



Open Research

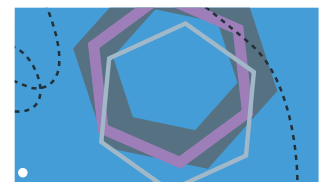
OPEN FOR ALL: EXPLORING THE REACH OF OPEN ACCESS CONTENT TO NON-ACADEMIC AUDIENCES

White paper

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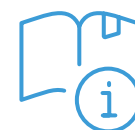
Open Research

Journals
Books

Data
Tools



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November 2020

This white paper and associated raw data from the survey have been made openly available in the Zenodo repository.

■ **Access whitepaper:**
<https://www.doi.org/10.5281/zenodo.4143313>

■ **Access survey data:**
<https://doi.org/10.5281/zenodo.4084841>

Foreword

Springer Nature believes that open research benefits not only the research community but society as a whole. This is particularly the case where that research relates to one of the UN's Sustainable Development Goals (SDGs), with the ambition of solving some of the world's biggest challenges. As such, our partnership with the Association of Universities in the Netherlands (VSNU) and the Dutch University Libraries and the National Library consortium (UKB) is a valuable exploration of where knowledge exchange and tool development can help to accelerate a transition to an open future.¹ Together, our partnership has resulted in a new public SDG classifier², enabling researchers, institutions and funders to explore all research publisher content for a specific SDG; a deeper understanding of how content is being consumed by non-academic audiences (the topic of this white paper); and, as a final result of the project, a new toolkit for researchers to maximise their societal relevance (forthcoming). From the results of this collaboration, it is clear that open research is enabling widespread use of academic content by a substantial number of non-academic audiences. From charities and NGOs, to educators, governments, corporates and industry, there are many beneficiaries when content is more easily accessible.

We knew from our own previous research that there is a direct benefit to the individual researcher in increased usage and reach for their open access (OA) document³ or book chapter⁴, but this is further reinforced here by looking both at the bibliometric picture and additionally the deeper analysis of who the direct beneficiaries of the work are. This proves that there is a real tangible societal impact where research is open. The case study of research output from the Netherlands provides a particularly strong argument in support of a national OA strategy, finding nearly twice as many downloads of SDG content compared with the global average. The Netherlands was our first Transformative Agreement partner in 2015, with our goals very clearly aligned in shifting funding and resources towards an open research future. Their results here demonstrate the impact of such a strategy, and strengthens the argument for a central, national infrastructure to enable OA uptake. These findings must spur us on towards a coordinated effort to ensure that Gold OA is supported on a wider scale, and to ensure there is continued acceleration towards addressing the SDGs.



**Steven Inchcoombe, Chief
Publishing Officer, Springer Nature**

**Open research is enabling
widespread use of
academic content by a
substantial number of
non-academic audiences.**

1. Towards Societal Impact Through Open Research <https://www.springernature.com/gp/researchers/sdg-impact>
2. Dimensions includes new research category filters for Sustainable Development Goals <https://www.dimensions.ai/blog/dimensions-includes-new-research-category-filters-for-sustainable-development-goals/>
3. Draux, H.; Lucraft, M.; Walker, J. (2018): Assessing the open access effect in hybrid journals. <https://doi.org/10.6084/m9.figshare.6396290>
4. Pyne, R.; Lucraft, M.; Emery, C.; Neylon, C.; Montgomery, L.; et al. (2020): Diversifying readership through open access: A usage analysis for OA books. <https://doi.org/10.6084/m9.figshare.12746177>

Foreword - UKB

The Dutch government envisions that research output based on (partly) publicly financed research should be publicly and freely available to the world. OA to the latest scientific insights potentially enables and accelerates not only research innovation itself and dealing with grand societal challenges. Moreover, the public availability of research output will result in a situation such that public interest groups, policymakers, industry, teachers etc. are up to date, informed and make use of science in optima forma, creating societal impact. The current partnership of VSNU and the Dutch Association of University Libraries and Royal Library with Springer Nature aims at making this societal impact visible. An important outcome of the report, that the online usage and attention advantage from OA is much bigger than the observed citation advantage, supports the assumption that one of the main advantages of open access is that it reaches a substantial number of user groups outside of academia that typically don't have access to a large amount of subscription journals. This white paper clearly reveals this impact and can be regarded as a building block for the translation to researchers, supporting them in working on societal impact.



Ingrid Wijk, UKB, Director
Maastricht University Library

Research output based
on (partly) publicly
financed research should
be publicly and freely
available to the world.

Executive Summary

This white paper summarises findings from a joint project between Springer Nature, the Association of Universities in the Netherlands (VSNU) and the Dutch University Libraries and the National Library consortium (UKB), exploring how research content is being used outside of academia. It draws together findings from a bibliometric analysis of nearly 360,000 documents published in 2017 (book chapters, journal documents and proceedings), and a survey of nearly 6,000 readers on Springer Nature websites, putting a spotlight on the potential impact of immediate Gold OA publishing on societal impact: who uses research content where this relates to the SDGs, and for what purpose? Our results show a strong OA advantage, with a high volume of readers from non-academic communities.

There is a notable OA advantage for usage and attention of SDG content.

Key findings:

There is a notable OA advantage for usage and attention of SDG content

- **Reinforcing previous studies, this analysis found OA documents receive substantially more online usage compared to Subscription content using both averages and regression models (Table 1).**
 - For the 36,800 Springer Nature SDG-related documents analysed, there were on average 4.4 times as many downloads for documents published immediately Gold OA under a Hybrid OA model and 2.7 times as many downloads on average for documents published in Fully OA publications.
- **OA content is shared more often and gets more attention than Subscription content.**
 - For 358,000 SDG-related documents in the Dimensions database published in 2017, Gold Hybrid OA publications have 2.1 times higher average Altmetric Attention Scores than Subscription content, and Fully Gold OA publications have 1.7 times higher scores.
 - Our model predicts 2.0 times higher scores for Hybrid OA and 1.5 times higher for Fully OA.
- **There is a less clear advantage found in the data for citations.**
 - While the average number of citations is somewhat lower for Gold OA content, the regression model predicts a small positive impact for Fully OA publications, and a 1.5 times higher number for Gold Hybrid documents. Since citations are mainly an indicator for academic content utilisation, these observations may support the assumption that one of the main advantages of OA is that it reaches a substantial number of user groups outside of academia that typically don't have access to a large amount of Subscription content, as witnessed by the substantial online usage and attention advantage.
- **A similar effect is found for a country-level analysis looking at the Netherlands, with higher downloads and attention.**

OA Type	Downloads		Altmetrics Attention Score		Citations	
	Average	Regression model predictions	Average	Regression model predictions	Average	Regression model predictions
Subscription	100%	100%	100%	100%	100%	100%
Gold OA: Hybrid	439%	374%	207%	198%	83%	153%
Gold OA: Fully OA	270%	254%	173%	150%	90%	105%

- **There is notable variation between Hybrid OA and Fully OA**

- These differences may reflect a number of factors, including the fact that Hybrid journals are more established. Although we controlled for journal prestige in our model, there may be limitations with this approach.

OA is reaching a substantial number of user groups outside of academia

- **Approximately 40% of readers surveyed for this analysis on Springer Nature websites were classified as non-academic audiences**, including 15% “Halo” users (likely to be reading research for professional purposes but not conducting or publishing research themselves) and 28% “General” users (likely to be reading out of personal or professional interest but outside of a role where conducting, publishing or citing research is typical).

OA significantly benefits non-academic audiences

- **Only half of all surveyed users said they were able to access the full text of Subscription content.** Access was notably more difficult for Halo and General users, with 62% of total respondents reporting that they often (“almost always” or “frequently”) have difficulties accessing full text content.
- **A large number of respondents in the General user group reported giving up if they cannot access a document.**

A high number of non-academic audiences intend to share findings with others

- **Where core academic audiences are most likely to cite or reference the content they read**, the Halo and General segments are more likely to share documents with others. This is significantly easier where the content is OA.

Conclusions

Our results show a substantial benefit from OA to users who are outside of academia, and that the biggest beneficiaries of immediate Gold OA may not be the core academic researcher community who “contribute” to research, but the many communities that “consume” this corpus of literature. The significantly higher usage and attention for OA content supports previous evidence on the benefits of publishing OA, and our survey takes this further, showing how wide the non-academic audience for OA content is. By combining these results, we can begin to see a substantial amplification effect in how research is being used, shared, and built up to increase knowledge and affect real world change outside academia. In doing so, this report makes a strong case for the further investment and funding for OA for the benefit of society, particularly in supporting research related to the SDGs.

Table 1. Comparison data for downloads, attention, and citations, based on average and regression model predictions

Introduction

In 2019, Springer Nature partnered with VSNU and UKB to jointly explore and answer the question “Is open research facilitating progress on global, grand societal challenges?” The UN’s SDGs were chosen as some of the world’s most pressing challenges, from good health to peace, justice, and strong institutions.

We wanted to investigate whether we could see any signs that open research is beneficial for user groups outside of the core academic readership, focusing in particular on research that has a strong societal connection. Where a number of studies have investigated the potential reach of OA, including a previous study of Hybrid journals by Springer Nature,⁵ very few have investigated the readership of this work in any detail.⁶

In his 2010 analysis of APS journal documents, Phil Davis concluded that “the real beneficiaries of OA may not be the scientific author community ... but communities of practice that consume, but rarely contribute to, the corpus of literature. These individuals may include students, educators, physicians, patients, and researchers employed by private industry who depend on the publication of scientific literature.”⁷ This assumes that OA reaches a number of user groups outside of academia that typically don’t have access to Subscription journals.

To begin to explore this further, for this white paper we have undertaken two separate projects. Firstly, a bibliometric analysis of SDG-related content, exploring whether we could see any signs that OA is particularly beneficial for user groups outside of the core academic readership. Secondly, we ran a user survey on Springer Nature’s SpringerLink, Nature and BioMed Central online publishing platforms to ask readers more about themselves.

Our underlying hypothesis was that a higher utilisation of OA content could indicate that these documents are reaching many more stakeholder groups outside of the core academic segment, which typically subscribe to or license a large number of academic/scholarly publications and are by far the largest customer group of academic/scholarly publishers. By asking readers on our platforms more about themselves, we learn more about the volume of readership coming from non-academic users, and in addition who they are, for what purposes they use research content, and how this differs from the core academic user base.

5. Draux et al. (2018)

6. An overview of research papers on the OA citation advantage can be found here: <https://www.scienceopen.com/collection/996823e0-8104-4490-b26a-f2f733f810fb>

7. Davis, P.M. (2010:) Does OA lead to increased readership and citations? *The Physiologist*, 53(6): 197–201

Methodology

Creating an SDG content corpus

As a first step in this project, the team developed a prototype for mapping scholarly content against five of the UN's SDGs, with Digital Science chosen as a technology partner. Keyword search strings for five SDGs were defined with input from subject matter experts to produce training sets based on publications from the Dimensions platform. The training sets were then used to apply natural language processing and supervised machine learning, resulting in a classification scheme based on five SDGs: SDG 3: Good Health and Well-being; SDG 4: Quality Education; SDG 7: Affordable and Clean Energy; SDG 11: Sustainable Cities and Communities; and SDG 16: Peace, Justice, and Strong Institutions. Initial results from this work was released in December 2019.⁸

In early 2020, Digital Science applied the resulting method and algorithm to the outstanding 12 goals, releasing results for all 17 goals in April 2020, and making these freely and permanently accessible via Dimensions.⁹ As a result of this mapping, it was possible to undertake a closer look at this complete corpus of SDG content.

The mapping of research content to the SDGs has been the subject of several projects, including the SDG bibliometrics analysis of the Aurora Universities Network or the SDG dashboard of the VU Amsterdam.^{10,11} The results of these projects depend heavily on the methodology chosen as well as the interpretation and translation of the SDGs into relevancy mappings. In general, three different methodologies can be applied: i) content that explicitly mentions the SDGs, ii) a set of keywords that try to 'translate' the SDG targets into search strings (the method currently used by the majority of other SDG relevancy mapping projects), and iii) a supervised machine learning algorithm which again is based on keyword search strings (the method chosen for this project).

In a recent blog post, Ismael Rafols from the Centre for Science and Technology Studies (CWTS) in Leiden highlighted the differences in approaches and concluded that "indicators on the contributions of science to the SDGs are not (yet) robust".¹² Researchers from the University of Bergen came to a similar conclusion when they compared the results of keyword search strings that they developed with the SDG classifier from Elsevier used in their SciVal product (also based on keyword search strings). They found little overlap between the two result sets, although they used the same 'keyword search string' methodology, and concluded that "currently available SDG rankings and tools should be used with caution at their current stage of development."¹³ Despite these known limitations, we believe that this corpus represents a meaningful subset of the overall scientific literature to further investigate the main research questions of this project.

8. Wastl, Jürgen, & Diwersy, Mario. (2019). Phase 1 and Phase 2 Summary of SDG Project by Springer Nature, VSNU/UKB, Digital Science. Zenodo. <http://doi.org/10.5281/zenodo.3904447>
9. Dimensions includes new research category filters for Sustainable Development Goals <https://www.dimensions.ai/blog/dimensions-includes-new-research-category-filters-for-sustainable-development-goals/>
10. SDG analysis: bibliometrics relevance <https://aurora-network.global/project/sdg-analysis-bibliometrics-relevance/>
11. Universiteitsbibliotheek VU ontwikkelt SDG-dashboard voor toetsen maatschappelijke VN-doelen <https://ub.vu.nl/nieuws-agenda/nieuwsarchief/2019/okt-dec/universiteitsbibliotheek-vu-ontwikkelt-sdg-dashboard-voor-toetsen-maatschappelijke-vn-doelen.aspx>
12. Consensus and dissensus in 'mappings' of science for Sustainable Development Goals (SDGs) <http://strings.org.uk/consensus-and-dissensus-in-mappings-of-science-for-sustainable-development-goals-sdgs/>
13. Armitage, C.S.; Lorenz, M.; & Mikki, S. (2020): Mapping scholarly publications related to the Sustainable Development Goals: Do independent bibliometric approaches get the same results? *Quantitative Science Studies*, 1:3, 1092-1108. https://doi.org/10.1162/qss_a_00071

Part one: bibliometric study

Our bibliometric analysis investigates whether we can see any signs that OA is particularly beneficial for user groups outside of the core academic readership. In Springer Nature's previously mentioned Hybrid OA white paper, the effects of OA on Hybrid journals were examined by comparing OA and Subscription documents in terms of usage (downloads), research impact (citations), and broader impact (Altmetric attention). In a similar approach this study also investigates these same usage and attention measures. Since the OA status is not the only factor that influences these metrics, we created a model that aims to correct the influence of variables at the document level (SDG, subject field, publication type and whether the document acknowledged any external funding), at the author level (institutional reputation, based on the proxy of the Times Higher Education World University Rankings, and country) and the journal level (Journal Impact Factor, as a proxy for perceived journal prestige). We used negative binomial regression models for all the analyses.

SDG-related content from the period 2010 to 2019 was downloaded from the Dimensions interface in May 2020 and further enriched with usage data from Springer Nature and data from Altmetric. In addition, only content containing information in all necessary metadata fields and defined as one of three publication types – article, proceeding or chapter – were considered.

Since all metrics build over time, the analysis focuses on publications from a single year in order to guarantee a 'like-for-like' comparison. The publication year 2017 was chosen (as an average time-frame of three years since the metrics were pulled in mid-2020), which seems to be a good compromise in terms of recency on the one hand and sufficient time-frame to build the various metrics on the other. In all, there are 36,823 Springer Nature documents included in the downloads analysis (where COUNTER usage data was available for Springer Nature records), and a larger sample of 358,293 documents for citations and Altmetric attention across all publishers available via the Dimensions database.

In addition, we looked at this research question from a global perspective, but also limited the analysis to all documents that have at least one author affiliated with a Dutch institution.¹⁴

Part two: user survey

Our user survey explores who is reading content, looking in particular at non-academic users. Who are they, how many are there, for what purposes do they use research content, and how do they differ from the core academic user base?

During May, June and July 2020, Springer Nature ran a survey of readers of its online documents hosted on nature.com, link.springer.com and biomedcentral.com. Visitors to a document page who remained for more than 30 seconds were shown a slide-out banner which invited them to take part in an online survey which asked them about themselves and their use of the content. The survey was hosted online on Qualtrics. In total, 5,994 people answered the survey.

It is possible that this method may have resulted in selection bias. Firstly, the 30-second delay before showing the survey invitation was intended to exclude users who had only a passing interest in the document concerned, but as a result may have

14. Using the Dimensions filter for Country: "The country in which the Research Organization is based"

skewed the sample slightly towards more engaged users. Secondly, users interested or particularly engaged in open research might have been more attracted by the survey announcement. And thirdly, there might be also a general selection bias of people who are willing to take part in surveys.

A copy of the questionnaire has been made available along with the anonymised raw data in Zenodo.¹⁵

We segmented respondents into three groups, based on the type of organisation they worked in, their stated role and job title, as well as the degree to which primary research is a major driver for their work. The three groups were named “Core”, “Halo” and “General” users. Core users were defined as those conducting and publishing research, primarily from academia. The non-core groups were then split depending on whether they were in a role where research is likely to play a major influence or motivation (Halo) or not (General). We then looked at the different proportions of usage by segment between OA and Subscription and SDG-tagged and non-SDG tagged content, as well as exploring variance in how content is used.



Figure 1. Slide out banner used to call for participation

15. <https://doi.org/10.5281/zenodo.4084841>

Results

Part one: bibliometric study

1.1 Online usage of Springer Nature documents

SDG-related content that is published under a Gold OA model has significantly more downloads.

36,823 Springer Nature documents were published in 2017 and are related to at least one SDG. On average, these documents were downloaded 1,437 times since with a median of 730.

We clustered all documents with regards to their access status in four different segments (Table 2):





	Subscription	Closed access to article or chapter on the publisher website
	Gold OA: Hybrid	Article is free under an open licence in a Hybrid journal, or chapter was published OA in an otherwise non-OA book
	Gold OA: Fully OA	Gold OA in a Fully OA Publication. Article is free under an open licence from a Fully OA journal, or chapter was published in a Fully OA book
	Bronze	Article or chapter freely available on publisher website, but without an open licence

Table 2. Classification of access status

We can see a clear OA advantage in the data. For example, documents published Gold Hybrid OA have the highest average and median number of downloads, 4,049 and 2,368 respectively. Second come Gold Fully OA documents with an average of 2,489 and a median of 1,699 downloads. This compares to an average of 923 and a median of 522 downloads for Subscription documents. So Gold OA Hybrid documents have 4.4 times as many downloads as Subscription documents, and Fully Gold OA publications have 2.7 times as many.

After controlling for several variables on a document, author and journal level, our regression model predicts similar numbers. According to the model, Gold Hybrid OA SDG-related documents on average have a download rate that is 3.7 times higher than Subscription documents; documents in Fully Gold OA publications have a rate that is 2.5 times higher.

The variation noted between Hybrid OA and Fully OA is worthy of note. Several factors could potentially be at play, including the fact that Hybrid journals are more established and therefore attract more users. Although we used the Journal Impact Factor as a proxy for journal prestige in our regression model to control for journal reputation, this metric certainly has its limitations.

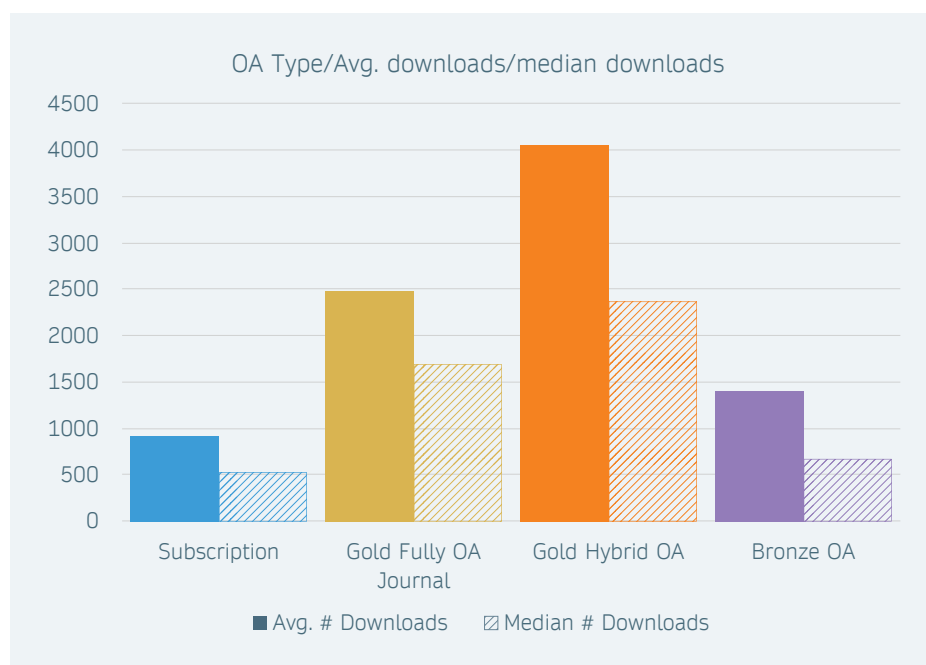


Figure 2. Average and median downloads of SDG-related Springer Nature documents published in 2017

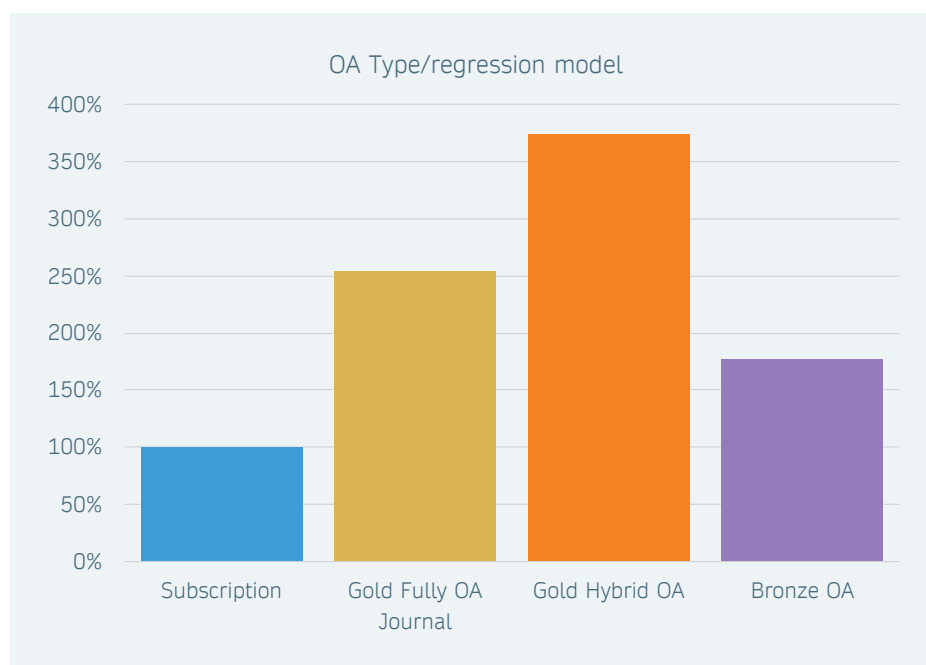


Figure 3. Regression Model Predictions SDG-related Springer Nature documents published in 2017

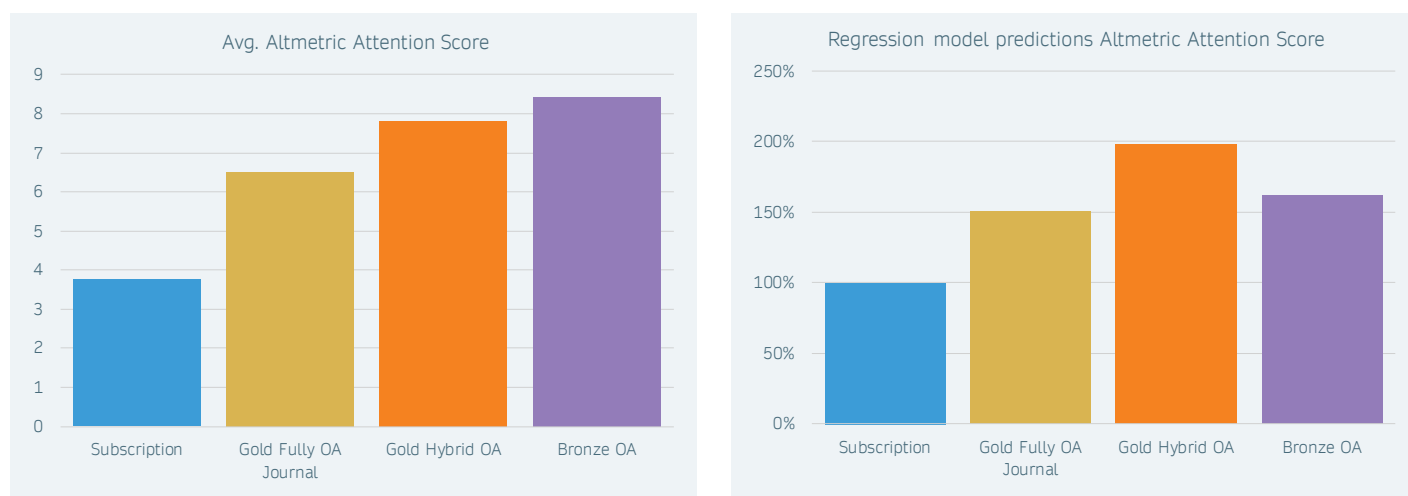
1.2 Altmetric attention data

OA content is shared more often and gets more attention than Subscription content.

358,293 SDG-related documents from the Dimensions database were analysed, all published in 2017. The vast majority (71%) of them don't yet have an Altmetric Attention Score, which is a weighted count of all of the online attention for an individual research output,¹⁶ meaning that no activity about them has been found by the provider of this score, Altmetric, in the sources they cover. However, a few documents get a lot of attention, which results in an average Altmetric Attention Score of 5.15 (the highest Altmetric Attention Score in the sample is 7,514). Looking deeper into the various sources that contribute to the Altmetric Attention Score, we see an average number of Twitter accounts tweeting about a document of 3.41, an average number of news outlets writing about content of 0.33, and an average number of policy documents mentioning content of 0.02. It is also important to consider that the Altmetric Attention Score differs significantly by the country of the author(s), since there is a regional bias with regards to the sources covered (e.g. the uptake in usage of Twitter is very different in different countries).

Despite these limitations, we can again see an OA advantage. For Gold OA SDG-related content, the average Altmetric Attention Score, as well as the average number of Twitter accounts, news outlets and policy documents are all higher than the Subscription scores. For example, Gold Hybrid OA documents have a 2.1 times higher average Altmetric Attention Score than Subscription documents, documents in Fully Gold OA publications are 1.7 times higher. The regression model predicts similar numbers: an Altmetric Attention Score that is 2.0 times higher for Gold Hybrid OA documents, and 1.5 times higher for documents in Fully Gold OA publications.

Figure 4, 5. Average Altmetric data by OA Type (SDG-related documents published in 2017)



16. More information on the Altmetric Attention Score can be found at: www.altmetric.com/blog/the-altmetric-score-is-now-the-altmetric-attention-score

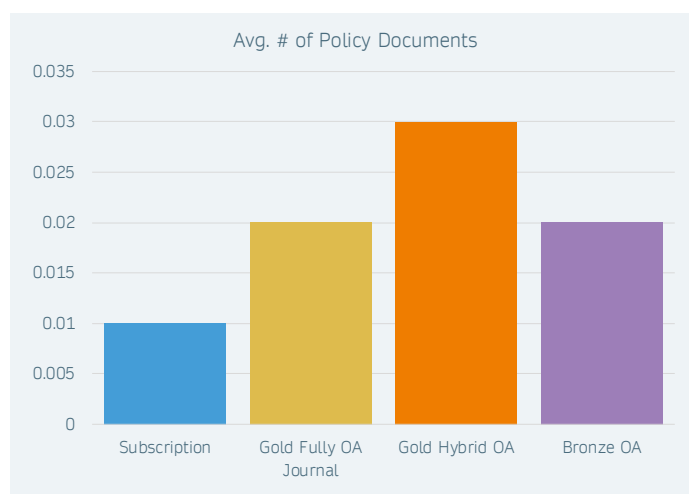
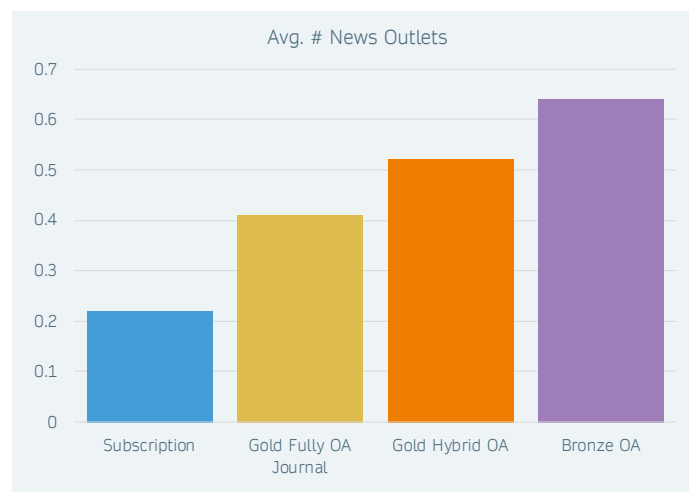
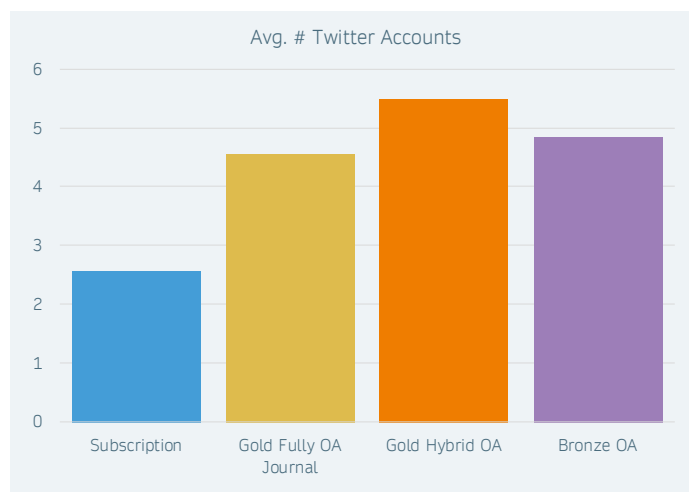


Figure 6, 7, 8. Average Altmetric data by OA Type (SDG-related documents published in 2017)

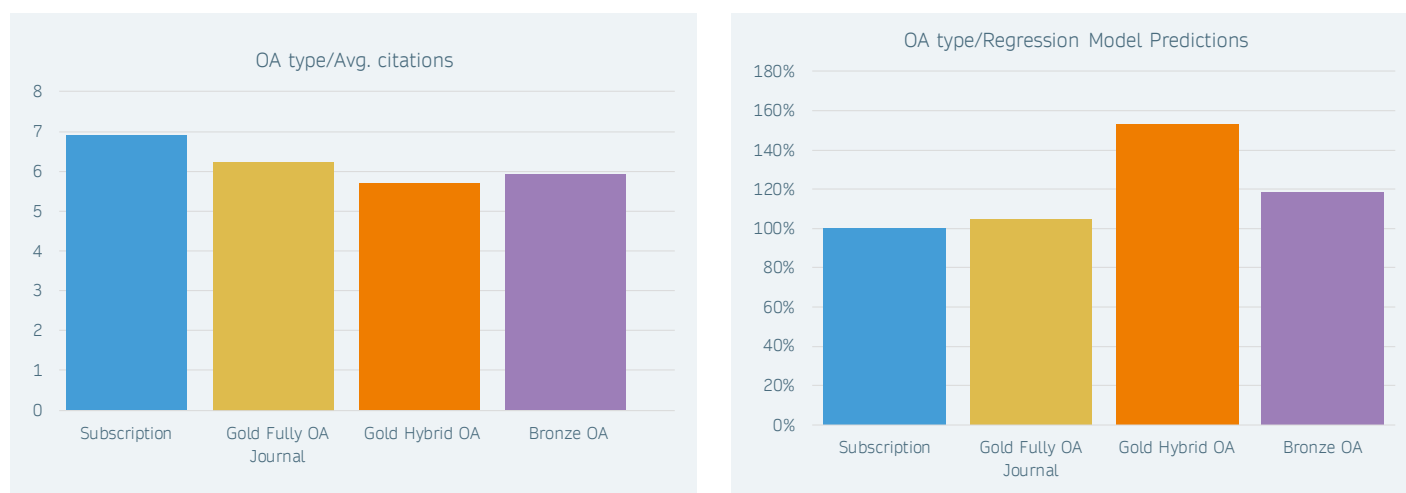
1.3 Citation data

There is not a clear OA citation advantage for this cohort of documents.

Like Altmetric data, citation data is heavily skewed. 36% of the documents in this sample (SDG-related content published in 2017) have not received a citation yet; the median number of citations is just 2. However, since there are again a few documents that perform particularly well by this metric, the average is 6.57.

Unlike the usage and Altmetric data, we can see only less distinct differences between Subscription, Gold Hybrid OA and Fully Gold OA documents. When controlled for other factors, however, the regression model suggests a citation advantage 1.5 times higher for Gold Hybrid OA documents and 1.1 times for documents in Fully Gold OA publications. For comparison, the previously mentioned Springer Nature study found that Gold OA documents in Hybrid journals attract 1.4 times more citations when controlled for various author and journal characteristics, so this analysis finds a similar result for Gold Hybrid OA across all publishers.

Figure 9, 10. Average citations by OA type (SDG-related documents published in 2017)



1.4 A case study of Netherlands SDG content

Netherlands research outstrips the global average number of downloads, with a high share of OA documents published.

When we look at documents with at least one Dutch author, we have a sample of 1,061 Springer Nature documents that were published in 2017 and are related to at least one SDG. So far, these documents have had an average of 3,046 and a median of 1,584 downloads. These numbers are well above the global averages of 1,437 and 730 average and median downloads respectively, so more than twice as high. A key reason for this is the fact that the share of OA content amongst Dutch content in Springer Nature publications is substantially higher than the global average, and the previously shown OA advantage.

When we compare the usage data by OA status, we see similar patterns compared to the global study (Table 3)¹⁷:

- There is again a clear OA advantage. For example, the regression model predicts that Gold Hybrid OA documents have on average 3.0 times as many downloads as their Subscription counterparts in the same journals, meanwhile content in Fully Gold OA publications have 1.7 times more.

17. As there were only 27 articles published Bronze in this sample, these have been excluded from the table since the sample size is too small to conclude significant results

- OA content is shared more often and gets more attention than Subscription content. The average Altmetric Attention Score, as well as the average number of Twitter accounts, news outlets and policy documents mentioning SDG-related content is higher for OA than Subscription content, with an average Altmetric Attention Score that is 1.9 times as high as for Gold Hybrid OA content, and 1.5 for Fully OA content.
- As in the global study, the data is less distinct when it comes to citations. Although we see higher average citations for OA compared with Subscription content, the results are less clear when controlled for other factors. For example, the model predicts the number of citations to be roughly the same for content in Fully Gold OA publications and Subscription content. However, the model suggests a citation advantage of 1.5 times for documents that are published Gold OA in Hybrid publications.

OA Type	Downloads		Altmetrics Attention Score		Citations	
	Average	Regression model predictions	Average	Regression model predictions	Average	Regression model predictions
Subscription	100%	100%	100%	100%	100%	100%
Gold OA: Hybrid	172%	298%	190%	168%	183%	148%
Gold OA: Fully OA	101%	174%	150%	148%	106%	96%

This analysis has shown that OA content has substantially higher online usage and attention than content that is only available under a Subscription model, both on a global basis and for content with at least one Dutch author. We wanted to investigate whether we can see signs that OA benefits user groups outside of the core academic readership. What we can see from the available data is a much stronger online usage and attention advantage from OA, compared with the observed citation advantage. This would support the assumption that one of the main advantages of OA is that it reaches a number of user groups outside of academia that typically don't have access to a large amount of Subscription content (since citations are mainly an indicator for academic utilisation). In part two, our online user survey will look deeper at this question, exploring who those non-academic users are and for what purposes they use academic/ scholarly content.

Table 3. Average downloads, attention and citations of SDG related documents with at least one Dutch author, published in 2017, based on average and regression model predictions. See also Table 1 for global comparison data.

Part two: user survey

2.1 Segmentation

More than 40% of respondents were non-academic users.

The survey asked its 5,994 respondents for information about the organisation they worked or studied at, and their role. Depending on their answers, they were then asked for more detail, such as what industry they worked in if they were a corporate user, or whether they had an academic background if they were retired. The overall audience was segmented based on category, grouping the type of organisation they worked in together with their stated role or job title. This grouping was then split into three segments, based on the degree to which primary research is a major driver for their work:

- Core users were defined as those conducting and publishing research, primarily from academia (Graduate student to PhD students, PostDocs, Professors and Principal Investigators).
- The non-core groups were then split depending on whether they were in an industry or role where research is likely to play a major influence or motivation (Halo) or not (General).

This top-level split is necessarily somewhat blurred, and arguments could be made for many individuals being re-categorised if they were close to a boundary. The survey gathered only very limited data about each respondent, but it was sufficient to provide distinction for further analysis on their use of content.

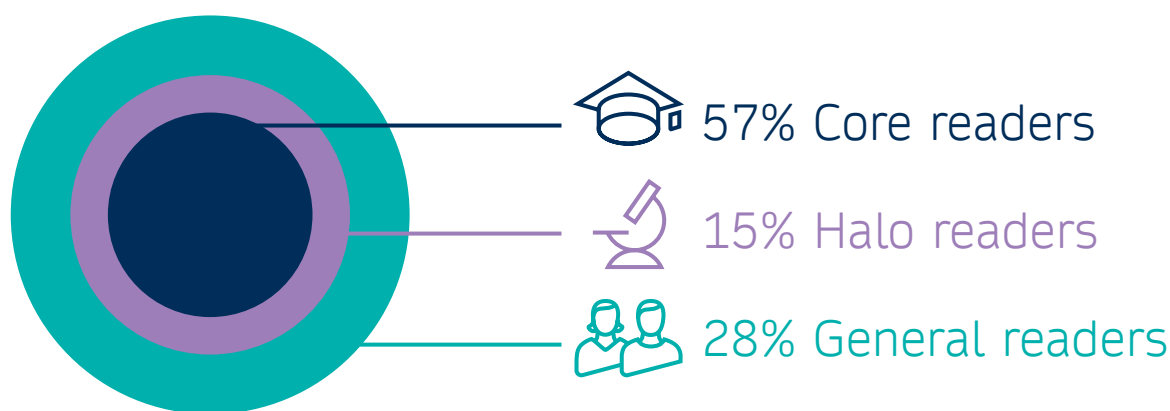


Figure 11. Sample audience breakdown

2.1.1 The Halo segment

 15%

The Halo segment covers those in industries or roles where a significant proportion are likely to read research for professional purposes, but where the primary part of their role is not conducting and publishing research.

The segment is dominated by those working in hospitals and medical practices, and in pharma/biotech. Other Halo groups include retired academics, who may potentially still have some advisory or influencing role, as well as members of government organisations and a long list of additional job roles (e.g. journalists, librarians or freelance editors).

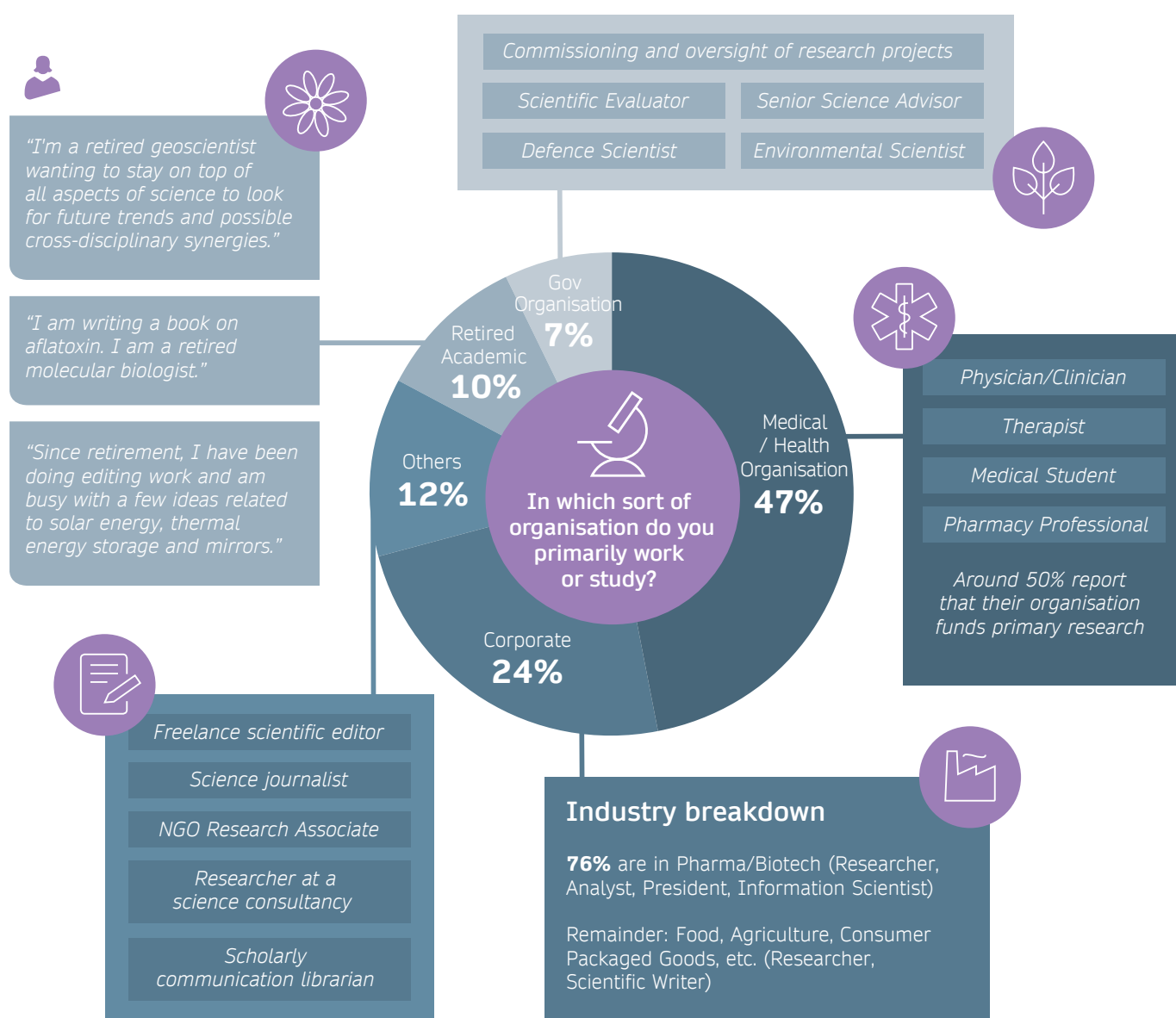


Figure 12. Halo segment profile

2.1.2 The General segment

 28%

The General segment comprises a very 'long-tail' of a wide variety of roles, which could be grouped and structured in multiple ways, and accounts for an astonishing 28% of respondents. As well as a wide variety of self-employed roles, there is a large group of corporate employees who are using research but who do not have research roles per se. They come from a wide range of industries and company sizes, including a substantial share of Small and Medium-Sized Enterprises (SMEs). Beyond that there is a broad swathe of roles, from teachers to homeworkers, and to carers and miscellaneous others.

Note that when an organisation type appears in both the Halo and General segments, such as Government organisation, this is because the categorisation has been carried out at organisational and job role level. In the Halo segment these individuals are likely to be carrying out researcher roles; in the General segment they will not (but may work at the same organisation).

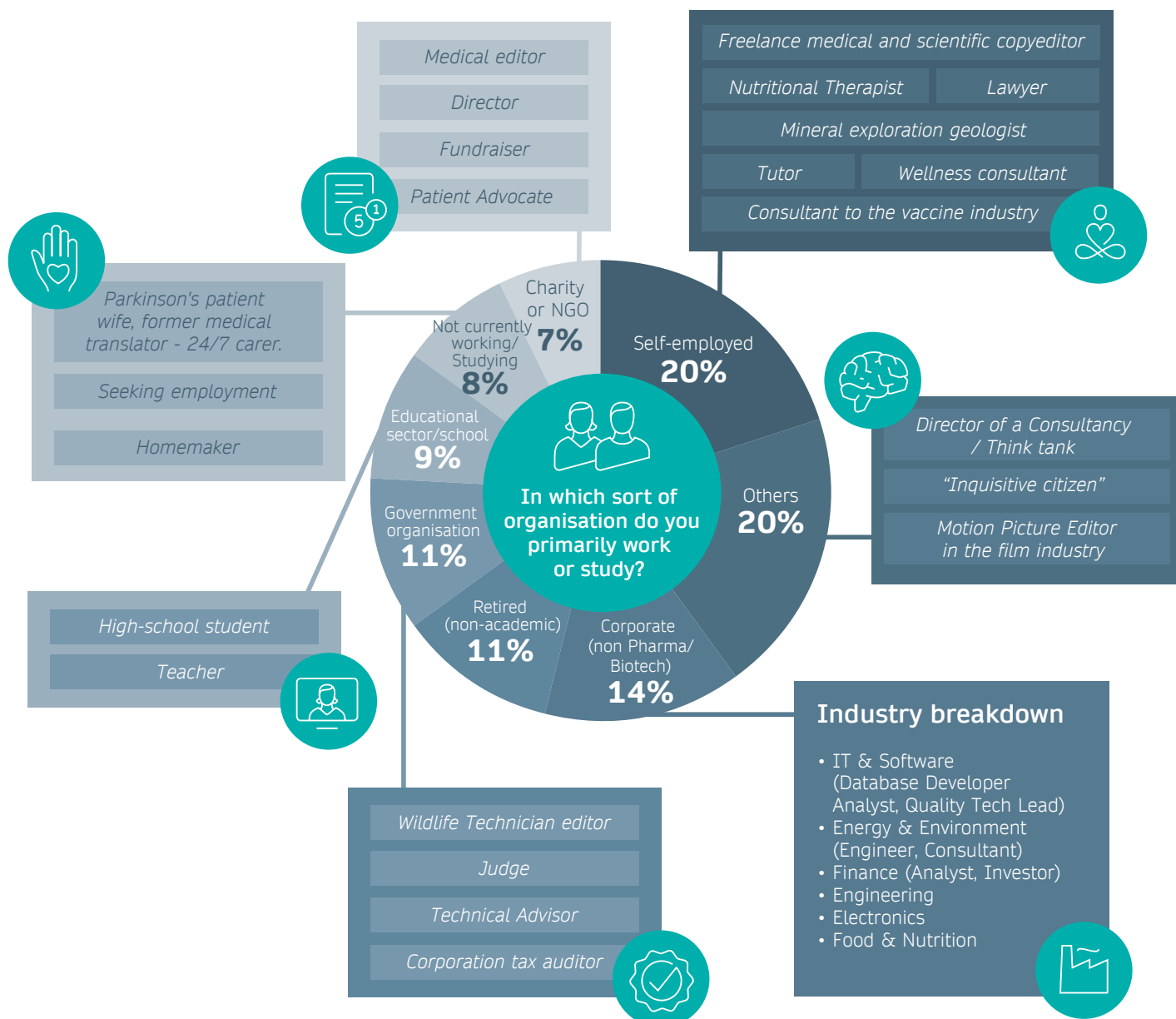


Figure 13. General segment profile

2.2 Access to research documents

Over 60% of the Halo and General segments find it difficult to access the full text of Subscription documents.

As mentioned in the Methodology section, respondents to this survey were recruited on document pages on nature.com, link.springer.com and biomedcentral.com. Those documents can be clustered in two different ways:

- Their OA status: Exactly 50% of the documents in this sample are Gold OA, the remainder are Subscription.
- SDG relevance: The majority of the documents (92%) in the survey sample are not SDG-relevant according to the SDG classification used, while 8% contribute to at least one SDG.

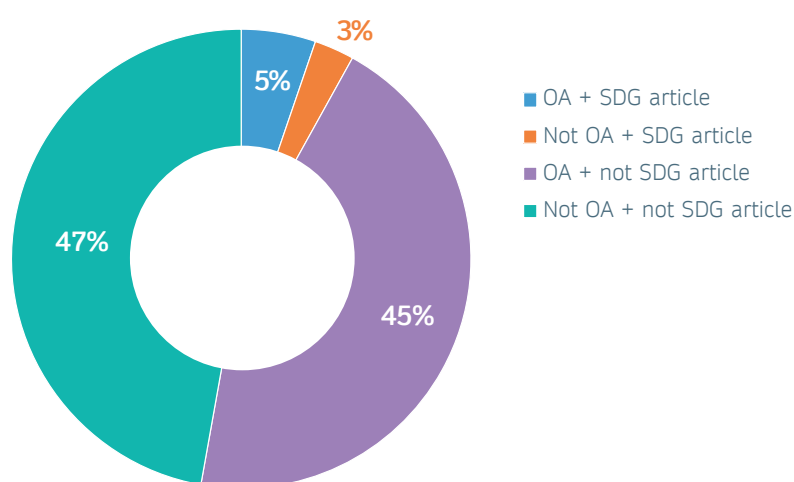


Figure 14. Documents in this sample from where respondents were recruited

For about half of the users, access to the full text of the documents was not an issue, since they were OA. What about the Subscription documents? Here we can see roughly a 50/50% split between respondents who said they were able to access the full text and those who could not. However, we can see significant differences between the three user segments. While over 60% of the Halo and General segments respectively said that they didn't have access to the full text, the percentage is much lower for the Core segment. All users from institution types other than University/College and Research Institute reported much higher rates of 'non-access'. The highest rates were seen from users categorised as Charity/NGO (69%), Self-Employed (68%), Corporate (64%), and non-academic educational sector (61%).

Were you able to access the full text of the research document(s) you wanted to read on this visit to our website? – Subscription documents only				
Letters signify where there are statistically significant differences between groups, with a,b,c indicating a difference at $p \leq 0.05$ and A,B,C indicating a difference at $p \leq 0.001$				
	Core (A)	Halo (B)	General (C)	Total
No	45%	62% A	62% A	52%
Yes	55% B C	38%	38%	48%
Column n	1,687	402	773	2,862

Table 4. Full-text access to subscription documents (self-reported)

In the survey, we also asked respondents about their general experience, and how often they have difficulties accessing the full text of research content. In total, 62% of respondents said that they often (“almost always” or “frequently”) have difficulties in accessing the full text. Again, the percentage is higher for the Halo (66%) and General (70%) segments. Even so, 57% of the Core audience felt like they often have issues accessing data, particularly when outside of their institution.

Self-reported access difficulties were significantly more common for readers in: Charity/NGO (83%), Corporate (72%), Self-Employed (68%), Medical/health organisations (67%), government organisations (67%), and the non-academic educational sector (66%).

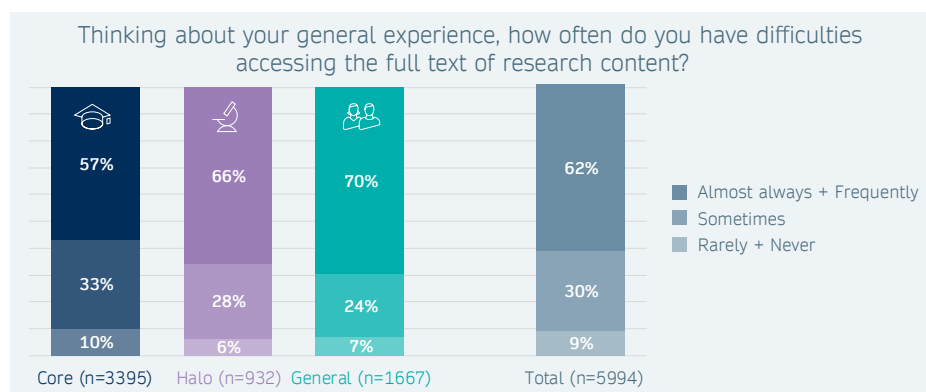


Figure 15. Self-reported general difficulties accessing full text research content

We also asked an open-ended question about how the respondents would try to access the full text if the publication was not open to them (Figure 16). Typical routes for users include contacting an institution's library or information centre, trying to get institutional access when off-campus via IP-enabled or federated access, asking a colleague or the authors, searching for alternative versions on Google or Google Scholar, or just giving up. Very often users said that they would consider a set of alternative routes that they would apply in sequence, often depending on the relevance of the document in question.

We find many similarities in approaches between the three user segments. However, some significant differences can be observed.

- Users belonging to the General audience were significantly more likely to say they would search Google or give up and move on from closed documents, looking for a similar document that they can access.
- As expected, the Core audience were significantly more likely to say they would try their institutional access. They were also more likely to use pirate sites, primarily Sci-Hub.

It is worth noting that this survey was running during May, June and July 2020, during what for many countries around the world was a time of lockdown and concern about the unfolding COVID-19 pandemic, forcing many users to work from home and access content remotely. In March, at the start of the pandemic, many institutions had not set up remote access, resulting in widespread access troubleshooting. During this period, Springer Nature registered a drop in the number of authenticated users by nearly 50% (year-on-year). Further, COUNTER downloads had decreased by 15% (year-on-year). Institutions and publishers moved swiftly to support users and operationalise remote access, and by early April, the situation stabilised. In July, usage on SpringerLink increased by approx. 20% compared to the same period in 2019, both from researchers and a general readership. As the survey was carried out from May-July 2020, it is unlikely that any encountered access issues during this period were due to the absence of remote access set up.

Alternative access routes



Core readers



"Write to colleagues who work at other research facilities and see whether they have access OR just not bother to read the document at all but look for a similar publication that I can access."



"Ask my library to order it, see if a friend has access who can send me the PDF, or use SciHub."



"I would try to sign in using my institution credentials, see if it is available through our library system, or look for the full text elsewhere on the web."



Halo readers



"Search Google, ResearchGate ... then discard the attempt if that didn't work."



"Look for other documents on the same subject that are open access. Rarely, I rent the document. My business is a small business start-up. Purchasing access to high quality journal documents is most often beyond our means."



"Purchase it ... or drop it, depending on urgency and relevance."



"Through my information office with a request to purchase. Or skip that publication by reading only the abstract."



"Try multiple websites. Google Scholar, PubMed full text links. And wait till my next work day to access at my institution. Or ask an MD friend who likely has access."



General readers



"Won't try, can't afford to buy access."



"Read just the abstract or give up. It's just for personal growth."



"Ask an academic friend to access for me if the abstract was extremely relevant, otherwise I would skip and search other documents."



"Use my husband's university account, or email authors."



"I would search for the document in other venues. But fundamentally this is one of the biggest frustrations we have in doing research is how much of it is gated. It limits the ability of government officials to apply research to real-world policy."



"Just read abstract even though that doesn't let me assess study strength or details; ask a student, friend, or colleague to access; more Google searches."



"I would probably just give up. I work for a small charity and we don't have funds to purchase many subscriptions."

Figure 16. Example answers on alternative access routes to Subscription documents

2.3 Motivations for reading research documents

Core users are most likely to cite, where Halo and General readers are looking to learn or to stay up to date.

The survey also asked users for what purposes they use research content, and what the underlying motivations were to start their discovery journey. One question asked about whether their interest in the content was triggered by professional or personal reasons. Interestingly, within the General segment, usage was much more likely to be for personal reasons, or a mixture of both professional and personal interest. But even within the Core and Halo groups roughly a third said that both professional and personal interest motivated them to search for research content. As we can see later in this report, a common use case for users is to stay informed or learn or understand something specific, both of which indeed can have a personal angle to it, e.g. advancing personal knowledge on a general or specific topic.

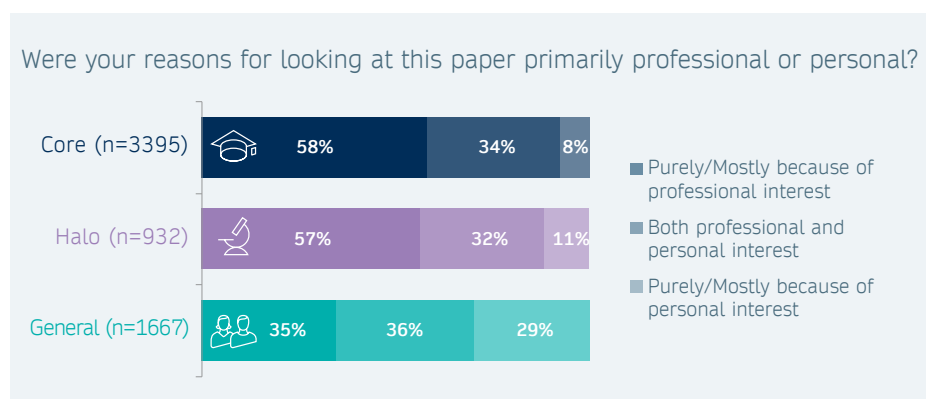


Figure 17. Reasons for looking at document

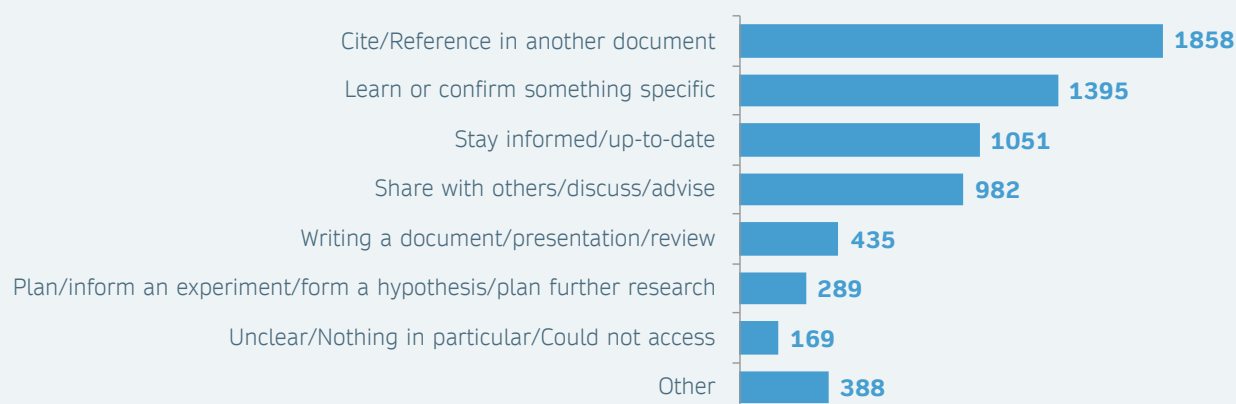
The survey also asked participants an open text question, to try to capture some detail and richness in usage scenarios: "What have you done, or what do you plan to do, with the information from the research document? It would also be useful to understand your aims in doing so." To encourage a useful volume of answers, the question also provided some examples:

- "Referred to it in a written document" (e.g. research paper, technical document, business plan, policy paper)
- "Shared and/or discussed it with other members within and/or outside of my organisation"
- "Used the information to learn more about a specific topic or keep me up-to-date"

Understandably, this skewed the answers towards the kind of answers shown in the examples, but these were in any case expected to have been the most common answers. There were 5,760 responses to this question, and analysis and grouping of the open text responses is shown in Figure 18 (p.22).

It should be remembered that the method of asking the question using an open text response does mean that the answers are necessarily non-exclusive. In other words, just because a respondent answered that they were using the document to plan an experiment does not mean that they would not also have planned to share the document. Most respondents would likely be trying to be brief, and so would be very unlikely to list all of their motivations. We should therefore perhaps interpret the answers as being the intention that was most 'top of mind' when answering.

"What have you done, or what do you plan to do, with the information from the research article?
It would also be useful to understand your aims in doing so." (n=5760, multiple coding)



Furthermore, there were at least two ways for respondents to interpret the question: either as "what were you doing with this document" or "why this document?". The two questions are not as distinct as they first sound, and the answers often cover both. But this question is only an attempt to explore the broad topic, not an attempt to tightly define the varieties of motivation and behaviour in reading research documents, much of which has been researched previously.¹⁸

Figure 18. Overall grouping of open text responses on motivations for reading document

Some of the answers shown here demonstrate the use of the research literature for diagnosis and to answer other medical questions – again a reflection of the timing of our research during the pandemic. A pertinent question arising is what publishers and other parts of the research ecosystem can and should do to better enable the use of the research literature by non-specialists.

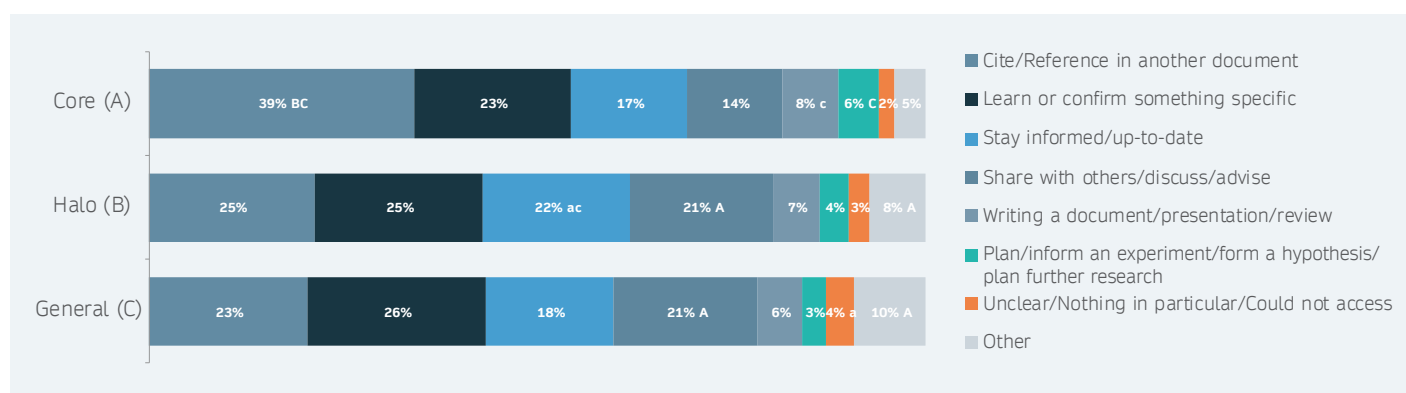
2.3.1 Variance of audience segment in reported motivations

Table 5. Variance of audience segment in reported motivations for using research documents

Behaviour	Definition	Variance By Segment
Cite / reference in another document	In the majority of cases this would mean other research documents, but there were plenty of examples of users planning to cite in books, reviews or websites. Many of the responses here also naturally overlap with "writing a document".	Higher in Core
Learn or confirm something specific	This category groups the large number of responses which were indicating the use of a literature search to find out something very specific. This type of intention contrasts with the following answer, stay informed/up to date. Given the timing of the survey, in Q2 2020, there was a reasonably large proportion of COVID-19 themed answers in this category.	
Stay informed / up to date	This represents the common but relatively passive need of many to stay in touch with the published research.	Higher in Halo, particularly government organisations

18. See, for example: Tenopir C., Christian, L.; & Kaufman, J. (2019): Seeking, Reading, and Use of Scholarly documents: An International Study of Perceptions and Behavior of Researchers. Publications, 7(1), 18

Share with others / discuss / advise	Intention to share the findings with others, or use for discussion or to advise others or advocate on policy. The method of sharing was generally not disclosed, but it is assumed it would typically be via email or even via a hard copy of the document.	Higher in Halo and General. Core segment more often shares via citations and publications
Writing a document / presentation / review	In fact all of those who said cite/reference would fit into this category, too. Included here are only those who specified a document. Documents mentioned ranged from documents to books, grants, presentations, dissertations and so on.	
Plan / inform an experiment / form a hypothesis / plan further research	Using articles for planning further research or forming ideas and hypotheses for further experiments. This would include short-term evaluation of experimental methodologies, and longer-term thinking about research strategy.	Higher in Core
Miscellaneous	A long-tail of miscellaneous reasons, or unclear responses, which are nonetheless instructive in their sheer variety. They include using material for teaching and training, investigating personal medical issues, simple curiosity and evaluating a journal for paper submission, amongst many other things.	Higher in Halo and General



2.3.1.1 Variance within Halo segment in reported motivations for using research documents

Within the Halo segment, there is further variance in reported motivations for usage. Those at medical organisations were less likely to be using documents to plan research. Corporate users were less likely to be creating documents but more likely to be using documents for discussion or sharing more widely. Finally, those in government organisations were more likely to cite documents.

Figure 19: Categorised responses to motivations for reading documents by proportions of top-level segments¹⁹

19. Letters signify where there are statistically significant differences between groups, with a,b,c indicating a difference at $p \leq 0.05$ and A,B,C indicating a difference at $p \leq 0.001$

	Medical/Health Organisation	Corporate	Retired Academic	Government Organisation	Others
Cite/Reference in another document	24%	20%	14%	41%	36%
Learn or confirm something specific	23%	29%	33%	25%	18%
Stay informed/up to date	20%	23%	35%	24%	15%
Share with others/discuss/advise	18%	28%	15%	27%	23%
Writing a document / presentation / review	9%	3%	6%	8%	8%
Plan/inform an experiment / form a hypothesis / plan further research	2%	9%	3%	6%	3%
Unclear/Nothing in particular/ Could not access	5%	1%	6%	2%	0%
Other	12%	6%	4%	2%	5%
Column n	419	214	93	63	110

Red indicates significantly lower, blue significantly higher at $p = 0.05$

Within the General segment, significant differences were as one would expect. Retired users are less likely to be citing a document (12%), while Corporate users were more likely to be researching something specific (33%).

Table 6. Categorical motivations for document use by sub-segments of the Halo user segment

	Self-employed	Corporate	Retired	Government Organisation	Educ. Sector / School	Not Currently Working / Studying	Charity or NGO
Cite/Reference in another document	22%	18%	12%	28%	25%	22%	34%
Learn or confirm something specific	28%	33%	28%	19%	24%	32%	14%
Stay informed/up to date	20%	20%	28%	13%	14%	22%	13%
Share with others/discuss/advise	18%	18%	21%	25%	19%	19%	29%
Writing a document / presentation / review	7%	4%	6%	5%	10%	2%	7%
Plan/inform an experiment / form a hypothesis / plan further research	5%	5%	1%	5%	2%	2%	6%
Unclear/Nothing in particular/ Could not access	5%	5%	4%	3%	4%	4%	5%
Other	9%	10%	18%	7%	13%	15%	3%
Column n	327	215	180	174	143	127	120

Red indicates significantly lower, blue significantly higher at $p = 0.05$

Table 7. Categorical motivations for document use by sub-segments of the General user segment

2.4 Sharing of research documents

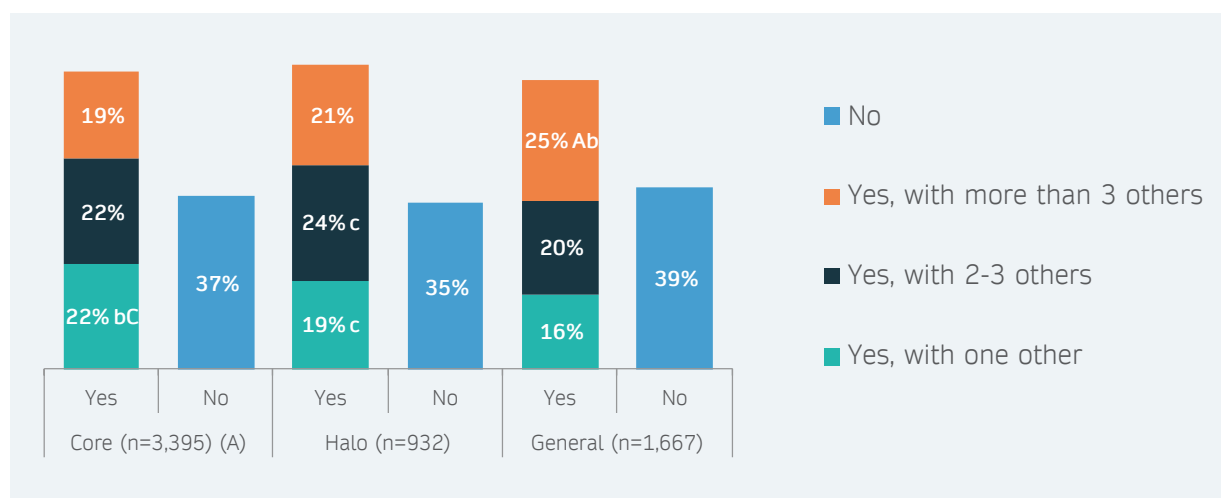
OA content is more likely to be shared with a higher number of people.

Although one of the categorised motivations for using research documents in the previous section was 'Share with others/discuss/advice', the survey also asked in more detail about intentions to share.

Although respondents from the General segment were overall slightly less likely to say that they would share the research document they read (61% vs 63% and 65%), those that said they would share were significantly more likely to say they would share with more than three other individuals, suggesting that the General segment overall may have a wider potential network and reach.

By contrast, those in the Core segment who said they would share were significantly more likely to report that they would share with just one other. It could be that for many respondents in this group the 'one other' would be their supervisor, and this is supported when we find a higher proportion giving this answer were aged under 35 (25% vs net of 22%).

Figure 20. Have you already, or do you plan to share the document with others, either informally or formally? Variance by top-level segments²⁰



Within the General segment, there is some significant variance in sharing behavior, with very high levels of sharing by those in government organisations, charities and NGOs, but very low levels of sharing by those not working or retired.

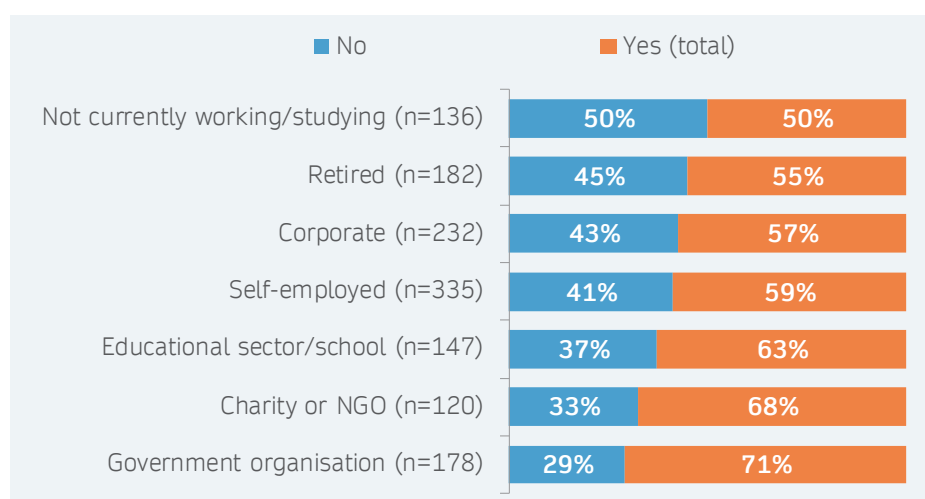


Figure 21. Have you already, or do you plan to share the document with others, either informally or formally? Variance within General sub-segment²⁰

20. Letters signify where there are statistically significant differences between groups, with a,b,c indicating a difference at $p \leq 0.05$ and A,B,C indicating a difference at $p \leq 0.001$.

Looking at how intention to share varies by OA status of the document, there is a statistically significant increase (at $p \leq 0.001$) in likelihood of sharing for users of OA documents. It is not clear whether the intention to share has driven the user to look at an OA article or book chapter, or whether the OA nature of the document means that the user is more likely to share. Regardless, this is a strong indication that OA documents are likely to have a greater penetration and reach.

Furthermore, users who do express an intention to share are more likely to intend to share with a larger number of people: a significantly higher proportion of OA users vs Subscription users (23% vs 21%) say they will share with 2-3 others, and a higher proportion of OA users vs Subscription users (22% vs 20%) say they will share with more than 3 others.

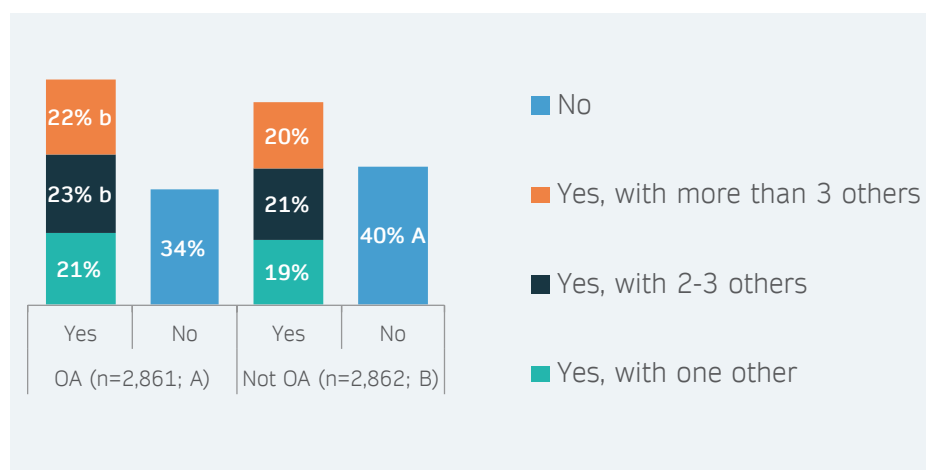


Figure 22. Have you already, or do you plan to share the document with others, either informally or formally?²¹

21. Letters signify where there are statistically significant differences between groups, with a,b,c indicating a difference at $p \leq 0.05$ and A,B,C indicating a difference at $p \leq 0.001$.

Discussion and conclusions

In undertaking this research, we wanted to learn more about non-academic users of research content, in particular looking at the effect of this work being made available OA, where research related to the SDGs.

Our bibliometric study on SDG-related content shows that Gold OA content has substantially higher online usage and attention than content that is only available under a Subscription model, both on a global basis and for content with at least one Dutch author. This supports previous research and further points to an OA advantage for researchers.

We found Gold OA documents in Hybrid publications are downloaded even more often than OA documents in Fully OA publications and receive more attention. As we noted, there are possible explanations for this, with Hybrid journals being better established and attracting more users. However, there may be a level of selection bias with the possibility that authors choose OA in a Hybrid journal for their most significant work, which therefore attracts higher attention. We used the Journal Impact Factor as a proxy for journal prestige in our model (which certainly has its limitations), but again found a higher advantage for Hybrid OA.

From a Dutch perspective it is certainly worth highlighting the fact that SDG-related documents published with Springer Nature in 2017 have recorded around twice as many downloads on average than the global figure, surely an effect of the Springer Compact agreement for Hybrid OA journals that has been in place between Dutch universities and Springer Nature since 2015. Furthermore, our results show that Dutch SDG-relevant content published under the Gold OA Hybrid model accrue significantly more societal attention as well as academic citations when compared to comparable Subscription documents. Thus it follows that the model is ideally suited for maximising the overall societal impact of SDG-research.

As noted earlier in this report, there are very many studies available that have looked at whether there is an OA citation advantage or not, with mixed results. It is important to note that many of these studies haven't controlled for confounding factors, were limited to just a few journals or a single discipline, and that many found a correlation but didn't suggest a causation. Although this study did find an OA citation advantage for SDG-related content when controlled for selected variables at the document, author and journal level, the effects are much smaller when compared to the online usage and attention advantage we observed. Given the particular interest of this study in exploring non-academic usage, this data in particular supports our assumption that OA reaches a substantial number of user groups outside of academia that typically don't have access to a large amount of Subscription content, and are typically less likely to cite this work.

Overall, these results support our underlying assumption that users outside of the core academic research audience do benefit in particular from OA. With our survey this assumption is put to the test, and we find a substantial number of non-core users who are interested in research content, with more than 40% falling into the Halo or General user segments.

Our results suggest that the biggest beneficiaries of immediate Gold OA may not be the core academic researcher community who “contribute” to research, but the many communities that rather “consume” this corpus of literature.

While the Halo group can be described relatively precisely (users who are likely to read – but not publish – research for professional purposes predominantly in a medical or corporate setting), the General audience consists of a very long-tail of different user groups. What they have in common is that they read research out of personal or professional interest, perhaps on a casual basis, but they are not in an occupation where they are likely to conduct and publish research or reference research in a scholarly publication.

Both the Halo and General user segments differ significantly from the Core segment. They typically have access to the full text of fewer journals than their academic counterparts, and therefore more often have difficulties accessing research content. No doubt, both the Halo and General user groups benefit particularly from OA. Future research could consider what the knock-on effect of not being able to access the content might be.

When looking at the reasons and motivations for reading research content, we can see that the Halo segment is more likely to be reading for the purposes of staying up to date. Both the Halo and General segments are more likely to share documents with others, possibly because the act of citing a document takes the place of sharing, to a certain extent, within the Core segment.

Interestingly, within the General segment, usage was much more likely to be for personal reasons, or a mixture of both professional and personal interest. Respondents particularly from the General audience also reported on a long-tail of miscellaneous reasons, which are instructive in their sheer variety. They include using material for teaching and training, investigating personal medical issues, simple curiosity and evaluating a journal for paper submission, amongst many other things.

To conclude, both studies suggest a significant benefit of OA to readers both in and outside of academia. The content is more widely and easily accessible, and as a consequence utilised more frequently in terms of online usage, sharing and attention, and citations. Our results suggest that the biggest beneficiaries of immediate Gold OA may not be the core academic researcher community who “contribute” to research, but the many communities that rather “consume” this corpus of literature. By combining these two studies, we can begin to see a substantial amplification effect in how research is being used, shared, and built up to increase knowledge and affect real-world change outside academia. In doing so, this report makes a strong case for the further investment and funding for OA for the benefit of society, particularly in supporting research related to the SDGs.

Case Studies

Utilization of open access SDG-related content from Dutch authors

In this section we call out the reach and overall impact of research made openly available. The following four SDG-related articles were published open access by Dutch authors in Springer Nature journals. The examples show the previously reported OA usage advantage, as witnessed by the high percentage of usage that has occurred outside of Springer Nature's institutional customer base. The very high number of shares and coverage of these articles in traditional and social media as well as policy documents is certainly supported by their OA status, too.

1. River plastic emissions to the world's oceans

<https://doi.org/10.1038/ncomms15611>

Published in *Nature Communications*, so far this article has been downloaded more than 94K times. 75% of the usage is from users who were not identified as being a Springer Nature institutional customer. It has been mentioned in 78 news stories from 48 outlets, including *The Guardian*, *The New York Times*, *CNN*, *National Geographic*, *Der Spiegel*, *Die Zeit*, *The Hindu*, and *The Japan Times*.

This article has been referenced in 16 policy documents, including from The Internal Union for Conservation of Nature, the UK Government and the Food and Agriculture Organization of the UN.

Its overall Almetric Attention score is 1,230 and Almetric has seen 897 tweets so far, with a reach of over 3 million followers.



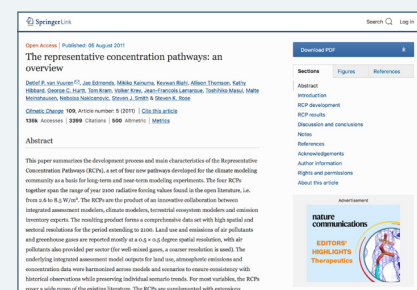
2. The representative concentration pathways: an overview

<https://doi.org/10.1007/s10584-011-0148-z>

Published in *Climate Change*, so far this article has been downloaded more than 136K times. 57% of the usage is from users who were not identified as being a Springer Nature institutional customer. It has been mentioned in 56 news stories from 37 outlets, including *de Volkskrant*, *de Morgen*, *Forbes*, *Bloomberg*, and *The Guardian*.

This article has been referenced in 49 policy documents, including from the World Health Organization, the UN Environment Programme, the Publications Office of the EU, and the World Meteorological Organization.

Its overall Almetric Attention score is 500 and Almetric has seen 96 tweets so far, with a reach of over 370K followers.



3. African migration: trends, patterns, drivers

<https://doi.org/10.1186/s40878-015-0015-6>

Published in *Comparative Migration Studies*, so far this article has been downloaded more than 84K times. 66% of the usage is from users who were not identified as being a Springer Nature institutional customer. It has been mentioned in 8 news stories.

This article has been referenced in 12 policy documents, including from the African Union, the International Organisation for Migration, and the Food and Agriculture Organization of the UN.

Its overall Almetric Attention score is 219 and Almetric has seen 218 tweets so far, with a reach of over 650K followers.



4. The global impact of non-communicable diseases on macro-economic productivity: a systematic review

<https://doi.org/10.1007/s10654-015-0026-5>

Published in the *European Journal of Epidemiology*, so far this article has been downloaded more than 5K times. 62% of the usage is from users who were not identified as being a Springer Nature institutional customer.

This article has also been referenced in 6 policy documents, including from the World Bank, the World Health Organization, the British Thoracic Society, and the National Academies Press.

Its overall Almetric Attention score is 16 and Almetric has seen 7 tweets so far, with a reach of 27.6K followers.



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Around our complex and interconnected world, the research community is advancing discovery for all of us. These illustrations celebrate some of the great minds who have helped advance discovery through history.



Construction of a reference genome sequence for barley

A 10 year research study by a multi-nation consortium has reported the first high-quality reference genome sequence of barley, a cereal crop that is used around the world as animal fodder and as the raw material for popular beverages such as beer and whisky. The barley genome is almost twice as large as the human genome and 80 percent consist of highly complex repetitive structures. This research means that scientists can now locate all genes precisely in the genome and analyse complex gene families that play a key role in the malting and resilience of the crop.

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