

The Oligopoly's Shift to Open Access. How For-Profit Publishers Benefit from Article Processing Charges

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Abstract

This study aims to estimate the total amount of article processing charges (APCs) paid to publish open access (OA) in journals controlled by the large commercial publishers Elsevier, Sage, Springer-Nature, Taylor & Francis and Wiley, the so-called oligopoly of academic publishing. Since the early 2010s, these five academic publishers control more than half of peer-reviewed journal articles indexed in the Web of Science (WoS), expanding their market power through acquisitions and mergers. While traditionally their business model focused on charging subscriptions to read articles, they have now shifted to OA, charging authors fees for publishing. These APCs often amount to several thousand dollars, excluding many from publishing on economic grounds. This study computes an estimate of the total amounts of APCs paid to oligopoly publishers between 2015 and 2018, using publication data from WoS, OA status from Unpaywall and annual APC prices from open datasets and historical fees retrieved via the Internet Archive

Wayback Machine. We estimate that globally authors paid the oligopoly of academic publishers \$1.06 billion in publication fees in the 4-year period analyzed. Of the 505,903 OA articles analyzed, 60.9% were published in gold OA journals, 8.6% in diamond (gold with APC=\$0) and 30.5% in hybrid journals. Revenue from gold OA amounted to \$612.5 million, while \$448.3 million was obtained for publishing OA in hybrid journals, for which publishers already charge subscription fees. Among the five publishers, Springer-Nature made the largest revenue from OA (\$589.7 million), followed by Elsevier (\$221.4 million), Wiley (\$114.3 million), Taylor & Francis (\$76.8 million) and Sage (\$31.6 million). With Elsevier and Wiley making the majority of APC revenue from hybrid fees and others focusing on gold, different OA strategies could be observed between publishers.

Introduction

Since the early 2010s, more than half of peer-reviewed journal articles have been published by the so-called oligopoly of academic publishers (Larivière et al., 2015). This oligopoly consists of a few for-profit companies, who, since the beginning of the digital era, have acquired small publishers to control the majority of scholarly publishing. While initially focusing on subscription models—leading to the serials crisis and big deals that libraries could no longer afford—these commercial publishing houses have now embraced open access (OA). Although the removal of paywalls is certainly a step in the right direction to providing access to the scholarly literature, the oligopoly's approach to OA is generally based on the author-pays model, which often involves article processing charges (APCs) that contribute to existing inequities that exclude many from publishing (Chan et al., 2020; Harle & Warne, 2019; Olejniczak & Wilson, 2020; Siler & Frenken, 2020). Since the five oligopoly publishers—Elsevier, Sage, Springer-Nature, Taylor & Francis, and Wiley—are for-profit shareholder companies with profit margins in excess of 30% (Larivière et al., 2015; “The Obscene Profits of Commercial Scholarly Publishers,” 2012; Van Noorden, 2013), a significant amount of fees that authors pay to publish are not justified by the actual costs related to the publication process itself (*The Fair Open Access Principles – Fair Open Access*, n.d.).

This study focuses on the cost of OA publishing for the academic community and the APC revenues generated by oligopoly publishers by analyzing the number of gold and hybrid OA

journal articles, defined as articles published under an open license that are free to read on the publisher website, during the 2015-2018 period.

Specifically, we aim to answer the following research question:

What are the costs associated with APCs for gold and hybrid OA articles published in Web of Science (WoS) indexed journals published by an oligopoly publisher between 2015 and 2018?

- a. How much does the academic community pay the five oligopoly publishers for publishing gold and hybrid OA articles?
- b. Which journals obtain the largest amounts of total APCs?
- c. How does the number of gold and hybrid articles and associated amount of APCs differ between countries and academic disciplines?

Literature Review

OA emerged in the 1990s with the acceleration of digital technologies and the establishment of the world wide web. The most significant event in the OA movement has been the Budapest Open Access Initiative (BOAI, 2002), which granted OA its most famous definition and initially suggested two main methods of OA dissemination, via repositories or publisher journal websites. The BOAI defined OA as scientific literature that is publicly available online, free of charge, unrestricted, discoverable, free of most copyright and licensing restrictions, and available for reuse.

Open Access models and trends

Dozens of models have emerged since the early days of OA (Willinsky, 2006). The more common ones include gold, green, and hybrid (Eve, 2014; Suber, 2012; Willinsky, 2006). Piwowar et al. (2018) introduced bronze OA to reflect the increasing occurrence of free-to-read articles on publishers' websites without licensing information. Diamond OA is a community-driven model, where journals do not charge authors a fee to publish (Becerril et al., 2021) The different OA models are not always mutually exclusive; for example, gold OA articles might also be green if they are self-archived by authors. Technically, the diamond and green models are the only ones that are compliant with the original BOAI definition.

Gold OA represents articles published in journals which make all articles free to read on the publisher's website upon publication (Archambault et al., 2014; European Commission, 2019; Gargouri et al., 2012; Piwowar et al., 2018; Suber, 2012). Although the majority of gold OA journals, where all content is freely available on the publisher's website, do not require the author to pay for publication (for example, nearly 70% - 12,358 out of 17,783 - journals indexed in the DOAJ (DOAJ,2022), most OA articles are published in APC-based journals (Crawford, 2019). APCs were first introduced around 2002 as a business model by OA publishers such as BioMed Central (BMC) and PLOS (Pinfield et al., 2016). The pricing of APCs can vary widely depending on academic discipline and publisher location. Since diamond OA describes gold OA journals without APCs, we consider diamond OA as a particular subset of gold OA where APC=\$0. For gold OA journals that do rely on APCs, the average author fees range from USD\$1,371¹ to \$2,000 (Crawford, 2022; Jahn & Tullney, 2016; Morrison et al., 2021a; D. Solomon & Björk, 2016). The variance in these amounts is due to each study's methodological approach and data sources. For example, Jahn and Tullney's (2016) analysis of APC spent by German institutions uses data from the OpenAPC Initiative, which relies on self-reported APC data, whereas Solomon and Björk's (2016) study triangulated data from WoS, APC list prices collected by Morrison et. al (2014), and manually collected APCs from journal websites to estimate the amount of APCs paid by authors at four large research institutions in Canada and the United States. Another thing to consider is the unit of analysis of the study. For instance, as illustrated by Siler and Franken (2021) results will strongly differ when using journals as the unit of analysis (i.e., one APC per journal) compared to individual papers (i.e., one APC per paper).

The first hybrid journals—subscription journals where individual articles are made freely available through APCs—were introduced a few years after the APC-based gold model (Pinfield et al., 2016) and have since been considerably more expensive than their gold OA counterparts (Jahn & Tullney, 2016; Laakso & Björk, 2016; Pinfield et al., 2016; Schönfelder, 2018; D. Solomon & Björk, 2016). Originally suggested as a transitional phase to flip subscription journals to OA (B.-C. Björk, 2012; Draux et al., 2018; Prosser, 2003), this model has been around for almost 20 years now. Large publishers offer hybrid options for most of their journals and market it as their solution

¹ All fees in this study will be represented in USD.

to OA (Springer-Nature, 2020; [Wiley, 2019: 25](#)). Hybrid OA has been criticized by the scientific community for its high APCs, as well as the potential for publishers to double-dip—charging twice for the same article, in the form of APCs and subscriptions (Eve, 2014; Matthias, 2018; Pinfield et al., 2016; Suber, 2012, p. 141). Previous studies have shown the average APC for hybrid journals is around \$3,000USD (B. Björk & Solomon, 2014; Shamash, 2016; D. Solomon & Björk, 2016). Björk and Solomon (2015) note that Springer set the trend for this \$3,000 average through their OpenChoice program launched in 2004, which was followed by most large commercial publishers (B.-C. Björk & Solomon, 2015).

In the context of changing funder requirements, the number of OA, and particular gold and hybrid publications, continues to grow. Using Web of Science, Crossref and Unpaywall, Piwowar et al. (2018) estimate that between 3.2% and 14.3% of scholarly articles published between 2009-2015 were published in gold OA journals. A recent analysis of gold OA articles in DOAJ-indexed journals indicates a 15.5% increase from 2020 to 2021 alone (Crawford, 2022). Laakso and Björk (2016) tracked the uptake of hybrid articles amongst the oligopoly between 2007 and 2013 and found growth from 666 to 13,994 articles, doubling almost every year. More recently, Jahn, Matthias, and Laakso (2022) found that between 2015 and 2019, Elsevier's hybrid OA articles doubled each year and that the share of OA relative to closed grew from 2.6% to 3.7%.

Publishing Market

The oligopoly's shift towards OA has happened in the context of an increasing amount of Big Deal cancellations as well as pressure from funding bodies. More and more research funders mandate that their grantees publish outputs OA. As more funders and organizations require their authors to publish OA, the more the OA market grows. For example, the Registry of OA Repositories (ROARMAP) shows that currently there are 1,113 OA mandates and/or policies, which has steadily risen since 2005 and started to level out around 2018 (ROARMAP, 2022). However, this growth has not correlated with a decrease in APC pricing, despite the increase in competition (Budzinski et al., 2020). Rather, the more the market is dominated by certain players, like the oligopoly, the more these publishers determine the pricing. Studies show just how much money can be made in scholarly publishing. In 2020, the global scholarly publishing market was valued at \$28 billion, with \$9.5 billion (38%) spent on scholarly journals. Pollock and Michael (2021)

estimate that the OA market accounts for \$975 million during the same year. The academic publishing market, and OA, are forecast to grow further in the coming years.

Larivière et al. (2015) found that Elsevier, Wiley-Blackwell, Springer (before the merger with Nature in 2015), and Taylor & Francis publish more than half of the scholarly journal literature. Based on the number of active, refereed, academic journals indexed in *Ulrichsweb* (N=86,110 as of October 27, 2020) the biggest publishers are Elsevier (n=5,158), Springer-Nature (n=4,574), Taylor & Francis (n=4,472), Wiley (n=3,266), and Sage (n=2,292). Traditionally, the oligopoly's profit margins stem largely from subscription revenue, where individual libraries or consortia pay for obtaining access to published content for their readers. Commercial publishers draw 68-75% of their revenues from university libraries (Haigh, 2016) (Ware & Mabe, 2012). According to the Canadian Association of Research Libraries (CARL), the subscription costs for their 29 member libraries increased by 5-7% per year (2011-2015), or approximately 25% over 4 years (Haigh, 2016). While prices for journal subscriptions have been rapidly increasing over the last few decades, library budgets have remained stagnant or decreased (Shu et al., 2018; UCSF Library, 2020). As a consequence of these unsustainable costs, libraries have struggled to maintain their collections and to ensure continued access to scholarly journals, which in many cases resulted in canceling their subscriptions (SPARC, n.d.). Yet, these cancellations have not stifled the market dominance of commercial publishers. Between 2014 and 2017, commercial publishers increasingly appear in the DOAJ (Morrison, 2018). Rodrigues et al. (2020) looked at journals with the DOAJ seal—a subset of DOAJ-indexed journals that adheres to best practices in OA publishing—and found a concentration of ownership by four publishers (BMC, Hindawi, MDPI & Springer Open) who are responsible for almost two thirds of all OA output. The authors argue the concentration of these four publishers is bigger than the one described by Larivière et al. (2015) in a traditional scenario (Rodrigues et al., 2020). Since BMC and Springer Open are both part of Springer-Nature, Rodrigues et al.'s results underline Springer-Nature's dominant position in the OA publishing market.

With strong growth rates, commercial publishers have been shifting from traditional subscription revenue to APC-based OA models, cementing their status in the scholarly publication market to dominate the OA landscape. For instance, Simard et al. (2021) estimated that APCs paid to the

oligopoly by Canadian Universities went from 2.2 million USD in 2015 to 3.2 million in 2019, representing 5.7% of the \$295.5 million USD spent on scholarly publishing between the same period. Studies also show the publishers with higher revenues tend to charge higher APCs (Pinfield et al., 2016; D. J. Solomon & Björk, 2012) (Solomon & Björk, 2012; Pinfield, 2016). Looking at four large OA publishers (BMC, Frontiers, MDPI, and Hindawi), Khoo (2019) found that authors are not price sensitive as APC increases led to increases in article volume. Furthermore, Khoo's (2019) study also suggests that potential economies of scale do not translate into reduced prices but more likely into increased profits.

A recent study by Zhang et al. (2022) has attempted to analyze the trend toward “paying to perform research” in six different countries between 2015 to 2020, estimating the APCs for each year using the latest available APC numbers from the DOAJ, and publishers' and journals' websites. They estimated that the global revenues from APC among twelve major publishers is now over 2 billion USD for the year 2022. Zhang et al.'s (2022) study was limited by geographical borders and top OA publishers while ours examines oligopoly publishers, there is also a significant difference in the way in which APCs were determined. We argue that our methodology of identifying annual APCs for the year an OA paper was published is more accurate than that of Zhang and colleagues, who applied current APC prices to articles published in previous years. Since Zhang's method does not capture recent price increases but is limited to current APCs readily available via publisher websites, we argue that it significantly overestimates actual APCs paid. By triangulating data on annual list prices from different sources, including historical data retrieved through the Internet Archive Wayback Machine, we argue that our method leads to more accurate estimates of APCs paid by the global community.

Materials and Methods

Data

This study combines data from WoS, Unpaywall, open datasets of APC list prices (Matthias, 2020; Morrison et al., 2021a), as well as historical annual fees manually retrieved via the Internet Archive Wayback Machine.

Publications

Peer-reviewed publications published by one of the oligopoly publishers (Elsevier, Sage, Springer-Nature, Taylor & Francis, Wiley) between 2015 and 2018 were identified using the Web of Science (WoS). Document types were restricted to articles and reviews, as these include original research findings and other document types are often exempt from APCs. Publications were further restricted to include only those with a Digital Object Identifier (DOI) to retrieve their open access status via Unpaywall. In order to identify all journal articles controlled by the oligopoly of academic publishers, imprints and/or subsidiary publishing companies were manually assigned to the parent oligopoly company. For example, journals published by Cell Press were assigned to Elsevier, those published by Palgrave Macmillan to Springer-Nature and those published by Holcomb Hathaway to Taylor & Francis. A total of 136 imprint publishers were assigned to one of the five oligopoly publishers.

OA status

We began data collection using an April 2020 snapshot of the Unpaywall.org database to obtain the OA status (gold, hybrid, bronze, green, closed) for each DOI in our dataset. This paper focuses on hybrid and gold articles only, as they are the ones potentially associated with APC charges. We excluded bronze articles, as it is still unclear whether these articles represent full and permanent OA, as they lack a clear creative commons license that would allow reuse and includes articles that publishers may only make free to read for a limited amount of time (Costello, 2019; Piwovar et al., 2018). There is some evidence that the bronze category includes articles that publishers make free to read for a limited amount of time. We therefore suspect that no APCs were paid for bronze articles, which is why we excluded these from our study. However, it should be noted that it might be possible that APCs were paid for articles flagged as bronze by Unpaywall. In this case, our study would significantly underestimate the total amount of APCs paid, particularly for hybrid articles. Combining data from WoS and Unpaywall, we computed the number of hybrid and gold OA articles, per journal and year. We later updated the OA status information using a March 2022 snapshot of Unpaywall. We noted some significant decrease in the number of hybrid publications, particularly for Elsevier, and thus lower overall APC revenues than we reported in preliminary findings (Butler et al., 2022; Haustein & Butler, 2022). We assume that the algorithms Unpaywall uses to determine OA status, particularly the differentiation between hybrid and bronze, has

improved and that the more recent version is more accurate. For more information on the robustness of hybrid and gold OA statuses via Unpaywall see Sanford (2022).

Journals and article processing charges (APCs)

For each combination of journal and publication year with at least one gold or hybrid article, we identified APC list prices. Due to annual increases, it was important to identify the APC per publication year and not use current prices for articles published between 2015 and 2018, whenever possible. Although current APCs are much easier to retrieve from journal websites and/or price lists released by publishers, we argue that using current APCs for older publications, an approach taken by Zhang et al. (2022) overestimates actual fees paid as fees increase over time.

We first used an open data set (Matthias, 2020) created in April 2020, which includes annual list prices for Elsevier, Sage, Springer Nature, Taylor & Francis and Wiley to provide an overview of their OA journal portfolios over time. The dataset is based on several data sources, including subscription and APC price lists, gold and hybrid OA title lists, and historical website snapshots of the publisher website that were manually collected through the Internet Archive's Wayback Machine. The dataset includes ISSNs, journal name, publisher, publication year, APC and currency for 95,792 journal-year combinations, 60,788 of which with APC information. Matching via journal title or ISSN in combination with publication year, we were able to retrieve 17,291 (91.7%) of 18,846 journal-year combinations from Matthias (2020). To retrieve additional APCs for gold journals we used another open dataset by Morrison (2021), which provides annual APCs and metadata (e.g., journal title, print and e-ISSN, publisher) for journals listed in the Directory of Open Access Journals (DOAJ). APCs are based on a previous dataset from Crawford (2019), DOAJ and frequent manual checks on journal websites over a period of 10 years (2011-2021). Matching via journal title, ISSN or eISSN in combination with publication year, we were able to retrieve 1,333 (7.1%) journal-year combinations from Morrison (2021).

For journals missing APCs, we manually searched for historical list prices using the Internet Archive Wayback Machine (<https://archive.org/web/>) to access historical snapshots of journal websites maintained by the publisher and/or academic societies that were affiliated with the journal. We attempted this time-consuming and complex approach for over 700 journal-year

combinations, 320 of which were removed from the dataset because the search revealed that the journal did not offer an OA option at the time of publishing (n=106), was only later acquired by an oligopoly publisher (n=203) or was a book or conference proceedings rather than a journal (n=11). APCs for 482 journal-year combinations were successfully obtained via Wayback Machine and used in this dataset. For the remaining journal-year combinations missing a fee, we applied APCs from a year for which we did have data. In an attempt to under- rather than overestimate fees paid, we prioritized older data from Matthias (2020). For 436 (2.3%) journal-year combinations we had to use current APCs due to a lack of information from other data sources.

Our final dataset contains APC information for 18,846 journal-year combinations, for 1,301 (6.9%) of which we had data from more than one source. For 408 of these, both sources report the exact same fees. For 893 journal-year combinations APCs differed. These differences might partially be due to conversion between currencies and partially due to erroneous APCs in either the Matthias or Morrison datasets, emphasizing the challenges of gathering accurate historical APC prices from the web. Since our manual check suggested that both data sources were correct some of the time, we chose not to prioritize one source over the other and use the lower amounts in case of conflicts. This way, we are more likely to under- rather than overestimate the actual fees paid. An exception was actual APCs obtained through Internet Wayback Machine, which was assumed to be the most reliable data source (n=23). The total estimate we use in this analysis is 7.3% lower (\$1.061 billion) than the APC total based on the higher fees (\$1.138 billion) overall, with differences per publisher (Table 1). We should note that this difference applies to gold APCs only, because we do not have more than one data source for hybrid fees, which partially explains the differences between publishers (i.e., those with larger amounts of gold APCs show higher differences).

Table 1. Difference between lower and upper estimate of total APCs (in USD) per publisher based on differing APC information for 933 journal-year combinations for gold OA journals. The lower estimate was used as the basis for this study.

Publisher	Lower estimate	Upper estimate	Difference	Difference %
Elsevier	\$221,441,616	\$230,750,669	\$9,309,054	4.2%
Sage	\$31,576,202	\$32,660,019	\$1,083,817	3.4%
Springer-Nature	\$589,674,3808	\$648,463,842	\$58,789,463	10.0%
Taylor & Francis	\$76,765,557	\$85,135,828	\$8,370,271	10.9%
Wiley	\$141,316,332	\$141,460,621	\$144,289	0.1%
All oligopoly publishers	\$1,060,774,086	\$1,138,470,980	\$77,696,894	7.3%

The exact number journal-year combinations for which APCs were obtained by different methods used for the analysis is shown in Table 2 below. The cost of OA was determined by multiplying the lower APC list price for a particular journal-year combination with the number of gold or hybrid OA articles published that year as determined by Unpaywall. Note that exemptions from APCs and discounts are not considered in the calculation of our estimates, as we do not have access to this information. The lack of discount and waiver information might lead to an overestimation of the total APCs paid to publishers. Zhang et al. (2022) similarly encounter this limitation in their study, noting that waiver and discount information remain with the institution and the invoicing publisher.

When analyzing fees on the country level, publications and fees APCs were fractionalized according to participating co-authors and their affiliations, as information on who was responsible for paying the APC is unknown. If, for example, a paper with an APC of \$2,000 was published by an author from Canada and one from China, \$1,000 was allocated to both countries. Similarly, when analyzing disciplines using the OECD Fields of Science (FoS) classification system, publications and fees were fractionalized if a journal was classified in more than one FoS class.

Table 2. APC data sources for journal-year combinations used for the analysis. “Actual” indicates that data for the particular year was available, “older”/”newer” indicates that an APC from the closest available previous or following years was used.

Data source	Number of journal-year combinations	%
Matthias (2020)	17,291	91.7%
Matthias: actual	6,2212	86.1%
Matthias: newer	369	2.0%
Matthias: older	3690	2.0%
Matthias: actual Morrison: actual	303	1.6%
Matthias: older Morrison: actual	27	0.1%
Matthias: newer Morrison: newer	2	0.0%
Morrison (2021)	1,358	7.2%
Morrison: actual	9,468	4.9%
Matthias: actual Morrison: actual	03	1.6%
Morrison: newer	38	0.2%
IWM: actual Morrison: actual	38	0.2%
Matthias: older Morrison: actual	27	0.1%
Matthias: newer Morrison: newer	2	0.0%
website: current Morrison: actual	2	0.0%
Morrison: older	1	0.0%
IWM: older Morrison: actual	1	0.0%
Internet Wayback Machine	482	2.5%
IWM: actual	436	2.3%
IWM: actual Morrison: actual	38	0.2%
IWM: newer	4	0.0%
IWM: older	3	0.0%
IWM: older Morrison: actual	1	0.0%
Current website	88	0.5%

website: current	86	0.5%
website: current Morrison: actual	2	0.0%
All journal-year combinations	18,846	100.0%

Results

APCs per publisher

Based on APC list prices and OA status, we estimate that the scientific community paid the oligopoly of academic publishers \$1.06 billion in OA publication fees, \$612.5 million gold and \$448.3 million hybrid, for 505,903 articles published in 6,252 journals between 2015 and 2018 (Figure 1).

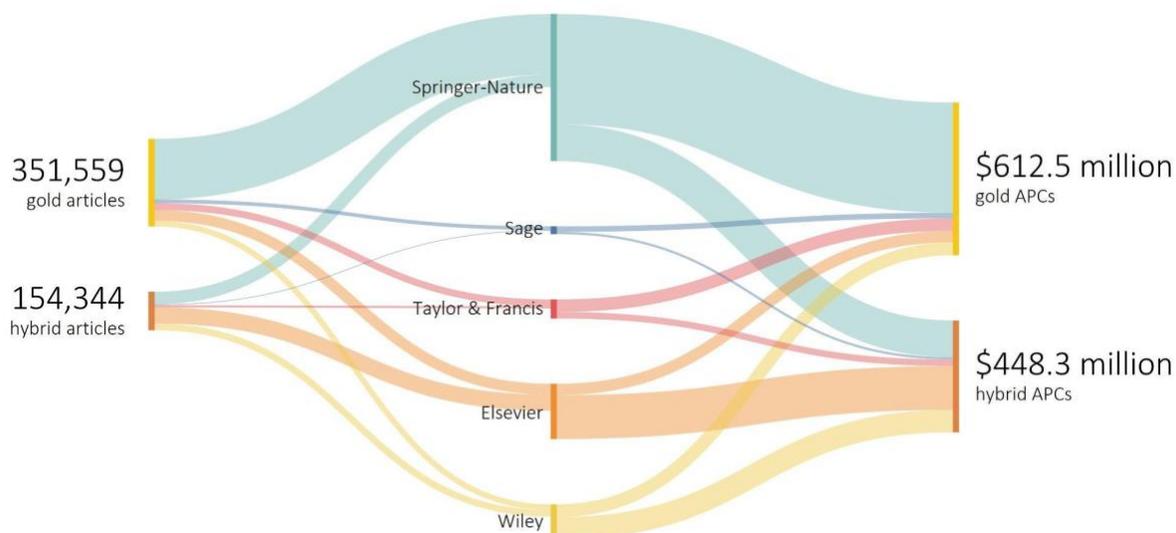


Figure 1. Number of gold and hybrid articles and estimated amount of APCs per oligopoly publisher.

The number of OA articles and APCs increased annually over the four-year period from \$201.5 million for 91,375 articles in 2015 to \$335.4 million for 153,746 articles in 2018 (Figure 2). According to our estimate, the largest amount of OA fees was obtained by Springer-Nature (\$589.7 million), followed by Elsevier (\$221.4 million), Wiley (\$114.3 million), Taylor & Francis (\$76.8 million), and Sage (\$31.6 million). Of the OA articles analyzed, 69.5% of articles were gold and

30.5% hybrid, with a slight increase for number of hybrid articles from 29.0% in 2015 to 32.4% in 2018.

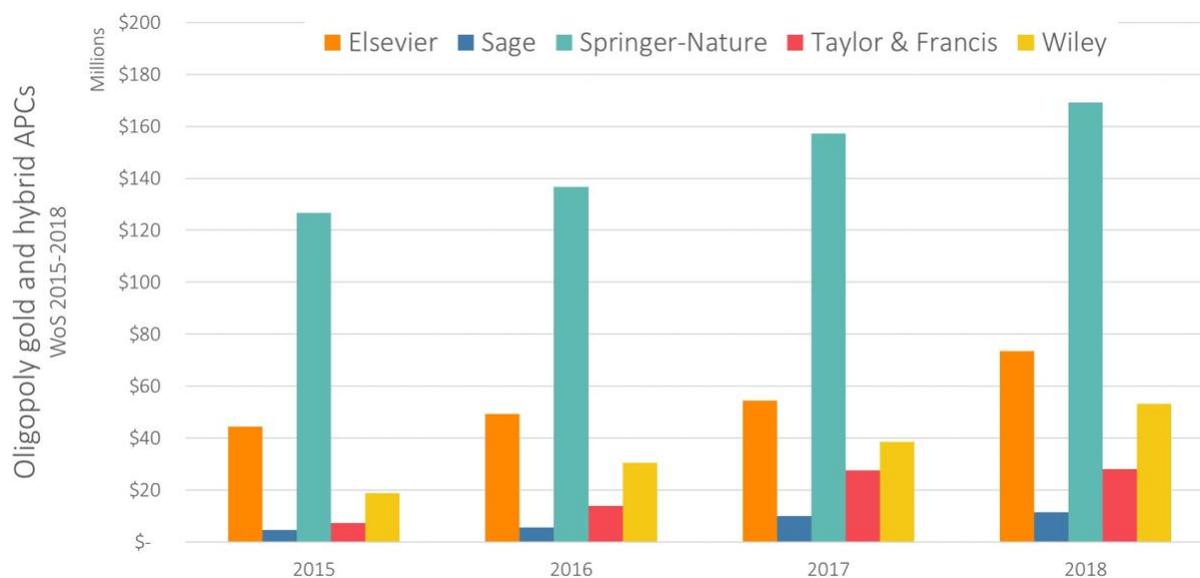


Figure 2. Total amount of gold and hybrid APCs per oligopoly publisher per year.

Our results show that in terms of article volume across the four years studied (2015 to 2018), the OA outputs of the oligopoly grew by 68.3% (60.1% for gold and 88.3% for hybrid). For gold articles, we see the largest rate of growth for the oligopoly occurring from 2015 to 2016 (26.2%), whereas there was only small growth from 2017 to 2018 (3%). For hybrid articles, growth from 2015 to 2016 was even more pronounced at 35.2% and remained fairly stable from 2016 to 2017 (18.2%) and 2017 to 2018 (17.9%). In terms of number of publications, there is variance between the five publishers we studied, demonstrating different levels of market control, as well as the different business strategies these publishers employ.

Figure 3 displays the share of total estimated APC revenues generated with gold and hybrid OA for each publisher. It is interesting to note that publishers seemed to follow different OA strategies in both number of publications and APCs obtained: Springer-Nature (82.7% articles gold; 75.0% APCs from gold), Sage (82.1%; 71.0%) and Taylor & Francis (75.8%; 66.0%) clearly focused on gold OA, while Elsevier (60.1% articles hybrid; 79.4% APCs from hybrid) and Wiley (53.9%;

63.4%) focused more on publishing hybrid OA articles in journals for which they already received subscription fees.

Despite only 30.5% of OA articles being hybrid over the four years analyzed, hybrid APCs make up 42.3% of total APCs. The oligopoly publishers obtained a total of \$612.5 million for gold and \$448.3 million for hybrid articles published between 2015 and 2018. The publishers' different OA portfolios, described above in terms of number of gold and hybrid articles, are also reflected in their APCs obtained. Springer-Nature received \$442.1 million from gold and \$147.6 million from hybrid APCs, while Elsevier obtained \$175.9 million in hybrid APCs and \$45.6 million in gold APCs (Figure 3). Wiley received \$51.7 and \$89.6 million, Taylor & Francis \$50.7 and \$26.1 million and Sage \$22.4 and \$9.2 million in gold and hybrid APCs, respectively.

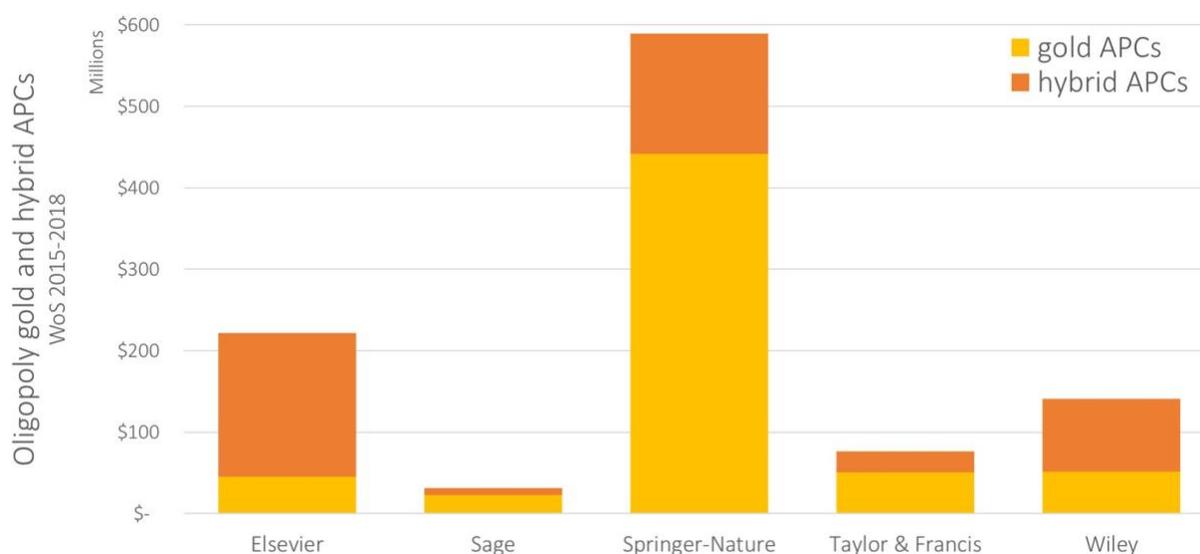


Figure 3. Total amount of gold and hybrid APCs per oligopoly publisher.

It should be noted that more than half (53.1%) of Elsevier's 43,080 gold OA articles had an APC of \$0. These so-called diamond OA articles are not captured in Figure 3 but listed separately in Table 3. The overall share of diamond OA articles for all oligopoly publishers was 12.4% (Table 3). This represents 43,623 of 351,559 gold OA articles, for which authors did not have to pay an APC. Elsevier published the largest number of gold OA articles without APCs ($n=22,888$; 53.1% of the publisher's gold OA articles), followed by Springer (16,957; 7.0%), Taylor & Francis (2,717; 9.8%), Sage (619; 4.2%) and Wiley (442; 1.9%). The overall share of diamond compared

to gold OA articles increased from 9.9% in 2015 to 13.6% in 2017 and then decreased again in 2018 to 12.0%.

Table 3. Number and share of diamond OA articles per publisher per year. Percentages are based on the share of gold OA articles with APC=0 compared to all gold OA articles per publisher per year.

	2015		2016		2017		2018		Total	
	n	%	n	%	n	%	n	%	n	%
Elsevier	2,208	31.7%	6,440	62.6%	7,726	61.8%	6,514	48.9%	22,888	53.1%
Sage	92	4.6%	81	3.0%	271	5.7%	175	3.2%	619	4.2%
Springer-Nature	3,748	7.5%	4,004	6.6%	4,520	6.7%	4,685	7.2%	16,957	7.0%
Taylor & Francis	223	9.5%	388	9.3%	1,116	11.6%	990	8.5%	2,717	9.8%
Wiley	136	4.0%	43	1.0%	128	2.0%	135	1.6%	442	1.9%
<i>All oligopoly publishers</i>	<i>6,407</i>	<i>9.9%</i>	<i>10,956</i>	<i>13.4%</i>	<i>13,761</i>	<i>13.6%</i>	<i>12,499</i>	<i>12.0%</i>	<i>43,623</i>	<i>12.4%</i>

Average APCs based on articles published were \$1,989 for gold OA (excluding diamond) and \$2,905 for hybrid OA. On average, hybrid APCs were thus 46.0% more expensive than their gold counterparts. Wiley had the highest APCs with on average \$2,297 paid for gold OA articles and \$3,343 for hybrid articles. At \$1,571 Sage had the lowest gold fees and \$2,715 Elsevier had the lowest hybrid APCs. As shown in Table 4, most hybrid APCs increased over the years, while gold APCs mostly decreased or stayed the same.

Table 4. Average gold and hybrid APCs paid per oligopoly publisher per year.

	Publisher	2015	2016	2017	2018	2015-2018
Gold (APCs>\$0)	Elsevier	\$2,461	2,259	\$1,756	\$2,463	\$2,256
	Sage	\$1,977	\$1,534	\$1,588	\$1,428	\$1,571
	Springer-Nature	\$2,181	\$1,813	\$1,866	\$2,013	\$1,957
	Taylor & Francis	\$2,644	\$2,019	\$1,948	\$1,964	\$2,025
	Wiley	\$2,241	\$2,237	\$2,274	\$2,368	\$2,297
	<i>All oligopoly publishers gold APCs</i>	<i>\$2,217</i>	<i>\$1,864</i>	<i>\$1,884</i>	<i>\$2,040</i>	<i>\$1,989</i>
Hybrid	Elsevier	\$2,458	\$2,737	\$2,742	\$2,848	\$2,715
	Sage	\$2,900	\$2,860	\$2,712	\$2,857	\$2,815

	Springer-Nature	\$2,897	\$2,877	\$2,901	\$2,963	\$2,914
	Taylor & Francis	\$2,914	\$2,926	\$2,942	\$2,948	\$2,938
	Wiley	\$3,156	\$3,367	\$3,424	\$3,341	\$3,343
	<i>All oligopoly publishers hybrid APCs</i>	\$2,713	\$2,906	\$2,924	\$2,989	\$2,905

APCs per journal

Analyzing amounts of APCs on the journal level, the highest totals were obtained by two Springer-Nature gold OA journals. Over the four-year period analyzed, *Scientific Reports* obtained \$105.1 million and *Nature Communications* \$71.1 million in APCs. As shown in Figure 4, those two journals generated by far the highest amount of APCs, which can be explained by the large number of articles published. *Scientific Reports* published 73,206 and *Nature Communications* 16,122 articles between 2015 and 2018, respectively, while the journal with the third largest APC amount, *Cell Reports* (\$10.3 million), published only 4,211 OA articles during the same period. Among the top 50 journals based on total APCs (Figure 4), all but 8 were gold OA journals (84.0%), which can again be explained by fact that all articles published in gold OA journals are subject to APCs while only a fraction of authors choose to pay for hybrid OA. Among the top 50 journals by total amount of APCs, the majority was published by Springer-Nature (58.0%).

When looking at the average APC per article (Figure 5), three Springer-Nature gold journals had the most expensive fees: *Diabetes Therapy* (\$5,478), *Infectious Diseases and Therapy* (\$5,295) and *Rheumatology and Therapy* (\$5,169). However, these were closely followed by a range of hybrid Elsevier and Wiley journals with APCs of or around \$5,000. Reflecting the higher APCs of hybrid vs gold OA journals, 86.0% of the 50 most expensive APC journals were hybrid. Twenty-nine (58.0%) of the most expensive journals according to average APC were published by Elsevier, all except one of which were hybrid, reflecting the publisher's OA portfolio described above.

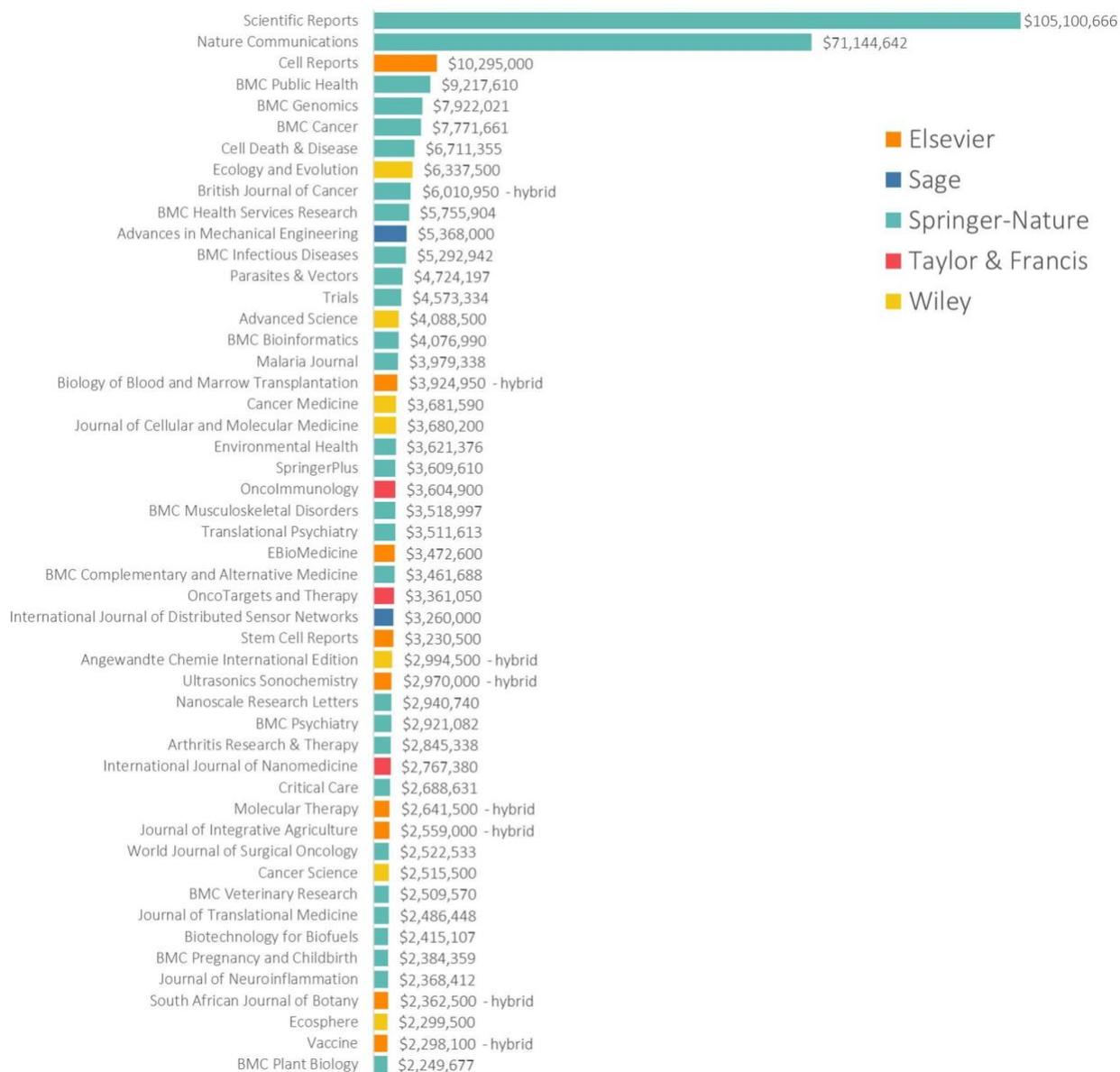


Figure 4. Top 50 journals by total amount of APCs 2015-2018. Hybrid journals are labeled, all others are gold.

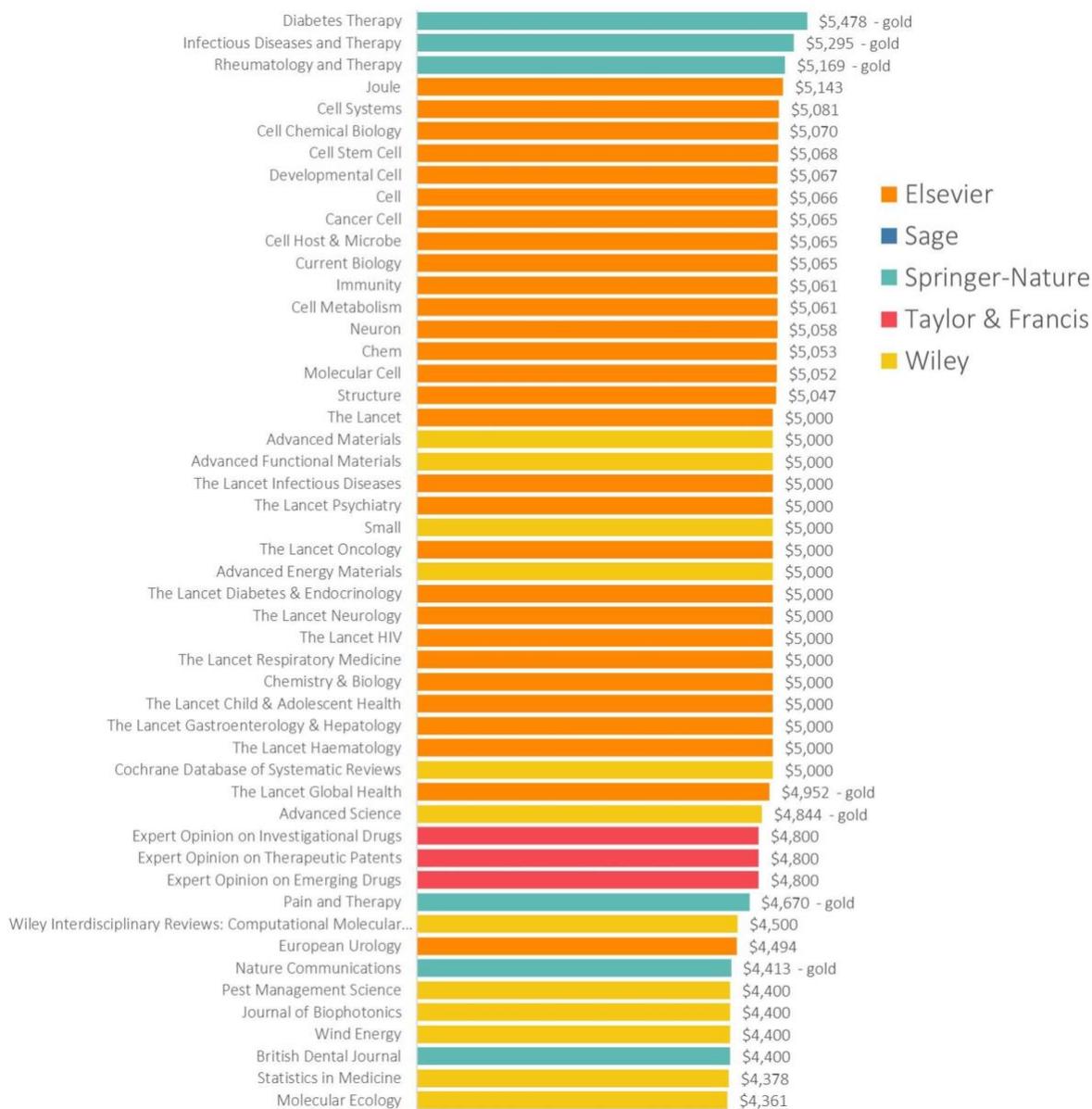


Figure 5. Top 50 journals by average APCs 2015-2018. Gold journals are labeled, all others are hybrid.

APCs per country.

Figure 6 displays the total fractionalized costs per country for the 25 countries with the largest amounts of APCs. According to our estimates, the US (\$184.7 million), China (\$148.0 million) and the UK (\$134.6 million) are responsible for paying the largest amounts of OA fees to oligopoly publishers. Some countries pay a larger share of hybrid APCs than expected. For example, Poland (82.9% of APCs, 71.5% of OA articles hybrid), Austria (76.1%, 66.2%), the Netherlands (75.4%, 65.8%), the UK (73.4%, 63.8%) followed by Sweden (62.2%, 51.1%), Brazil (53.4%, 38.4%), Norway (52.7%, 40.6%) and Finland (52.2%, 40.3%) pay more APCs for hybrid than for gold publications. For comparison, the expected rates for the entire dataset would be 42.3% of APCs and 30.5% of OA publications to be hybrid. On the other end of the spectrum, among the top 25 countries shown in Figure 6, Taiwan (85.8% of APCs, 91.7% of OA articles gold), South Korea (85.0%, 90.0%) and China (83.7%, 88.2%) pay and publish more gold OA articles with oligopoly publishers than expected.

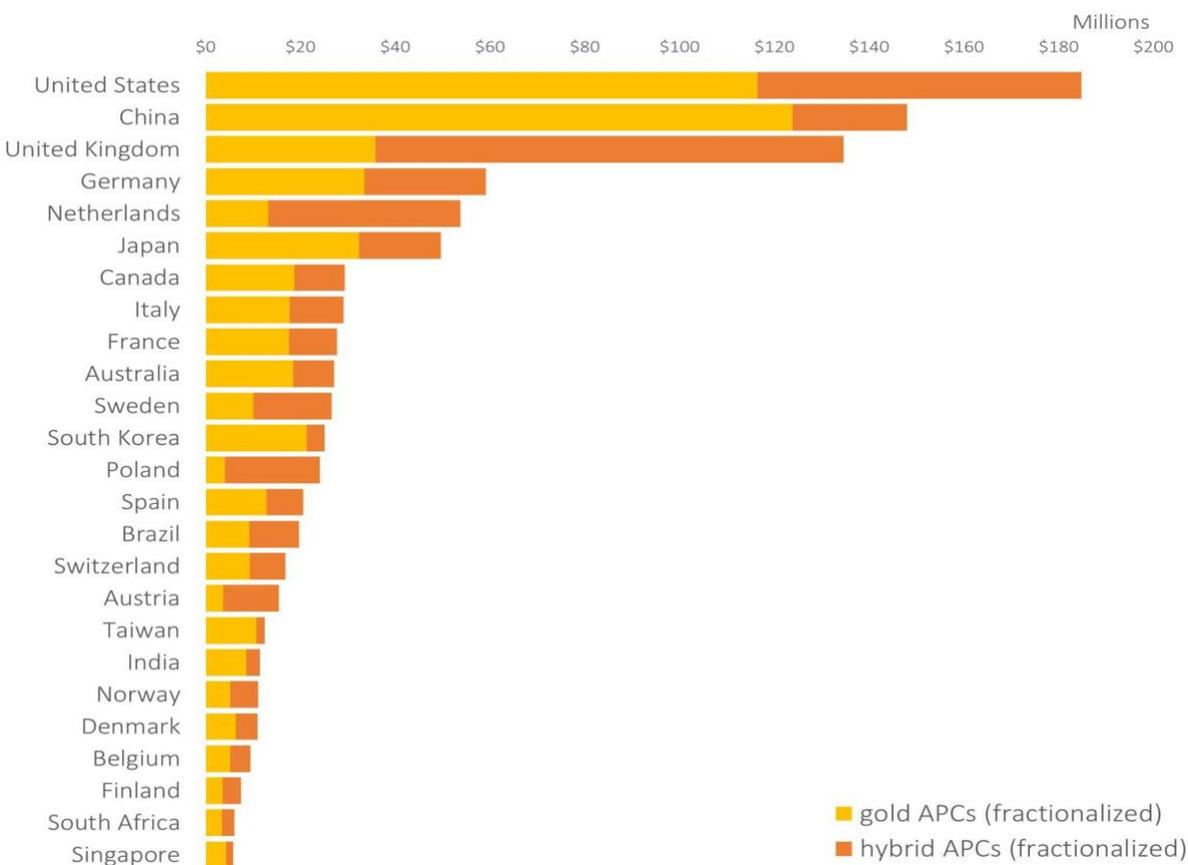


Figure 6. Top 25 countries by total amount of APCs 2015-2018 based on fractionalized publications.

APCs per discipline

When analyzing the APC estimates per discipline (Figure 7), the majority of fees can be allocated to journals from either the Natural Sciences (\$450.5 million) or the Medical and Health Sciences (\$423.1 million). Together these two disciplines make up 82.7% of the global estimate of APCs paid to oligopoly publishers during the four-year period analyzed. APCs paid to publish in Humanities journals make up the smallest amount of \$8.3 million, which may be explained by poor indexation of journals in WoS, the disciplinary portfolios of oligopoly publishers as well as the importance of book rather than journal publications. Interestingly, the Humanities as well as the Social Sciences pay the great majority of OA fees for hybrid OA. 89.9% and 85.1% of OA fees were for hybrid publications in the Humanities and Social Sciences, respectively. In the Natural Sciences authors spent 65.5% of OA APCs on publications in gold journals.

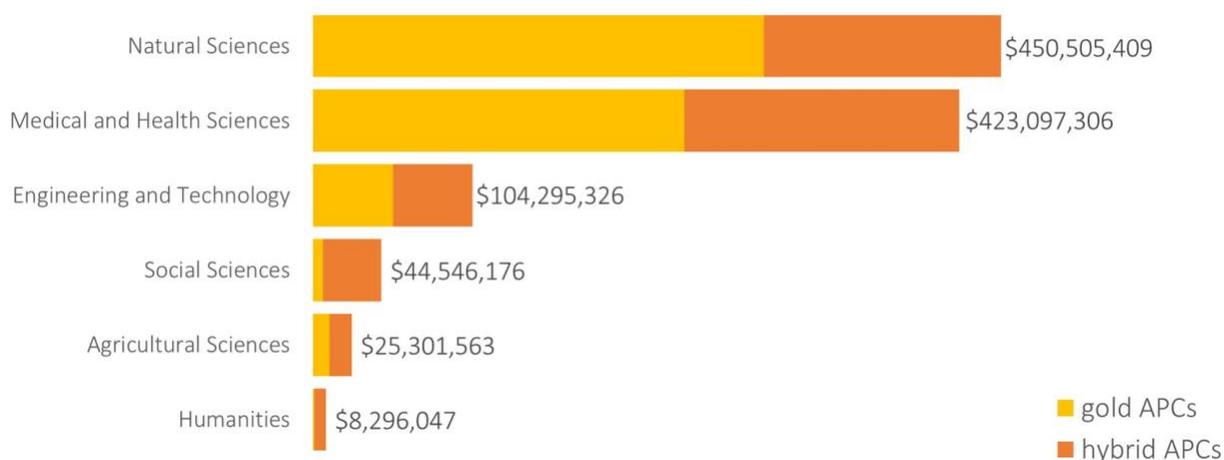


Figure 7. Total amount of APCs for gold and hybrid publications (n=505,555) per OECD Field of Science. APCs of journals classified in more than one OECD FoS were fractionalized.

Figure 8 shows the share of publications per OA status per discipline, reflecting the high share of hybrid articles in the Humanities and Social Sciences described above. It also shows the share of diamond articles, which are OA articles published in gold OA journals that do not require the author to pay (APC=\$0). Our data shows that diamond journals are more popular in Engineering and Technology (11.2%) as well as Natural Sciences (11.2%) but not very common in the Humanities (3.3%) and Medical and Health Sciences (5.2%).

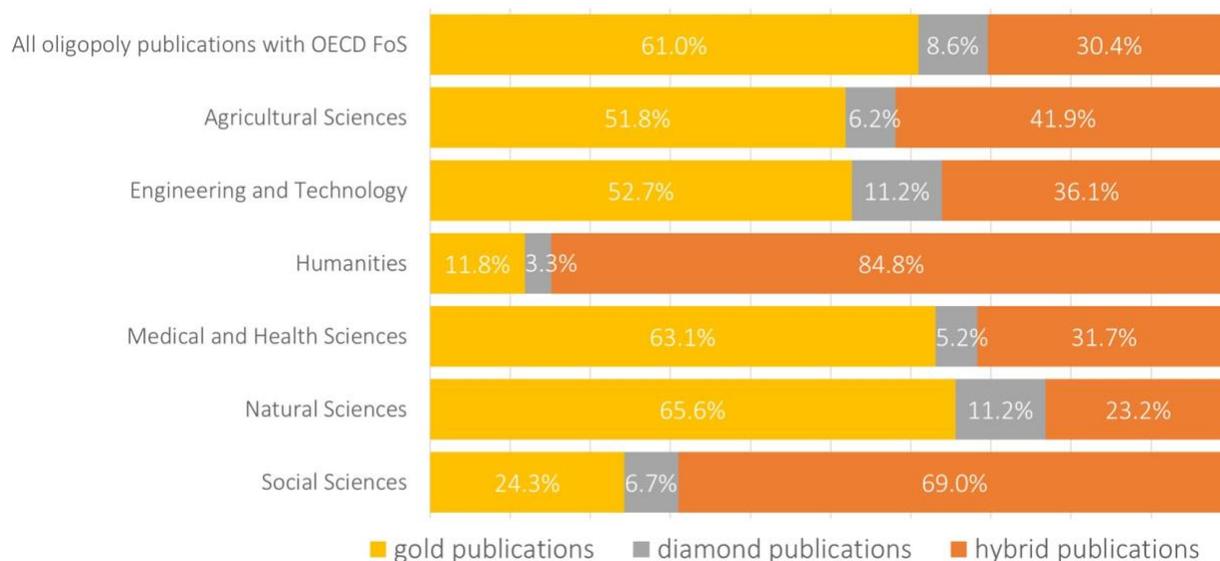


Figure 8. Share of gold, diamond and hybrid publications (n=505,555) per OECD Field of Science.

Discussion

Our estimates of APCs charged by five oligopoly publishers (Elsevier, SAGE, Springer-Nature, Taylor and Francis, Wiley) illustrate the continued growth in the OA market. Although OA was meant to remove inequities and break the oligopoly's control of the traditional scholarly market, these publishers have found a new revenue by equating OA with APCs and are now exerting their power in this system (Holley, 2018).

We estimate that the five publishers included in our study generated \$1.06 billion in revenues from gold and hybrid APCs during the 2015-2018 period. Our results highlight that APCs have become a considerable source of revenue in addition to their traditional business model of subscription fees paid by academic libraries. It should be emphasized that by limiting the analysis to five publishing companies and WoS-indexed journals, the \$1.06 billion estimate represents only a fraction of the total market for gold and hybrid OA. By focusing on the oligopoly, we did not include various OA mega-journals and publishers such as PLOS, Hindawi, MDPI, and Frontiers, which have been identified to be major players in the OA publishing landscape (Khoo, 2019; Zhang et al., 2022)

The significant amounts of revenues the oligopoly draws from the OA market suggests that these publishers were able to use their dominance in the traditional market to quickly establish themselves as leaders in the emerging OA market in the face of competition from new players such as PLOS, Frontiers and others. That market power translates to APCs, where publishers apply tactics like price discrimination, charging higher APCs and subscriptions for high-impact journals, which many authors and libraries are willing to pay due to the prestige and influence that these journals have on the academic reward system (Brembs, 2017; Khoo, 2019; Shu et al., 2018; Siler & Frenken, 2020). Mergers and acquisitions as well as general growth of publication output led to further consolidation of the market, allowing these publishers to control APC prices. The Fair Open Access Alliance (FOAA), an organization that evaluates sustainable OA publishing, analyzed the cost to publish OA and demonstrated that much lower APCs, of no more than \$50 per page, are feasible to sustain an OA journal. FOAA advocates for transparency in APC prices and recommends that author fees should not exceed \$1,000 per article (FOAA, 2022). Factoring in differences between journals' rejection rates, staffing, editorial services and publishing volume, Grossman and Brembs (2021) similarly estimate that fees between \$200 and \$1,000 per article are sufficient to sustain a gold OA journal. They calculate that an APC of \$500 could still accommodate a 10% profit margin (Grossmann & Brembs, 2021). Rodrigues et al. (2020) found that 59% of gold journals indexed in DOAJ charge APCs less than \$1,000, demonstrating the possibility of this average price point, when profit is not the main purpose. As shown in many previous studies (Crawford, 2022; Jahn & Tullney, 2016; Morrison et al., 2021b) and corroborated by our findings, commercial publishers do not follow these recommendations. Our data indicates that on average between 2015 and 2018, oligopoly publishers charged \$1,989 for gold and \$2,905 for hybrid articles. Breaking down average pricing demonstrates how APCs influence the publisher's overall revenues. For example, Crawford's (2021) analysis of journals in the DOAJ shows that although Wiley publishes fewer gold articles, they draw more revenues than Elsevier due to higher APCs. Previous studies (Budzinski et al., 2020; D. Solomon & Björk, 2016) have shown that higher APC pricing correlates with a journal that produces a high publication volume. This suggests that traditional commercial publishers can dictate pricing once they exert their dominance in the OA market, especially since authors display a lack sensitivity to the high pricing (Khoo, 2019; Morrison, 2021). Reputation seems to be the commodity that drives researchers to select a certain journal, and publishers set their APC fee accordingly (Budzinski et al., 2020). It is

precisely because of this intertwining of prestige and profit that commercial publishers have managed to equate OA with APCs, excluding many authors from publishing. In terms of number of articles, the APC-based model continues to dominate OA publishing (Siler & Franken, 2020), at least partly due to the central role that oligopoly publishers play in this growing market. Profit and prestige represent the Western worldview on academic publishing and the reward system at large. A look at the publishing landscape in the Global South demonstrates that sustainable and affordable OA publishing exists outside the author-pays model. More than two thirds of OA journals indexed in the DOAJ do not charge APCs. Simard et al. (2022) show that diamond journals are more prevalent in the Global South and many low and middle-income countries, with some regions such as South America achieving nearly 100% of diamond OA through regional initiatives.

Our findings show that Springer-Nature leads in terms of both overall OA article volume and total APCs with a clear focus on generating revenue from gold OA, which corroborates findings from previous studies (Crawford, 2021; Rodrigues et al., 2020; Zhang et al., 2022). Rodrigues et al.'s (2020) found that Springer-Nature publishes 35% of journals in DOAJ, which represents an even larger share than what they control in the traditional publishing market. Springer-Nature's dominance in the gold OA market can partially be attributed to their strategy to focus on acquiring well-established OA publishers and journals, but also publishing a large volume of new journal titles (Rodrigues et al, 2020). For example, in 2008, Springer-Nature acquired *BioMed Central (BMC)*, a prominent and large OA publisher with more than 300 journals². Jahn and Tullney's (2016) found that most APC fees for German institutions were spent on Springer-Nature journals, possibly owing to their merger with BMC and other publishers like Springer Science + Business Media and Nature Publishing Group in 2015. Such acquisitions are typical for the oligopoly of academic publishers and significantly influence their market power (Larivière et al., 2015). Our data shows that Springer-Nature publishes the two gold journals that generate the highest revenues: the megajournal *Scientific Reports*, which accounts for revenues from APCs of \$105.1 million, followed by the large multidisciplinary journal *Nature Communications*, associated with revenues of \$71.2 million. Together, these two flagship journals, bring in 39.9% of Springer-Nature's

² See <https://www.biomedcentral.com/about>

\$442.1 million gold OA revenues. Even though its APCs are higher, Khoo (2020) found that *Scientific Reports* overtook the well-established OA journal PLOS ONE as the largest megajournal in 2017. Despite their focus on gold OA, Springer-Nature also generates \$147.6 million from hybrid APCs and demonstrates significant growth with the number of hybrid articles increasing by 83.9% from 2015 to 2018. This suggests that Springer-Nature is likely to maintain and further build on its dominance in the OA market. As of 2021, Springer-Nature's flagship journal *Nature* charges a hybrid APC of \$11,200 (Noorden, 2020).

Elsevier's OA portfolio has a clear focus on hybrid, with 60.1% of their WoS-indexed OA articles published in hybrid journals, accounting for revenues of \$175.9 million. Jahn et al. (2022) found that Elsevier's number of hybrid articles is doubling each year and their share of hybrid articles continue to increase, showing their continued investment in the traditional market, where they yield revenues from both subscriptions and APCs. At \$45.6 million, the total estimate for Elsevier's gold APC revenue is comparatively small among oligopoly publishers, as smaller players like Wiley and Taylor & Francis generate more gold APCs than Elsevier. Elsevier's lower revenue from gold can be explained by the amount of gold articles, but also by their large share of diamond OA papers: Over half of Elsevier's gold OA articles were diamond OA and did thus not generate revenue from APCs.

Although diamond OA is a more equitable approach to academic publishing, as it excludes neither readers nor authors on economic grounds, it should be noted that publishers do not provide this service for free. Most diamond OA journals are financed through different sources, such as membership fees or grants (Bosman, Jeroen et al., 2021). This revenue stream is not reflected in our estimates. Our data shows significant growth for OA articles of any type published by Elsevier between 2015 and 2018: hybrid output increases by 49.9% and gold with APC by 43.1% and diamond by 195.0%. Interestingly, after tripling from 2015 to 2016, the growth in diamond OA slowed down in 2017 and decreased by 15.7% in 2018. Although our study did not focus on investigating the prevalence of diamond OA, we found that 12.4% of gold articles (8.6% of all OA) published by the oligopoly had an APC of \$0. Elsevier's uptake of diamond OA stood out among the five publishers, as more than half (53.1%) of their gold OA papers were published at no cost for the authors. The other oligopoly publishers take less advantage of diamond OA. Taylor

& Francis publish 9.8%, Springer-Nature 7.0%, Sage 4.2% and Wiley 1.9% of their gold OA articles without an APC. With the exception of Elsevier, the uptake of diamond OA remains far below the 43.2% of diamond articles found by Siler and Franken (2020) using the DOAJ. This illustrates that diamond OA is still a phenomenon that is much more common outside of the Western-based oligopoly of publishers, as the DOAJ is a more inclusive source of data that indexes publications from all over the world.

We find that the oligopoly charges more APCs for hybrid OA than for gold OA, which corroborates previous studies (Zhang et al., 2022; Pinfield, 2016; Morrison et al., 2015, Budzinski et al., 2020; Solomon & Björk, 2016; Jahn & Tullney, 2016). This remains counterintuitive since hybrid fees are charged in addition to subscription fees, while gold OA journals with APCs are mostly funded through the author-pays model. The oligopoly's ability to set higher prices for hybrid, where they already draw significant revenues from subscriptions, demonstrates a successful strategy to grow profits, an indication of their market power (Budzinski et al., 2020) owing largely to their long-standing history and well-established business models (Budzinski et al., 2020; Jahn & Tullney, 2016; Laakso et al., 2011; D. Solomon & Björk, 2016). Our findings show that similarly to Elsevier, Wiley generates more APC revenues from hybrid OA than gold OA, although the difference between gold and hybrid is less pronounced for Wiley. Our dataset ends in 2018, and Wiley recently acquired the large OA publishing house Hindawi (Business Wire, 2021). When it comes to OA output and revenues, Taylor & Francis and Sage are smaller players among the oligopoly publishers. They account for 7.2% and 3.0% of the \$1.06 billion of APC revenue.

Conclusion and outlook

OA was initially proposed as a way to make research output available to everyone in order to “accelerate research, enrich education, share the learning of the rich with the poor and the poor with the rich, make this literature as useful as it can be, and lay the foundation for uniting humanity in a common intellectual conversation and quest for knowledge” (BOAI, 2001). However, this movement conflicts with the traditional profit-driven model of traditional commercial publishing (Logan, 2017), which reap obscenely high profit margins (Smith, 2018). For instance, in 2017, Elsevier's made \$1.8 million in journal revenue with a 37% profit margin annually, while Springer

Nature earned \$1.3 million with a 23% annual profit margin (Aspesi et al., 2019). The high profit model is built on the work of academics who generally produce the labor as authors and reviewers as part of their jobs, free of cost to publishers (Buranyi, 2017). This mostly voluntary labor has been previously estimated to about 1.9 billion in unpaid labor per year (Logan, 2017). While OA could theoretically overcome inequities of academic publishing, for-profit publishers have used APCs, and more recently Read-and-Publish deals (Pooley, 2021), to keep their businesses highly profitable. Regardless of the model — subscription, APC or diamond fees — publishers generate these profits using university and funder budgets, which are often taxpayer funded.

While APC waivers and other initiatives such as the Research4Life program do exist, they may be insufficient to overcome inequalities in academic publishing. Rouhi, Bears, and Brundy (2022) discuss how APCs exacerbate inequalities, since the existence of waivers demonstrates the model works best for well-funded researchers and institutions — often those in the Global North — as well as disciplines. Waivers do not solve equity issues because they often exclude hybrid publishing or cover only a share of high APCs, leaving an unaffordable amount to the author in a Low-to-Middle-Income Country. The existence of such programs and initiatives illustrates the problematic nature of the current model and the inequities it creates. Initiatives to (temporarily) open access to literature and data during the Covid-19 pandemic and the war in Ukraine, illustrates the inequities built into the overall system, where during times of crisis it becomes clear the economic barriers restrict scientific advancement.

Publishers appear to be leveraging the growth in the OA market to shift business strategies from traditional subscriptions to OA, coinciding with global developments like Plan S and the increase in funder OA mandates and policies. As of 2021, Plan S, a consortium of mostly European funders, is in effect which bans hybrid publishing and limits the APC of gold journals (cOAlition S, 2022) and encourages subscription and hybrid journals to transition to become fully OA. Plan S and the general increase in OA mandates from funders worldwide has and will certainly affect the oligopoly's portfolios and business strategies. For example, publishers have begun to create so-called transformative agreements, contractual agreements between institutions (i.e., libraries or consortia) and publishers, including “read-and-publish” and “publish-and-read” models (Hinchliffe, 2019). The majority of transformative agreements are with oligopoly publishers since

the negotiations and the implementation of those deals require large investment (Hinchliffe, L., 2020). For example, the German Max Planck Society agreed to a Plan S-compliant deal with Springer-Nature to pay an APC of \$11,200 per article to publish OA in and gain access to 34 journals and 21 Nature Review titles (Noorden, 2020).

Transformative deals have been criticized for their lack of transparency (Esposito, 2018; Pooley, 2020; Poynder, 2018) and continued exacerbation of the affordability problem within the scholarly publishing system. Many consider it highly problematic that instead of removing author fees, these deals merely carry APCs over into the agreement for a reduced cost (Borrego et al., 2020). Moreover, with transformative agreements publishers can also lock-in their prices, similarly to Big Deals (Poynder, 2018). Similarly, to the original motivation of creating hybrid journals, transformative agreements are meant to be transitory in a bid to move publishers toward full gold OA. It remains to be seen whether these agreements will successfully transform the academic journal landscape into equitable and sustainable OA publishing or whether they are just another source of revenue for commercial publishers.

Our estimates of total APCs paid to oligopoly publishers shows that the shift from reader pays to author pays merely switches their revenue sources from subscription to OA. Despite many efforts to lower subscription fees and the increasing adoption of OA, university libraries have been paying more and more to access scholarly literature (Simard, 2021). Instead of making scholarly publishing sustainable and accessible for all, high APCs and transformative agreements seem to preserve the status quo.

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