of 85 (8 %), of which an amazing 56.9 % of articles are already accessible in Open Access.

Other than this, there are no other known 'traditional' positive incentives and rewards mechanisms from other institutions. In acknowledging the effectiveness of such a requirement, FCT is also in a process of reforming its reporting mechanisms in such a way that, in the future, only publications deposited in one of RCAAP's repositories will ever be considered for research assessment purposes, as detailed in a previous answer.

- **Is there any training structure in place to provide information and skills about Open Science practices? Who is providing it?**

Only one respondent answered negatively, with most others noting that library services are the main providers of support. In addition:

SLOVENIA: Currently, there is no training structure in place for information and skills concerning Open Science. The Action Plan for Open Access to Scientific Publications and Research Data in Slovenia 2016-2020 includes provisions for setting up supports services and regular activities for researchers on open peer-reviewed scientific articles and preparing research data for Open Access. Training is envisaged for Open Access and Open Science stakeholders.
BELGIUM: BELSPO has set up an Open Access helpdesk and a yearly training session for institutional OA contacts. Quite a lot of information activities are organised at the institutional level, by the universities and academic libraries themselves. This is focus in particular on early-stage researchers, and may be part of their PhD training. But there is no central provision/funding/monitoring for this kind of activity, although there is a website that coordinates the OA/OS related activities in Belgium: https://openaccess.be/
MOLDOVA: The Institute for Development of Informational Society organises different events to provide information on Open Science: http://idsi.md/en/home. The librarian community is also organising events about Open Access.
SWEDEN: The research libraries in Swedish HEIs are generally active in this field, arranging lectures, etc. One of the HEIs offers a course for PhD candidates on 'Open Science and reproducible research': htpp://kiwas.ki.se/katalog/katalog/kurs/2521.
SWITZERLAND: Universities – particularly libraries – provide training on Open Access. See for instance: http://www.oai.uzh.ch/en/at-the-uzh/events/introductory-course-zora. Open Access is also addressed in doctoral schools.
CROATIA: A handful of people are working on Open Access and Open Science and/or projects in this area, educating the scientific community and librarians and promoting OA and OS. For example, the FOSTER project, currently being implemented in Croatia, was designed to educate all stakeholders across the country for two months, although it was only a project activity. It is hard to provide adequate education and promotion on OA and OS across Croatia. The IRB Centre for scientific information also provides education (primarily for librarians) via cooperation with DABAR, as well as through their daily activities. However, this is still insufficient.
AUSTRIA: The Open Knowledge Network Austria Branch is very active in Open Science training. An ongoing series of events is being co-organised with the Technology Transfer Centre East (WTZ-Ost), for example: http://www.wtz-ost.at/veranstaltungen/
PORTUGAL: There are discussions, triggered by the Open Science National Policy working subgroup on Open Access and Data and other relevant stakeholders, on a proposal to create a competence hub in data skills to address researchers' Open Data needs, such as training, and problems, such as legal advice, since this is the Open Science area mainly found to be lacking.

- **Is there any institutional structure or specific venue dedicated to Open Science implementation and monitoring? Please provide links where possible.**

Two respondents answered negatively, and many others remarked on the absence of a national-level system, noting however that some research organisations are investing efforts in this. In addition:

SLOVENIA: There is currently no institutional structure or specific venue dedicated to Open Science in Slovenia. Open Science implementation and monitoring is implemented mainly through dedicated web portals such as OpenAccess Slovenia (http://www.openaccess.si/, created by Slovenian universities and research institutions and supported by the ministry and research agency), and Open Science Slovenia (http://openscience.si, also created by Slovenian universities and supported by the ministry and research agency). In 2016, the National Institute of Information Science (IZUM) introduced altmetrics (http://scimet.izum.si/en/altmetrics) into Slovenian researchers' bibliographic data (http://splet02.izum.si/cobiss/BibPersonal.jsp?init=t&lang=eng&code=&type=conor). From a practical and technical point of view, Altmetrics can already be practised in Slovenia for testing and learning purposes, although this is not yet part of the official evaluation system.
BELGIUM: The BELSPO Open Science project administrator and the Royal Library Open Access contact person.
SWEDEN: When it comes to Open Access to publications, please see the National Library, www.kb.se/openaccess. Open Access to data is going to be monitored by the Swedish Research Council: www.vr.se. The Association of Swedish Higher Education, SUHF, has established a coordinating group on Open Science: www.suhf.se (only in Swedish).
SWITZERLAND: Swiss universities' 'Scientific Information Programme' "promotes the concentration of today's distributed efforts of universities to provide and process scientific information. This includes the development and support of services which may be of use for Open Science": https://www.swissuniversities.ch/en/organisation/projects-and-programmes/p-5/ https://www.swissuniversities.ch/fileadmin/swissuniversities/Dokumente/Organisation/SUK-P/SUK_P-2/PgB5_Antrag_2017-2020_kurz_EN.pdf
LITHUANIA: The Research Council of Lithuania has a section in its web page dedicated to Open Access with information about Lithuanian and EU documents, projects, etc. http://www.lmt.lt/lt/atviroji_prieiga.html
AUSTRIA: The FWF has implemented monitoring for Open Access compliance: https://zenodo.org/record/55249#.WQr0Wx5QiP4
PORTUGAL: See information above about the creation of the Interministerial Working Group whose mission is to present a proposal for a strategic plan for the implementation of an Open Science National Policy (WG-NOSP).

Future directions:

- **What aspects of Open Science are most discussed and valued in your country, and by whom?**

All respondents highlighted Open Access to scientific publications as the key aspect of Open Science currently under debate in their country. Three respondents (Slovenia, Portugal and Switzerland) also mentioned some interest in Open Data and citizen science, although these issues are not yet considered a priority.

- **Are you considering changes in incentives and rewards for researchers, funders, universities and research organisations? What kind of changes, and why?**

With the exception of two who reacted negatively, respondents provided positive answers to this question, highlighting a number of national initiatives and committees in charge of considering potential changes to Open Access policies, research evaluation models, Open Science incentives and support for Open Research Data. These include the National Library of Sweden, the Swedish Research Council, the Region of Brussels-Capital, the Wallonia-Brussels Federation, the Croatian Ministry of Science and Education (working on a future Croatian Current Research Information System), and Austrian Science Funding.

In the words of one respondent (Slovenia): "Changes are important to enable further progress in development of effective and successful publicly funded research system in Slovenia as well as to support more effective international cooperation. We expect that further progress of EU and ERA in that respect will provide EU Member States with the basic source of information, best practices and role models to enable and support us in making proper steps in that direction." The Croatian delegate similarly remarked that the goal is "a comprehensive system that will be used for systematic design of medium-term and long-term research, development and innovation priorities in the public research organisations in the future." At the same time, respondents generally view such a change as requiring several years to be fully implemented, thus overshooting the European requirement of full implementation by 2020.

- **What kinds of cultural changes are required for wider adoption of Open Science?**

Respondents provided a variety of answers to this question, which are reported below as each response exemplifies a specific interpretation of what Open Science means. Interpretations include:

- Open Science as most closely associated to advances in information and communication technologies, which are shifting the ways in which knowledge is developed and shared.
- The idea that rather than a cultural shift, all that Open Science requires is additional funding.
- Open Science as an opportunity to acknowledge how pluralistic and varied the methods, goals and communities of researchers are.
- Open Science as a shift in the expectations and priority of researchers, which would involve more collaboration and sharing, as well as moving away from the 'publish or perish' ethos.

This diversity is significant and important to take into account for further discussions at the national, European and global levels.

> Open Science is in particular related to the research which is performed within ICT and web-based environments. The promotion of the advances in that environment, which are supporting better interdisciplinary and international collaboration as well as the 'openness' of research work to the society and research community is therefore important. Certain centralised services at the level of research institutions could therefore be beneficial to promote and help get researchers on track with the mainstream solutions. As developments in ICT and web-based environments are extremely fast and versatile, it may be good for research disciplines to develop and promote, within their research communities, best practices in implementing an Open Science culture and share them with a larger scope of research institutions.

No cultural changes apart from a general conservatism. What is most needed is better funding of research so that institutions do not have to be worried about losing income and researchers about losing impact.
Open mind and modern attitude towards science, communication and spreading science.
Incentives and reward systems, costs for publishing.
The better acknowledgement of a diversity of profiles within academia, rather than the focus on the super publisher. A proper acknowledgment of the diversity of research outputs, according to the disciplines and the type of research conducted (curiosity driven, strategic and applied). And definitely, not using IF anymore for assessing individual researchers!
In some disciplines, the orientation toward 'publish or perish' and the demand to publish only in 'top journals' should change towards a stronger orientation to the quality of the content.
One of the biggest challenges will be to change the way scientists perceive OS and to improve their willingness to share. This is something they are not used to, for multiple reasons. Most of them are very well defined in ERAC's Opinion on Open Research Data. In addition, on the national level, it will be important to address and improve the overall digital science policy and governance. For that reason, we are considering participating in the OECD 'Digital Science and Innovation Policy and Governance' project that should start in 2017. Furthermore, on the EU level, it is important to bring more synergies between different policy streams (Cohesion Policy, Horizon 2020, ERA policies, Erasmus+, etc.). Without this synergetic effect of all the policies, there will always be contradictions and the research community will have a hard time following different sets of regulations and implementation rules when it comes to framework projects and all other types of funding.
Almost all initiatives regarding OA or OS come from Brussels and we lack active researchers or research leaders promoting OS ideas. Optimisation of the higher education institutional system is currently on the top of the political agenda in Lithuania and OS matters go on the second plan. OA initiative is actively supported by universities' librarians, but part of older academic society needs a better understanding about advantages of OS.
Best practice examples - incentives - mentality of 'expert knowledge' by policy-makers on which fields of research are needed/funded, etc.
To form a habit requires time. Thereafter implementation of Open Science will require time for the different stakeholders to adjust to the new models, requirements and regulations. It will require time for some scientific communities to embrace the advantages of Open Science and to capitalise on its opportunities. A clear, transparent and open discussion on the opportunities and the potential limitations of Open Science will certainly contribute to a faster adoption of the new habit.
More knowledge by the researchers of the range and advantages of different communication practices by disciplines different than their own and, as defended above, more respect and promotion to those communication practices that do not rely so much on publications (especially the ones that are published in closed-access journals or in unfairly priced Open Access journals) could help spread a wider adoption of Open Access practices. Also, a more profound consciousness, both by the public and the researchers, of the benefits of Open Science and of knowledge resulting from public funds and money itself that is wasted every year in information that is unjustifiably not open to everyone, could help trigger more demand for Open Science from the public and a greater sense

of social responsibility from researchers and assist them in taking up Open Science practices.

A cultural change towards the intellectual property of research by research managers, funders and policymakers is also very much needed, in my humble opinion. It simply is not ethical to publicly fund research whose results will be handed over for free to be published in closed-access journals which, in turn, will charge huge amounts of money to public institutions for them to access the research they ultimately produced in the first place, or which will provide Open Access by also charging authors or institutions huge amounts of money while failing to create effective countermeasures for double dipping.

Intellectual property of publicly funded research should be cherished and valued and not be given away for free in such a manner, which creates most of the imbalances and inequalities of the current academic publishing system. Commercial publishers, if handed over for free the publicly funded scientific information they wish to publish, should have certain duties or obligations to respond to. One of them would be to allow the author's final version of the publication to be deposited and made available in Open Access in a public repository, at no extra charge and with no embargo delay whatsoever to the publications content, so that anyone with an internet connection could access and reuse the publication. This provision would put into the publishers' hands the decision and responsibility whether or not they wished to abide by these rules and how the publishing system would be shaped, hopefully in a fairer way.

- **What skills and training in Open Science are necessary for different stakeholders?**

Respondents mentioned the need for skills and related training programmes specifically for:

- Policymakers, including awareness of the stakes involved in Open Science and the situation in other countries, and options for Open Access that are not limited to deals with major publishers;
- All researchers, including Open Education, copyright issues and understanding of different models of Open Access publishing and self-archiving;
- Specialists in Open Science, such as evaluators of OS implementation and providers of support (which could be provided by the EU and ERA structures);
- Early-career researchers, including in science communication and in understanding the impact that publishing choices may have on their future career;
- Industry stakeholders, concerning particularly IPR dimensions;
- Editors, including the technical and legal challenges of publishing Open Access;
- Librarians and information specialists who need to provide OA support concerning publications and research papers, as well as instruct researchers on the options available for publishing;
- Funders, particularly tools to monitor publication of (all types of) research results;
- The general public, more tools – such as better education in science or dedicated collaborative fora – to derive meaning, value and usefulness from all the scientific information and knowledge available to them.

- **What incentives, reward systems and strategies for Open Science implementation would you like to be able to adopt in the future (whether or not this is currently feasible)? Why?**

Respondents disagreed on the extent to which Open Science implementation should be top-down (mandated by governments and research funders) or bottom-up (fostered by researchers and supported by research-performing institutions). Responses included the following suggestions:

- Better and attractive metrics (the carrot) make Open Science part of researcher evaluation and adopting the Liège Model (the stick);
- Generalisation of OS modules in third-cycle education. Working on/with ESR is the only way to change the mindsets for the better!
- Articles should remain central in the ecosystem of science production and dissemination, but the other elements of this ecosystem should be better taken into account. In particular, those research outputs with a societal impact should be better valorised at each step of the career (and not only for those senior researchers who no longer need to prove anything);
- The link between Open Science and Open Education should be investigated, in particular for the development of altmetrics able to track the use of research within (open) educational research;
- The bottom-up approach, which is already at the core of the current national Open Access strategy should be maintained;
- Research funders and universities should take into account an applicant's previous practice of green Open Access and data management plans as evaluation criteria in their funding and hiring decisions;
- One of the best solutions would be to link elections in science, teaching and other vacancies with the obligation of storing publications in OA repositories and ensuring OA to so-preserved publications;
- Favour copyright-retention provisions, changes in the assessment system to adequately consider Open Science practices and different research outputs, and incentives, including financial, to researcher-led publishing initiatives.

- **What Open Science requirements or provisions, if any, have been adopted by the main research funders in your country?**

SLOVENIA: Resolution on Research and Innovation Strategy of Slovenia 2011-2020 (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Strategije/01.06._RISSdz_ENG.pdf), Chapter 4.5, Action 55 (Preparation of action plan for free access to data from publicly funded research); National strategy of open access to scientific publications and research data in Slovenia 2015-2020 (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Zakonodaja/Strategije/National_strategy_for_open_access_21._9._2015.pdf); Slovenian strategy for strengthening the European Research Area 2016-2020 (ERA Roadmap) (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Zakonodaja/Strategije/SI_ERA_Roadmap.pdf); Research Infrastructure Roadmap 2011-2020, Revision 2016 (http://www.mizs.gov.si/fileadmin/mizs.gov.si/pageuploads/Znanost/doc/Strategije/NRRI_2016_ENG.pdf). Financial support to universities and research institutes in performing-related projects and setting up required infrastructure.
SWITZERLAND: Open Access policy: http://www.snf.ch/en/theSNSF/research-policies/open-access/
SWEDEN: Three out of the four largest Swedish funders have mandates on Open Access: www.vr.se; www.formas.se; www.forte.se – but also some foundations: www.rj.se; www.ostersjostiftelsen.se; www.wallenberg.com.
BELGIUM: Federal government-funded researchers are invited to deposit in a repository and to publish in OA. An elaborate OA policy, including 6/12-month embargoes, quality exigencies, caps on APC and the Liège Model has been drafted but has had no success in being accepted at a higher level. For OD, no action has been taken yet, as agreed in consultation between the Federal, Flemish and French-speaking administrations.

Universities were the first to adopt OA mandates, following the trend launched by the University of Liège and its IDOA approach (Immediate Deposit Optional Access): https://www.ulg.ac.be/cms/c_17700/en/open-access FRS-FNRS has since adopted a similar mandate: http://www.fnrs.be/docs/Reglement_OPEN_ACCESS_EN.pdf. A decree is currently in preparation to extend this kind of mandate to all public funding within the Wallonia-Brussels Federation: http://marcourt.wallonie.be/le-libre-acces-aux-publications-scientifiques-en-federation/

CROATIA: Croatian Law on Science and Higher Education mandates that all higher education theses should be available in Open Access in the corresponding university library repository. To my knowledge, the Croatian Science Foundation has so far not adopted any Open Science requirements or provisions.

LITUANIA: The main outline for the policy concerning Open Access is set up in Article 51 of the Law on Higher Education and Research according to which "the results of all research works carried out in state higher education and research institutions must be communicated to the public (in the internet or in any other way), to the extent this kind of communication is in compliance with the legal acts regulating the protection of intellectual property, commercial or State secrets". The Resolution regarding the approval of The Guidelines on Open Access to Scientific Publications and Data adopted by Research Council of Lithuania (the document http://www.lmt.lt/lt/nuorodos/atvirosios_prieigos_dokumentai.html click pdf 'Lietuvos mokslo tarybos nutarimas dėl atvirosios prieigos prie mokslo publikacijų ir duomenų gairių patvirtinimo, 2016 m. vasaris (anglų kalba)').

PORTUGAL: For FCT, I.P., Open Science has been a high topic in its strategic agenda for a number of years.

This has been reflected in FCT's continuous investment and support to the deployment of an Open Science e-infrastructure in the form of Repositório Científico de Acesso Aberto de Portugal (RCAAP) – Portugal's Open Access Scientific Repository – which is central to the national Open Science strategy; in FCT's policy on Open Access to publications arising from FCT-funded research (which is mandatory); and in FCT's policy on management and sharing of data and other results arising from FCT-funded research (policy statement, non-mandatory). RCAAP offers a range of services to the research community (mainly around the SaaS – Software as a Service – concept) such as the hosting of institutional Open Access repositories to applicant institutions; the hosting of scientific Open Access journals to applicant publishers, journals or editorial boards; the RCAAP portal, which is a single point of search, discovery, location and access to the publications deposited in its network of repositories, and in the Brazilian repositories aggregated in OASIS.br; a pilot Scientific Data Hosting Service; and communication, dissemination and training services, providing training for the local managers who will be responsible for the services at the institutions. The main requirement in FCT's Open Access policy is to deposit in one of RCAAP's repositories and make available in Open Access the final peer-reviewed version of the publication that results from research funded by FCT (maybe the author's final peer-reviewed version, not necessarily the journal's published .pdf version, as long as the content is the same). At this stage, FCT and its partners (institutions participants of the RCAAP network of repositories) are implementing technical measures for making the network of RCAAP's integrated institutional repositories interoperable and able to communicate with FCT's internal research project and scholarships management and evaluation systems, so as to automatically extract information regarding published research resulting from FCT funding from the publications deposited in RCAAP into FCT's databases for evaluation. The objective is that every publication deposited in RCAAP associated with a specific FCT-funded project will automatically appear in FCT's internal systems and be reflected in the project's mid-term and final project reports. After guaranteeing that this works as it should, the next step will be for FCT to only accept such publications for reporting, i.e. no non-deposited publication will be allowed to be reported for project evaluation purposes and technically there will be no way for researchers to report publications other than depositing them in RCAAP and expecting them to be automatically harvested into FCT's project management systems (and

reporting templates). This is a method which FCT expects to guarantee compliance with the Open Access policy at its maximum extent and also assist its monitoring, in a natural way. Simultaneously, it is also expected to substantially improve its present, manual reporting systems, making them much more user-friendly, fast, efficient and helpful to the researchers. It must be referred that this tight integration of the repository network and FCT's internal research management systems is part of an ongoing effort to develop a national CRIS under the project PT-CRIS which intends to connect all national research infrastructures and entities, through the use of unique identifiers and the establishment of interoperability frameworks, so that maximum benefit and usability may be derived in favour of researchers, funders and institutions alike. PT-CRIS motto is: input once, reuse multiple.

RCAAP project: http://projecto.rcaap.pt/index.php/lang-en/sobre-o-rcaap/servicos

Policy on Open Access to publications arising from FCT-funded research (in Portuguese only): http://www.fct.pt/documentos/PoliticaAcessoAberto_Publicacoes.pdf

Policy on management and sharing of data and other results arising from FCT-funded research (in Portuguese only): http://www.fct.pt/documentos/PoliticaAcessoAberto_Dados.pdf

PT-CRIS: https://ptcris.pt/en/hub-ptcris-en/

AUSTRIA: FWF's Open Access policy: https://www.fwf.ac.at/en/research-funding/open-access-policy/ – Adapting Science Europe's Principles on Open Access to Research Publications – Signatory of the Berlin Declaration (2003): https://openaccess.mpg.de/Berlin-Declaration – Signatory of OA2020 (2016) – Expression of Interest in the Large-scale Implementation of Open Access to Scholarly Journals: https://oa2020.org/mission/ – Supporter of the Open Access recommendations by the Open Access Network Austria (OANA): https://zenodo.org/record/51799#.WQRItR5Qh2M

- **What Open Science requirements or provisions, if any, have been adopted by research institutions and governmental agencies in your country?**

SLOVENIA: Portal OpenAccess Slovenia (http://www.openaccess.si/), built by Slovenian universities and research institutions (supported by the ministry and research agency); Portal Open Science Slovenia (http://openscience.si), built by Slovenian universities (supported by the ministry and research agency); Open access repositories are built up at several universities and research institutes (University of Ljubljana, University of Maribor, University of Primorska, University of Nova Gorica, digital repositories of the Slovenian public research institutes: refer to http://openscience.si); active participation in OpenAIRE (https://www.openaire.eu/). Formal requirements regarding Open Access publishing or other open science requirements are not yet adopted by the universities or research institutions.

BELGIUM: Publications are required to be deposited in a compatible OA repository with only one research intuition at the federal level: the Belgian Health Care Knowledge Center (KCE). Universities were the first to adopt OA mandates, following the trend launched by the University of Liège and its IDOA approach (Immediate Deposit Optional Access): https://www.ulg.ac.be/cms/c_17700/en/open-access

MOLDOVA: http://idsi.md/en/academica – probably, the academia network is a sample of requirements adopted by the Academy of Sciences of Moldova.

SWITZERLAND: Switzerland has set in place specific regulations that mandate research funding and performing institutions to ensure public access to research results, in accordance with the legal provisions. The Federal Act on Promotion of Research and Innovation (RIPA) sets the legal basis for the transfer of knowledge and technology from publicly funded institutions and for Open Access to research data and results. Article 50

of the Federal Act on Promotion of Research and Innovation requires: "that the results of research are available to the public in accordance with the legal provisions". In 2015, the SERI mandated local universities and the SNSF to develop a national strategy on Open Access and to analyse its financial flow (see swissuniversties and SNSF answer for further information). At the organisational level, there are specialised repositories where universities and other research organisations have made available their institutional policies on Open Access; for example, the Registry of Open Access Repositories Mandatory Archiving Policies (ROARMAP) and the OpenAIRE's website. In moving forward, a national study has identified the need to improve infrastructure for research data, while an ongoing study is exploring different measures to promote Open Access and research data existing at Swiss universities. The latter study will inform a system "to access, process and storage science-related digital content" by 2020 (see swissuniversities' answer for further information). At governmental level, thus indirectly related to Open Science, the federal administration is legally required to open government. According to the Freedom of Information Act from 2004, everyone must in principle be given access to any information or document from the federal administration as long as the privacy of other individuals or the national security are not affected. Currently, different universities follow various policies concerning Open Access. Some universities require their researchers – as long as there is no legal obstacle – to deposit their issued publications in an institutional repository. Other institutions are less strict but recommend it. Some examples of institutional policies: http://www.unibe.ch/universitaet/dienstleistungen/universitaetsbibliothek/service/elektronisch_publizieren/open_access/open_access_policy_der_universitaet_bern/index_ger.html; http://www.library.ethz.ch/ms/Open-Access-an-der-ETH-Zuerich/Open-Access-Policy-der-ETH-Zuerich; http://www.ub.unibas.ch/ub-hauptbibliothek/dienstleistungen/publizieren/open-access/open-access-policy/. Since 2017, Switzerland has a national Open Access strategy. Its vision is that by 2024, "all scholarly publication activity in Switzerland should be OA, all scholarly publications funded by public money must be freely accessible on the internet. The OA landscape will consist of a mix of OA models:"https://www.swissuniversities.ch/fileadmin/swissuniversities/Dokumente/Hochschulpolitik/Open_Access/P06_7.01-01_Open_Access_strategy_EN.pdf

CROATIA: Croatian Law on Science and Higher Education mandates that all higher education theses should be available in Open Access in the corresponding university library repository. A similar mandate on national level for other types of publications does not exist, but Ruđer Bošković Institute has declared the first Croatian institutional self-archiving mandate which mandates Open Access for all publications according to publisher's copyright (Decision on the obligation to store scientific, professional and popular papers at the Ruđer Bošković Institute Repository – FULIR). The mandate was followed by the Faculty of Mechanical Engineering and Naval Architecture at the University of Zagreb and the Physics Department of the Faculty of Science of the University of Zagreb. The University Computing Centre (Srce) of the University of Zagreb fully supports the principles and objectives of the Croatian Declaration on Open Access since 2012. Through its annual work, Srce incorporates the idea of Open Access to scientific information and educational materials in the area of construction and maintenance of open and sustainable national infrastructure and promotes Open Access and systematic care for data and keeping them reliably. Work of Srce is based on two fundamental principles present in Croatia Declaration on Open Access, as well as in other international documents related to Open Access and Open Education content: 1. Open Access is of public interest, since it abolished barriers and inequality, improving transparency and quality of public action, wider opportunities for access to knowledge and increase opportunities, competitiveness and the capacity of society as a whole; 2. results of the activities financed by public funds, especially in the field of education and science, should be made available in Open Access.

LITHUANIA: Almost all biggest Lithuanian state universities in web pages declare support to EU policy on Open Access to research information and some of them adopted internal documents like guidelines on Open Access to scientific publications and data. Some links:

https://www.mruni.eu/mru_lt_dokumentai/biblioteka/pdf/Atvira_prieiga.pdf
http://www.lsmuni.lt/lt/biblioteka/informacija-vartotojams/elektronine-lsmu-publikaciju-ir-e-dokumentu--registravimo-forma/lsmu-atviros-prieigos-mandatas/
http://www.vgtu.lt/mokslas-ir-inovacijos/mokslo-publikacijos/atviroji-prieiga/274301
http://www.vu.lt/site_files/Senatas_Taryba/S-2016-9/vu_mtdv_gaires_Senatui.pdf
http://ktu.edu/uploads/files/Bibliotekos/KTU_AP_nuostatai.pdf

PORTUGAL: Research institutions, deeply connected to universities in Portugal, have been investing in Open Science, especially Open Access, from some time, mainly motivated by the emergence and spread of research information digital repositories promoted and supported by the aforementioned RCAAP project. Almost every public research institution or university has an Open Access repository (as well as several private institutions) and 21 institutions at least, including most of the major universities, have published and implemented Open Access policies, requiring their researchers or faculty to deposit and make freely available their research publications in the respective repositories. At the same time, the number of Open Access journals under institutional publishing initiatives has also been growing. The increase in the number of full Open Access journals and other types of Open Research publications, ranging from books to individual articles, is deeply related to the support to these types of initiatives provided by RCAAP's hosting of scientific Open Access journals service (SARC), by the Portuguese branch of the SciELO project – SciELO Portugal – which is run by a department of the Ministry of Education, and also to isolated institutional initiatives, such as LusOpenEdition – the Portuguese branch of the OpenEdition project – fostered by ISCTE-IUL, and UC Digitalis, developed by the University of Coimbra. Finally, there is an incipient, but far from generalised, institutional interest and concern in research data management, including its sharing, such as demonstrated in the projects TAIL and Dendro led by the University of Porto, as well as in citizen science, reflected in initiatives like the project Invasoras.pt.

However, these concerns generally manifest themselves through researcher-led project-based initiatives supported by institutions rather than in the frame of institutional strategies.

RCAAP's directory of harvested resources, including networked repositories and Open Access journals: https://www.rcaap.pt/directory.jsp?locale=en

Institutional Open Access policies in Portugal (including both universities and research institutions):
http://roarmap.eprints.org/cgi/search/archive/advanced?exp=0%7C1%7Cpolicymaker_name%7Carchive%7C-%7Ccountry%3Acountry%3AANY%3AEQ%3A620%7Cpolicymaker_type%3Apolicymaker_type%3AANY%3AEQ%3Aresearch_org+multiple_research_orgs+research_org_subunit%7C-%7Ceprint_status%3Aeprint_status%3AANY%3AEQ%3Aarchive%7Cmetadata_visibility%3Ametadata_visibility%3AANY%3AEQ%3As

SciELO Portugal: http://www.scielo.mec.pt/scielo.php?script=sci_home&lng=en&nrm=iso

SciELO Portugal directory of Open Access journals: http://www.scielo.mec.pt/scielo.php?script=sci_alphabetic&lng=en&nrm=iso

LusOpenEdition (only in Portuguese): http://lusopenedition.org/aceraca

UC Digitalis: https://digitalis.uc.pt/en/content/uc_digitalis

UC Impactum (directory of periodicals made available under UC Digitals): https://digitalis.uc.pt/en/content/uc_impactum

Project TAIL: http://confdados.rcaap.pt/wp-content/uploads/2016/09/ConfDados_Cristina_Ribeiro.pdf

Project Dendro: http://dendro.fe.up.pt/blog/index.php/dendro/

Project Invasoras.pt: http://invasoras.pt/en/ ; http://invasoras.pt/en/the-project/ ; http://confdados.rcaap.pt/wp-content/uploads/2016/09/ConfDados_Elia_Marchante.pdf

- **What are the main challenges in your country towards the implementation of Open Science?**

Several respondents mentioned a lack of knowledge, interest and initiative at the governmental level, and a lack of commitment towards introducing a national Open Science agenda. In cases where the government has made relevant commitments, respondents mentioned the lack of appropriate financing and resources for the required infrastructure and systemic changes in administration and evaluation procedures. For instance, Slovenia mentioned the fact that while a governmental agenda is in place (the Action Plan for Open Access to Scientific Publications and Research Data in Slovenia 2016-2020), it is not yet clear who will be responsible for developing and monitoring the concrete measures and resources necessary to implement it.

Three respondents mentioned academic culture, and particularly the reluctance in some research fields to publish in Open Access journals (which typically have a lower reputation than top, closed journals) and spend time in archiving articles in OA repositories.

Switzerland emphasised the tension between the public support expected towards the implementation of Open Science and the fact that "about two-thirds of the funding for R&D as well as two-thirds of the R&D personnel in Switzerland come from the private sector (Federal Statistical Office). Private-sector research is thus very dominant and given its larger interest in intellectual property and industrial secret than public research institutions, this poses a major challenge for Open Science."

The publication of monographs in the humanities and social sciences was highlighted as a particularly problematic issue. In addition, one respondent mentioned the lack of agreed standards as a considerable obstacle, and another highlighted publishers' policies.

- **Is the legal and institutional system in your country, including norms and regulations over intellectual property, conducive to the implementation of Open Science? If so, how? If not, how not?**

Some respondents signalled that such a system did not currently exist in their countries, but would be needed to establish a balance between protected data and Open Access to information. Other respondents mentioned that their own country aimed to harmonise their policies with EU practice, although this may present problems when no specific provisions are made for research vis-à-vis other types of activities.

Potential confusion between legislations initiated by different ministries was mentioned as a barrier (for instance, when one ministry establishes intellectual property protection for the results of applied research, while another ministry emphasises Open Science licensing for all products of publicly funded research).

Furthermore, the following countries offered specifics of their own situation:

SLOVENIA: Present legal and institutional system, including norms and regulations over intellectual property, is not preventing Open Science, but it is not very conducive. The basic provisions (as an instruction measures) are already embedded in an existing Act on research and innovation activities in Slovenia. Nevertheless, present legal and institutional system in Slovenia is not supportive enough in terms of addressing and regulating Open Science essential attributes and/or promoting its values. This is now the challenge of the Action Plan for Open Access to Scientific Publications and Research Data in Slovenia 2016-2020, which is already prepared by the Ministry of Education, Science

and Sport and is just to be submitted to the approval of the Government of the Republic of Slovenia.
BELGIUM: At the federal level, all authors' rights will soon be ceded to the state by Royal Arrest. Should the federal level choose to make research funded by itself open, it could. Moreover, the Belgian law for Legal Deposit will soon be extended to online digital content so no mandate furthering deposit will be needed any longer. This is currently examined in the context of the draft decree on Open Access in Wallonia-Brussels Federation.
MOLDOVA: http://agepi.gov.md/en/legislatie/nationale. The State Agency for Intellectual Property has regulations including recommendations for Implementation of Open Science.
LITHUANIA: The Lithuanian legal and institutional system is favourable but not mandatory for implementation of OS policy.
PORTUGAL: The Decree-Law 115/2013, published in 2013, mandates in its Article 50 the legal deposit of a print copy of every national master's degree dissertation and doctoral theses at the National Library and, simultaneously, the deposit of a digital copy in one of RCAAP's network repositories with the aim to provide for Open Access and long-term preservation of the scientific information. This has been seen as a huge step to promote the dissemination of scientific information since every higher education institution is now legally obliged to comply with this requirement in relation to the dissertations and theses they issue. Decree-Law 115/2013 (only in PT): https://dre.pt/web/guest/pesquisa/-/search/498487/details/maximized As for the situation of the intellectual property legislative framework, there remain serious doubts among authors and also institutions regarding their contractual positions with the academic publishers and their own Open Access intentions and duties. More information to researchers and authors is needed in this domain and possibly even legislative actions could be useful to make clear the rights and duties of all parts. This situation is for sure severely inhibiting the full acceptance and ownership of the Open Science principles and practices. This has been acknowledged by the Open Science National Policy working subgroup on Open Access and Open Data and may become the subject of a specific recommendation for the Open Science National Policy.

Incentives and rewards

- **Are there any types of incentive or reward in place to support Open Science activities in your country? If so, which ones, and who is implementing and monitoring them?**

Three respondents answered "no" or "very few". In addition:

SLOVENIA: Research data, deposited into data archives and catalogued for the national CRIS (SICRIS – Slovenian Current Research Information System) are rewarded with points. Besides, the ministry responsible for science is financing repositories for Open Access in the country.
BELGIUM: In University of Liège, only what has been archived in the Green OA repository ('ORBI') counts in the evaluation. This is a strong stick/carrot kind of incentive. Besides, there is a general feeling that engaging in citizen science, although important, is not well rewarded. Researchers are cautious too about publishing in new OA journals, since the impact factor cult is very present and hard to circumvent.

SWEDEN: Swedish research funders give grants to researchers for publishing Open Access. Some institutions do have publishing funds .These funds support researchers to pay APC: https://www.unisg.ch/en/forschung/foerderung/wissenschaftskommunikation/publikationsfonds http://www.oai.uzh.ch/en/at-the-uzh/funding/publishing-fund

CROATIA: There are very rare practical examples of incentive or reward in place to support Open Science activities. One of the examples is the Ruđer Bošković Institute (IRB) – one of the criteria for the awards for the best scientific papers in a given year is given on the basis that these works are stored in our institutional repository FULIR and if available in Open Access. This is a very good example of how scientists are willing to store their work in a digital repository if this commitment is linked to some other processes (rewards, advancement in scientific professions, recruitment, etc.).

LITHUANIA: In the Guidelines on Open Access to Scientific Publications and Data, adopted by Research Council of Lithuania, there is statement: "Research Council of Lithuania ... establish the transitional period for the implementation of the Guidelines by 31 December 2020. In case during the transitional period any infringements of the Guidelines are established apply warnings only." The Research Council of Lithuania monitors the implementation of Guidelines.

PORTUGAL: The incentives are in the form of infrastructure-related services and facilities, as well as training, provided to research stakeholders by our national research and education network provider/manager, FCCN, which is one of FCT's departments. These consist mainly in platform and software-providing services and training given by the RCAAP project to institutions which wish to erect an institutional Open Access repository and to journals, editorial boards and publishers who wish to initiate a digital version of their academic journals. All these services are provided for free to applicant stakeholders. The aforementioned hosting of institutional repositories (SARI) is supplied under SaaS, i.e. based on RCAAP infrastructure (hardware, hosting, connectivity, OS, applications, security perimeter, service, back-ups, monitoring and alarms) whose management and operation is done by RCAAP's project team. However, the operation and administration of each institutional repository is the responsibility of member institutions. Similarly, the Scientific Journal Hosting Service (SARC), developed to facilitate the scientific journal management and to support best practices, is supplied under SaaS (Software as a Service) based on the OJS – Open Journal System platform. To facilitate all these tasks, the RCAAP project team offers support for the initial set-up of managerial and operational applications for publishing the journals (applications which will be run by the publishers themselves in the later phases), a helpdesk support system and training sessions directed towards managers and administrators of the journals but excludes all editorial content and design-related tasks. Publishers of existing online and offline journals who wish to join the programme, whether to start publishing online (for exclusively offline journals) or only to benefit from the advantages – technical facilities, indexing and support – provided by RCAAP (for those cases when the journal is already being published online), make an application to (usually) an annual call, making sure that the journal meets all the eligibility requirements. The publisher, not RCAAP, is always the sole responsible for all the journal's editorial process (organising the peer-review process and ensuring its results, editorial content, journal design, language and copy editing), and after the journal is up and running, the publisher is also responsible for managing and operating the publishing application software. There are no APC charges for authors who submit their works to journals published under the SARC service.

Apart from this, there are two institutions which have a strong requirement for making the scientific output of their researchers and faculty Open Access. These are the Instituto Politécnico de Bragança and the University of Minho which, in their assessment regulations, determine that only the researchers' publications which are deposited and made available in the institutions' respective Open Access repositories will be considered in their assessment and career-progression processes. Also, the University of Porto

assessment regulation for the faculty staff determines that deposit of the publication in the institution's own CRIS, SIGARRA, is mandatory. This may not be a 'positive' incentive such as prizes, bonus points in evaluation processes or considering the researcher's proven track record of the uptake of Open Science practices as tiebreakers in application processes, but it is nevertheless a really effective incentive measure for researchers to make their work Open Access. This is proven by the Minho and Bragança institutions results in having their output in Open Access, which according to the Pasteur4OA project report Open Access Policy: Numbers, Analysis, Effectiveness, puts them in 2nd and 5th place respectively, of all the worlds' research institutions in terms of amount of repository content. The results achieved by the IP Bragança are particularly impressive, since they have a full-text article deposit rate of 85, (8 %), of which an amazing 56.9 % of articles are already accessible in Open Access.

Other than this, there are no other known 'traditional' positive incentives and rewards mechanisms by other institutions. In acknowledgment of the effectiveness of such a requirement, FCT is also in a process to reforming its reporting mechanisms in such a way that, in the future, only publications deposited in one of RCAAP's repositories will ever be considered for research assessment purposes, as detailed in a previous answer.

- **Is there any training structure in place to provide information and skills about Open Science practices? Who is providing it?**

Only one respondent answered negatively, with most other respondents noting that the main providers of support are library services. In addition:

SLOVENIA: Currently, there is no training structure in place for information and skills about OS. The Action Plan for Open Access to Scientific Publications and Research Data in Slovenia 2016-2020 contains provisions for the establishment and regular activities of support services for researchers on open peer-reviewed scientific articles and preparation of research data for OA. Training of OA/OS stakeholders is envisaged.
BELGIUM: BELSPO has set up an OA helpdesk and a yearly training session for institutional OA contact persons. There are quite a lot of information activities that are organised at institutional level, by the universities and the academic libraries themselves. This is particularly focused on early-stage researchers, and may be part of their PhD training. But there is no central provision/funding/monitoring for this kind of activity. A website coordinates OA/OS-related activities: https://openaccess.be
MOLDOVA: This is the Institute for Development of Informational Society which is organising different events in order to inform about the Open Science: http://idsi.md/en/home Also, the librarian community is organizing events about OA
SWEDEN: The research libraries at Swedish HEIs are generally active in this field; they arrange lectures, etc. One of the HEIs provides a course for PhD candidates – 'Open Science and reproducible research': htpp://kiwas.ki.se/katalog/katalog/kurs/2521
SWITZERLAND: Yes, universities – particularly libraries - provide training on OA. See for instance: www.oai.uzh.ch/en/at-the-uzh/events/introductory-course-zora. OA is also addressed in doctoral schools.
CROATIA: A handful of people are working on Open Access and Open Science and/or projects from this area and work on educating the scientific community, librarians and promoting OA and OS. For example, the FOSTER project, currently implemented in Croatia, was designed to educate all stakeholders in Croatia for a couple of months, but it was only a project activity. It is hard to provide adequate education and promotion of OA and OS across Croatia. The IRB Centre for scientific information also carries out education (primarily for librarians) through cooperation with DABAR, as well as through their daily activities. However, this is still insufficient.

AUSTRIA: The Open Knowledge Network Austria Branch is very active in training for OS. There is an ongoing series of events co-organised with the Technology Transfer Centre East (WTZ-Ost), for example: http://www.wtz-ost.at/veranstaltungen/
PORTUGAL: There are discussions, triggered by the Open Science National Policy working subgroup on OA and Open Data and other stakeholders, concerning a proposal to create a competence hub in data skills to address researchers Open Data needs, such as training, and problems, such as legal advice, because this is the OS area where it is mainly found lacking.

- **Is there any institutional structure or specific venue dedicated to Open Science implementation and monitoring? Please provide links where possible.**

Two respondents answered negatively, and many others remarked on the absence of a national level system, noting however that some research organisations are investing efforts into this. In addition:

SLOVENIA: No institutional structure or specific venue dedicated to Open Science exists presently in Slovenia. Open Science implementation and monitoring is implemented mainly through the dedicated web portals such as OpenAccess Slovenia (http://www.openaccess.si/, built by Slovenian universities and research institutions and supported by the ministry and research agency) and Open Science Slovenia (http://openscience.si, built by Slovenian universities and supported by the ministry and research agency). The national institute of information science (IZUM) has introduced altmetrics (http://scimet.izum.si/en/altmetrics) into bibliographic data of Slovenian researchers: (http://splet02.izum.si/cobiss/BibPersonal.jsp?init=t&lang=eng&code=&type=conor) in 2016. From the practical and technical point of view, altmetrics can already be practiced in Slovenia for testing and learning purposes, but are not yet part of the official evaluation system.
BELGIUM: The BELSPO Open Science project administrator and the Royal Library Open Access contact person.
SWEDEN: When it comes to Open Access to publications, please see the National Library, www.kb.se/openaccess. Open Access to data is going to be monitored by the Swedish Research Council, please see www.vr.se. The Association of Swedish Higher Education, SUHF, has established a coordinating group on Open Science: www.suhf.se (only in Swedish).
SWITZERLAND: The 'Scientific Information' programme of swiss universities "promotes the concentration of today's distributed efforts of universities to provide and process scientific information. This includes the development and support of services which may be of use for Open Science": https://www.swissuniversities.ch/en/organisation/projects-and-programmes/p-5/ https://www.swissuniversities.ch/fileadmin/swissuniversities/Dokumente/Organisation/SUK-P/SUK_P-2/PgB5_Antrag_2017-2020_kurz_EN.pdf
LITHUANIA: Research Council of Lithuania has a section in the web page dedicated to OA with information about LT and EU documents, projects, etc. http://www.lmt.lt/lt/atviroji_prieiga.html
AUSTRIA: The FWF has implemented a monitoring for Open Access compliance: https://zenodo.org/record/55249#.WQr0Wx5QiP4
PORTUGAL: See above about the creation of the Interministerial Working Group whose mission is to present a proposal for a Strategic Plan for the implementation of an Open Science National Policy (WG-NOSP).

Future directions:

- **What aspects of Open Science are most discussed and valued in your country, and by whom?**

All respondents highlighted Open Access to scientific publications as the key aspect of Open Science currently under debate in their country. Three respondents (Slovenia, Portugal and Switzerland) also mentioned some interest in Open Data and citizen science, although these issues are not yet seen as a priority.

- **Are you considering changes in incentives and rewards for researchers, funders, universities and research organisations? What kind of changes, and why?**

Except for two who reacted negatively, respondents provided positive answers to this question, highlighting a number of national initiatives and committees in charge of considering potential changes to Open Access policies, research evaluation models, Open Science incentives and support for Open Research Data. These include the National Library of Sweden, the Swedish Research Council, the Region of Brussels-Capital, the Wallonia-Brussels Federation, the Croatian Ministry of Science and Education (working on a future Croatian Current Research Information System) and Austrian Science Funding.

In the words of one respondent (Slovenia): "Changes are important to enable further progress in development of effective and successful publicly funded research system in Slovenia as well as to support more effective international co-operation. We expect that further progress of EU and ERA in that respect will provide EU Member States with the basic source of information, best practices and role models to enable and support us in making proper steps in that direction." The Croatian delegate similarly remarked that the goal is "a comprehensive system that will be used for systematic design of medium-term and long-term research, development and innovation priorities in the public research organisations in the future". At the same time, respondents generally view such a change as requiring several years to be fully implemented, thus overshooting the European requirement of full implementation by 2020.

- **What kinds of cultural changes are required for wider adoption of Open Science?**

Respondents provided a variety of answers to this question, which are reported below as each response exemplifies a specific interpretation of what Open Science amounts to. Interpretations include:

  - Open Science as most closely associated to advances in information and communication technologies, which are shifting the ways in which knowledge is developed and shared;
  - The idea that rather than a cultural shift, all that Open Science requires is additional funding;
  - Open Science as an opportunity to acknowledge how pluralistic and varied the methods, goals and communities of researchers are;
  - Open Science as a shift in the expectations and priority of researchers, which would involve more collaboration and sharing, as well as moving away from the 'publish or perish' ethos.

This diversity is notable and important to take into account for further discussions at the national, European and global levels.

Open Science is related in particular to the research which is performed within ICT and web-based environments. Promoting advances in that environment, which are supporting better interdisciplinary and international collaboration as well as 'openness' of research work to both society and the research community is therefore important. Thus, certain centralised services at the level of research institutions could be beneficial to promote and help researchers get on track with the mainstream solutions. As developments in ICT and web-based environments are extremely fast and versatile, it may be good for research disciplines to develop and promote, within their research communities, best practices in implementing Open Science culture and share them with a larger scope of research institutions.
No cultural changes apart from a general conservatism. What is most needed is better funding of research so that institutions do not have worry about losing income and researchers about losing impact.
Open mind and modern attitude towards science, communication and spreading science.
Incentives and reward systems, costs for publishing.
Better acknowledgement of a diversity of profiles within academia, rather than the focus on the super publisher. Proper acknowledgment of the diversity of research outputs, according to the disciplines and the type of research conducted (curiosity driven, strategic and applied). And definitely not using IF anymore for assessing individual researchers!
In some disciplines, the orientation towards 'publish or perish' and the demand to publish only in 'top journals' should change towards a stronger orientation to the quality of the content.
One of the biggest challenges will be to change the way scientist perceive Open Science and to improve their willingness to share. This is something they are not used to, for multiple reasons. Most of them are very well defined in the ERAC Opinion on Open Research Data. In addition, at the national level it will be important to address and improve the overall digital science policy and governance. For that reason, we are considering participating in the OECD 'Digital Science and Innovation Policy and Governance' project due to start in 2017. Furthermore, at the EU level, it is important to bring more synergies between different policy streams (Cohesion Policy, Horizon 2020, ERA policies, Erasmus+, etc.). Without this synergetic effect of all the policies, there will always be contradictions and the research community will have a hard time following different sets of regulations and implementation rules when it comes to framework projects and all other types of funding.
Almost all initiatives regarding Open Access or Open Science come from Brussels and we lack active researchers or research leaders promoting OS ideas. Optimisation of the higher education institution system is currently on the top of political agenda in Lithuania and OS matters are on the second plan. The OA initiative is actively supported by university librarians, but some of the older academics need a better understanding of the advantages of OS.
Best practice examples - Incentives - Mentality of 'expert knowledge' from policymakers on which fields of research are needed/funded, etc...
To form a habit requires time. Thereafter, implementation of Open Science will require time for the different stakeholders to adjust to the new models, requirements and regulations. It will take time for some scientific communities to embrace the advantages of Open Science and to capitalise on its opportunities. A clear, transparent and open discussion on the opportunities and the potential limitations of Open Science will certainly contribute to a faster adoption of the new habit.

More knowledge among researchers of the range and advantages of different communication practices by disciplines different than their own and, as defended above, more respect and promotion to those communication practices that do not rely so much on publications (especially those that are published in closed-access journals or in unfairly priced Open Access journals) could help spread the wider adoption of Open Access practices. Also, a more profound consciousness, by both the public and researchers, of the benefits of Open Science and of knowledge resulting from public funds and money itself that is wasted every year on information that is unjustifiably not open to everyone, could help trigger more demand for Open Science from the public and a greater sense of social responsibility from researchers, and help them to take up Open Science practices.

A cultural change towards intellectual property of research by research managers, funders and policymakers is also very much needed in my humble opinion. It simply is not ethical to publicly fund research whose results will be handed over for free to be published in closed-access journals which, in turn, will charge huge amounts of money to public institutions for them to access the research they ultimately produced in the first place, or which will provide Open Access by also charging authors or institutions large sums of money while failing to create effective countermeasures for double dipping.

Intellectual property of publicly funded research should be cherished and valued and not given away for free in such a manner, which creates most of the imbalances and inequalities in the current academic publishing system. If the publicly funded scientific information commercial publishers wish to publish is handed over for free to them, they should have certain duties or obligations to respond to. One of them would be to allow the author's final version of the publication to be deposited and made available in Open Access in a public repository, at no extra charge and with no embargo delay whatsoever to the publications content, so that anyone with an internet connection could access and reuse the publication. This provision would put into the publishers hands the decision and responsibility whether or not they wished to abide by these rules and how the publishing system would be shaped, hopefully in a fairer way.

- **What skills and training in open science are necessary for different stakeholders?**

Respondents mentioned the need for skills and related training programmes specifically for:

- Policymakers, including awareness of the stakes involved in Open Science and the situation in other countries, and options for Open Access that are not limited to deals with major publishers;
- All researchers, including Open Education, copyright issues and understanding of different models of Open Access publishing and self-archiving;
- Specialists in Open Science, such as evaluators of its implementation and providers of support (which could be provided by the EU and ERA structures);
- Early-career researchers, including in science communication and in understanding the impact that publishing choices may have on their future career;
- Industry stakeholders, concerning particularly IPR dimensions;
- Editors, including the technical and legal challenges of publishing Open Access;
- Librarians and information specialists who need to provide Open Access support concerning publications and research papers, as well as instruct researchers on the options available for publishing;
- Funders, particularly tools to monitor publication of (all types of) research results;
- The general public, more tools – such as better education in science or dedicated collaborative fora – to derive meaning, value and usefulness from all the scientific information and knowledge available to them.

- **What incentives, reward systems and strategies for Open Science implementation would you like to be able to adopt in the future (whether or not this is currently feasible)? Why?**

Respondents disagreed on the extent to which Open Science implementation should be top-down (mandated by governments and research funders) or bottom-up (fostered by researchers and supported by research performing institutions). Responses included the following suggestions:

- Better and attractive metrics (the carrot) make Open Science part of researcher evaluation and adopting the Liège Model (the stick).
- Generalisation of OS modules in third-cycle education. Working on/with ESR is the only way to change the mindsets for the better!
- Articles should remain central in the ecosystem of science production and dissemination, but the other elements of this ecosystem should be better taken into account. In particular, those research outputs with as societal impact should be better valorised at each step of the career (and not only for those senior researchers who no longer need to prove anything).
- The link between Open Science and Open Education should be investigated, in particular for the development of altmetrics able to track the use of research within (open) educational research.
- The bottom-up approach, which is already at the core of the current national Open Access strategy should be maintained.
- Research funders and universities should take into account an applicant's previous practice of green Open Access and data management plans as evaluation criteria in their funding and hiring decisions.
- One of the best solutions would be to link elections in science, teaching and other vacancies with the obligation of storing publications in OA repositories and ensuring OA to so-preserved publications.
- Favour copyright-retention provisions, changes in the assessment system to adequately consider Open Science practices and different research outputs, and incentives, including financial, to researcher-led publishing initiatives.

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This report provides a systematic overview of the advantages and challenges of supporting Open Science activities, and the incentives and rewards that most effectively encourage the adoption and implementation of Open Science policies. Building on discussions among participants in the Mutual Learning Exercise on Open Science, the report identifies key concerns and feedback by Member States on how Open Science can and should be fostered. It then suggests the incentives and rewards (and related motivations and strategies) that apply to three groups of key stakeholders in Open Science: (1) researchers themselves; (2) research-performing institutions and funding bodies; and (3) national governments. In conclusion, a summary of the main advantages and disadvantages of each type of incentive is provided, with suggestions on who is responsible for managing its implementation.

Studies and reports