European Commission

Validation of the results of the public consultation on Science 2.0: Science in Transition

Research and Innovation

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1. Background

Between July and September 2014 the European Commission conducted a public consultation on Science 2.0. The consultation sought to gather the opinions of a broad sample of interested parties from across the EU research landscape. It aimed to better understand the potential impact of Science 2.0 and the desirability of policy action.

While the consultation was open to all citizens, organisations and public authorities, the Commission identified several groups that it would mainly target as respondents: universities and university associations, research performing organisations, research funding organisations, scientific libraries, academies, learned societies, scholarly publishers and intermediaries, and businesses in fields related to Science 2.0.[1]

Respondents were invited to answer an online questionnaire that asked for their opinions on the main aspects of the background document for the consultation, *Science in transition.* This online consultation was open to all interested parties.[2] Respondents could also submit separate position statements on the topic. In addition, the Commission held four stakeholders' workshops between the 22nd of October 2014 and the 4th of December 2014, to which representatives from specific stakeholder groups were invited:[3]

- University organisations and research performing organisations (Leuven, 22 October 2014);
- Academies, learned societies and research funding organisations (London, 6 November 2014);
- Representatives of member states, citizen science groups (Bucharest, 20 November 2014);
- Publishers and research intermediaries (Madrid, 4 December 2014).

Objectives of the consultation

According to the background document, 'Science 2.0' describes an on-going evolution in ways of doing and organising research. These changes are enabled by digital technologies, and they are driven by globalisation and growth of the scientific community as well as the need to address the grand challenges of our time. The changes impact the modus operandi of the entire research cycle, from the inception of research to its publication, as well as the way this cycle is organised.
The three main objectives of the consultation, as identified by the Commission, were:

- To assess the degree of awareness amongst the stakeholders of the changing modus operandi;
- To assess the perception of the opportunities and challenges; and
- To identify possible policy implications and actions to strengthen the competitiveness of the European science and research system by enabling it to take full advantage of the opportunities offered by Science 2.0.

[1] Consultation website: http://ec.europa.eu/research/consultations/science-2.0/consultation_en.htm
[2] European Commission Directorate General for Research and Innovation (RTD) and DG Communications network, content and technology (CNECT) (2014) *Science in transition background document*, p. 1, URL: http://ec.europa.eu/research/consultations/science-2.0/background.pdf
[3] Details about the workshops and material that were provided to participants are available at http://scienceintransition.eu/: DG RTD is grateful for the services RAND Europe provided during the validation process and for the support of the wokshops. In the remainder of the text, the workshops are referred to by their location, namely Leuven, London, Madrid and Bucharest.

This policy brief summarises the results of the consultation. It covers:

- The 498 complete responses received for the online questionnaire[4] (both closed questions and free text comments).
- The key points from 27 position statements submitted by stakeholders around the European Union

Key points from discussions in the four stakeholder workshops.[5]

It should be emphasised that the mandate of this brief is to summarise the outcomes of the public consultation. As a result, it is limited to the topics raised in the questionnaire, position statements and workshop discussions, and does not attempt to reflect views expressed outside of the consultation survey, position statements and workshops.

This brief is organised as follows. Section 2 summarises the general findings from the consultation. Section 3 concentrates on the main areas for discussion. Section 4 summarises policy recommendations. The brief also includes three appendices. Appendix 1 includes a list of potential actions to be undertaken by the European Commission and highlighted in the material gathered for this analysis. Appendix 2 provides a further breakdown of the percentage of support for each of these actions as it appeared in position statements. Appendix 3 underlines topics raised by stakeholders during the consultation which are not directly within the remit of DG Research and Innovation (DG RTD).

[4] In this document, statements about percentages of respondents will refer to the questionnaire analysis. For each figure, we state the overall number of responses and the number (in each case a range) of 'missing' responses for each sub-question.

[5] Methodological notes: While the summary aims to reflect the views articulated by the stakeholders responding to the consultation through the above-mentioned means, the insights gained from these sources are limited by the collection methods. First, responding to the consultation was voluntary and offered the possibility of anonymity. Therefore it cannot be assumed that all relevant stakeholders responded to the questionnaire. And while we aimed at accurately capturing views expressed by consultation participants, this brief is a summary and does not necessarily include every view from every participant. Moreover, the views captured in this exercise do not necessarily constitute a representative sample of the entire stakeholder community. Second, the stakeholders' landscape in research in Europe is complex. For example, some of the key stakeholders that engaged with the consultation are umbrella organisations representing groups of institutions or individuals. A potential consequence is that the percentages in the survey results refer to the distribution of answers amongst respondents. They do not necessarily reflect a similar distribution in the wider stakeholder community. Furthermore, this implies that the brief tends to present a relatively aggregated view of stakeholders' positions (rather than an attempt to dissect opinion by stakeholder).
The rest of the brief uses the following terminology: 'Respondents' refers to those who have replied to the online questionnaire and 'workshop participants' refers to those who attended one or more workshops. Unless otherwise specified, references to comments made by organisations refer to their position statement. 'Stakeholders' refers to all individuals and organisations involved in the consultation, regardless of their mode of participation (some stakeholders fall into more than one category).

2. General findings

In general, the level of agreement with the main trends identified by the European Commission was high. For example, more than two thirds of respondents (70%) agreed that the trends identified in the background paper are aspects of Science 2.0. The trends identified were: a significant increase in scientific production, a new way of doing science (data-intensive science), and an increase in the number of actors and addressees of science.

Other findings included the points presented below.

2.1. From Science 2.0 to Open science

The results of the consultation suggest that many stakeholders prefer using an alternative term to 'Science 2.0'. 'Open science' appeared to be the most popular alternative term. It was selected from among six options by 43% of respondents and discussed during the workshops as the most viable alternative.

Other suggestions made by questionnaire respondents included 'participatory science', 'science highway', 'better science', 'open research' and 'open scholarship' – the latter two were included as alternatives to the word 'science', which could be interpreted as excluding the humanities in some cultural contexts.
In this document, we will use the term 'Open science' from this point forward.

2.2 The concept of Open science

In position statements, stakeholders emphasised that Open science refers to multiple, related developments. For instance, LERU described it as 'an umbrella term for a series of movements in research' (p. 1). Science Europe said it is a 'series of related practices' (p. 2) and the Public Library of Science (PLOS) said it is a 'system of related changes that must be considered in relation to one another'.

Science Europe identified three essential aspects of Open science: its relation to digital technology, the idea that it explores changing research practices and their impact on the research system as a whole, and the fundamental importance of "a certain vision of science as a community of practice" (p. 2).

2.3 Opportunities related to Open science

Overall, more respondents were more positive towards Open science than critical of it.[6] The majority of respondents indicated they thought that Open science could yield several opportunities at the individual and institutional levels. Opportunities listed in the questionnaire that yielded the highest level of agreement (total or partial) from respondents included wider dissemination and sharing of research outputs (95% of respondents) as well as the ability to design accountable and collaborative research modes (86%). Workshop participants also agreed that open science could help to increase transparency in funding decision and reduce cases of malpractice in academic publications.[7]

[6] More precisely, in the other comments category, 114 respondents did not express any attitude towards science 2.0, 17 were positive, 8 were negative and 12 were mixed (out of 151 valid responses).
[7] Madrid, Bucharest

However, a lack of awareness of Open science was seen as an issue for realising these benefits. As LERU wrote in its position statement: 'The concept of Science 2.0 is little understood in European universities, and a fundamental cultural change is needed if research communities are to embrace the benefits' (p. 5).
Some stakeholders, such as the European Federation for Science Journalism (EFSJ), recognised the potential that Open science could have implications for society as a whole. The EFSJ, in its position statement, suggested that Open science could lead to 'a new social contract between science and society'" (p. 1).[8]

Workshop participants also emphasised some wider opportunities linked to Open science, such as the promotion of cultural and linguistic diversity in science across the European Union, and the promotion of evidence-based policymaking by increasing the visibility of scientific evidence. Finally, respondents highlighted that most disciplines had the potential to engage with the concept of Open science.[9]

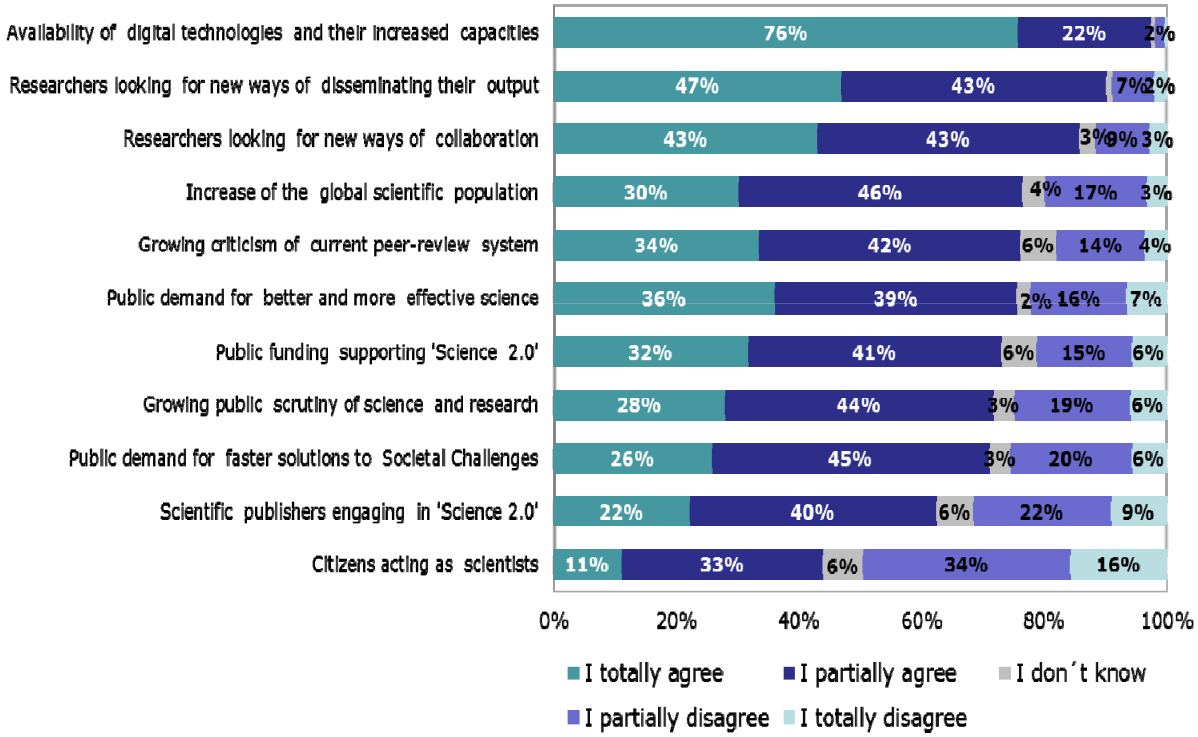
2.4 Drivers of Open science

The majority of respondents agreed with the Open science drivers suggested in the questionnaire (see Figure 1).

[8] The EFSJ also suggested that independent science journalists would play an important role by linking science, politics, culture and morality

[9] For instance, open responses in the survey as well as discussions during the workshop showed that social sciences were able to engage in open dialogue with the public through new (social) media, using public responses to check scientific propositions (e.g. about behaviour); to make use of vast amounts of administrative data for social scientific investigation; and to develop an understanding of cultural and social structural contexts that is beneficial to the digital world. STEM disciplines were seen as generally attuned to technology and well-placed to explore new technologies. Publication pressure and rapid innovation are high in these disciplines, which mean that researchers need to use any tools they can to organise their work, find collaborators and stay on top of the latest developments in their field.

Figure 1 Drivers of open science (Questionnaire responses to 'What are the key drivers of 'Science 2.0'?')



Sample size: 492, missing: 8 to 12.

For a majority of respondents (98% totally or partially agreed), the availability of digital technologies and their increased capacity were key drivers for Open science. Science Europe's position statement identified two main drivers, which reflected ideas that emerged in general in the consultation. The two drivers were: 'A strongly-held belief in the value of free circulation (and criticism) of ideas…' and 'A re-appreciation of the role of data by researchers' (p. 3).

The growing competitiveness in the world of scientific research was seen as both a barrier and a driver. On the one hand, some stakeholders recognised that Open science could help to generate competitive academic research, strengthen international research collaboration and ties with society and the private sector. On the other hand, other stakeholders feared that Open science could contribute to a dilution in scientific quality. Concerns were also raised that the speed of innovation from the private sector (e.g. in developing digital platforms and tools for use by researchers) could exceed the pace at which policies are adopted to regulate these innovations and result in a 'lose-win' geopolitical scenario.[10]

A range of actors, including industry and members of the research community (e.g. researchers, universities, funders) were also mentioned as potential drivers of Open science by workshop participants.[11] Stakeholders tended to characterise Open science as a bottom-up or 'grassroots' phenomenon driven by researchers and the research

[10] The discussion on international competitiveness was particularly prominent during the London workshop. These discussions also linked to the wider debate regarding the role of science in the broader economic context, including job creation and linking science to labour markets (see section 3 on research careers).
[11] London

community. They generally agreed that policies should reflect the fact that Open science was and should remain researcher-driven[12]. Industrial collaboration was also seen as a major driver in Open science innovations and a fundamental enabler of European competitiveness in the face of mounting global competition and the role of science in a competitive space.[13]

Open science was also viewed, to some extent, as being driven by scientific publishers and technology platforms, several of which appeared supportive of Open science trends. Several publishers and platforms presented examples of initiatives they had introduced to raise awareness and encourage Open science. For example, the company Altmetric.com presented its initiatives in developing open access publications. Representatives from PLOS observed that successful innovation in creating online social tools for research had come largely from new players (that had often started in academia and moved to the private sector), while traditional publishers had failed in attempts to introduce features such as online commenting for journal articles[14].

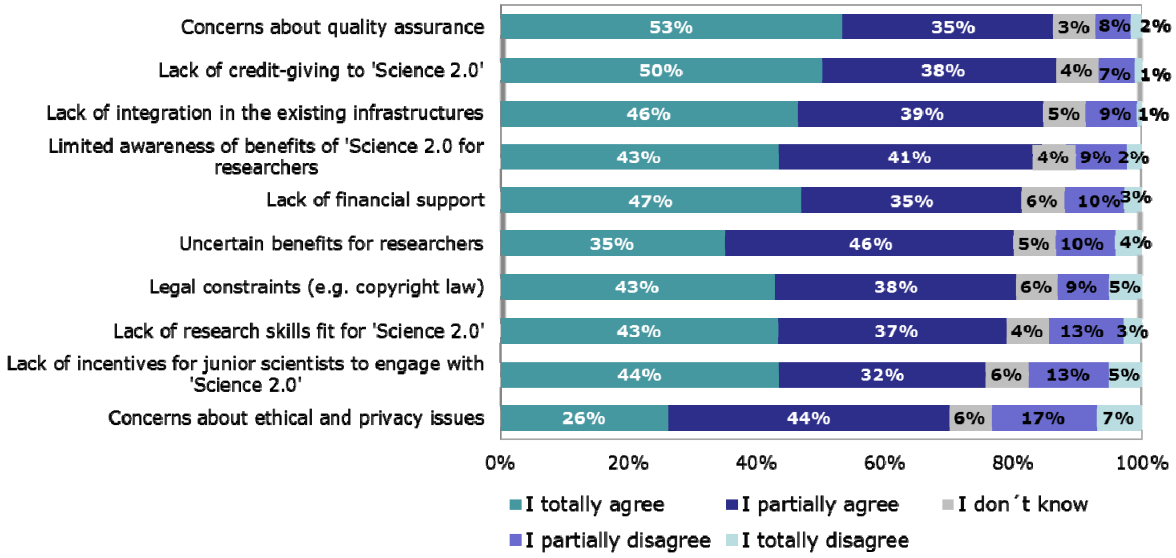
The only driver that did not obtain a majority of agreement was citizens acting as scientists (only 44% totally or partially agreed in the survey). However, during the workshops several stakeholders underlined the relevance of involving citizens, for example to contribute to the further diffusion of science or to contribute to crowdfunding. The debate about the role of citizens in science is discussed further in section 3.2.

2.5 Barriers to Open science

In general, respondents agreed with the majority of the barriers listed in the online questionnaire, as detailed in Figures 2 and 3.

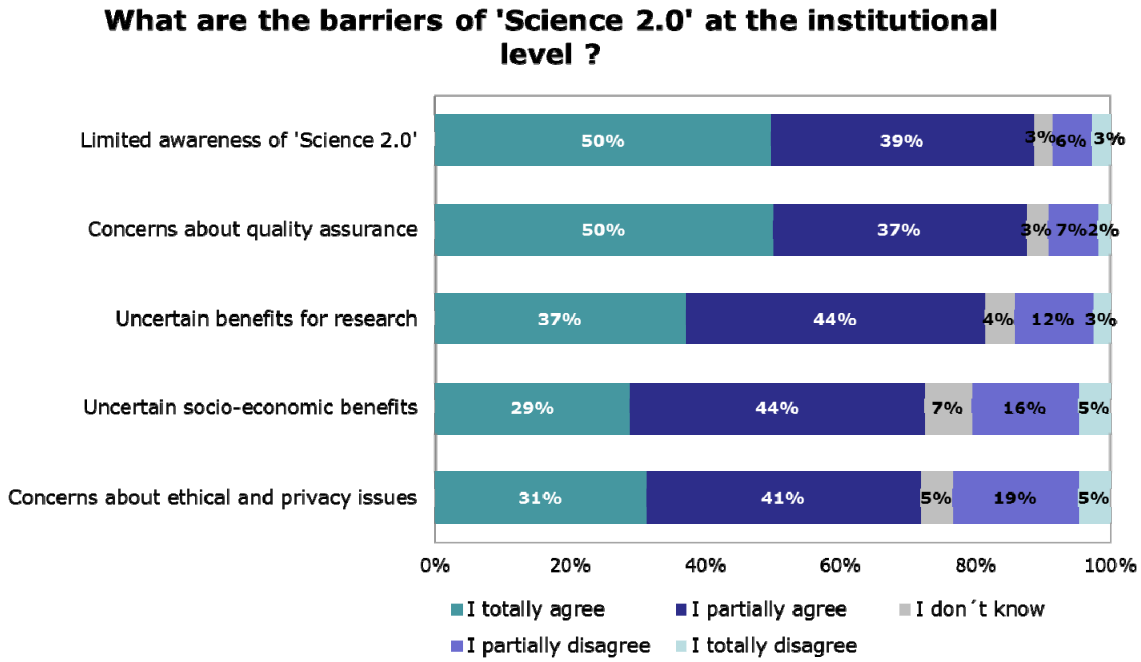
[12] This point was particularly highlighted by universities and research performing organisations, academies, learned societies and research funding organisations.
[13] Leuven, London
[14] Another organisation noted that other efforts such as the Orcid identification system, digital object identifiers (DOIs) and commitments on text and data mining were not sufficiently emphasised in the background document.

Figure 2 Barriers for Science 2.0 at the level of individual scientists (Questionnaire responses to 'What are the barriers for 'Science 2.0'?)



Sample size: 498, missing: 15 to 22.

Figure 3 Barriers for Science 2.0 at the institutional level (Questionnaire responses to 'What are the barriers for 'Science 2.0'?)



Sample size: 498, missing: 15 to 18.

The highest level of agreement was obtained regarding the barrier for individual scientists, 'concerns about quality assurance of new and non-traditional research outputs'.[15] For institutions, the main barrier was a perceived lack of awareness of Science 2.0, in addition to concerns about quality assurance. Some stakeholders cautioned against what they perceived to be a trade-off between publicity (facilitated by Open science) and scientific quality and excellence, and they queried how to maintain scientific standards in an Open science context.

Respondents agreed that additional barriers are also present, including a lack of credit for researchers involved in Open science activities (88% of respondents). Science Europe, in its position statement, noted that Open science activities 'should not be curbed by unnecessary exclusion from consideration in peer review evaluation' (p. 5). Other barriers agreed on were: a cultural resistance to change among stakeholders, a lack of incentives to engage with Open science,[16] a lack of strategic management and limited coordination among stakeholders, a lack of skills among researchers and academics at all career stages, and legal constraints. The increasing costs related to open access publications and data, and more particularly uncertainty regarding who should bear them, were also mentioned as a significant barrier, (for instance by LERU and representatives from the Madrid Business School).[17] Finally, workshop participants from EARTO emphasised the barriers represented by difficulties in commercialising research projects.[18]

2.6 Benefits of Open science

Position statements mentioned several benefits to open science: more collaboration and new forms of collaboration, breaking down discipline barriers, interactions with actors outside the research community, interest in new ways to disseminate findings, and a public demand for faster solutions to societal challenges.

Further benefits were identified under the category 'implications' in the online questionnaire. The majority of respondents and stakeholders agreed with the main implications of Open science listed in the consultation's questionnaire, including an increase in the reliability and efficiency of science (83% totally or partially agreed), faster and wider innovation (82% totally or partially agreed), data-intensive science as a key economic driver (79% totally or partially agreed), greater scientific integrity (78% totally or partially agreed), a way of reconnecting science and society (76% totally or partially agreed) and science being more responsive to societal challenges (76% totally or partially agreed).

[15] 87% of respondents agreed that concerns about quality assurance would be a barrier at the level of individuals and 88% agreed at the level of organisations.

[16] For example, The International Consortium of Research Staff Associations (ICoRSA), in its position statement, mentioned that increased competition for funding creates incentives for researchers to protect their ideas, not share them.

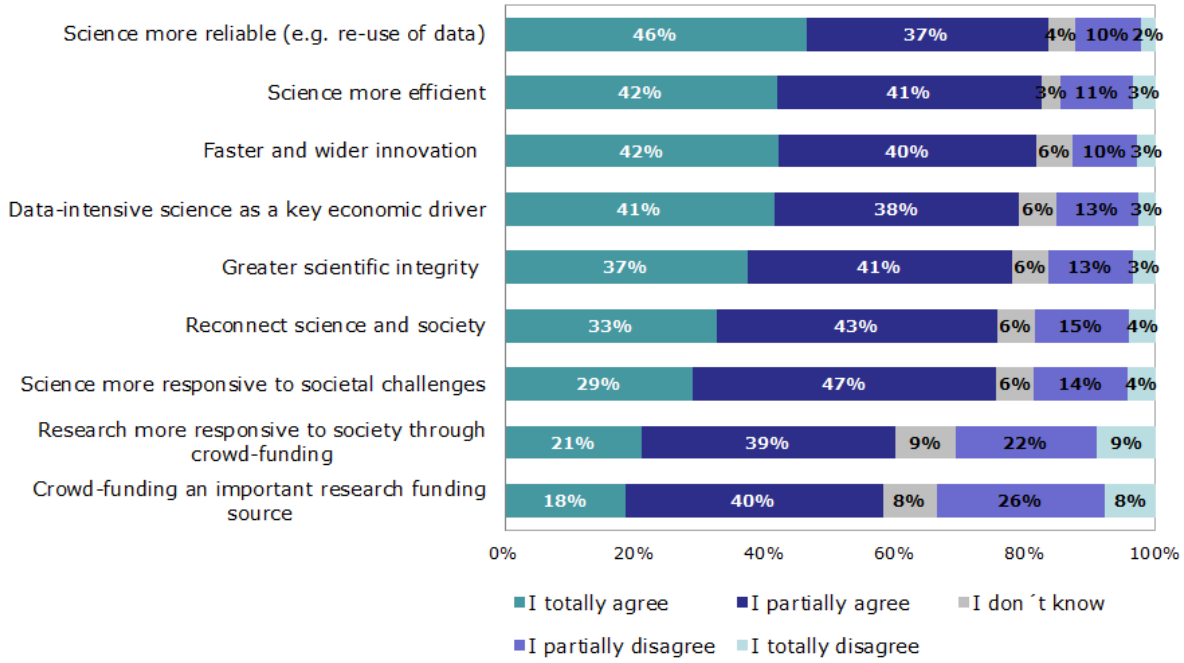
[17] There is a large debate about green versus gold access in publishing and is discussed, for instance, in Houghton, J., and Swan, A., Going for Gold? The costs and benefits of Gold Open Access for UK research institutions: further economic modelling. Report to the UK Open Access Implementation Group, JISC repository, URL: http://repository.jisc.ac.uk/610/
This paper raises the issue that while research on the costs and benefits of open access for UK universities estimates that worldwide adoption of (green or gold) open access could lead to significant cost savings at system level, unilateral adoption of these approaches results in net losses for the adhering institutions. LERU also called for caution in advocating mechanisms that shift the cost of access from readers to the producers of articles, as these are likely to have implications for the business models of research performing organisations.

[18] Leuven

2.7 Implications of Open science

Open science could have profound implications for the scientific landscape as a whole. Some of these implications were debated by stakeholders. For example, some stakeholders (e.g. the Royal Society of Chemistry) underlined that these potential implications were mostly hypothetical since it was too early to evaluate them. In addition, other stakeholders (e.g. the Danish Council for Research and Innovation Policy DCRIP) also debated whether a trend toward more openness in science was occurring. The Council instead identified a trend toward scientific closure coming from difficulty identifying quality content in the growing number of journals. The International Consortium of Research Staff Associations (ICoRSA) raised a similar point, questioning whether the growing volume of scientific production and growing number of scientists were bringing enhanced scientific accountability. They argued that it was on the contrary 'much harder for a large system to self-regulate' (p. 2).

Figure 4 Implications of Open Science (Questionnaire responses to 'What are the implications of 'Science 2.0' for society, the economy and the research system?')



Sample size: 498, missing: 8 to 13.

Open science could also require changes in funding mechanisms, as discussed in the workshops. Open science fosters the creation of scientific network, which require adapting the allocation of funding accordingly (and potentially away from a concentration on individual funding) according to some stakeholders.

Open science could increase the relevance of crowdfunding as an important source of funding (58% of respondents totally or partially agreed)[19], and connect the science community to a broader network including entrepreneurs for example (Science Europe and the Royal Society).

In addition, Open science could impact research careers, although stakeholders underlined that this does not necessarily imply a radical overhaul of existing recruitment and career progression processes.

[19] Crowdfunding remained somewhat of a contentious point. The impact of crowdfunding on scientific excellence was debated among stakeholders (a concern being that crowdfunding could introduce some bias in the selection of research topics and the scientific research process).

More generally, the nature and extent of change that Open science would bring to research culture and the research ecosystem as a whole were debated. Some of the key issues were: whether Open science should be used as a tool for research or to generate research interactively; the extent to which Open science changes the way science is done; and how Open science could support the objectives of the European Research Area. Moreover, Open science should be related to discussions on the societal relevance of research and responsible research and innovation.

3. Main areas of discussion

The following issues arose in the consultation responses as areas of debate.

3.1 Need for policy intervention

In the questionnaire, 72% of respondents stated that they totally or partially agreed that there is a need for policy intervention in Open science[20]. Some respondents highlighted that the intervention of the European Commission as a way to speed up the implementation of Open science. As one respondent wrote: 'While I believe that the evolution of [the way in which] scientific development is performed is inevitable, I think that EC and the policy forming agencies are in a position to change the time scale over which this happens from 40 years to 7 years.'[21]

The key issue of the debate was not whether but how to design and implement policy intervention on Open science. In general, all stakeholders underlined that policy intervention should be designed to enable the research community as drivers of change (i.e. The Research Council of Norway, the Royal Society of Chemistry and Science Europe) and some explicitly stated that they were opposed to a policy intervention which would imply the introduction of 'more red tape for Horizon 2020 grantees' in position statements (e.g. Universities UK).

3.2 General types of policy intervention

Some stakeholders underlined that the main type of policy intervention should be to encourage a debate to understand the Open science phenomenon more clearly, and that it is too early to pursue more invasive interventions (LERU, European University Association (EUA)). Some stakeholders saw the need for policy intervention to diffuse information and raise awareness about Open science. In a related recommendation, OpenAIRE and COAR suggested that standardised funder and grant information should be included in publication metadata.

Others, such as LERU, underlined the value of unblocking more funds for research on Open science in Horizon 2020. Science Europe encouraged an evidence-based policy intervention articulated around the removal of barriers to engaging in Open science activities. This intervention could tackle the issues of financial costs, administrative burdens and potential negative impacts on careers associated with Open science. Another suggested intervention was Science Europe's idea of developing 'Science Administration 2.0' (p. 9), which would build on Open science approaches to data to bring together information on grants and job opportunities.
A final policy intervention discussed by several stakeholders was support for data sharing, management, curation and storage. Specific interventions would include building relevant infrastructure, developing data skills, incentivising data sharing, and nurturing the development of good practice in handling data.

3.3 Open access and copyright regulation

Open access to publications and data, and copyright regulations pertaining to text and data mining were discussed by a number of stakeholders, particularly those with greater involvement in scholarly publishing (e.g. libraries and publishers).

[20] Or more accurately 72% disagreed with the fact that there was no need for policy action in reply to the question 'public authorities could facilitate the uptake of Science 2.0 by … no need for policy action because it will happen anyway'.
[21] An individual based in the Netherlands

Stakeholders debated the need for further policy intervention in the areas of open access to publications and research data[22]. Several organisations (YAS, RC Norway, Royal Society, and NWO) stressed the importance of open data in their position statements, and they discussed the importance of encouraging activities such as data creation, curation and sharing.

Encouragement in the form of rewards and career merits was suggested, as was making activities requirements for obtaining funding. For example, the NWO reported that it was preparing to introduce a data section in funding proposals, which requires researchers to provide a data management plan at the start of their project, and make data management costs eligible for funding.

The need for policy intervention in the field of open access and copyright regulation, which has been the object of a debate over several years, was more debated within certain stakeholder groups, for example academic publishers and research intermediaries.[23] Scientific Publisher Reed Elsevier stated that there was little need for further intervention for Open science in open access to publications, or for copyright regulation that impacts text and data mining, but that these areas should be monitored[24]. PLOS, however, advocating a system-wide policy approach, supported policy action across all areas related to Open science, including open access and copyright regulations. PLOS also discussed the importance of monitoring and assessment. Other academic publishing and research intermediaries groups – LIBER, Nessi, and OpenAIRE and COAR – also favoured policy actions to support open science.[25]

3.4 The role of citizen science

Citizen science was ranked by respondents as having the lowest need for policy intervention (for all respondents taken together and within the 'individuals' and 'organisations' subgroups).[26] It should be noted that the majority of consultation participants were involved in the research community; and their views may differ from the views of those members of the general public who might have an interest in citizen science.

On the one hand, some stakeholders noted the importance of involving the larger public in research endeavours and taking advantage of new media and Open science to bring science closer to the public through various means (e.g. open labs, personal engagement of scientist with local communities). In addition, some stakeholders

[22] Both open access to publications and open access to research data ranked 9 or above respectively by 47% and 44% of the respondents, both with a mean ranking position of 7.4

[23] Academic publishers and research intermediaries included publishers and related industry groups (Reed Elsevier, PLOS, the European Technology Platform for Software and Services Nessi and two others), libraries (the Association of European Research Libraries LIBER), open access infrastructure organisations (the Open Access Infrastructure for Research in Europe OpenAIRE and Confederation of Open Access Repositories COAR, which submitted a joint statement).

[24] Two other industry groups generally agreed that policy intervention was not needed in these areas, with one saying that open access to data can discourage industry participation in research and another saying that current copyright regulations act not as a barrier but an enabler for new licensing options and developments.

[25] According to LIBER, funders should mandate open access to publications, data and tools, and that copyright reform must be an immediate priority. LIBER stated that 'the lack of harmonisation of copyright law across Europe and globally is hampering access and collaboration'. They added that US researchers, who benefit from a more favourable copyright regime, have produced over half the world's text and data-mining related publications and patents (p. 2). OpenAIRE and COAR said that policy support (e.g. from funders) is needed for the use of open licences for both publications and data. OpenAIRE and COAR also said that legal clarity and harmonisation is needed across the EU and the world for IP laws (see also section 2.2.).

[26] 'Citizen science' had a mean score position of 4.7, while all the other options for policy intervention had a higher mean ranking position (each respondent had to score the importance of a given issue on a scale of 1 to 11, with 11 being the highest need). More importantly, 30% of the respondents ranked it either 1 or 2.

recognised that involving the public in a constructive dialogue could help make research more responsive to societal challenges.[27] PLOS, for instance, suggested that Open science could help shift research focus to locally relevant problems through Open science-facilitated networking[28].

On the other hand, there was recurrent agreement on the need for more debate on the role of citizens in science, crowdfunding and the setting of research agendas. Some stakeholders stressed that citizen involvement and democratic policymaking must not compromise the intellectual freedom of science.[29] LERU warned that citizen science might not be appropriate to provide an opinion in some subject areas which can only be appropriately understood with a high level of technical expertise.

LERU also recommended that the European Commission help broker discussions regarding the purpose of citizen science (as public engagement or robust research) and what the role of universities should be.

One organisation from outside the research community advocated for more involvement of civic organisations, such as NGOs, in multiple aspects of Horizon 2020 on the basis that they often act as brokers between researchers and policymakers.

3.5 Researchers' careers

With regards to taking Open science-related activities into account for career progression, stakeholders' points of view generally: On the one hand, they recognised that activities falling under the umbrella of open science, such as data curation, should be recognised and considered for recruitment (FCT Portugal) and career progression (e.g. Science Europe, ISE).

On the other hand, some stakeholders suggested that that the mandatory inclusion of Open science activities into career progression could constitute an additional stress factor to the already high workload of junior scientists (e.g. Young Academy Europe). Furthermore, Science in Transition Netherlands recommended taking a look at the incentive systems which characterise academic research, publication and teaching goals to ensure that the quality of teaching and publications remain high.

Stakeholders also engaged in a more general discussion regarding the current shortcomings of research careers. Stakeholders attending the workshop in Leuven agreed that there was a lack of clarity regarding career progression options. Stakeholders encouraged the promotion of greater transparency and merit-based research careers in all EU Member States, and the improvement of links between research degrees and the job market (see policy recommendations).

3.6 Open science in the future of peer review and research evaluation

Workshop participants agreed on the value of peer review in the research evaluation process, although there was some disagreement about whether criticism of peer review is a driver of Open science. For example, Reed Elsevier said, in its position statement, that 'peer review is an essential dividing line for judging what is scientific and what is speculation' adding that 'change is… more to do with the drive for efficiency and accountability' (p. 4).

[27] Bucharest

[28] Organisations that discussed citizen science and crowd funding generally agreed that these activities may be helpful in public engagement, but their role should not be overstated. FCT Portugal said that crowd-funding should not replace other funding sources, especially "in all but the richest countries" (p. 1). The Initiative for Science in Europe identified Wikipedia as playing an important role in the dialogue between scientists and the wider public. They noted that it was an important example of online collaboration and often the first source that citizens turn to for scientific information.

[29] Leuven, London, Bucharest

Several stakeholders also highlighted the contribution that Open science could make to the current peer review system. They discussed the potential of digital tools and open policies to create a more efficient and transparent review system without overhauling or replacing the current system.[30] For instance, stakeholders recognised that Open science could increase efficiency by reducing the costs of peer review, promoting collaborative peer review methods and encouraging a wider range of researchers to engage with the evaluation of publications and grants.

However, the discussion also converged on the limitations of the current system. Representatives from PLOS emphasised the inability of traditional peer review to scale to the extent of the current networked research system. Trends such as the growing number of publications in both English-speaking and non-English-speaking countries and proportional shortages of peer reviewers, the growing multidisciplinarity of scientific collaborations, lack of recognition for reviewers, and the use of large and complex datasets were all cited as putting a growing strain on the peer review system. They also stated that the validity of reviews is often called into question due to a lack of transparency (given that these reviews were often anonymous).

Stakeholders hence recognised that incentives should be targeted towards involving more researchers in peer review.[31] For example, Science Europe suggested that, instead of performing separate stand-alone evaluations for every article and grant, a centralised evaluation system, building on the concept of Open science, could bring together reviews carried out over time. This system would then build up profiles of researchers or projects and present a broader picture of performance, potentially covering diverse outputs (e.g. via altmetrics). This approach could also reduce the burden placed on researchers to carry out peer review.

3.7 The use of new metrics

The question of how to evaluate research is heavily tied to how research output is measured and ongoing debate on the use of metrics in general and alternative metrics (or 'altmetrics') more specifically.

3.7.1 The inadequacy of traditional metrics

There was general acceptance of the idea that traditional metrics are inadequate and that alternative ways to monitor Open science activities were necessary. Existing metrics were criticised as part of a general debate regarding the fitness-for-purpose of research evaluation, as LERU underlined in its position statement (p.4). Traditional metrics (e.g. citation scores, impact factors) were seen as often leading to a 'function creep', used as inappropriate proxies (for instance citation numbers used to indicate quality).

Traditional metrics are even less applicable in Open science, according to several stakeholders (where the number of citations may differ significantly from the number of views online, for example). Therefore, several stakeholders highlighted the importance of incentivising desirable behaviours related to Open science in reviews and evaluation. Elsevier recommended diversifying current metrics by using a basket of metrics; involving peers; and increasing transparency in the use of research metrics.

Stakeholders also discussed examples where the trend was undeniably to move away from 'productivity' metrics. For example, the Commission has noted that Dutch Universities and funding organisations have adopted a new standard evaluation protocol for research to omit 'productivity' (in terms of number of publications) and

[30] London
[31] London, Madrid

include the societal relevance of research as an assessment element. Science in Transition Netherlands also suggested attributing a greater relevance to qualitative criteria rather than quantitative metrics to evaluate publications, grant applications and researchers.[32]

3.7.2 The debate surrounding altmetrics

The majority of stakeholders recognised that some form of alternative metrics could be used to measure the involvement of researchers in Open science to complement (rather than substitute for) conventional metrics. Hence, it was mentioned that 'altmetrics' may not be a suitable term for these new measures, since the prefix 'alt' implied a notion of substitution. Instead, these metrics could be complementary and additional to traditional bibliometrics (and in this sense a suitable term could be 'addmetrics').

However, discussions in the workshops showed that the precise dimensions to be covered by altmetrics remained relatively unknown. As such, altmetrics were recognised as bringing the evaluation of scientific research impact into unchartered territories, by including new measures (such as those approximating public reach; public engagement; societal relevance or policy impact). Stakeholders hence agreed that further discussion was needed in order to find the appropriate composition and role for these metrics (FCT Portugal, RSC, EUA, ICorsa, OpenAIRE, COAR, PLOS).

Participants at the workshop in Madrid appeared to agree with the European Commission, which stated that 'altmetrics' should be a multidimensional concept. According to them, the concept should also include an element of technical skills such as the ability to use new technologies ('techmetrics'), ability to use quantitative data ('datametrics'), or to be used to evaluate research ('submetrics').[33] Finally, stakeholders generally agreed that altmetrics should be developed in partnership across different stakeholder groups, including university and research organisations and academic publishers and research intermediaries[34].

4. Policy Recommendations

This section summarises the main policy recommendations emerging from this consultation and formulated by stakeholders during the workshops. It includes recommendations that received particular emphasis in discussions and statements. While the research team has aimed to accurately represent what appeared to be the main recommendations based on the questionnaire, position statements and workshop discussions, the team has not validated this selection with consultation participants or other stakeholders.

4.1 Policy recommendations from the respondents related to universities and research performing organisations included:

- Modify patterns of research funding (cross-border funding, promote open access)
- Need to set clear expectations about role of Open science in research career paths
- Provide or support training on 'innovative digital skills'

[32] Bucharest
[33] Madrid
[34] An example of such a collaborative effort was presented by Reed Elsevier, which highlighted its initiative, Snowball Metrics. Snowball metrics aims to encourage universities to agree on and develop international standards for metrics to build and monitor institutional strategies.

- Target funding towards Open science, including for the creation and maintenance of research infrastructures
- Cross-cutting message: Open science is highly discipline specific (no 1-fit-4-all)
- Three categories of potential actions come out strongly:

  (1) Financial support (big science is costly)

  (2) Enforcement of rules & governance (e.g. on data protection, quality assurance and use of (alt)metrics)

  (3) Non-financial incentives (e.g. acknowledgement in recruitment & careers)

4.2 Policy recommendations from academies, learned societies and research funders included:

- Need to raise awareness and support stakeholders take-up
- Increase openness and remove barriers to publications and research data
- Develop infrastructure for Open science, for example through H2020
- Provide support for highlighting and spreading best practices and ethical behaviour in data management
- Encourage skills and training for Open science at all levels, possibly adapting university curricula to new needs
- Further discussion and consultation are needed to better understand Open science and the realm of policy intervention within it
- Consider including Open science in peer review outputs

4.3 Policy recommendations relating to civil society groups and societal engagement included:

- Enhance recognition of organisations and platforms that bridge the gap between science and society, such as NGOs, science journalists, Wikipedia
- Support development of citizen science platforms
- Support discussions on the role of citizen science
- Discuss and agree best practice in citizen science
- Encourage communication between scientists and citizens.
- Rely on crowdfunding as an additional source of funding rather than a substitution to traditional funding sources.

4.4 Policy recommendations from academic publishers and research intermediaries included:

- Encourage more discussion, awareness-raising and development of metrics
- Include monitoring of policy interventions and progress in policy interventions- this can influence direction while reducing risk of unintended consequences
- Commission should set example of best practice in optimising a networked research system in Europe; it should use a systems approach to policy
- Encourage or mandate open access to publications data and tools, and interoperable licenses with clear reuse statements
- Ensure open access to publications and data is implemented and host repositories, provide tools and training for open science, and raise awareness about open access (possibly through incentives and recognition).

4.5 Recommendation on the scope of 'Open Science': research integrity, societal relevance of research and reviewing the science-policy relationship

A substantial number of respondents are in favour of extending the scope of open science.

These include issues such as scientific integrity, societal relevance of research, and reviewing the science-policy relationship. 68 Percent of the respondents to the consultations agree or partially agree that 'growing public scrutiny of science and research integrity is a driver of 'open science, whereas 78 percent agree/partially agree with that 'open science' will lead to greater scientific integrity. The issue of scientific integrity has been discussed among other in the context of the future of peer review. There are various fora which experiment with a more open and transparent peer review process.

During the validation process, stakeholders also discussed the current pre-dominance of 'productivity' metrics for evaluating the work of researchers and the wish to have alternative assessments available for, among other, the societal relevance of research. In some of Member States of the EU, there has already been an institutional change. For example, Dutch Universities and funding organisations have adopted a new standard evaluation protocol for research to omit 'productivity' (in terms of number of publications) and include the societal relevance of research as an assessment element. The discussion on 'Science in Transition' in the Netherlands, for example, suggested attributing a greater relevance to qualitative criteria rather than quantitative metrics to evaluate publications, grant applications and researchers. The trend to relativize the use of productivity bibliometrics is undeniable.

Several stakeholders also believe that 'Open Science' can improve the science-policy relationship, for example by a more transparent process concerning the establishment of scientific evidence for policy purposes.

Appendix 1 Preliminary topics for policy action on Open science

Appendix 1 provides an overview of the topics for policy action were prepared by the European Commission. The table shows the stakeholders support for the various actions.

Table 1 provides a list of these topics and is divided in the following columns:

(1) 'Policy action' is the general category which requires action [Suggested by the European Commission]

(2) 'Need to act' is understood as the identified gap or blockage in science 2.0' (or reasons why there is a need) [Suggested by the European Commission]

(3) 'Required action' is what policy-makers could do in general [Suggested by the European Commission]

(4) 'Implementation at EU level' includes what the European Commission (or European institutions) could do [Suggested by the European Commission]

(5) 'Questionnaire responses corresponding to these issues' provides the quantitative results from the online questionnaire, broken down to the responses regarding the issues discussed in each row.

Table 1 List of topics for policy action on Open science

Policy action	Need to act (Issue to address-gap/blockage)	Required action	Implementation at EU level	Questionnaire responses corresponding to these issues[TA= totally agree; PA= partially agree]
Foster Open science	1a Need to raise awareness and support stakeholders take-up Need for reinforcement of stakeholders ownership and trust	Organise debates at national and European levels Put representative stakeholders in charge	Establish a stakeholders forum at European Level and a self-regulation/ clearinghouse mechanism for addressing Open science issues	Questionnaire analysis: 50% TA (39% PA) that 'limited awareness of Science 2.0' is a barrier at the institutional level. 43% TA (41% PA) that 'limited awareness of benefits of Science 2.0 for researchers' is a barrier at the level of individual scientists. Most effective channels for awareness raising: top choice was integration in research training (65% TA, 28% PA), followed by funding of specific actions (59% TA, 30% PA) Altmetrics: 22% TD (41% PD) that 'Recent metrics (e.g. altmetrics) are well known. Just 5% TA 53% TA (35% PA) that 'concerns about quality assurance' are a barrier for Science 2.0 at the level of individual scientists 26% TA (44% PA) agree that concerns about ethical and privacy issues are a barrier at the level of individual scientists. Figures are roughly similar for looking at these concerns as barriers at the level of institutions Altmetrics: 54% TA (27% PA) that 'research metrics cannot be determined by private actors.
	1b Need to foster: -More reliable science (by allowing to verify data); more efficient science (by sharing resources); more responsive science (by contributing to societal challenges)	Provide incentives to make scientific work available on online platforms as early as possible	Establish a European Portal and/or support market take-up of existing solutions (e.g. Research Gate, Mendeley)	Drivers of Science 2.0 include public demand for… Better and more effective science is a key driver of Science 2.0: 36% TA (39% PA) Faster solutions to societal challenges: 26% TA (45% PA) Science 2.0 implies science that is… More reliable: 46% TA (37% PA) More efficient: 42% TA (41% PA) More responsive to societal challenges: 29% TA (47% PA) Science 2.0 opportunities at institution level include: Accountable and collaborative research modes: 48% TA (42% PA) Better science: 44% TA (37% PA).Avoiding duplication: 37% TA (39% PA)

Policy action	Need to act (Issue to address-gap/blockage)	Required action	Implementation at EU level	Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]
	1c Need to foster: Better knowledge circulation within science and to society	Provide specific support for spreading Open science good/best practices	Provide H2020 support, e.g. in the form of prizes	[Wide stakeholders support (recent SIS-RRI Italian conference)] Drivers of Science 2.0 include… Growing public scrutiny of science and research: 28% TA (44% PA) Science 2.0 implies… Reconnecting science and society: 33% TA (43% PA) Science 2.0 opportunities at individual level include: Wider dissemination and sharing of research outputs: 73% TA (22% PA) Involvement in international networks of research: 63% TA (31% PA) Involvement in more multidisciplinary research: 59% TA (32% PA) Greater publication opportunities: 39% TA (45% PA) Engaging with society: 45% TA (38% PA) Science 2.0 opportunities at institution level include: Creating scientific output to underpin public policy: 28% TA (46% PA) Respondents ranked open access to publication and data as the two areas with the highest need for policy intervention Public authorities could facilitate uptake of Science 2.0 by: Policies for easier public access to scientific publications: 73% TA (23% PA) Policies on data sharing for research purposes: 71% TA (24% PA) (these were the two most agreed-with responses)

Policy action	Need to act (Issue to address-gap/blockage)	Required action	Implementation at EU level	Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]
Remove barriers to Open science	2a Lack of credit for Open science activities of researchers	Reward researchers engaged in Open science activities	Consider adapting the European Charter of Researchers and Code of Conduct for the Recruitment of Researchers	Barriers to Science 2.0 at level of individual scientist: Lack of credit for Science 2.0: 50% TA (38% PA) Uncertain benefits for researchers: 35% TA (46% PA) Lack of incentives for junior scientists to engage with Science 2.0: 44% TA (32% PA) Barriers to Science 2.0 at level of institutions: Uncertain benefits for research: 37% TA (44% PA) Science 2.0 activities should be taken into account for researchers' career progression: 48% TA (37% PA) Science 2.0 activities shouldn't impact the recruitment modes of research organisations: 33% TD (35% PD) The third most agreed option as a channel for awareness-raising was: Integration in career promotion procedures (53% TA, 31% PA) Least agreed option for Science 2.0 opportunities at the level of individual scientists was 'Enhanced career perspectives' (23% TA, 42% PA) Public authorities could facilitate Science 2.0 uptake by: Acknowledging Science 2.0-based output (48% TA, 38% PA)
	2b Obstacles to the involvement in research (as co-producers) of non-academic actors	Allow research funders to provide specific incentives for 'collaborative science' including societal actors	Consider adapting rules of participation and launching Open science pilots (incl. under H2020)	Least agreed option as a driver of Science 2.0: Citizens acting as scientists (11% TA, 33% PA) Most agreed option as a barrier for Science 2.0 at level of individual scientist: concerns about quality assurance (53% TA, 35% PA) Least agreed option as implications of Science 2.0: Crowd-funding an important research funding source Lowest ranked option of issues that need policy intervention: Citizen Science (4.7 on scale of 1-11)

Policy action	**Need to act (Issue to address-gap/blockage)**	**Required action**	**Implementation at EU level**	**Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]**
	2d Legal constraints for using personal data in (health) research	Better take into account public benefits and social interest when reviewing personal data protection	Create a research exception under the General Data Protection Regulation	See above on barriers at level of individual scientist, and: Concerns about ethical and privacy issues: 26% TA (44% PA).
	2e Lack of e-skills amongst researchers	Adapt university curricula to new needs	Foster/support the voluntary introduction of academic modules for e-skills	<u>Barriers at level of individual scientist:</u> Lack of research skills fit for 'Science 2.0': 43% TA, 37% PA Integration in research training was the most agreed option as an effective channel for awareness-raising (65% TA, 28% PA)
Develop research infrastructures for Open science	3 Insufficiently effective inter-connexion of research infrastructures	Enable Big data solutions in secured virtual environments to generate smart solutions for analysing complex data from different sources	Mandate the development of common interfaces and data standards Coordinate at European Level the funding/ maintenance and interoperability of research infrastructures Support the development of a Research Cloud for data, protocols and methodologies	<u>Barriers to Science 2.0 at the level of individual scientist:</u> Lack of integration in existing infrastructures (46% TA, 39% PA) In ranking question (need for policy intervention) research infrastructures were ranked on average 6.9 out of 11 by participants

Policy action	**Need to act (Issue to address-gap/blockage)**	**Required action**	**Implementation at EU level**	**Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]**
Mainstream Open Access to publications and data	4 Principle of wide access to publically funded research results/data Improvement of the overall functioning of science: more easily findable and better/ broader use of results/data (e.g. beyond academic context, making other actors co-producers of science) Increasing responsiveness of science to societal challenges	Step up existing Open Access policies in Europe	Consider extending the H2020 pilot on OA to data Develop EU guidelines for addressing IPR issues and the funding of data-management	Drivers of Science 2.0: Researchers looking for new ways of disseminating their research (47% TA, 43% PA) Scientific publishers engaging with Science 2.0 (22%TA, 40% PA) Public demand for faster solution to Societal challenges (26% TA, 45%PA) Implications of Science 2.0 for society and the ecosystem: Science more reliable (e.g. re-use of data) (46% Ta, 37% PA) Science more responsive to societal challenges (29% TA, 47%PA) Opportunities for Science 2.0 for individual scientists: Wider dissemination and sharing of research outputs (77%TA, 22% PA) Greater publication opportunities (39% TA, 45% PA) Opportunities for Science 2.0 at the institutional level: Accountable and collaborative research modes (48% TA, 42% PA) Creating scientific output to underpin public policy (28% TA, 46% PA) Barriers to Science 2.0 at the level of the individual scientist: Legal constraints (e.g. copyright law): (43% TA, 38% PA) The role of public authorities Policies for easier access to scientific publications the most popular option (73%TA, 23% PA) Policies on data sharing for research purposes (71%TA, 24%PA) The EC should promote Science 2.0 under H2020 (52% TA, 34%PA) The EC should promote Science 2.0 under ERA (48% TA, 32%PA) In the ranking questions on the need for policy intervention, Open access to publications and research data were both ranked on average 7.4 out of 11. Open source was ranked 5.5 while open code was ranked 5.4.

Policy action	**Need to act (Issue to address-gap/blockage)**	**Required action**	**Implementation at EU level**	**Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]**
Open science as economic driver	5 Stronger relation between science and business actors to accelerate innovation	Create 'knowledge coalitions' among societal, entrepreneurial and scientific actors.	Set up and implement a European Open science Agenda to address common societal challenges as part of the DSM	Drivers of science 2.0 include: Public demand for faster solutions to societal challenges (26% TA 45% PA) Barriers at institutional level include: Uncertain socio-economic benefits (29% TA 44% PA) Science 2.0 implies: Faster and wider innovation (42% TA, 40% PA) – ranked third Data-intensive science as a key economic driver (41% TA, 38% PA)- ranked fourth Opportunities for science 2.0 at institutional level include… Driving economic growth (26% TA, 49% PA)

Policy action	Need to act (Issue to address-gap/blockage)	Required action	Implementation at EU level	Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]
Altmetrics				Alternative reputation systems ranked 5th overall as an issue that needs policy intervention (5.7 on scale 1-11); research metrics were 10th (5.3 on scale 1-11)
	Traditional metrics do not capture full range of Open science activities (e.g. data sharing, open access, engagement outside academia)	Discuss how science is evaluated (e.g. for funding decisions and publications)	Support an EU-wide review of established indicators and metrics used in science evaluation (what they measure, how they might affect research culture and behaviour)	
	Need a way to evaluate Open science outputs	Identify aspects of Open science to evaluate and develop methods for evaluating them	Support activities to explore how to evaluate Open science activities	
	Need to raise awareness about Altmetrics and become aware of possible unintended consequences of their use, and reach agreement about how they should be used	Promote dialogue and awareness-raising activities and events with a wide range of stakeholders	Sponsor awareness-raising activities	Altmetrics should include impact beyond academia (22% TA, 9% TD) Altmetrics should include involvement of civil society (20% TA, 9% TD) Altmetrics should replace conventional metrics (28% TD, 27% PD) Altmetrics are well known (22% TD, 41% PD)
	Need to ensure reliability, accuracy, transparency of Altmetrics, and build understanding of what they measure (and what they cannot measure)	Continue development of altmetrics	Support research programme on Altmetrics (in Horizon2020 for example)	Data and algorithms should be transparent (85% TA, 10% PA) Research is needed to advance quality assurance: (59% TA, 29% PA) Research metrics cannot be determined by private actors (54% TA, 27% PA)

	Need to act (Issue to address-gap/blockage)	Required action	Implementation at EU level	Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]
Citizen Science	Scientists perceived to be (and may be feeling) distant from citizens. Societal relevance of research not communicated enough	Encourage communication between scientists and citizens. Encourage policymakers to engage more with scientific evidence	Facilitate academic-citizens dialogue Best practice exchange	Topic was lowest ranking priority of all options (average 4.7/11, mode=1). Stakeholders expressed a variety of views in the workshops; many supporting stronger synergies between research and the wider public. Drivers of Science 2.0: - Citizens acting as scientists was least consensual option, with 11% TA and 33% PA (34% PDA and 16 %TDA) Growing public scrutiny of science and research was recognised as a driver by 28% TA (44% PA) of respondents.
	Need to clarify role of citizen science in research	Discuss and agree best practice in citizen science	Establish a platform for best practice at EU level	Implications of Science 2.0 for society, economy and research system: - Reconnecting science and society (33% TA, 43% PA) - Research more responsive to society through crowd funding (21%TA, 39%PA) and Crowd-funding as an important source of funding (18%TA, 40% PA) were the two answers with lowest consensus. Opportunities for Science 2.0 at the level of individual scientist: Engaging with society (45%TA, 38% PA)
The future of peer review	Increased global science activity and funding competition is driving up demand for peer review. Meanwhile, there are concerns about the quality of peer review	Explore ways to use Open science to aid peer review (e.g. trialing public reviews, sharing reviews across journals) Reward and incentivise peer review	Support research to evaluate novel peer review approaches (e.g. open reviews) Offer prizes for innovative peer review solutions, and to recognise researchers who do a lot of good quality peer reviewing	Drivers of Science 2.0 include: Growing criticism of peer review (34% TA, 42% PA) Science 2.0 opportunities at level of individual scientist include: Possibility to review the peer review system (38% TA, 42% PA) Public authorities could facilitate Science 2.0 uptake by: Reviewing procedures of quality assessment of research (53% TA, 38% PA) Reviewing evaluation criteria of research proposals (54% TA, 33% PA)

Policy action	**Need to act (Issue to address-gap/blockage)**	**Required action**	**Implementation at EU level**	**Questionnaire responses corresponding to these issues [TA= totally agree; PA= partially agree]**
Open science as tool for competitiveness	Lack of clarity regarding benefits of open science in an international environment	Justify open science in the context of international competitiveness	Encourage bilateral and multilateral negotiations regarding open access and open data	
Research careers	Need to set clear expectations about role of Open science in research career paths	Encourage universities and others to develop common standards on Open science role in careers	Consider adapting European Charter of Researchers and Code of Conduct for the Recruitment of Researchers	

Appendix 2 Stakeholders' positions summary table

Appendix 2 presents an analysis of the agreement or disagreement to the suggested policy actions in appendix 2, drawing upon the position statements provided by stakeholders. (If a position statement did not address a particular issue or action, it was not counted).

Table 2 presents this analysis in the form of percentages while Table 3 lists the names of stakeholders supporting policy intervention on a policy issue.

Strong agreement appears on the need to raise awareness of Open science and support stakeholder ownership of it and the associated action: organising debates and putting stakeholders in charge (row 1a). There was also strong support for the need for research infrastructures and associated actions (row 3), and for mainstreaming open access to publications and data (row 4).

Other areas receiving strong support were the idea that Open science can lead to better circulation of knowledge among scientists and between science and society, the need for Open science skills training, and the need to ensure 'altmetrics' are reliable, accurate, transparent and well understood.

Areas with stronger disagreement related to text and data mining and copyright legislation, open access, using Open science to aid peer review, and the need to increase ties between citizens and science (this area also had the lowest level of agreement).

In general, there was less support for particular actions – in part because position statements often did not include suggestions of specific actions or included actions that were much less specific than the ideas outlined in the table above.

The columns in Tables 2 and 3 follow the typology issued by DG RTD.

i. 'Need for intervention' is understood as the identified gap or blockage in science 2.0' (or reasons why there is a need)
ii. 'Required action' refers to what policy-makers could do in general

'Implementation at EU level' refers to what the European Commission (or European institutions) could do.

Table 2 Percentage of agreement for certain policy actions (based on analysis of position statements)

	Need for intervention		Required action		Implementation at EU level	
Question/issue	**Agree**	**Disagree**	**Agree**	**Disagree**	**Agree**	**Disagree**
1 Foster open science a- raise awareness, SH ownership	52%	4%	48%	4%	19%	4%
1b- potentially more reliable, efficient, responsive science	33%	7%	0%	7%	4%	4%
1c-better knowledge circulation	41%	11%	30%	4%	7%	7%
2 Remove barriers a- lack of credit for Open Science	37%	7%	26%	4%	0%	4%
2b- obstacles to non-academic involvement	7%	4%	4%	4%	0%	4%
2c- laws on TDM	19%	7%	11%	7%	11%	7%
2d-laws on personal data	19%	7%	22%	7%	11%	7%
2e- lack of e-skills	44%	4%	19%	11%	15%	7%
3 Develop research infrastructures	56%	4%	11%	4%	48%	4%
4 Mainstream Open Access to pubs and data	63%	11%	33%	26%	26%	11%
5 Open science as economic driver	22%	7%	7%	7%	7%	7%
6 Altmetrics a- Trad metrics do not capture OS	22%	7%	22%	7%	4%	7%
6b Need way to evaluate OS outputs	30%	4%	19%	4%	4%	4%
6c raise awareness	33%	4%	15%	4%	0%	4%
6d ensure accuracy etc	41%	0%	4%	7%	4%	7%
7 Citizen Science a- scientists distant from citizens	11%	11%	7%	4%	0%	4%
7b Citizen Science - what is its role	11%	4%	7%	0%	4%	4%
8 Future of peer review	19%	11%	22%	7%	15%	7%
9 International competitiveness	26%	4%	19%	4%	0%	4%
10 Research careers	33%	7%	0%	7%	0%	11%

Table 3 Table of issues and stakeholders' positions

Question/issue	Need for intervention		Required action		Implementation at EU level	
	Agree	**Disagree**	**Agree with EC suggestion**	**Disagree with EC suggestion**	**Agree with EC suggestion**	**Disagree with EC suggestion**
Foster open science 1a- raise awareness, SH ownership	Icorsa LERU Leibniz EUA UUK Univ Denmark RCUK RSC Sci Europe NWO RCN EPHA Elsevier LIBER	STM	Icorsa LERU Leibniz EUA UUK Univ Denmark RCUK RSC Sci Europe NWO RCN EPHA Elsevier	STM	LERU Leibniz Sci Europe EPHA Elsevier	STM
Foster open science 1b- potentially more reliable, efficient, responsive science	LERU EUA UUK Univ Denmark Royal Soc RSC FCT (be careful of ext. demands) NWO EPHA	DFIR (closure also occurring) STM		STM Elsevier	NWO	STM
Foster open science 1c-better knowledge circ	Icorsa LERU Leibniz EUA EuroTech Flemish Univ Denmark Royal Soc NWO EFSJ EPHA	DFIR (closure also occurring) STM Elsevier	LERU EUA Eurotech Royal Soc ISE YAS EFSJ EPHA	STM	EFSJ EPHA	STM Elsevier

Question/issue	Need for intervention		Required action		Implementation at EU level	
	Agree	**Disagree**	**Agree with EC suggestion**	**Disagree with EC suggestion**	**Agree with EC suggestion**	**Disagree with EC suggestion**
Remove barriers 2a- lack of credit for Open Sci	Icorsa LERU EUA Royal Soc Sci Europe ISE (need to recognise it takes time) FCT NWO LIBER PLOS	UUK (did not include in their list of barriers) STM	Icorsa LERU EUA Royal Soc Sci Europe ISE NWO (esp good practice)	STM		STM
Remove barriers 2b- obstacles to non-academic involvement	EuroTech PLOS	STM	EuroTech	STM		STM
Remove barriers 2c- laws on TDM	EUA UUK NWO LIBER OPENAIRE	STM Elsevier	EUA UUK LIBER	STM Elsevier	EUA UUK LIBER	STM Elsevier
Remove barriers 2d-laws on personal data	EUA UUK EuroTech Univ Denmark (need to find balance) ISE	STM Elsevier	EUA UUK EuroTech Univ Denmark ISE YAS	STM Elsevier	EUA UUK ISE	STM Elsevier
Remove barriers 2e- lack of e-skills	LERU EUA UUK EuroTech Univ Denmark RCUK Royal Soc Sci Europe NWO Elsevier LIBER PLOS	STM	EUA UUK EuroTech Royal Soc LIBER	LERU (First agree on needs) STM Elsevier	EUA EuroTech Royal Soc LIBER	STM Elsevier

Question/issue	Need for intervention		Required action		Implementation at EU level	
	Agree	**Disagree**	**Agree with EC suggestion**	**Disagree with EC suggestion**	**Agree with EC suggestion**	**Disagree with EC suggestion**
3 Develop research infrastructures	LERU Leibniz EUA UUK EuroTech Univ Denmark RCUK Royal Soc Sci Europe FCT NWO RCN Elsevier LIBER OPENAIRE	STM	LERU Elsevier LIBER	STM	LERU (re: coordination) Leibniz (re: cloud) UUK EuroTech Univ Denmark RCUK Royal Soc Sci Europe FCT NWO RCN Elsevier LIBER	STM
4 Mainstream Open Access to publications and data	Icorsa LERU EUA Russell Group UUK Univ Denmark Royal Soc Sci Europe FCT NWO RCN EFSJ EPHA Digital Europe (pubs) Elsevier (pubs) LIBER OPENAIRE	STM Digital Europe (research data) Elsevier (data)	Icorsa EUA Royal Soc NWO RCN EFSJ EPHA Digital Europe (pubs) LIBER	LERU (advice better than policy papers) Russell Group (do not over-complicate situation) UUK (keep current policy) Univ Denmark STM Digital Europe Elsevier	EUA (on standards) UUK (on monitoring funding) RCN EFSJ EPHA Digital Europe LIBER	Russell Group (should evaluate pilot first) STM Elsevier
5 Open science as economic driver	LERU (via potential to develop drugs etc) UUK Royal Soc NWO EFSJ Digital Europe	STM Elsevier	EFSJ PLOS	STM Elsevier	EFSJ PLOS	STM Elsevier

Question/issue	Need for intervention		Required action		Implementation at EU level	
	Agree	**Disagree**	**Agree with EC suggestion**	**Disagree with EC suggestion**	**Agree with EC suggestion**	**Disagree with EC suggestion**
Altmetrics 6a Trad metrics do not capture OS	Icorsa EUA Flemish Univ Denmark Elsevier Plos	STM LIBER	EUA Icorsa LERU UUK Univ Denmark PLOS	STM Elsevier	PLOS	STM Elsevier
Altmetrics 6b Need way to evaluate OS outputs	Icorsa EUA UUK Univ Denmark Royal Soc NWO RCN Sci Europe	STM	EUA Icorsa UUK Univ Denmark RCN	STM	UUK	STM
Altmetrics 6c raise awareness	LERU Russell Group UUK Flemish Univ Denmark RSC DFIR FCT OPENAIRE	STM	LERU Russell Group UUK Univ Denmark	STM		STM
Altmetrics 6d ensure accuracy etc	Icorsa EUA LERU Russell Group UUK Flemish Univ Denmark FCT STM PLOS OPENAIRE		UUK	LERU (need to decide how/if to use metrics) STM	UUK	Russell Group STM
7a Citizen Science - scientists distant from citizens	Icorsa Flemish Univ Denmark	LERU (there are good examples of citizen science) STM Elsevier	Flemish Univ Denmark	STM		STM
7b Citizen Science - what is its role	LERU DFIR EPHA	STM	LERU STM		LERU	STM

Question/issue	Need for intervention		Required action		Implementation at EU level	
	Agree	**Disagree**	**Agree with EC suggestion**	**Disagree with EC suggestion**	**Agree with EC suggestion**	**Disagree with EC suggestion**
8 Future of peer review	Icorsa LERU RCUK Royal Soc Sci Europe	UUK STM Elsevier	EUA Icorsa LERU UUK (but peer review needs to remain main way) RCUK Sci Europe	STM Elsevier	Icorsa LERU Sci Europe	STM Elsevier
9 international competitiveness	Icorsa EUA LERU Leibniz Russell Group Univ Denmark Royal Soc	STM	EUA LERU Russell Group Univ Denmark Royal Soc	STM		STM
10 research careers	EUA Icorsa LERU Univ Denmark ISE FCT Sci Europe (re: data) NWO (data careers) EPHA	STM RSC (need is unclear)		RSC STM		Icorsa (just discuss now) EUA (just discuss now) STM

Appendix 3 Topics raised by stakeholders which go beyond the mandate of DG Research and Innovation

In addition to the actions listed above, the following topics were raised by stakeholders but do not appear to directly relate to the mandate of DGRTD. These topics covered the following:

Open innovation 2.0

The first topic includes open innovation 2.0. Stakeholders encouraged the European Commission to undertake the following actions:

- Supporting better IT infrastructures across the EU (E.g. infrastructure for data management)
- More generally, promoting access to new technologies, overcoming Digital divides within and across European countries
- Reviewing business models between publishers and higher education providers (in particular libraries), and providing incentives to open access under the competition regulation.

Education 2.0

In addition, several stakeholders underlined the need to foster training and skills.

- Supporting the training on digital skills for doctoral students (and researchers at all stages of their careers).

Additional suggestions related to topics which were of the remit of member states, and included the following:

- Reforming research careers and peer review in general.
- Reform the system of national grant awards.
- Clarify the purpose and use of quality indicators used by national governments.