

How open are hybrid journals included in transformative agreements?

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Abstract

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Introduction

For over two decades, hybrid open access journal publishing, which makes some articles openly available while others remain behind a paywall, has been discussed as a means for transitioning the subscription system to full open access (Prosser, 2003). The idea was that when journals increasingly publish open access articles, they could reduce revenues from subscriptions, while libraries and funders could change their funding models and shift expenditures from subscription to open access. However, initial approaches, mainly based on publication fees, also called article processing charges (APCs), did not contribute substantially to a large open access uptake. In 2009, Springer reported open access to 1% of articles in hybrid journals (Dallmeier-Tiessen et al., 2010). Other studies also recorded a low uptake. In 2011, only 1-2% of articles were open access (Björk, 2012), growing to around 4% between 2011 and 2013 (Laakso & Björk, 2016).

With the introduction of central funding mechanisms for publication fees in some European countries since 2012, an increase in hybrid open access could be observed (Björk, 2017; Huang et al., 2020; Jubb et al., 2017; Piwowar et al., 2018). For example, studying university output, Robinson-Garcia et al. (2020) estimated a median uptake of 7.1% in the period 2014-2017. In particular, British (17%), Austrian (15%) and Dutch (13%) universities stand out. However, this shift in funding policy towards hybrid open access also added to the overall cost of publishing, which includes subscription spending and the administrative efforts required to handle payments (Pinfield et al., 2016). Moreover, established large commercial publishers, which already dominated the publishing market (Larivière et al., 2015), disproportionately benefited from hybrid open access funding in comparison to full open access publishers (Butler et al., 2023; Jahn & Tullney, 2016; Shu & Larivière, 2023).

As a consequence, libraries and their consortia began to develop licensing strategies aimed at avoiding such ‘double dipping’ scenarios, in which well-established commercial publishers gain twice from reading and open access publishing

(Mittermaier, 2015), as well as to increase publisher-provided immediate open access (Björk & Solomon, 2014; Schimmer et al., 2015). These considerations resulted into transformative agreements¹, which cover a broad range of contracts between library consortia and publishers from mid-2010s onwards where institutional spending for subscriptions and open access publishing are considered together (Borrego et al., 2020; Hinchliffe, 2019). Transformative agreements seek to control costs while allowing a transitional phase for publishing more open access articles. Similar to big deals, transformative agreements mainly bundle hybrid and subscription-only journals from commercial publishers, but aim at a higher degree of transparency than previous big deals, where contracts including payments were confidential (Bergstrom et al., 2014).

The introduction of transformative agreements aligns with funding policy changes, such as the decision made by the cOAlition S, a consortium of national funders including the European Commission, to no longer provide financial support for individual publication fees when publishing in hybrid journals. According to its Plan S launched in 2018, the cOAlition S funders only accept hybrid open access through transformative agreements “during a transition period that should be as short as possible” (Schiltz, 2018). Specifically, they agreed to support hybrid open access only through transformative agreements from 2021, until the end of 2024. Notably, the German Research Foundation (DFG), despite not being part of cOAlition S, has also extended its financial support for hybrid open access through transformative agreements (Mittermaier, 2021). Previously, the DFG only provided funding for full open access journals (Jahn & Tullney, 2016).

By the end of 2023, many transformative agreements were implemented, but interim outcomes are mixed. The ESAC Transformative Agreement Registry², the

¹ In this paper I use the term “transformative agreement”, addressing also offsetting, read-and-publish or publish-and-read deals, and other variants (Borrego et al., 2020; Hinchliffe, 2019). Although the term is criticised as misleading and not useful to describe the different types of open access agreements between library consortia and commercial publishers (Babini et al., 2022), it is widely used in policy discussions and in the research literature.

² <https://esac-initiative.org/about/transformative-agreements/agreement-registry/>

largest source of disclosure, recorded more than 800 transformative agreements, resulting in up to 900.000 open access articles published in both full open access and hybrid journals according to the accompanying ESAC Market Watch³. Library consortia reported increased open access volume, streamlined payment and monitoring procedures, as well as extensive utilization of open access options by the researchers they serve (Marques & Stone, 2020; Parmhed & Säll, 2023; Pinhasi et al., 2020). The ongoing standardisation of transformative agreements contributed to improved transparency in terms of contracts and publisher-provided article metadata (Marques et al., 2019; Pinhasi et al., 2021). However, with the growing trend toward transformative agreements, continued reliance on big deals is perceived as problematic, because it perpetuate market concentration (Butler et al., 2023; Shu & Larivière, 2023). Whether transformative agreements lead to reduced pricing remains uncertain (Borrego, 2023) and a substantial transition of hybrid journals towards full open access could not be observed (Matthias et al., 2019; Momeni et al., 2021). The focus on large commercial publishers might also increase inequality (Klebel & Ross-Hellauer, 2023), because transformative agreements focus on pay to publish open access mainly targets institutions from high-income countries, furthering a questionable journal prestige culture (Babini et al., 2022). Besides, an editorial-board resignation raised concerns that publishers' desire to maximize journal publication volume "without regard to quality" is a consequence of transformative agreements (Rasmussen, 2023).

The controversies surrounding hybrid open access and transformative agreements have led to varying policy conclusions. For instance, the Association of Swedish Higher Education Institutions (Sveriges universitets- och högskoleförbund, SUHF) recommended to only support agreements for publishing in full open access journals⁴. Likewise, most cOAlition S funders will discontinue financial support for transformative agreements by the end of 2024 (Liverpool, 2023). The consortium also removed most

³ <https://esac-initiative.org/market-watch/>

⁴ <https://www.su.se/english/news/>

hybrid journals from its Transformative Journal program in 2023 due to publishers' failure to meet self-defined open access growth targets (Brainard, 2023). In contrast, the German DEAL consortium announced a five-year transformative agreement with Elsevier starting in 2024, while also renewing its contracts with Springer Nature and Wiley until the end of 2028. At the same time, the Colombia Consortium signed the first transformative agreements in Latin America (Muñoz-Vélez et al., 2024).

Despite these controversies around transformative agreements as a means of transitioning journal publishing to full open access, there is limited evidence available on the adoption of open access in hybrid journals, and the extent to which this uptake can be attributed to transformative agreements. Previous studies have focused on specific countries (Haucap et al., 2021; Huang et al., 2020; Pölönen et al., 2020; Taubert et al., 2023; Wenaas, 2022) or publisher portfolios (Bakker et al., 2024; Fraser et al., 2023; Jahn et al., 2022; Momeni et al., 2023; Pieper & Broschinski, 2018), while large-scale studies relied on self-reported agreement data (Moskovkin et al., 2022), or used APC pricing lists (Shu & Larivière, 2023). Particularly, data availability is a limiting factor when studying the impact of transformative agreements (Bakker et al., 2024), because bibliometric databases, even though many allow the retrieval of open access articles in hybrid journals, do not directly attribute them to specific transformative agreements. Likewise, article-level open access invoicing data is only partly available (Jahn et al., 2022).

The present study aims to address these limitations by combining multiple openly available data sources to determine the open access uptake in hybrid journals, while distinguishing between open access through transformative agreements and other means. With this novel and open approach, this first large-scale analysis aims to answer the following questions:

- What was the number and proportion of open access articles in hybrid journals in transformative agreements between 2018 and 2022?
- To what extent did institutions with a transformation agreement contribute to the adoption of open access in hybrid journals?

For both of these research questions, this study will analyse the variability by publisher, journal subject, and country.

Methods

This study combines data from multiple publicly available data sources as shown in Figure 1. Initially, transformative agreement data retrieved from the cOAlition S Journal Checker Tool⁵ provided information about journal portfolios and participating institutions. After identification of hybrid journals by excluding full open access journals, Crossref served as the primary data source for article-level metadata including Creative Commons (CC) license information to indicate open access availability on publisher websites. To determine open access articles published through transformative agreements, first author affiliations from OpenAlex (Priem et al., 2022) were subsequently linked to eligible institutions according to the transformative agreement data. In the following, these steps are described in more detail.

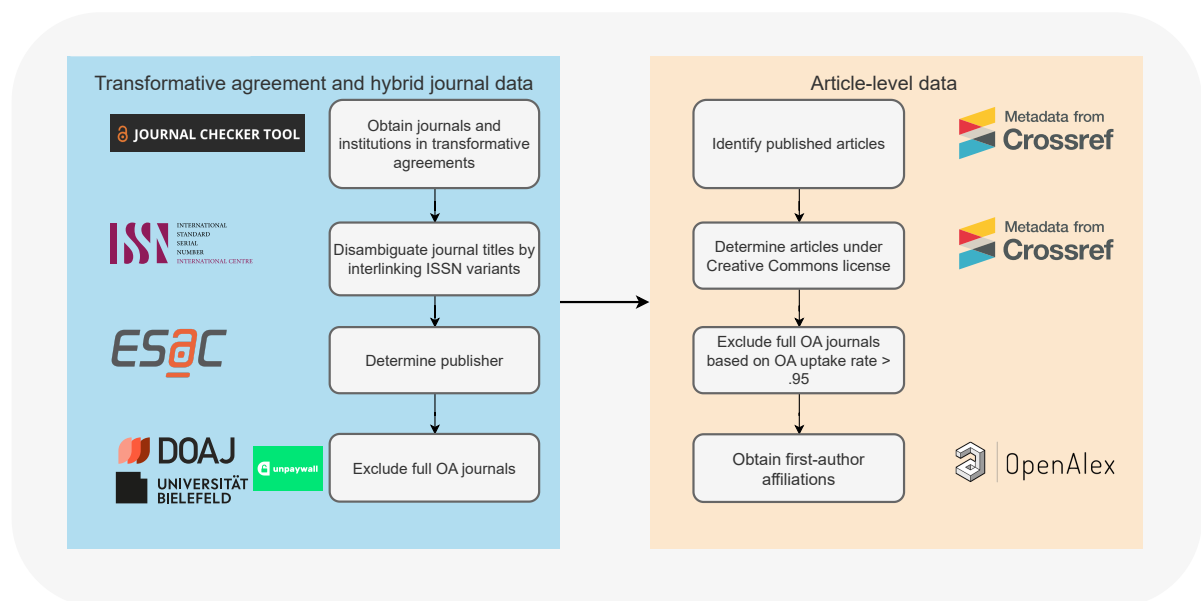


Figure 1. Data collection workflow

⁵ <https://www.coalition-s.org/blog/enabling-accurate-results-within-the-journal-checker-tool/>

[//www.coalition-s.org/blog/enabling-accurate-results-within-the-journal-checker-tool/](https://www.coalition-s.org/blog/enabling-accurate-results-within-the-journal-checker-tool/)

Transformative agreement and hybrid journal data

Data gathering started with obtaining journals included in transformative agreements from the publicly available Transformative Agreement Data dump⁶ used by the cOAlition S Journal Checker Tool.⁷ The dump consists of multiple online Google spreadsheets where each data file represents one agreement listed in the ESAC Transformative Agreement Registry.⁸ From the retrieved spreadsheet files, journals and institutions involved per agreement were obtained.

A limitation of using the Journal Checker Tool and its underlying publicly available data dump to study the development of transformative agreements over time is that expired transformative agreements are constantly removed. To address this, four different snapshots were safeguarded and combined for this study: self-archived versions from July 2021, July 2022, and May 2023, as well as the most current dump downloaded on 11 December 2023. This ensured that transformative agreements, which ended from 2021 onwards, were included, representing the majority of transformative agreements. Overall, the four combined Transformative Agreement Data dumps used in this study contained 729 out of 869 agreements listed in the ESAC registry by December 2023.

The Transformative Agreement Data dumps link agreements to journals represented by journal names and ISSN. After mapping ISSN variants to the corresponding linking ISSN (ISSN-L) as provided by the ISSN International Centre, journals were associated to publishers using the ESAC ID, a unique identifier for transformative agreements in the ESAC Transformative Agreement Registry. Furthermore, journal subjects according to the All Science Journal Classification code (ASJC) were added from the Scopus journal source list as of August 2023.

Because transformative agreements can include both full open access and hybrid journals, the data were complemented with information about a journal's open access

⁶ <https://journalcheckertool.org/transformative-agreements/>

⁷ <https://www.coalition-s.org/blog/enabling-accurate-results-within-the-journal-checker-tool/>

⁸ <https://esac-initiative.org/about/transformative-agreements/agreement-registry/>

status using multiple sources: the Directory of Open Access Journals (DOAJ) downloaded on 12 December 2023⁹, OpenAlex (November 2023) and the the Bielefeld list of GOLD OA journals (Bruns et al., 2022). As shown in Figure 2A, combining different data sources considerably extended the journal matching. In total, 3,439 full open access journals were excluded based on ISSN matching. The overlap between the three data sources was 72%. The Gold OA journals dataset alone added 176 journals, while the DOAJ comprised 10 full open access journals not listed in either of the other two sources. These full open access journals were mostly launched in 2022.

Article and author metadata

After identifying hybrid journals included in transformative agreements, article metadata was retrieved from the Crossref November 2023 database snapshot for the five-year period 2018 to 2022 according to the issued date, representing the earliest known publication date. Because Crossref metadata lacked information to distinguish between original research articles including review and other types of journal content, which are often not covered by transformative agreements (Borrego et al., 2020), only articles published in regular issues indicated by non-numeric pagination were included. Furthermore, an expanded version of Unpaywall's paratext recognition approach was applied to exclude non-scholarly journal content such as table of contents.

Open access articles in hybrid journals were identified through Creative Commons (CC) license information in Crossref metadata. License information relative to the "accepted manuscript (AM)" version were not considered. Crossref was used for open access identification because transformative agreements workflows generally require publishers to deliver CC license information to this DOI registration agency (Geschuhn & Stone, 2017).

Comparing Crossref license coverage with OpenAlex, which re-uses open access evidence from Unpaywall, a widely used open access discovery service that also parses journal websites for open content licenses (Piwowar et al., 2018), highlighted ongoing challenges to identify hybrid open access (Butler et al., 2023; Jahn et al., 2022;

⁹ <https://doaj.org/csv>

Martín-Martín et al., 2018; Zhang et al., 2022). Here, 742,369 articles with CC license were retrieved using Crossref, while 950,260 articles were tagged as “hybrid” according to the OpenAlex November 2023 release, which was used throughout this study. The biggest differences concerned articles published between 2018 and 2020. In 2022, however, Crossref and OpenAlex open access numbers only differ slightly (249,511 records using Crossref vs. 255,344 in OpenAlex). Notable difference could be furthermore observed among some publishers that presumably did not provide CC license information to Crossref including AIP Publishing, American Physiological Society, Emerald and the Royal Society. Crossref license metadata was more complete with regard to articles from the publisher Wiley and American Chemical Society. Finally, inconsistent open access status information in previous OpenAlex versions was observed (Jahn et al., 2023). After reporting it to OpenAlex, fixing this issue was still ongoing according to the release notes, which might also explain part of the discrepancy.

After retrieving article metadata, the publication volume including open access was calculated per journal. To improve the identification of hybrid journals, journals with an open access proportion above 95% were excluded. This further step allowed to remove additional 241 full open access journals.

Affiliation metadata about corresponding authors are crucial for the planning and evaluation of transformative agreements, because they are considered to be responsible to arrange open access publication (Borrego et al., 2020; Geschuhn & Stone, 2017; Schimmer et al., 2015). Here, country and institutional affiliations were retrieved from OpenAlex. However, because of low coverage in OpenAlex, this study focused on first authors and their affiliations instead. First authors typically contribute most to a paper and are often considered lead author research papers (Larivière et al., 2016). Related studies therefore assumed first authors as a proxy to measure to open access payments and the impact of transformative agreement (Haucap et al., 2021; Shu & Larivière, 2023; Zhang et al., 2022). Overall, around 90% of studied articles had first author affiliation metadata in OpenAlex, whereas the coverage of articles with corresponding author information was around 54%.

To assess the impact of transformative agreements to hybrid open access, participating institutions from the Transformative Agreement Data dump, which were crowd-sourced from the agreements and consortia that successfully negotiated an agreement, were matched with first author affiliations recorded by OpenAlex using the ROR-ID. The matching also took into account the duration of an agreement according to the ESAC registry. Upon inspection, Transformative Agreement Data did not cover associated institutions comprehensively like university hospitals or institutes of large research organisations like the Max Planck Society. To improve the matching, Transformative Agreement Data was automatically enriched with associated organisations using OpenAlex’s institution entity data.

In total, the compiled data set consists of 8,922,146 articles published in 12,857 hybrid journals between 2018 and 2022 (see Figure 2B). Hybrid journals in transformative agreements represented 40% of total global output over the same time period according to Crossref, while full open access journals recorded 35%.

Data analysis

Throughout this mostly automated data gathering and analysis process, tools from the Tidyverse (Wickham et al., 2019) for the R programming language (R Core Team, 2020) were used. The resulting data is openly available through an R data package, `hoaddata`, version 0.2.91 Following Marwick et al. (2018), `hoaddata` contains not only the datasets used in the data analysis. It also includes code used to compile the data by connecting it the cloud-based Google Big Query data warehouse, where the big scholarly data from Crossref, OpenAlex and Unpaywall were imported. To increase the computational reproducibility, the data aggregation through `hoaddata` was automatically carried out using GitHub Actions, a continuous integration service.

Results

Overview

Between 2018 and 2022, a total of 11,189 out of 12,857 hybrid journals in transformative agreements published at least one open access article under a Creative Commons license. During this period, these hybrid journals provided open access to

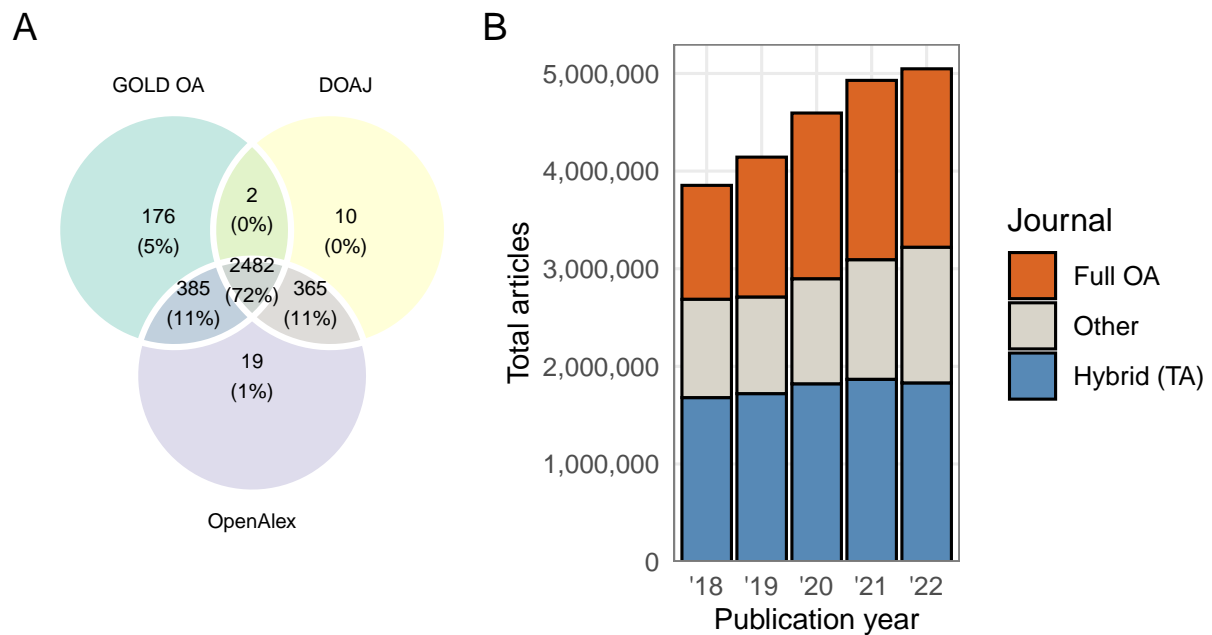


Figure 2. Initial data characteristics. (A) Full open access journals included in transformative agreements by evidence source Directory of Open Access Journals (DOAJ), OpenAlex and the Bielefeld GOLD OA list. (B) Number of articles in Crossref by journal types. The blue bars show the overall article volume of hybrid journals in transformative agreements, which were initially included in the study, in comparison with full open access journals according to OpenAlex. The remainder represents closed access journals not covered by transformative agreements.

742,369 out of 8,146,958 articles, representing a five-year open access proportion of 9.1%. Authors who could make use of transformative agreements at the time of publication contributed 328,957 open access articles to the total.

Figure 3A shows a moderate growth in the proportion of open access articles in hybrid journals, comparing the overall open access uptake and the impact of transformative agreements on this trend. Over the five-years period from 2018 to 2022, open access increased from 4.3% ($n = 65,486$) to 15% ($n = 249,511$). At the same time, the total article volume of the investigated journals grew from 1,528,051 in 2018 to 1,676,928 in 2022.

Figure 3B highlights that the majority of hybrid open access was made available through transformative agreements in 2021 and 2022, contributing 58% of the total

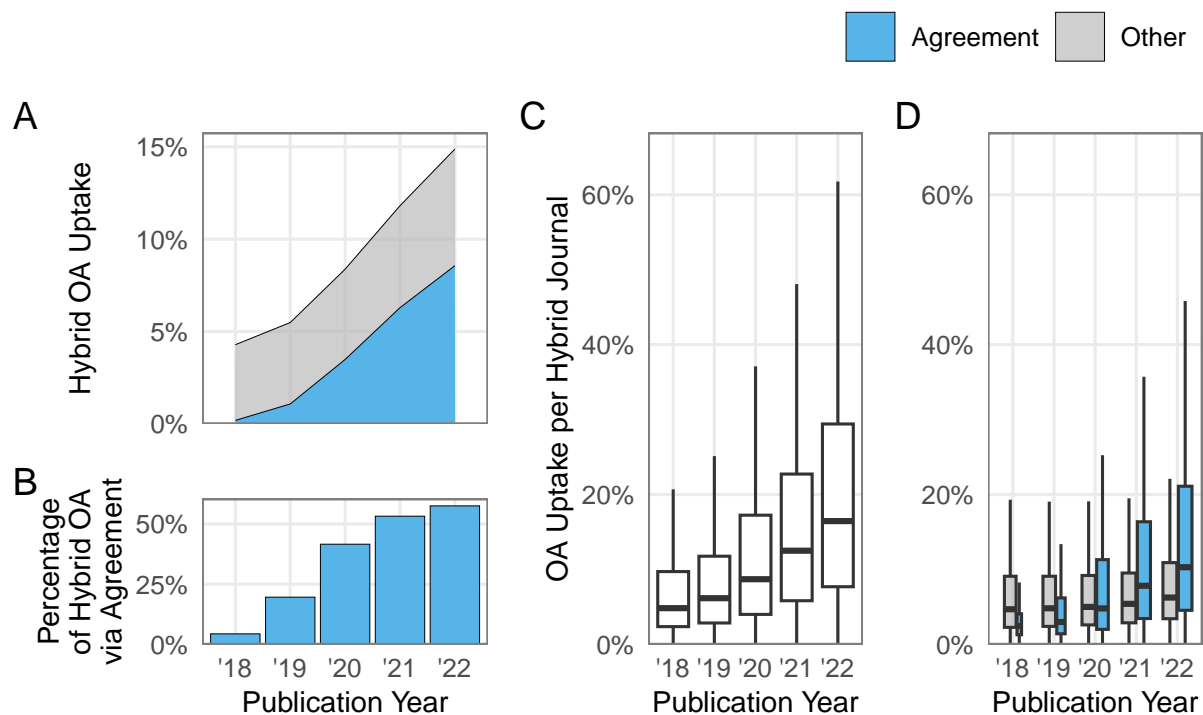


Figure 3. Relative growth of open access in hybrid journals in transformative agreements between 2018 and 2022 per publication year. The blue areas represent open access through transformative agreements, the grey areas depict open access articles where no link to an agreement could be established. (A) Proportion of open access articles in hybrid journals per year. (B) Percentage of hybrid open access via agreements per year. Boxplots show the proportion of open access articles by individual hybrid journals (C) and individual open access uptake rates by individual hybrid journals and open access funding (D) per publication year. The individual outliers are not shown. Note that data on transformative agreements ending before June 2021 were not available for this study.

open access article volume in 2022. However, there was also a notable growth in open access provision through other means, presumably publication fees being not invoiced through transformative agreements, which increased from 4.1% ($n = 62,625$) in 2018 to 6.3% ($n = 105,896$).

Figure 3C depicts the substantial variations among the hybrid journals included in transformative agreements in terms of open access uptake. Although the median generally follows the trend shown in Figure 3A, the farther stretch of upper quartiles

and whiskers over the years illustrates that an increasing number of journals published an above-average proportion of open access articles. In 2022, 25% of hybrid journals ($n = 2,576$) had an open access uptake of 29%, and 6.6% of journals ($n = 744$) provided the majority of their articles under a Creative Commons license in the same year. These journals were, on average, smaller ($M = 75$, $SD = 186$) than those with an open access share below 50% ($M = 164$, $SD = 347$).

When comparing the impact of open access through transformative agreements across journals, it shows that for many journals these agreements substantially contributed to the growth of open access over the years (Figure 3D). Despite the rise in transformative agreements, it is worth noting that other means of publishing open access remained common across the investigated hybrid journals. In total, 9,153 journals published open access articles from authors affiliated with institutions without transformative agreements in place, while 8,780 journals published at least one open access article through a transformative agreement in the same year.

Publishing market

Analysing hybrid open access across publishers between 2018 and 2022 reveals a large market concentration. Although 48 publishers offered transformative agreements, the big three commercial publishers Elsevier, Springer Nature, and Wiley accounted for 49% of total article volume published (see Table 1). Together, they published 500,878 or 66% of open access articles in hybrid journals. Elsevier, Springer Nature, and Wiley made 243,891 articles open access in hybrid journals through transformative agreements, resulting in an even larger market share of 74%.

Table 1

Hybrid open access through transformative agreements market shares 2018-2022

Publisher	Hybrid journals		Articles		OA articles		TA OA articles	
	Total	%	Total	%	Total	%	Total	%
Elsevier	1,936	17	2,770,826	33.8	172,723	22.9	60,440	18.3
Springer Nature	2,274	20	1,330,430	16.2	175,432	23.3	100,008	30.3
Wiley	1,410	12.4	1,043,052	12.7	152,723	20.3	83,443	25.3
Other	5,767	50.6	3,061,337	37.3	252,523	33.5	86,294	26.1

However, there are notable differences among the three big publishers. Although Elsevier published the largest volume of articles ($n = 2,770,826$, 34%), it recorded a comparable low number of open access articles, including those that can be associated with transformative agreements. In contrast, Springer Nature and Wiley provided open access to a larger proportion of their articles (13% of Springer Nature articles and 15% of Wiley articles were open access), leading to higher open access market shares (23% Springer Nature resp. 23% Wiley). This difference between Elsevier on the one hand and Springer Nature and Wiley on the other can be attributed to transformative agreements, as the latter made the majority of their open access articles available through such deals (Springer Nature 57% resp. Wiley 55%).

Figure 4 takes a closer look into the growth of hybrid open access across publishers by year with a focus on open access enabled by transformative agreements. Although all publishers show a general long-term trend towards transformative agreements, Figure 4A and B indicate that, in particular, Wiley experienced a substantial increase in its open access share from 5.9% ($n = 11,628$) in 2018 to 26% ($n = 53,503$) in 2022, representing an 4.5-fold increase. In contrast, Elsevier's hybrid journals demonstrated a more modest increase, from 3.3% ($n = 16,872$) in 2018 to 10% ($n = 60,821$) in 2022, which is a relatively low open access share compared to the general trend. In 2018, Springer Nature had the largest open access proportion among the three publishers of

8.4% ($n = 19,701$), but experienced a relatively slower growth, resulting in 18% ($n = 52,616$) of articles being open access in Springer Nature hybrid journals in 2022.

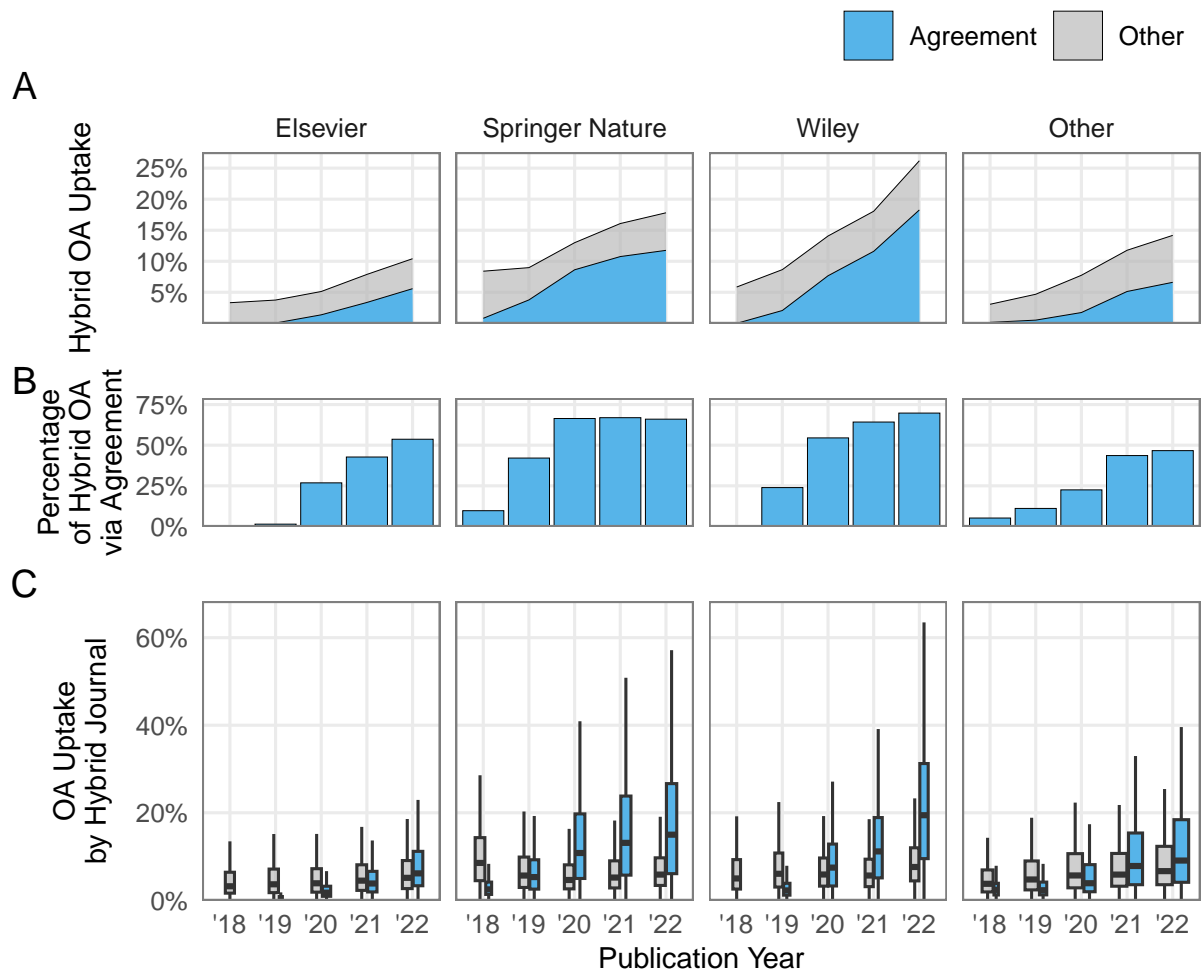


Figure 4. Development of open access in hybrid journals included in transformative agreements between 2018 and 2022 by publishers. The blue areas represent open access through transformative agreements, the grey areas depict open access articles where no link to an agreement could be established. (A) Proportion of open access articles in hybrid journals per year and publisher. (B) Percentage of hybrid open access via agreements per year and publisher. Boxplots (C) show individual open access uptake rates by individual hybrid journals and open access funding per publication year and publisher. The individual outliers are not shown. Note that data on transformative agreements ending before June 2021 were not available for this study.

The varying degrees of adoption of open access across the three major publishers can be attributed to distinct approaches to transformative agreements. Springer

Nature, for example, began in 2015 offering selected consortia, such as the Max Planck Society, the Swedish Bibsam consortium, and the Finnish FinELib consortium, open access agreements for its hybrid journal portfolio under the name Springer Compact¹⁰. However, these agreements were not included in the data as they concluded prior to the start of the transformative agreement data collection in June 2021. Nonetheless, the results demonstrate the importance of agreements for Springer Nature's hybrid open access business over the past five years (Figure 2B). In 2022, 66% (n = 34,725) of open access in Springer Nature hybrid journals were enabled through transformative agreements. In the same year, 70% (n = 37,316) of Wiley's open access articles could be linked to transformative agreements in 2022. In contrast, Elsevier published fewer than half of its open access articles through transformative agreements (n = 32,627; 54%).

The increasing trend towards transformative agreements can be also observed at the journal-level (Figure 4C). While no substantial differences between open access enabled through transformative agreements and other revenue sources could be observed across Elsevier's portfolio, the distribution of open access across Springer Nature and Wiley hybrid journals indicates that the growth is not limited to a few journals, but extends across the portfolio. In particular, Wiley's upper quantile, which represents the top 25% of journals in terms of the proportion of open access articles from transformative agreements, increased markedly from 13% in 2020 to 31% in 2022. At the same time, the median proportion grew from 7.5% to 19%. It is interesting to note that a small but increasing number of journals from these two publishers are providing open access to the majority of articles through transformative agreements. Wiley recorded 68 and Springer Nature 102 hybrid journals with an open access share above 50% that could be solely attributed to transformative agreements. Upon inspection, these journals were mainly society or local language journals with a small yearly article volume.

¹⁰ https://web.archive.org/web/20180414062853id_/http://www.liber2015.org.uk/wp-content/uploads/2015/03/Springer-Compact.pdf

Journal subjects

Table 2 presents a high-level overview of hybrid open access by AJCS subject area using fractionalised counting to account for journals belonging to more than one category. Between 2018 and 2022, most hybrid journals with at least one open articles could be attributed to the category Social Sciences, which also includes the Arts and Humanities. However, these journals published the fewest number of articles, whereas Physical Sciences journals recorded most articles, followed by the Health Sciences and the Life Sciences. In terms of open access, Physical Sciences journals accounted for more than one third of articles published in the five-years period, followed by the Health Science, the Social Sciences and the Life Sciences.

Table 2

Hybrid open access through transformative agreements by journal subject 2018-2022

Journal subject	Hybrid journals		Articles		OA articles		TA OA articles	
	Total	%	Total	%	Total	%	Total	%
Health Sciences	2,376	22.5	2,709,906	27.8	286,592	27.3	117,746	25
Life Sciences	1,403	13.3	1,477,808	15.1	191,880	18.3	71,593	15.2
Physical Sciences	2,732	25.9	4,291,833	44	366,794	35	167,686	35.6
Social Sciences	4,050	38.3	1,280,460	13.1	203,461	19.4	114,190	24.2

Figure 5 presents the relative growth of hybrid open access by subject area between 2018-2022. In particular, Social Sciences and Humanties journals accounted for the strongest growth in the five-years period from 6.4% (n = 8,361) to 23% (n = 51,938), followed by the Life Science from 7.6% (n = 15,003) to 18% (n = 39,494) , Health Science from 5.3% (n = 18,279) to 16% (n = 63,089) and Physical Sciences from 4.5% (n = 22,364) to 12% (n = 85,428). Growth in the Social Sciences can be largely attributed to transformative agreements. In 2022, two-third of open access articles (67%, n = 34,759) were published by first authors affiliated with participating institutions (see 5B).

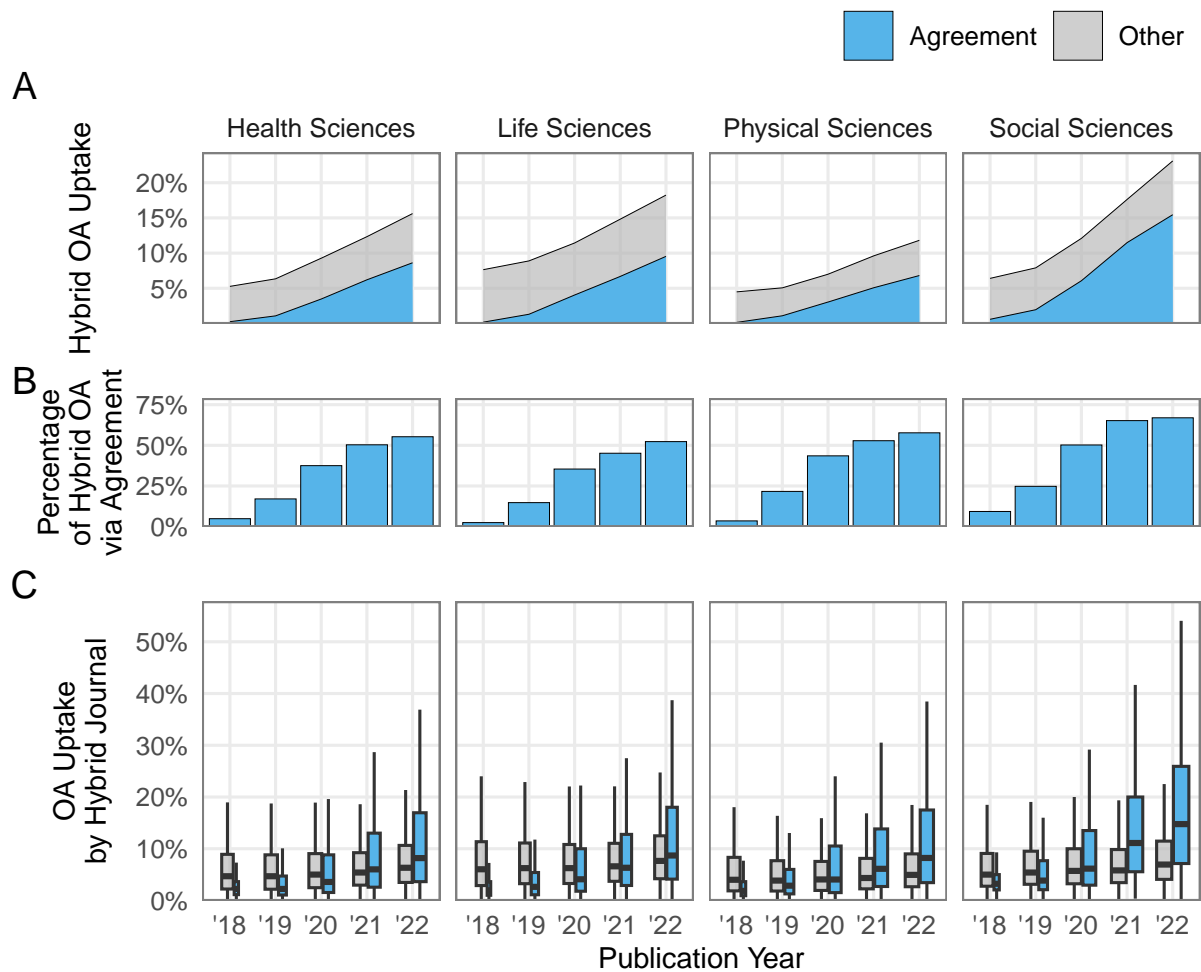


Figure 5. Development of open access in hybrid journals in transformative agreements between 2018 and 2022 by AJCS subject area. The blue areas represent open access through transformative agreements, the grey areas depict open access articles where no link to an agreement could be established. (A) Proportion of open access articles in hybrid journals per year and publisher. (B) Percentage of hybrid open access via agreements per year and publisher. Boxplots (C) show individual open access uptake rates by individual hybrid journals and open access funding per publication year and publisher. The individual outliers are not shown. Note that data on transformative agreements ending before June 2021 were not available for this study.

Figure 5C shows that this trend is consistent across hybrid journals belonging to the ASJC subject area Social Sciences. In 2022, 25% of Social Sciences journals provided open access to at least every fourth article exclusively through transformative agreements. However, hybrid open access through transformative agreements played a

comparable lesser role in the Life Sciences and Health Sciences. In these two subject areas, only about half of the open access articles can be linked to these agreements, both overall and on median average across journals. In contrast, the majority of Physical Science Journals, shows an increase of open access through transformative agreements compared to other options to publish open access in hybrid journals.

Comparing countries

Between 2018 and 2022, high-income countries almost exclusively dominated hybrid open access publishing through transformative agreements. During this period, first-authors affiliated with institutions from Organisation for Economic Co-operation and Development (OECD) member countries published 602,050 open access articles in hybrid journals, representing 81% of the investigated open access articles. This disparity between OECD nations and other countries becomes even more evident when considering open access through transformative agreements, as 310,712 of 328,957, or 94% of open access articles were associated with such agreements.

Figure 6A shows the development of hybrid open access publishing by countries, comparing the OECD area with the BRICS, an intergovernmental organisation, which comprised the countries Brazil, Russia, India, China and South Africa as of 2022. The residual category “Other” includes the remaining countries. From 2018 to 2022, the proportion of open access in hybrid journals increased from 6.1% in 2018 to 26% in 2022. On the other hand, BRICS recorded a low uptake, from 1.6% in 2018 to 3.7% in 2022.

Despite the rise of open access across OECD countries, the overall publication output decreased sharply, dropping to 786,903 in 2022 after peaking 892,197 articles in 2020. In stark contrast, the number of articles published in hybrid journals by first authors affiliated with institutions from BRICS countries increased steadily over the years, more than doubling from 356,632 in 2018 to 786,903 in 2022. Upon closer examination, this trend can be observed across all big three publishers, although the shift towards BRICS is particularly evident in Elsevier’s hybrid journal portfolio, in particular with regard to articles published in Physical Sciences journals. While OECD publication output in Elsevier’s Physical Sciences journals declined from 112,822

articles in 2018 to 103,766 in 2022, BRICS output increased from 104,654 to 171,713 in the same five-year period. Furthermore, OECD publication output in Health Science Journals and Life Science journals stagnated across the investigated hybrid journal portfolios after a peak in 2020.

To illustrate the situation in 2022, Figure 6B compares total publication output with the number of open access articles. With 391,530 articles, China was the most productive country, followed by the United States (268,965 articles) and India (87,428 articles). In contrast, West and Nord European countries published a considerable high number of open access articles. Particularly, Germany, Great Britain, the Netherlands, Sweden, Switzerland and Spain recorded an above-average open access share as indicated by the linear trend line. As represented by the point size, as well as it can be seen in Figure 6C, transformative agreements contributed to these market positions. Interestingly, the United States had a notable open access market share of 15%, although transformative agreements contributed to a lesser extent. Similarly, China's open access market share of 7.2% in 2022 was comparable to that of the Netherlands, which was 7.1%.

Figure 7 illustrates the development of hybrid open access from 2018 to 2022, highlighting the top 20 most productive countries in terms of articles published in hybrid journals that were included in transformative agreements over the five-year period. Notably, The Netherlands (27%), Sweden (24%), Poland (17%) and Great Britain (17%) exhibited a relatively high level of uptake in 2018 which continued to increase in the following years. In 2022, Sweden had the highest proportion of open access relative to its publication output (78%), followed by the Netherlands (67%) and Switzerland (57%), with these countries benefiting from transformative agreements. In Germany, however, hybrid open access only began to increase from 2019 onwards after the successful negotiation of nationwide agreements with Wiley (July 2019) and Springer Nature (January 2020). Prior to this, only a few organisations had agreements in place, for the example the Max Planck Society with Springer Compact.

Since 2021, there has been a general trend towards hybrid open access among

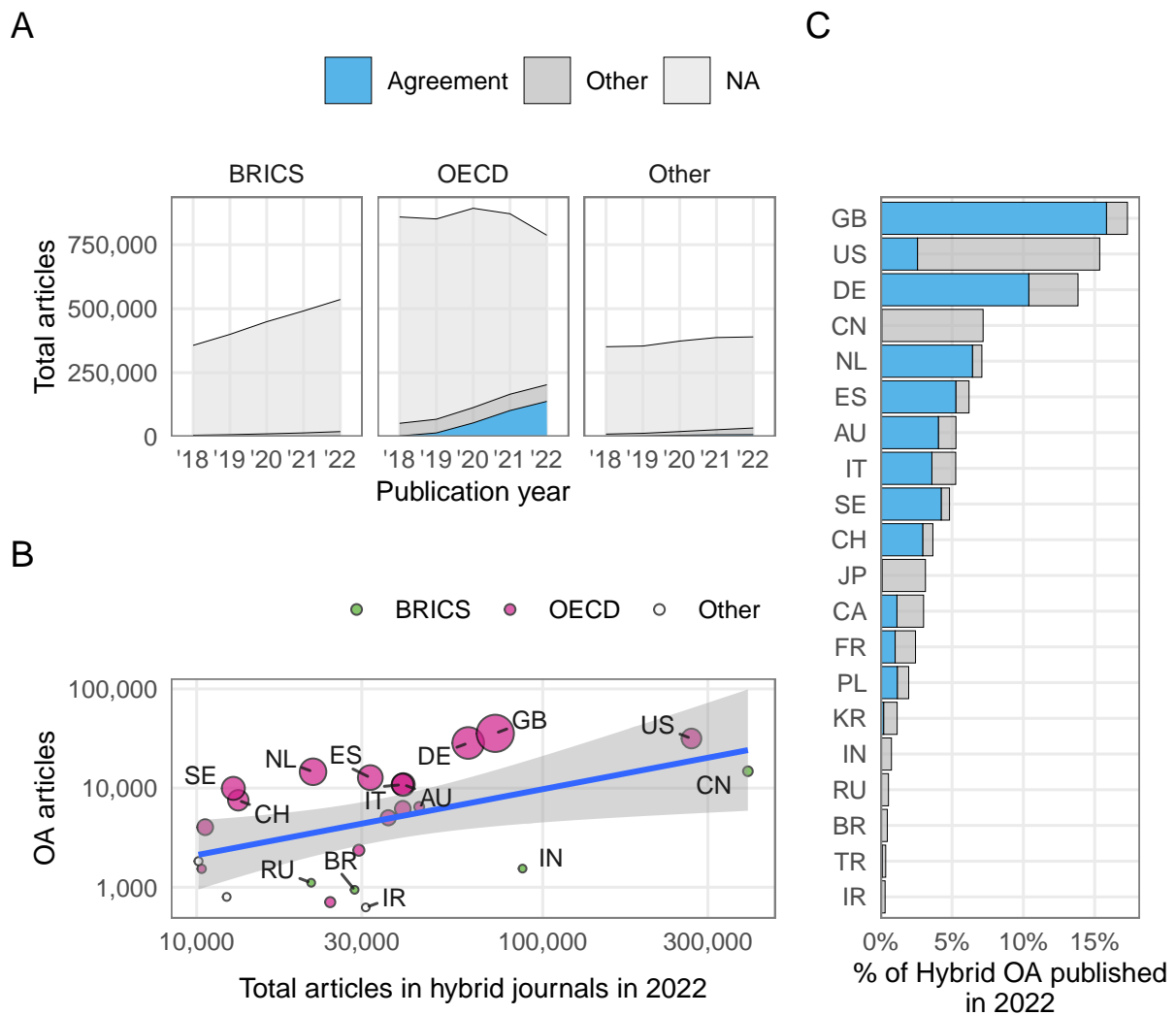


Figure 6. Development of hybrid open access publishing by country. (A) presents the number of articles published in hybrid journals included in transformative agreement, distinguishing between BRICS as of 20222, OECD and other countries. (B) Scatterplot contrasting total articles with open access article volume in 2022, by country. Point size represents the number of articles enabled through transformative agreements. (C) Hybrid open access market share in 2022 by country. In (A) and (C), the blue areas represent open access through transformative agreements, the grey areas depict open access articles where no link to an agreement could be established. Country names are represented as ISO two-letter country codes.

many high-income countries, primarily driven by transformative agreements. However, proliferation of transformative agreements differed across these countries. For instance, Germany successfully negotiated an agreement with Elsevier not until 2023.

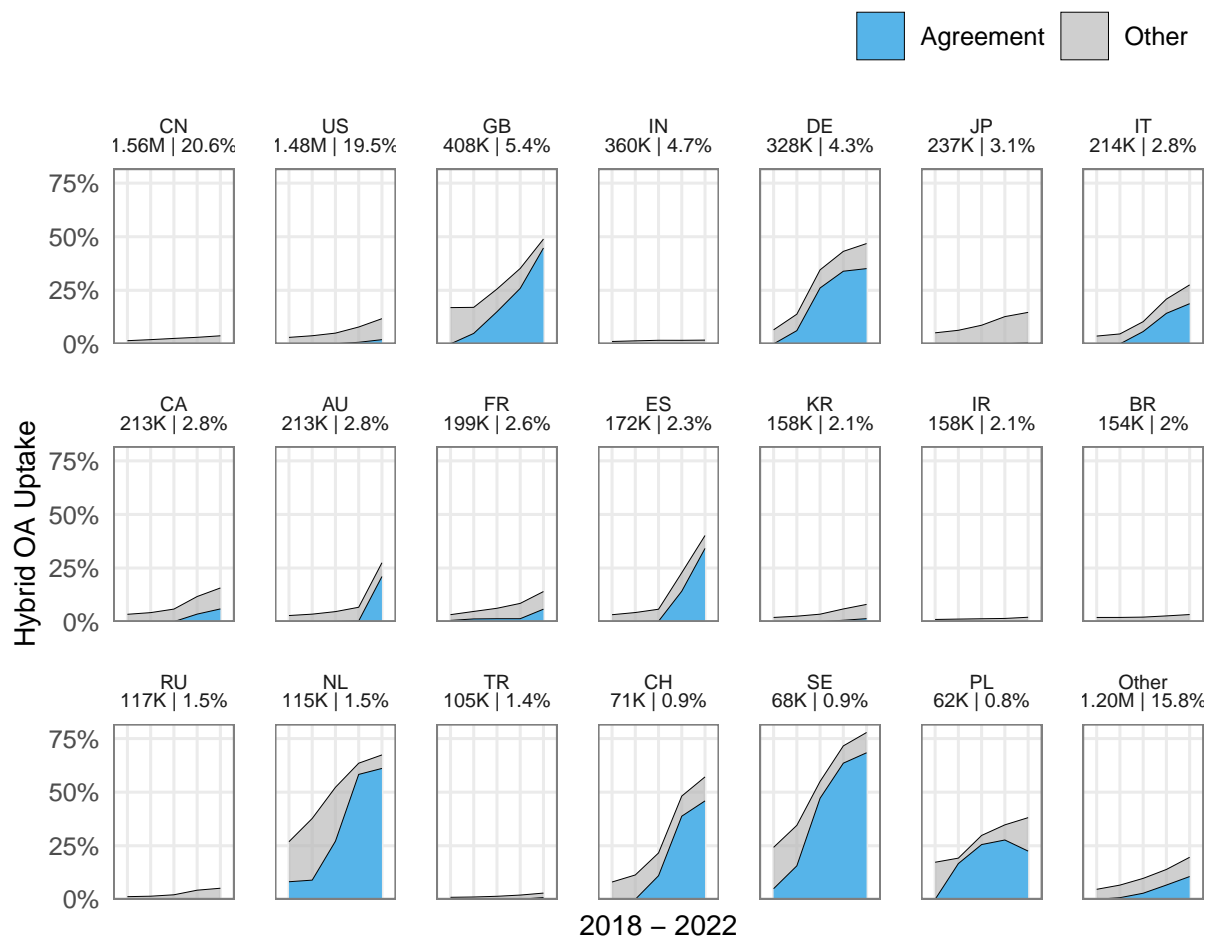


Figure 7. Development of open access in hybrid journals in transformative agreements between 2018 and 2022, by the Top 20 most productive countries in terms of total articles published in the five-years period. Blue areas represent open access through transformative agreements, the grey areas depict open access articles where no link to an agreement could be established. Country names are represented as ISO two-letter country codes

Additionally, publication limits or eligibility criteria for institutions and article types may explain why even countries with widespread agreement implementation like Sweden or the Netherlands did not achieve 100% hybrid open access. Interestingly, in Japan and the US other options than transformative agreements were the main driver for the increase in hybrid open access. Once again, the graph highlights countries with low hybrid open access, particularly non-OECD countries, where only a few or no agreements were in place.

Discussion

The primary aim of this study was to investigate the adoption of open access in hybrid journals in transformative agreements, which were introduced as a temporal means to support the transition of subscription-based academic publishing to full open access. This study presents a novel approach based on open data, which leverages metadata on over 700 agreements and nine million journal articles to estimate the extent to which transformation agreement contribute to the transition of this journal business model. The results highlight a strong growth in open access between 2018 and 2022, particularly driven by an increasing number of institutions that had transformative agreements in place. Yet, the majority of research literature published in hybrid journals in this five-year period remained behind a publisher's paywall. Growth in the adoption of open access in hybrid journals, in particular through transformative agreements, can be largely attributed to three large commercial publishers – Elsevier, Springer Nature, and Wiley – but varies substantially across journals, publishers, subjects, and country affiliations. Despite the limitations of the data used, the findings indicate that the current level of implementation of transformative agreements is insufficient to bring about a large-scale transition to fully open access.

A key finding of the analysis is that transformative agreements increase market concentration. Specifically, the three largest commercial publishers Elsevier, Springer Nature, and Wiley dominate, particularly in regard to open access provided through transformative agreements. Together, the three publishers accounted for three-fourths of open access articles through transformative agreements, despite publishing less than half of the total publication volume published between 2018 and 2022. This observation aligns with previous research on shifts in the publishing market following the introduction of funding opportunities for hybrid open access (Butler et al., 2023; Jahn & Tullney, 2016; Shu & Larivière, 2023). Additionally, the results confirm previously observed variations by publisher, with Elsevier exhibiting a different development than Springer Nature and Wiley (Butler et al., 2023; Jahn et al., 2022). However, it must be noted that the focus of transformative agreements on publishers with large hybrid

journal portfolios is intentional (Campbell et al., 2022). Because of transformative agreements with a few large publishers, national consortia were able to substantially increase their country's annual open access article volume (Bosman, Jonge, et al., 2021; Huang et al., 2020; Pinhasi et al., 2021; Taubert et al., 2023; Wenaas, 2022).

Moreover, this study presents varying levels of open access uptake through transformative agreements across journals, which can be attributed to the alignment of authors' affiliations and the availability of such agreements at their institutions. In line with previous research findings (Butler et al., 2023; Jahn et al., 2022), high uptake rates were observed across hybrid journals in the Social Sciences and Humanities. However, it is important to emphasise that these hybrid journals do not encompass the entire field. For example, a study by Khanna et al. (2022) found that approximately 60% of journals utilizing the open-source publishing platform Open Journal Systems (OJS) fall within the Social Sciences and Humanities. In these fields, the majority of full open access journals are so-called "Diamond OA journals" that do not charge publication fees (Bosman, Frantsovåg, et al., 2021). Rather, this result can be more accurately attributed to the substantial proportion of authors from high-income countries who publish in these hybrid journals included in transformative agreements, particularly when journals are of local relevance, such as through the belonging to national societies or regional research scope.

Surprisingly, the total publication output of high-income countries belonging to the OECD in hybrid journals declined substantially after peaking in 2020, whereas that of BRICS countries doubled from 2018 to 2022. Because the BRICS expansion can be exclusively attributed to closed access articles, this development has the potential to hinder the transition of academic journal publishing to full open access through transformative agreements and demands discussion. In China, the country with the highest volume of articles in hybrid journals, limited research funding to pay for open access is available, with expenditures for open access publishing already surpassing subscription costs (Shu & Larivière, 2023). Furthermore, the focus of Chinese authors on established journals may contribute to this trend (Zhang et al., 2022). Although

China supports Plan S (Schiermeier, 2018), this is not reflected in the data in terms of open access uptake in hybrid journals. As highlighted by Koley & Lala (2023), India faces similar challenges in terms of resources to pay for open access. At the same time, access to research literature is a pressing, which is addressed by the “Indian one nation, one subscription” policy proposal. However, this policy focuses on centrally negotiated subscriptions and does not entail open access.

But open access uptake also differs among OECD countries. In the United States, for example, hybrid open access including transformative agreements plays a lesser role compared to some European countries. The smallest share of federally funded research was hybrid open access between 2017 and 2021 (Schaes, 2023). While some university consortia like the California Digital Library signed transformative agreements, others attempt to depart from big deals and unbundle large journal portfolios to address cost increases (Brainard, 2021; Schaes, 2022). Despite the relatively low penetration of transformative agreements in China and the United States compared to Europe, 22% of open access in hybrid journals in 2022 originates from these two countries, indicating the availability of funding sources for publication fees.

This large-scale study provides first empirical evidence about the influence of transformative agreements on the transition of hybrid journals to full open access. However, several limitations need to be acknowledged. From a data perspective, estimations of open access through transformative agreements were established by linking first author affiliations with publicly available agreement data from cOAlition S, and not through invoicing data because these data are usually not shared by publishers. Moreover, this study is unable to account for the various types of transformative agreements, particularly with regards to article types and capping. Similarly, assessing the quality of the OpenAlex and Crossref data used, particularly in terms of affiliations and article types, in comparison with established bibliometric databases was beyond the scope of this analysis. Overall, the methodology is designed in such a way that the results underestimate rather than overestimate the adoption of open access through transformative agreements. In addition, the data used in this study are openly

available, along with the code used for this analysis.

Additionally, it must be noted that the study period was significantly impacted by the COVID-19 pandemic, which led to an unprecedented number of publications as well as restrictions on migration flows, which could have influenced the country-specific results (Aviv-Reuven & Rosenfeld, 2021; Zhao et al., 2023). Furthermore, the study design did not consider emerging publication practices such as preprints (Fraser et al., 2021) and questionable special issues (Hanson et al., 2023), which have grown particularly rapidly since 2020. Lastly, it should be emphasized that the study aims to estimate articles enabled through transformative agreements but does not address financial shifts due to a lack of data on expenditures.

This present study allows multiple strands of further research. One is to complement this large-scale study with more specific evidence from individual countries or subjects, particularly those with low hybrid open access rates. Incorporating full open access and subscription-based journals, as well as considering global trends in scholarly migration and collaboration could also be promising. Financial studies could build upon the presented study design and incorporate subscription and open access expenditures to evaluate the cost-effectiveness of transformative agreements.

But the study also has practical implications for research funders and libraries. Of primary concern should be observed differences across countries, in particular the relationship between economic development and open access adoption. From a data perspective, the reporting of open access funding is not harmonised, but often crowd-sourced from various sources. To improve the assessment of transformative agreements, libraries and publishers could contribute by providing information about respective journal portfolios, participating institutions and open access invoicing.

In summary, the aim of this study was to provide empirical insights into the development of hybrid open access following the introduction of transformative agreements. The results are important for both researchers and stakeholders engaged in negotiating and evaluating these agreements. The presented approach relies on open data, which enables follow-up studies and open access monitoring activities to further

explore the role of transformative agreements in facilitating the shift towards full open access in academic publishing.

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