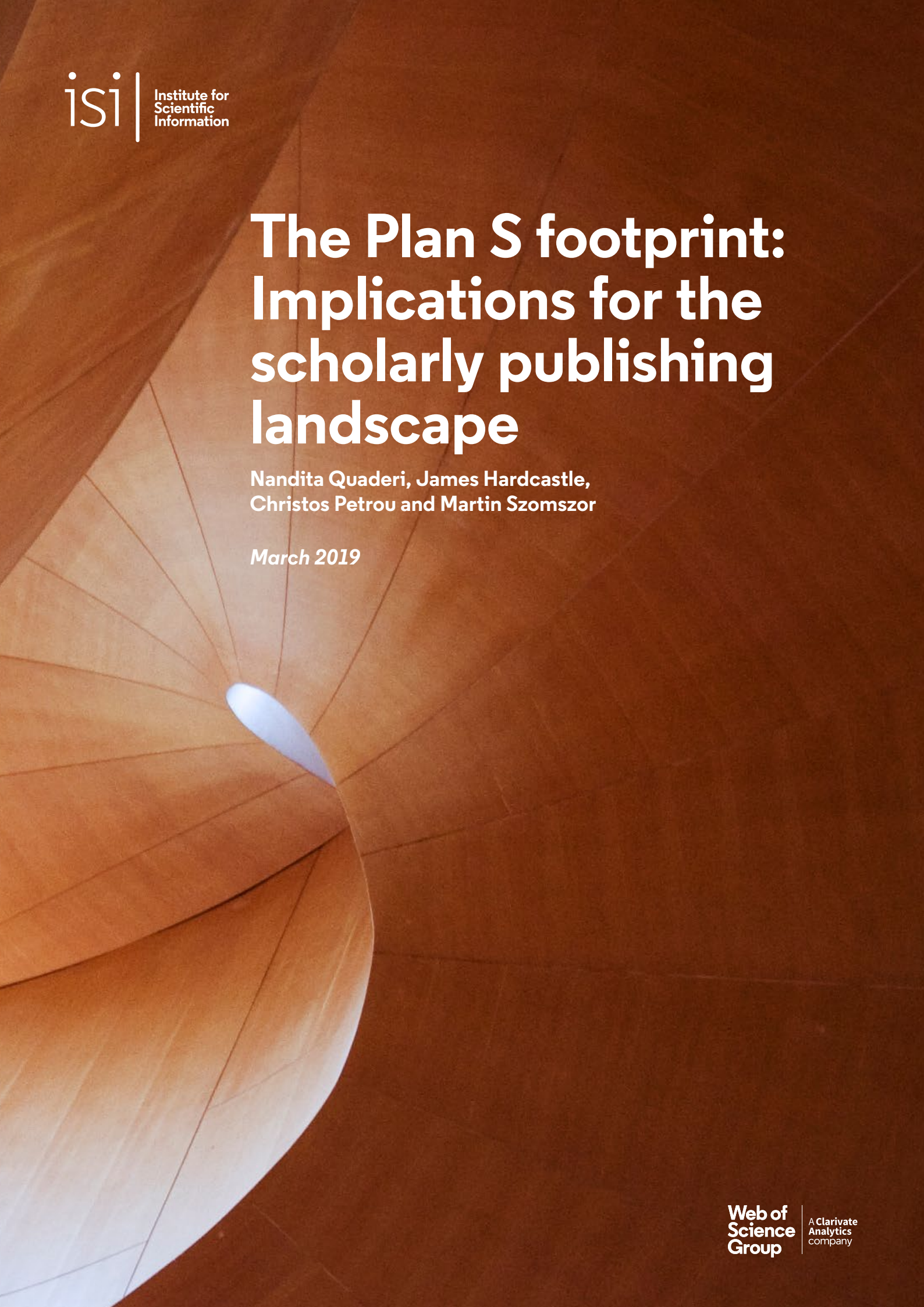

Institute for Scientific Information

The Plan S footprint: Implications for the scholarly publishing landscape

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Web of Science Group
A Clarivate Analytics company

Contents

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About the Global Research Report series from the *Institute for Scientific Information (ISI)*

Global Research Reports from *ISI* is a new publication series to discuss and demonstrate the application of data about the research process to management issues in research assessment, research policy and the development of the global research base. *ISI* is the 'university' of the *Web of Science Group* at *Clarivate Analytics*: it maintains the knowledge corpus upon which *Web of Science* and related information and analytical content, products and services are built; it disseminates that knowledge internally through reports and recommendations and externally through events, conferences and papers; and it carries out research to sustain, extend and improve the knowledge base.

About *Web of Science*

Web of Science is the world's most trusted and largest publisher-neutral citation index, powering global discovery and citation analytics across the sciences, social sciences and art & humanities. With more than 1.4 billion cited references going back to 1900 and millions of users per day — from leading government and academic institutions and research-intensive corporations — *Web of Science* citation network serves as the foundation for the *Journal Impact Factor*, *InCites* and other powerful and trusted citation impact measures. *Web of Science* helps researchers, research institutions, publishers and funders discover and assess the citation impact of over a century of research papers found in the most prestigious journals, books, and conference proceedings.

Summary

This report provides background analysis for debate about a research system in transition. Plan S, launched by Science Europe on 4 September 2018, is intended to increase Open Access (OA) to research data and reports produced through publicly-funded academic research. OA is expected to enable and accelerate discovery and innovation. Plan S requires research funded by signatory organisations to be published in open repositories or in journals where all papers are publicly accessible. This report looks at recent patterns of papers funded by Plan S supporters using perspectives related to funders, subjects, countries, publishers, and journals. It focuses on analysis and variances rather than scenarios.

Funders

Some research funders have already endorsed the Plan S proposals to widen OA. The research they support led to *circa* 6.4% of 2017 papers indexed in the *Web of Science*; the EU funded about half of this. Although OA compliance is already substantial, the proportion varies by funder.

Research areas

Existing mandates in research areas well-funded by Plan S organisations have led to relatively high OA compliance. Other research areas, such as Social Sciences, receive relatively less Plan S funding and have lower compliance. Research areas significantly challenged by Plan S are those which currently demonstrate low OA compliance plus relatively more Plan S funded papers, such as Mathematics. Journals that are currently Plan S compliant are not evenly distributed, either across or within research areas.

Citation frequency

On 2017 citation counts, Plan S funded papers are cited more frequently on average than other papers, and this is true in all research areas.

Countries

Under Plan S, some European countries would publish more than 40% of their output as OA. This could reach 50% where the national funder is also a Plan S supporter. About 19% of European international collaborative papers are supported by Plan S funders and therefore involve non-Plan S researchers. The USA is (in absolute terms) the second largest producer of papers that acknowledge Plan S funding and a high proportion of some institutions' output is Plan S supported. But the USA government has yet to endorse the plan.

Publishers

Across the landscape of publisher data, it is possible to typecast and populate a number of scenarios among the 200 larger houses (which collectively publish 95% of papers acknowledging a Plan S funder). There are those: not heavily affected; affected a little; a few (including some big houses) affected significantly; and OA-adopters who are well-positioned. Smaller houses, including some learned societies, are diverse and less readily categorised.

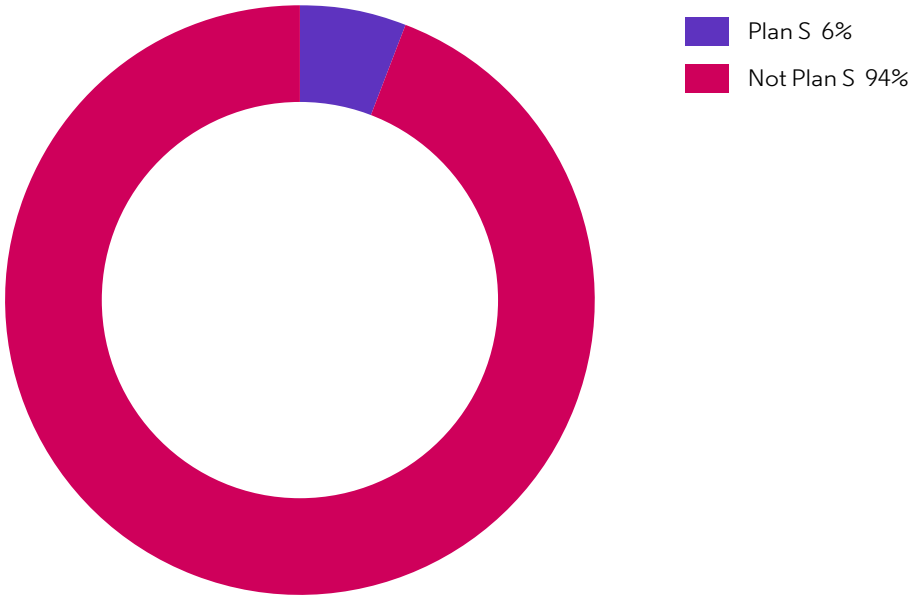
Journals

Plan S funded outputs make up less than 7% of global papers but they are well cited, published in high impact journals and, often, in journals from major publishing houses. They will influence the publishing landscape. Some 90,000 Plan S papers published as part of Hybrid or Subscription journals will need to be 'rehoused' if the journals do not change to fully OA. There are few Hybrid journals with a medium to high percentage of OA that might readily change. This implies challenging business decisions.

Some leading multidisciplinary journals contain as much as one-third Plan S content but are not Plan S compliant. Learned society journals have a central communication role in their research field but are not always OA. The relocation of content to OA titles would represent a 29% overall movement in the volume of well-cited papers to existing compliant venues, could be disruptive in some subjects, and suitable compliant venues are not always available.

Resources

The cost of publishing will shift, *ex post*, from the reader or their library, typically via a subscription charge, to an *ex ante* obligation on the author or their institutional proxy to pay via an APC. This would require a redirection of around €150 million. Meeting these costs will fall on research funders. It is not evident whether marginal resources are available to support all affected authors.



The share of papers indexed in *Web of Science* that contain an acknowledgment to one or more research funding agencies signed up to Plan S at December 2018. Plan S funders account for about 6% of papers indexed on the *Web of Science*. They are concentrated in around 10,000 of the 20,000 journals indexed.

Papers funded by Plan S organisations

Open Access (OA) is expected to enable and accelerate research and discovery. Some research funders have already endorsed an EU proposal (Plan S) to widen OA. The research they support led to *circa* 6.4% of 2017 papers indexed in *Web of Science*; the EU funded about half of this. Although OA compliance is already substantial, the proportion varies by funder.

"Open access" (OA) to research literature, as an enabling and accelerating factor for better outcomes, is a long-held ambition formalised in the early 2000s through the Budapest OA Initiative (2002), the Bethesda Statement on OA Publishing (June 2003) and the Berlin Declaration on OA in the Sciences and Humanities (October 2003). OA has spread rapidly and now constitutes about one-fifth of research output indexed in *Web of Science*. Plan S is a proposal to increase the spread of OA papers produced through publicly-funded academic research. It was launched by Science Europe on 4 September 2018 and is an initiative of "cOAlition S": a consortium of the European Research Council and national research agencies and funders, initially in Europe and then more widely. Plan S requires researchers who benefit from state-funded projects and institutions to publish in open repositories or in journals where all papers are publicly accessible. Papers are usually made accessible by Article Processing Charges (APCs) to the author, whereas conventional access is by subscription charges to the reader, or to their institution's library.

Paper, in this report, is used to include scholarly journal articles and reviews; it excludes conference proceedings and other papers. **Open Access (OA)** refers to scholarly research papers made available online and free at point of readership, usually using a Creative Commons license to promote reuse. **Gold OA** is content made freely available on publication frequently including an article publication charge (APCs) levied by the journal. **Hybrid**, in the OA sense, refers to a journal that publishes some Gold OA papers and also charges a subscription for access to the full non-Gold journal content. **Green OA** is where an author self-archives a copy of a journal paper in a freely accessible institutional or specialist online archive (repository) or on a website.

Plan S has stimulated many discussions and consultations and its likely implementation is evolving in response. As background information for this, we draw on data and metadata in *Web of Science* index to analyse the pattern of Plan S funded papers with respect to publishers, subject groups and other stakeholders in scholarly communication. Data sources and methods are described in an Annex.

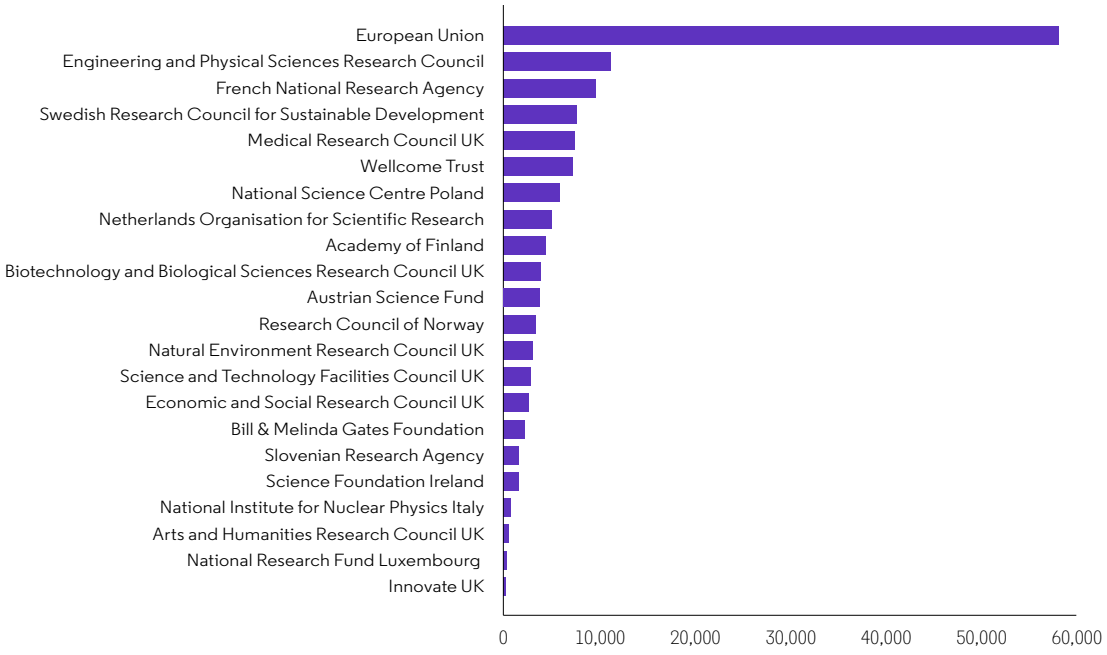
Plan S principles differ from existing OA policies and mandates: for example, Gold OA papers in a Hybrid journal may only be considered 'compliant' under specific circumstances; other exceptions may include circumstances where a paper is Green OA. For the purposes of this report, we assume that publishing in a journal listed in the Directory of Open Access Journals (DOAJ-listed) will be the main route to Plan S compliance. Such details remain to be worked through and the precise pathway of Plan S will likely change further. Some journals may convert to fully OA; additional funders may join Plan S; and other routes to compliance may appear.

We outline only the more obvious consequences. Plan S takes effect at journal level. Our analysis is mostly about papers, whether they are Plan S funded and whether they are OA. We discuss generic effects at journal level, but we have explicitly avoided carrying the analysis to specific titles.

As of December 2018, 20 funders were signed up to Plan S. The volume of 2017 papers acknowledging their funding varies across two orders of magnitude, from the EU with over 58,000 papers to the UK based Arts & Humanities Research Council with around 600 papers (Figure 1).

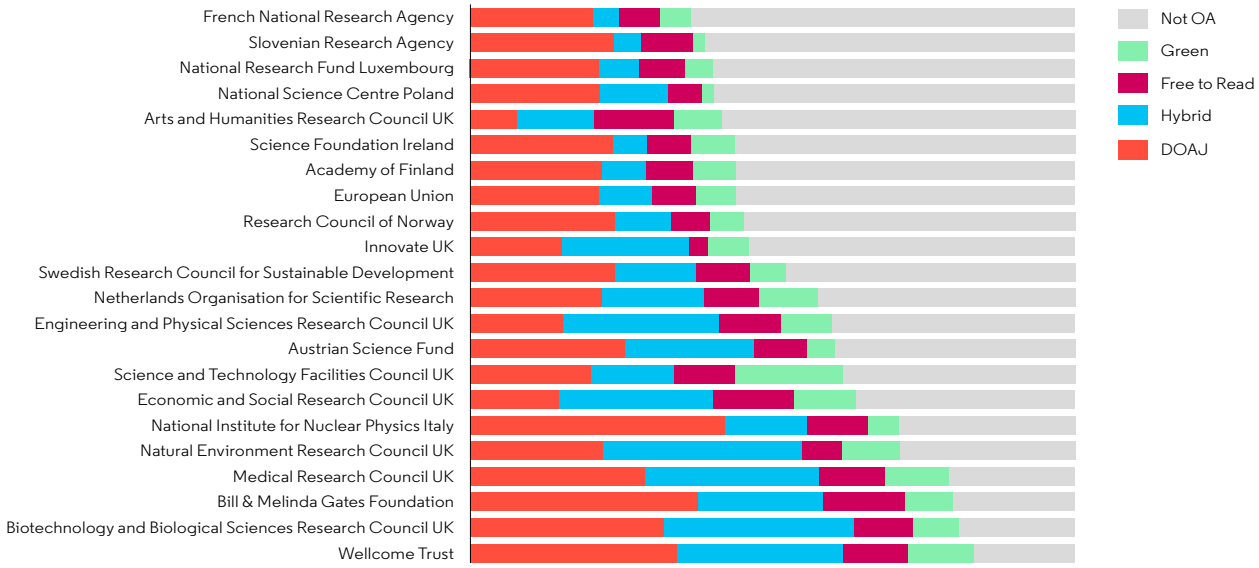
The use of OA by authors supported by Plan S funders is far from uniform (Figure 2). Some national figures may hide significant agency (and subject) diversity. The Wellcome Trust and the Bill & Melinda Gates Foundation have strong existing OA mandates and Gold OA uptake of 60%. National funders such as the National Science Centre of Poland, Slovenian Research Agency and French Research Agency have OA uptake at around half of these levels. Granular diversity can be seen among subject-based Research Councils supported from the UKRI Science Budget: the biomedical BBSRC and MRC have fairly high levels of Gold OA uptake but in social sciences (ESRC) and humanities (AHRC) Gold OA coverage is lower.

Figure 1.



Count of papers published in 2017 and indexed in *Web of Science* that acknowledge one or more funding organisations that have indicated support for Plan S.

Figure 2.



The proportions of papers published in 2017 that acknowledge one or more funding organisations that have indicated support for Plan S grouped by Open Access status.

How does Plan S affect research areas?

The papers funded by Plan S that are not currently published in Gold DOAJ-listed journals might be described as 'papers at risk'.

Existing mandates in research areas well-funded by Plan S organisations have led to relatively high OA compliance. Other research areas, such as Social Sciences, receive relatively less Plan S funding and have lower compliance. Research areas with low current OA compliance and relatively more Plan S funded papers, such as Mathematics, are significantly challenged by Plan S. The availability of journals that are currently Plan S compliant is not evenly distributed, either across or within research areas.

Data can be disaggregated by main research areas, using the 22 broad categories established in the Essential Science Indicators (ESI). These are science-based, covering the Science and Social Science Citation Indexes, so an Arts & Humanities category was added to include journals indexed only in the Arts & Humanities Citation Index. The ESI categories are primarily allocated at the journal level. The exception is for multidisciplinary journals such as *Nature* or *PLOS One* where paper-level classification is applied, using the references cited in each paper to associate them with a subject category.

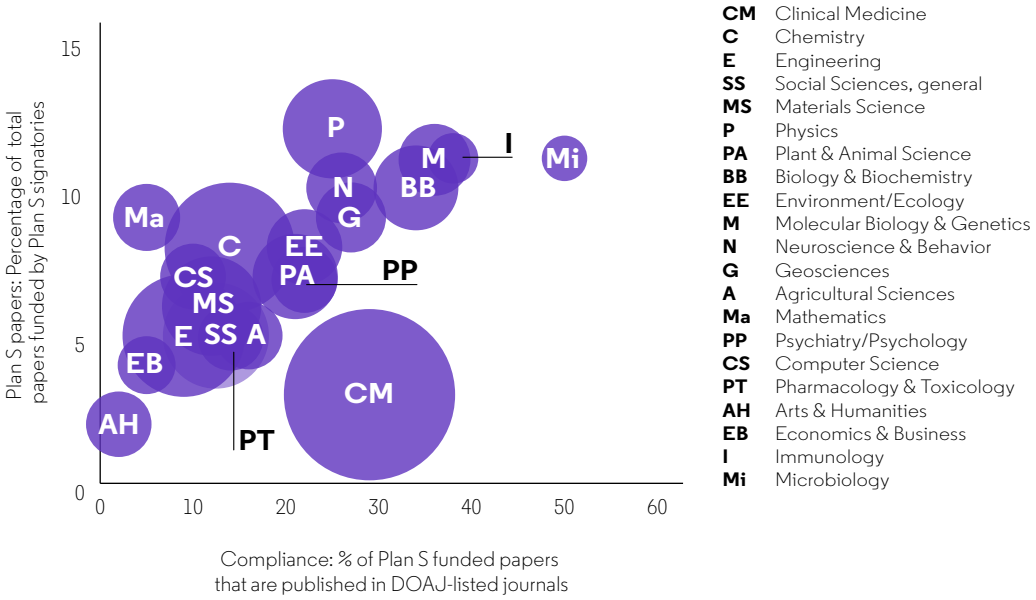
Around 3,000 papers published in 2017 (0.2% of all indexed papers) could not be assigned to a specific ESI category: these are excluded from further analysis in this section. Fewer than 2% of the papers indexed in the Emerging Sources Citation Index (ESCI) were by authors who acknowledged Plan S funding. These have also been excluded from this part of the analysis, because ESCI journals are not assigned to ESI categories and Plan S coverage was small.

Arts & Humanities has both the lowest proportion of papers acknowledging Plan S funders with 2.4% and the lowest share of Plan S funded papers in DOAJ-listed journals. Microbiology is at the other extreme. More than 11% of Microbiology papers acknowledge one or more Plan S funding agencies and more than 50% of the funded papers are published in DOAJ-listed journals. The other outlier is Space Science, where 26% of papers are funded by Plan S but less than 1% are published in DOAJ-listed journals.

There is a broad association between a greater rate of Plan S funding and a greater likelihood of publication in a DOAJ-listed journal. Clinical Medicine is a major outlier from this pattern, with a high rate of OA publication but a low likelihood of Plan S funding. (Figure 3)

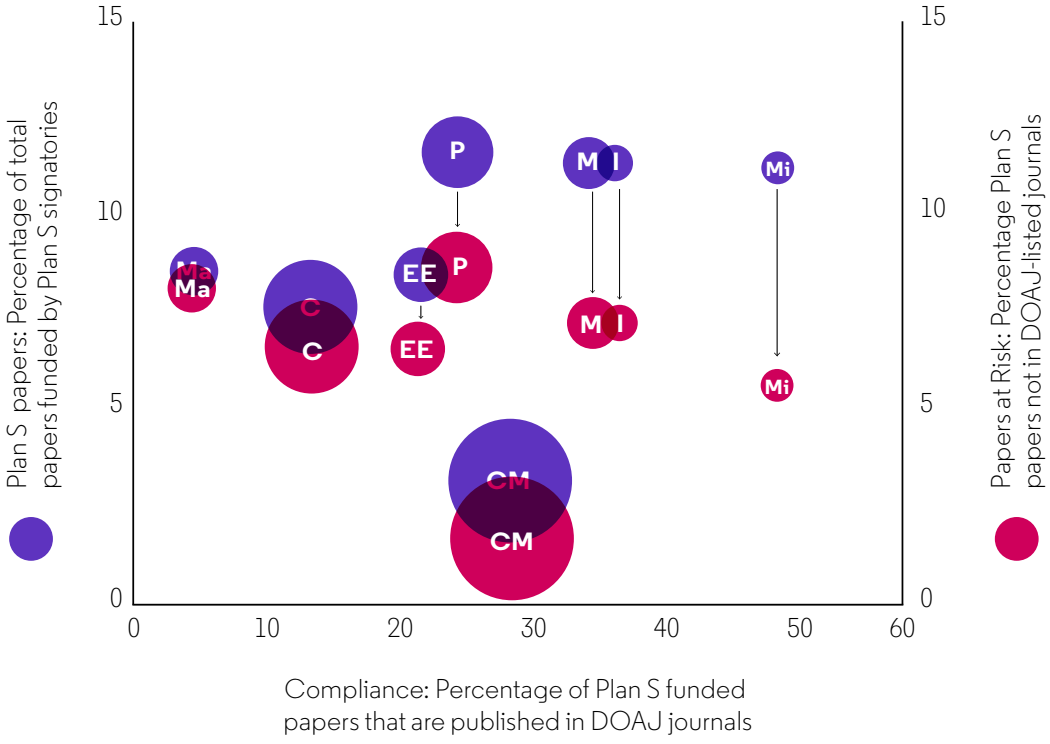
The papers funded by Plan S that are not currently published in DOAJ-listed journals might be described as *'papers at risk'*. An analysis of the balance of such papers by research area suggests that areas like Mathematics and Chemistry may find Plan S particularly challenging. This is because a relatively large share of papers in these areas acknowledge Plan S funders, but a relatively small percentage are currently published in DOAJ-listed journals: there is little difference between the count of Plan S funded papers and 'papers at risk'. By contrast, research areas like Immunology and Molecular Biology & Genetics have much greater current compliance. The share of papers funded by Plan S that are not in compliant venues is similar to Chemistry but they have many other papers that are already in DOAJ-listed journals. This implies, in these Life Science research areas, both that suitable venues exist and that they are widely used by Plan S funded researchers. By contrast, this appears not to be the case for Mathematics or Space Science. (Figure 4)

Figure 3.



Analysis by main research area of the percentages of papers acknowledging Plan S funding and the percentage of those funded papers that are published in DOAJ-listed journals. Space Science is outside the plot with 26% funding and <1% compliance. Each bubble is scaled to the number of papers.

Figure 4.

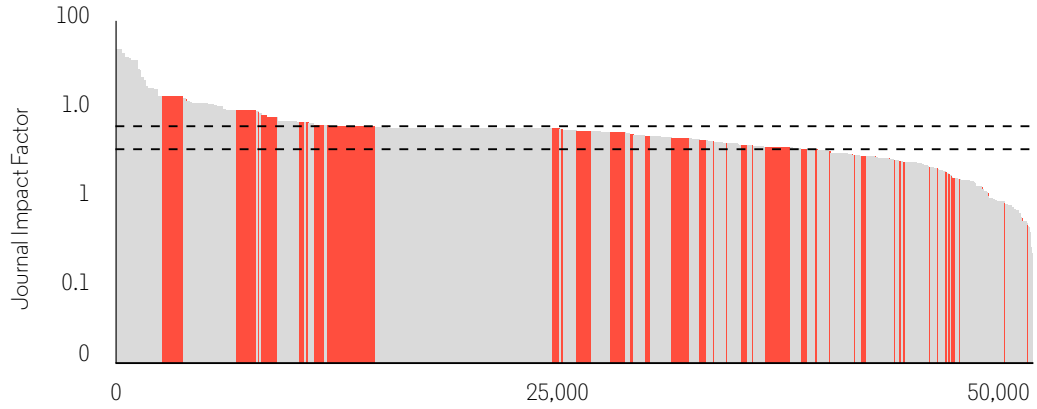


Analysis by select research areas of the percentages of papers that are 'at risk' under Plan S, because they are Plan S funded but not in a journal that is Plan S compliant. Life Science areas have many Plan S papers but a relatively high level of current compliance so are less 'at risk' than Mathematics where few Plan S funded papers are in DOAJ-listed journals. Each bubble is scaled to the number of papers.

There is evident variation in the availability and use of DOAJ-listed journals in different research areas. We can analyse the distribution of Plan S funded papers across journals to assess the association with journal characteristics. One such characteristic, which allows us to present the data in a simple, grouped and structured way, although it should not be taken to imply any information about the quality of the individual papers, is the *Journal Impact Factor (JIF)*.[1] In Figures 5 and 6, 2017 papers are ranked by the *JIF* of the journal in which they were published. Papers in a DOAJ-listed journal are highlighted in red against a grey background for all other papers.

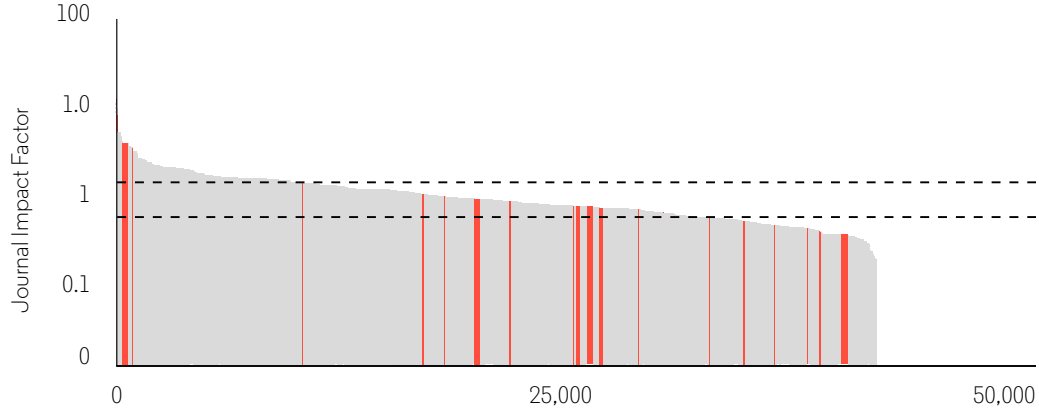
Molecular Biology & Genetics (Figure 5) has many DOAJ-listed journals. These tend to be substantial in volume (i.e. the relevant block is fairly broad within the distribution) and are distributed across the range of *JIF* values. Within Mathematics (Figure 6) there is only a limited pool of DOAJ-listed journals and these account for only a relatively small proportion of the published papers.

Figure 5.



Molecular Biology & Genetics: 2017 papers ranked by descending *JIF*. DOAJ-listed journals shown in red. There are about 52,000 papers in this ESI category published in journals with a *JIF*, of which 35% are in DOAJ-listed journals spread across the *JIF* range. About 6,200 papers acknowledge a Plan S funder. Upper and lower *JIF* quartiles are shown with a dotted grey line.

Figure 6.



Mathematics: 2017 papers ranked by descending *JIF*. DOAJ-listed journals shown in red. There are 43,000 papers in this ESI category published in journals with *JIF* of which 8% are in DOAJ-listed journals. About 4,100 papers acknowledge a Plan S funder. Upper and lower *JIF* quartiles are shown with a dotted grey line.

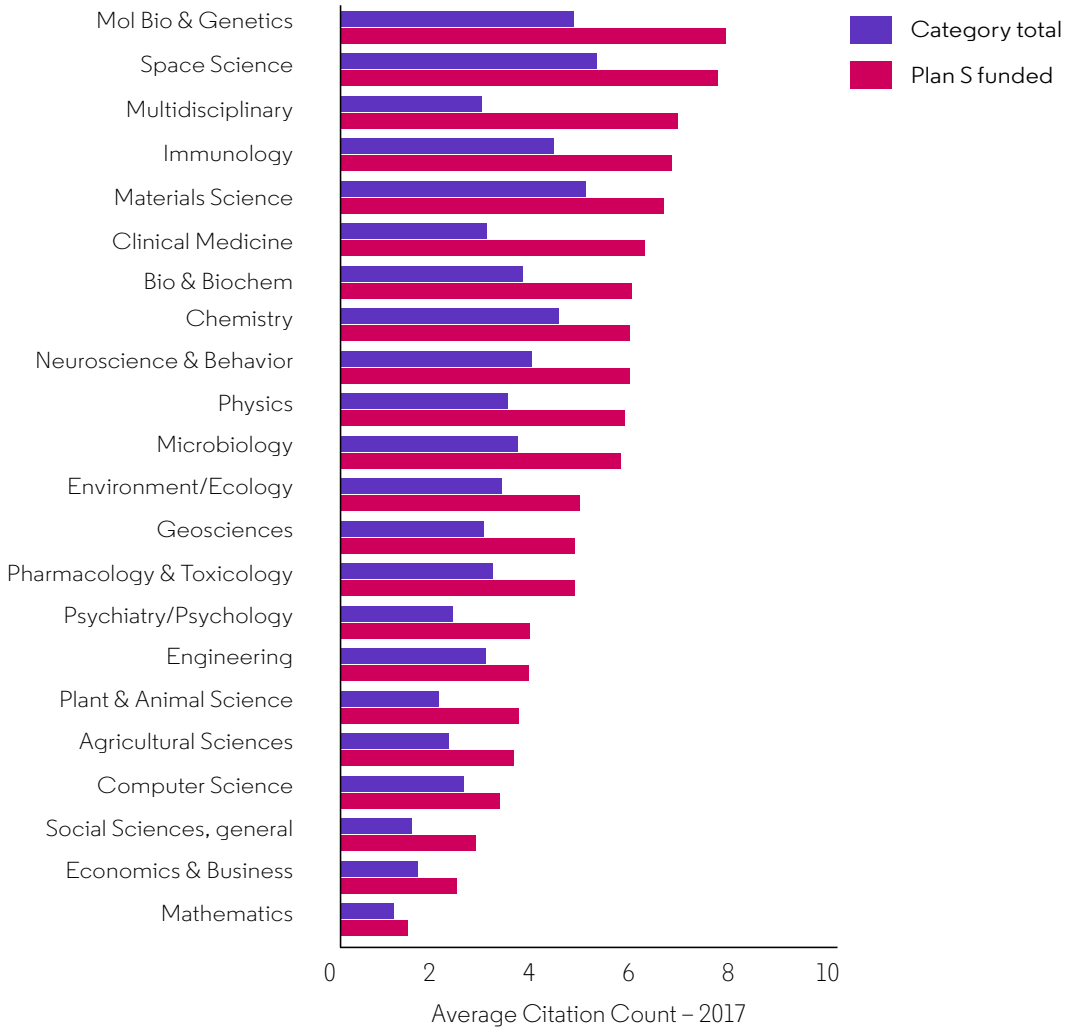
1. *JIF* is defined as the ratio of citations in one year to content published in the journal in the prior two years to the count of scholarly works published in those two years.

How frequently are Plan S papers cited?

On 2017 citation counts, Plan S funded papers are cited more frequently on average than other papers, and this is true in all research areas.

A differential distribution across journals could be associated with other differences; papers published in 2017 have had little time to be cited and those published late in the year will likely be cited less often than those published early in the year. Nonetheless, the total batch of papers in a broad ESI category represents a reasonably large sample for indicative if not for statistical purposes. Comparing the average citation counts of Plan S funded papers within each category with the overall population we can see that the average Plan S funded paper is cited more frequently than the global benchmark. (Figure 7)

Figure 7.



Average citation counts for papers published in 2017, grouped by ESI research categories, comparing those funded by Plan S agencies with overall *Web of Science* content.

How does Plan S affect countries and regions?

The effect of Plan S elsewhere in Europe is much smaller, but it still could increase the percentage of OA papers by more than 10%.

Under Plan S, some European countries would publish more than 40% of their output as OA. This could reach 50% where the national funder is also a Plan S supporter. About 19% of European international collaborative papers are supported by Plan S funders and therefore involve non-Plan S researchers. The USA is (in absolute terms) the second largest producer of papers that acknowledge Plan S funding and a high proportion of some institutions' output is Plan S supported. But the USA government has yet to endorse the plan.

There is significant variation in population size, GDP and research investment across countries so direct comparisons are not always informative. For each country, we tallied the numbers of papers that were or were not in journals in the DOAJ list and the share that did or did not acknowledge a Plan S funder. Then, to enable equitable comparisons for reporting purposes, countries were allocated to one of three functional groups.

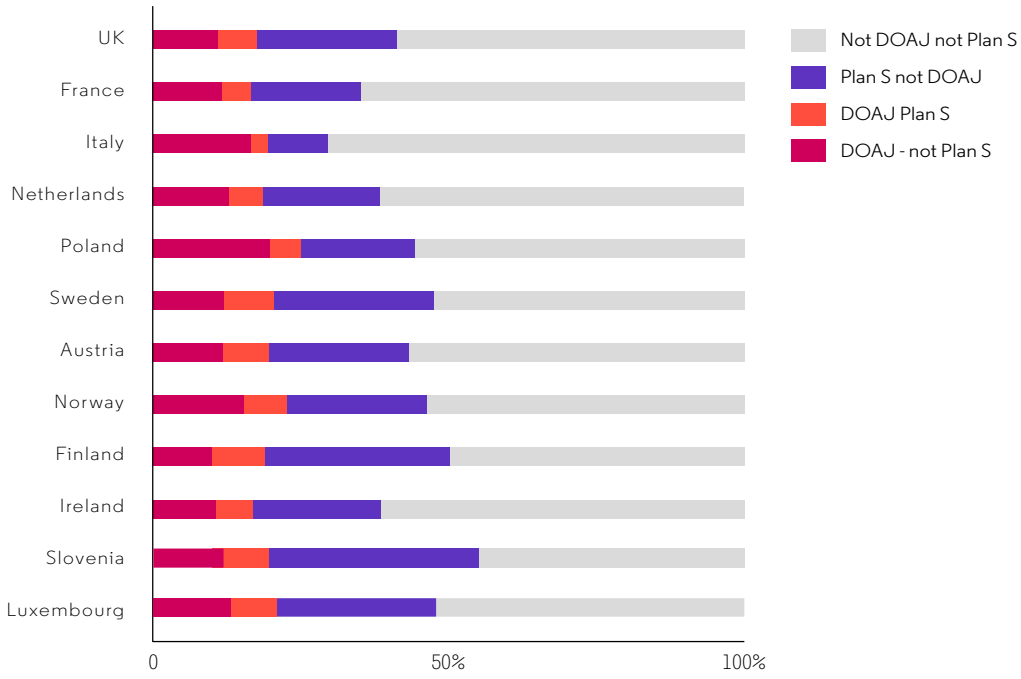
Some European countries have a national funder that has already endorsed Plan S (Figure 8). Such funders in the UK are acknowledged in 30,000 'at risk' papers that are not currently published in a DOAJ-listed journal. In Sweden, Finland, Slovenia and Luxembourg the percentage of 'at risk' papers is over 25%. If these authors were to comply with Plan S then there would be an increase of papers in DOAJ-listed journals in these countries to over 40%.

The effect of Plan S elsewhere in Europe is much smaller, but it still could increase the percentage of OA papers by more than 10%. (Figure 9)

In 2017, approximately 215,000 papers indexed in *Web of Science* were the product of collaboration between a European country and the rest of the world. Of these papers, 40,000 (19%) acknowledged support from a Plan S funder. Europe's most prolific collaborative partner is the United States - 80,000 papers co-authored between European and American researchers and 20,000 (25%) of these listed a Plan S funder. Thus, half of all Plan S acknowledged collaborative research implicates co-authorship with researchers in the United States. (Figure 10)

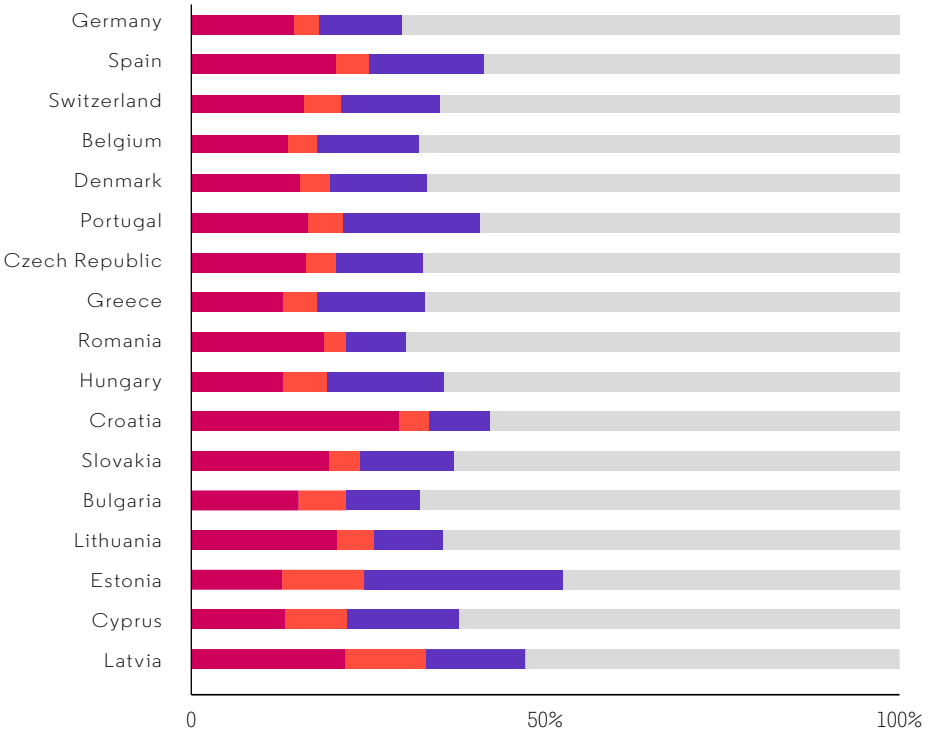
In absolute terms, the papers with a United States co-author make the United States the 2nd largest producer of Plan S funded work after the United Kingdom. There are several American institutions, including MIT and Caltech, that have over 15% of papers that list Plan S funding, which is primarily driven by their high levels of international collaboration.

Figure 8.



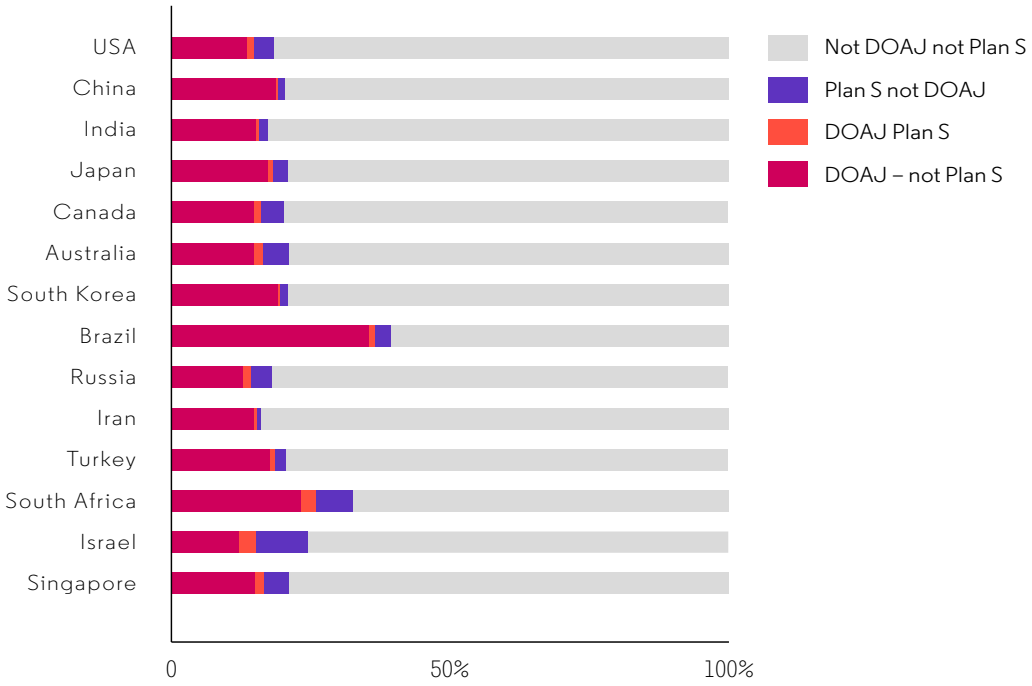
The balance of OA papers and research funding in European countries in which a national funder has endorsed the principles of Plan S, ranked by volume of output.

Figure 9.



The balance of OA papers and research funding in European countries that had not endorsed Plan S by December 2018, ranked by volume of output.

Figure 10.



The balance of OA papers and research funding in selected countries and regions outside Europe, ranked by volume output.

How does Plan S affect publishers?

Across the landscape of publisher data, it is possible to typecast and populate a number of scenarios among the 200 larger houses (which collectively publish 95% of papers acknowledging a Plan S funder). There are those not heavily affected; affected a little; a few (including some big houses) affected significantly; and OA-adopters who are well-positioned. Smaller houses, including some learned societies, are diverse and less readily categorised.

To analyse the spread of Plan S funded papers across journals issued by different publishers, the various imprints were grouped together under their parent: for example, Routledge and Taylor & Francis appear as parts of Taylor & Francis. Following this aggregation, there are 4,900 publishers in *Web of Science* that have one or more journals in the data used for analysis. There is significant variance in scale with the largest 20% of publishers accounting for more than 90% of papers. More than 3,500 publishers had no Plan S papers and a further 550 published only one paper acknowledging Plan S funding.

Analysis focused on the largest 200 publishers: each published more than 420 papers in 2017, which accounts for more than 85% of the overall count of papers and includes more than 95% of papers that acknowledged Plan S funders. Among the 200 largest publishers, about one-quarter have less than six Plan S funded papers and none have more than 30% of their papers Plan S funded.

The largest 200 publishers could be grouped by considering the percentage of Plan S funded articles and the volume that is already published in DOAJ-listed journals. It is possible to distinguish six, somewhat arbitrary but usefully indicative, groups. This grouping is illustrated in Figure 11.

The groups represent a range of 'scenarios' (situations and challenges) that publishers will encounter in responding to a requirement for Plan S compliance. Table 3 summarises a spread of relevant parameters, in terms of volume and current compliance. Group (a) contains mostly regional publishers that have less than 1.5% of their papers funded by Plan S; (b) is those publishers that are already >35% compliant, including those with a large number of DOAJ- listed journals that host Plan S content; (c) are publishers that have good compliance, but also a significant volume of 'at risk' papers that are Plan S funded but non-compliant; (d) are publishers with a limited amount of Plan S funded work, primarily Social Science or Humanities focused.

Groups (e) and (f) contain those publishers that have a large proportion of papers 'at risk' and it is in these groups that a need for greater adaption may be implied. For some such publishers, a majority of Plan S manuscripts are concentrated in a small number of journals. For example, in the area of Space Sciences we identified one journal which accounts for nearly 95% of non-compliant papers for its publisher.

Table 1.

Publisher size, based on papers indexed in *Web of Science*

All papers in 2017	Publisher count	% of publishers	Paper count	% of all papers
0-99	4,000	83%	140,000	7.4%
100-999	750	15%	180,000	10%
1,000-9,999	80	1.6%	220,000	12%
10,000-99,999	16	0.3%	425,000	22%
>100,000	4	0.1%	915,000	49%

(Numbers rounded for reporting purposes: total differs between tables)

Table 2.

Papers acknowledging Plan S funding

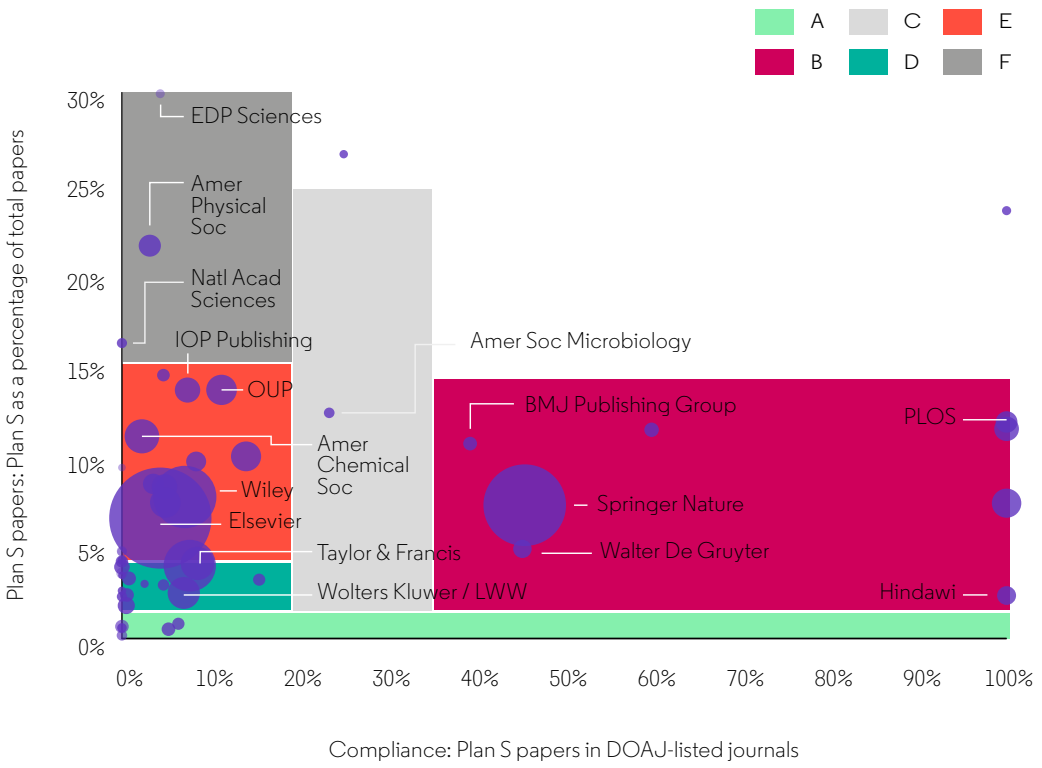
Papers funded by Plan S	Publisher count	Paper count
0	3,600	175,000
1	550	35,000
2-5	450	31,000
6-10	120	25,000
>10	210	1,500,000

Table 3.

Characteristics of the publisher groups illustrated in Figure 11

Group	Criteria	Number of publishers	Total papers	Total Plan S papers	Plan S non-compliant papers	Plan S papers: Percentage of total papers funded by Plan S signatories	Compliance: Percentage of Plan S funded papers that are published in DOAJ journals
a.	1.5% or less under Plan S	74	83,000	430	390	1%	11%
b.	At least 35% compliance	25	393,000	30,000	11,500	8%	62%
c.	20% to 35% compliance	6	13,000	2,500	1,800	18%	25%
d.	Up to 4% Plan S	32	256,000	8,750	8,200	3%	7%
e.	4% to 15% Plan S	53	830,000	65,000	61,000	8%	6%
f.	At least 15% Plan S	10	32,000	6,600	6,500	21%	3%

Figure 11.



Comparison for the 50 largest publishing houses of Plan S papers (as a share of total papers) with the percentage of those papers published in DOAJ-listed journals. Each bubble represents one publisher, scaled by volume of papers.

What could change under Plan S?

Plan S funded outputs make up less than 7% of global papers but they are well cited, published in high impact journals and, often, in journals from major publishing houses. They will influence the publishing landscape. Some 90,000 Plan S papers published as a part of Hybrid OA or Subscription journals will need to be 'rehoused' if the journals do not change to fully OA. There are few Hybrid journals with a medium to high percentage of OA that might readily change. This implies challenging business decisions.

Some leading multidisciplinary journals contain as much as one-third Plan S content but are not Plan S compliant. Learned society journals have a central communication role in their research field but are not always OA. The relocation of content to OA titles would represent a 29% overall movement in the volume of well-cited papers to existing compliant venues, could be disruptive in some subjects, and suitable compliant venues are not always available (Figure 12c).

As noted, this report focuses on information about the significance of Plan S funded papers in the publishing landscape. It is not intended as a deconstruction of possible scenarios. Some likely effects stand out, however, and are summarised here.

In 2017, Plan S funders were acknowledged in more than 120,000 papers indexed in *Web of Science*, accounting for about 6.4% of papers across more than 10,000 journals. However, an analysis restricted to journals with six or more papers acknowledging a Plan S funder would cover just 3,700 journals. 3,200 of these are not presently listed by DOAJ and are therefore not Plan S compliant.

Figure 12 a.

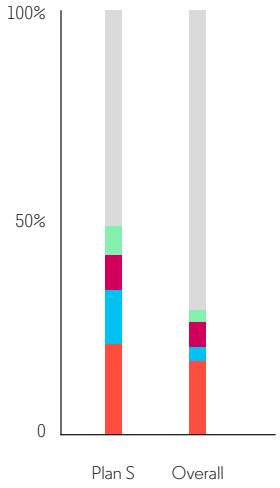


Figure 12 b.

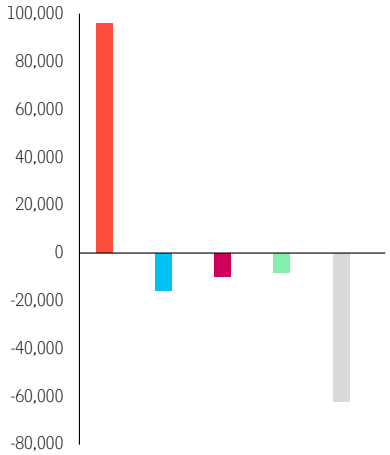


Figure 12 c.

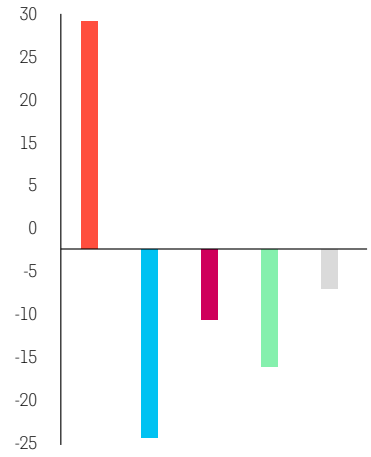
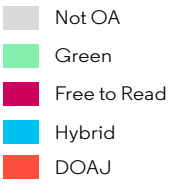


Figure 12 a. Current OA spread

Figure 12 b. Change in OA types driven by Plan S (absolute shift)

Figure 12 c. Change in OA types driven by Plan S (relative shift percentage)



Many large publishers offer Hybrid OA options across a range of journals, but the use of OA by authors has been uneven. While 20% of around 20,000 journals indexed in the *Web of Science Core Collection* published 100% of their papers as Gold OA, 50% of journals published no OA papers in 2017. Of the remaining journals, most published fewer than 5% of their papers as Hybrid OA with relatively small numbers between 20% and 99% OA level. (Table 4)

Table 4.

Journals grouped by the percentage of Open Access (OA) papers.

OA papers % in journal	Count of journals	Count of papers		Share of total papers	
		Total	Plan S	OA only	OA or Plan S
No OA papers	10,600	573,930	17,150	0%	3%
0-5%	2,600	617,000	44,000	2%	8%
5-20%	2,100	265,000	26,000	10%	18%
20-40%	300	32,000	4,000	26%	37%
40-60%	80	8,000	350	48%	55%
60-80%	70	4,000	150	69%	74%
80-100%	230	26,000	700	92%	94%
Fully OA	4,000	354,000	25,433	100%	100%

It is difficult to model scenarios where journals gather an increasing OA share and then 'flip' to fully Gold OA because the data indicate that relatively few journals publish an equal mix of OA papers and non-OA papers.

Papers authored by Plan S funded researchers are not evenly distributed across the publishing landscape:

- They appear more often in higher *JIF* journals that are frequently not DOAJ-listed.
- The distribution and availability of compliant journals varies markedly between disciplines. (Figures 5 and 6)
- Plan S funded papers appear to be of above-average significance to other researchers because they are cited relatively frequently. (Figure 7)

Some widely respected multidisciplinary journals (*Nature, Science* and *Proceedings of National Academy of Sciences*) are over-represented, if one compares the relative volume of papers acknowledging Plan S funding with the global share (6.4%) but are not Plan S compliant. (Table 5)

Table 5.

For three leading cross-disciplinary journals, the number and percentage of papers published in 2017 that acknowledged a Plan S funder.

Journal	Total papers	Plan S papers	Plan S percentage
Nature	836	290	35%
Science	769	235	31%
Proc US National Academy of Sciences	3,261	639	20%

Plan S compliance implies an effect of around 95,000 additional papers would need to be published in DOAJ-listed journals every year, which would be a 6% decrease in non-OA papers. Two widely discussed responses are that: existing journals change their content to become fully OA; or Plan S papers are redirected to journals that are DOAJ-listed. (Figure 12)

We could assume that no journal changes its status and that all papers that acknowledge a Plan S funder move to a DOAJ-listed output. Such a shift would represent a 29% overall increase in the volume of well-cited research published in the existing compliant venues and an equivalent decrease in such research in non-compliant venues.

This shift is only possible where authors have the opportunity to submit to a fully Gold OA journal appropriate for their research, which is not universally the case. There are research areas, such as Mathematics, where current OA journal coverage is limited (Figure 6). The few existing compliant journals will face a substantial challenge to scale up to manage the quantity of submissions and papers within the current timeframes assuming that authors are willing to publish in them.

It is unlikely that movements would be balanced by subject or time. Some existing fully Gold OA venues may well find themselves inundated with submissions. Others may see little change. It is likely that new venues will appear. In some subjects there will either be a significant lag as the landscape shifts to accommodate change or, in extreme cases, there could be a temporary dearth of compliant publication venues.

Responsibility for costs

The cost of publishing will shift, *ex post*, from the reader or their library, typically via a subscription charge, to an *ex ante* obligation on the author or their institutional proxy to pay via an APC. This would require a redirection of around €150 million. Meeting these costs will fall on research funders. It is not evident whether marginal resources are available to support all affected authors.

Plan S implies a change in the responsibility for publishing costs. As noted at the outset, most current journals are paid for by, and accessible only to, subscribers. Many Gold OA journals require payment via an APC, so the paper can be freely accessible to all. Authors, or their institutional proxies, must therefore find the resources at the point of publication instead of readers at the point of use.

The charges made by publishers for an OA paper vary, but we can base a representative analysis using £2,401 as the average APC in a Hybrid journal and £1,943 as the average DOAJ-listed APC (as reported by the Wellcome Trust). Based on these figures current Plan S OA outputs are linked to £86 million of OA publishing support through APCs. If all 120,000 2017 Plan S funded papers were published in DOAJ-listed journals this would increase to £230 million, an increase in research funds committed to publication support of £144 million. However, if this shift to 100% Gold OA were to happen under the current DOAJ-listed/Hybrid ratio that cost would rise even further. There are other factors that would drive the total costs within the system.

The change in the funding of academic papers will happen whether authors redirect papers to Gold OA journals or the existing journals change their business model, so research-producing organisations (such as universities, institutions, corporations, and laboratories) will need to plan to distribute resources to researchers either directly or indirectly to enable them to maintain their current capacity to choose where to publish.

Funding at the point of accepting a publication may constrain those individuals, organisations and emerging research economies that do not have access to sufficient resources, irrespective of the quality of the work they submit for publication. There could also be an issue for those charities that support research, particularly in the health and medical sector. Many charities have research spend in the range from £1 million to £10 million, so a marked increase in costs for publication would be significant in Biomedical fields where publication rates are relatively high.

Tasks for a system in transition

It has been more than 15 years since the Budapest (2003), Berlin and Bethesda (2004) declarations were published. There has been a significant expansion in OA publishing and a more general awareness of and support for open research policies. There is also recognition that not all disciplines are ready for OA under current funding structures and journal availability.

Plan S was announced with a set of principles that implied very significant, even disruptive, change for some stakeholders. That led inevitably to positive and negative reactions, then dialogue and an invitation to comment, and then both shifts in Plan S narrative around routes to and the timing of implementation and shifts in stakeholder perceptions.

Commentary has been widespread and from diverse sources.

- The 300-member Association of Learned & Professional Society Publishers (ALPSP) raised concerns about Plan S' indicative pace of change compared to business planning and asked for clarity regarding transformative agreements, since these would have serious implications for large publishers over 'collection' contracts with clients and for small publishers with limited room for negotiation.

- An initial reaction from some publishers was to consider 'mirror' journals, where a new OA sister would share editorial process with an existing Hybrid or Subscription journal, but these are not likely to be considered compliant.[2]

- Researcher-led open letters attracted many signatories. Kamerlin et al[3] highlighted concerns about the imposed choice of publishing venue, the cost of Gold OA and the lack of distinction between subject areas. Eisen's[4] open letter strongly supported the right of funders to mandate specific OA options. Willighagen and Tennant[5] believe that the focus on publishing models missed an opportunity for funders to focus on open science more widely.

- Institutions broadly agreed with Plan S's overall goals but had concerns over the indicative timeline. University College London (UCL)[6] had queries on clarity regarding compliance and sought more engagement with universities as research-producing organisations. The University of Oulu[7] highlighted compliance costs as a challenge. The European Federation of Academies of Sciences and Humanities[8] focused on the IP issues which may be created by mandating CC-BY, along with the current lack of global signatories. The Global Young Academy[9] expressed concerns that Plan S might lead to a two-tier system between those with funding and those without.

- The International Association of Scientific, Technical and Medical Publishers (STM), in a statement of February 2019, built on UCL's position and described key factors it suggested would drive global OA including flexibility in academic publication choices and commercial publishing models.

- New 'Read and Publish' deals, such as Wiley's recent agreement with Projekt DEAL, have been described as a compliant transformation by members of cOAlition S.[10] For Wiley the effect of various deals already publicly signed would increase their compliance to 30%.

The likely path of change continues to evolve. There appear to be some nuances of policy among cOAlition S members, which may translate into different approaches by region, agency and - perhaps - discipline. There is also movement amongst publishers in creating imaginative deals, supportive of research, while drawing attention to constraints, necessarily safeguarding a heritage valued by their research communities. Among researchers, there is also a diversifying debate, with advocates pointing to OA benefits while the more cautious point to the benefits of an established publishing structure.

The data and analyses in this report are intended to provide material to scope parameters for these discussions. There are no dramatic conclusions, and the responsive approach of the stakeholders suggests that no drama need be expected, but some considerations suggested by the data should be borne in mind.

These include, but are not limited to:

- Some research areas have very few journals that are currently Plan S compliant (Figures 3-6). Without carefully paced transition to allow for the emergence of new titles, is there a risk of unusual constraints and disjunctions in publishing opportunities in affected subjects?
- The disparity of citation impact between Plan S funded outputs and others is likely to be a factor in the subsequent reshaping of the publishing landscape (Figure 7). Citations are not a defining metric of quality, but might the restructuring of the spread of well-cited papers have unplanned contingent consequences?
- Plan S funded papers include many authors who publish in leading subscription journals and in many currently Hybrid journals. Not all such authors are in countries endorsing Plan S. Some are G20 countries; many are in the Global South (Figure 10). How can the shift to Gold OA and associated APCs be managed equitably to protect the positions both of unfunded researchers in G20 economies and of a wider spread of authors in emergent research regions?
- The large publishers, with a diverse stable of titles, will be influential in discussions, (Tables 1 and 2, Figure 11) but there are many small publishers, including those linked to learned societies, who publish an important part of the Plan S funded output in serials central to their discipline. Will transition be more difficult for them and, if so, can this be managed effectively but flexibly?

Increased and more open access to research outcomes is a public good. If an accelerated shift towards this can be balanced with careful implementation and the retention of those features of the research publishing system that have been of such benefit to society and the economy over the last century then the debate and the effort will be amply repaid.

2. https://www.coalition-s.org/implementation/
3. https://sites.google.com/view/plansopenletter/open-letter
4. http://michaeleisen.org/petition/
5. https://docs.google.com/forms/d/e/1FAIpQLSc4dWYFnGI-RoZIzYLnQ8tPyMANSeVruY35kBrMMzJyTGshag/viewform
6. http://blogs.ucl.ac.uk/open-access/files/2019/01/UCL-response.pdf
7. https://www.oulu.fi/sites/default/files/186/Plan%20S%20final%20feedback.pdf
8. https://www.allea.org/wp-content/uploads/2018/12/ALLEA_Response_PlanS.pdf
9. https://globalyoungacademy.net/ec-in-person-meeting-2018/
10. https://www.projekt-deal.de/faq-wiley-contract/

Annex – Data Sources

Publication records were drawn from *Web of Science Core Collection* (Science Citation Index Expanded, Social Science Citation Index, Arts & Humanities Citation Index and Emerging Sources Citation Index). These records were filtered for content published in 2017 and, from this annual tally, we selected documents classified as articles or reviews. Proceedings papers are not identified as a document type under the Plan S proposals. Articles and reviews are the primary forms of original scholarly output in journals and are collectively referred to in this report as papers.

Document records in *Web of Science* contain 'acknowledgments', which include funding sources. These are indexed and can be used to identify papers sponsored by Plan S funder organisations, by cross-reference to a manually curated list of funder variants. This enables broad capture of papers that would be affected by Plan S mandates. Some authors will have failed to identify Plan S funding and there will also be papers not included because of missing data or obscure name variants. The Plan S funded records analysed here therefore represent a minimum estimate of Plan S papers published and of those indexed in *Web of Science*.

Web of Science integrates data from Impactstory's Unpaywall Database which is one of the widest sets of data on article level OA information. *Web of Science* augments this with a direct journal level feed from the Directory of Open Access Journals. Unpaywall data are translated by *Web of Science* into a set of OA statuses. Two represent Gold OA: DOAJ Gold represents content published in journals listed in DOAJ; Gold Other represents content that is identified as having a Creative Commons license on the publisher platform but is not in a DOAJ-listed journal. Free to read is content that has been identified as freely available, but with no identified Creative Commons license. Because papers in *Web of Science* may be both Gold & Green Open Access, a single status is allocated to each paper to avoid duplicate counting. The following priority order is used: Gold DOAJ-listed; Gold other; Free to read; Green.

The data for this report were extracted from *Web of Science* on 10 January 2019.

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