



# The oligopoly of open access publishing

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## Abstract

Open access (OA) publishing is often viewed as a promising solution for the future of scholarly publishing, as it has the potential to reduce global inequalities in access to scientific literature by removing paywalls. However, the adoption of OA publishing may not necessarily lead to a decrease in the overall cost of knowledge dissemination, as Article Processing Charges (APCs) can create an additional financial burden for scholars, particularly those from developing countries. Despite being intended as a way to disrupt the scholarly publishing oligopoly, OA publishing has faced challenges in achieving this goal. These challenges were revealed through a comprehensive analysis of OA publishing from 2008 to 2020, as detailed in this study.

**Keywords** Open access · Article processing charge · Web of Science · Dimensions · Oligopoly

## Introduction

Over the last decades, academic libraries have been undergoing serials crises associated with the increase in the cost of journal subscriptions (Panitch & Michalak, 2005; Young, 2009). Between 1984 and 2010, the average cost of academic journals rose by more than eight times, while the inflation rate during the same period was only 109.87%. (Tafari, 2010). Due to their fixed budgets, academic libraries were unable to afford the increased prices, leading to the cancellation of some serial subscriptions to maintain core journals in their collections.

Previous research has attributed the recurring crisis in scholarly publishing to the oligopoly of a few dominant commercial publishers (Larivière et al., 2015). These publishers employ product differentiation and pricing strategies to manipulate the market for scholarly

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journal subscriptions (Bergstrom et al., 2014; Shu et al., 2018; Varian, 1996). Open access (OA) publishing has been regarded as a solution to the serials crisis (Pinfield et al., 2014; Spezi et al., 2017; Wilbanks, 2006) as publishers don't charge the subscriptions but levy article processing charges (APCs) paid by authors upon acceptance. However, the adoption of OA publishing does not necessarily decrease the overall cost of publication for academic institutions (Pinfield et al., 2016) as APCs become the extra cost of scholarly publishing (Björk & Solomon, 2014; Crow, 2009).

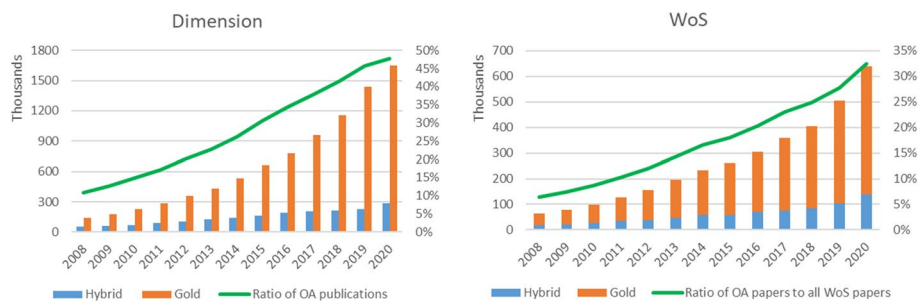
Through analyzing the migration of academic journals between 1973 and 2013, Larivière et al. (2015) revealed that the top five commercial academic publishers disseminated more than half of all papers indexed in the Web of Science in 2013. Despite being considered an approach to breaking the oligopoly of scholarly publishing, open access (OA) publishing faced challenges in achieving this goal. (Spezi et al., 2017; Wilbanks, 2006). In this context, recent studies analyzed the evolution over time of market shares in OA publishing (Butler et al., 2022; Zhang et al., 2022). The latter study examined the article processing charges (APCs) of a sample of 40 journals from 12 publishers, while the former analyzed OA publishing using APCs of journals published by Elsevier, Springer-Nature, Wiley, Sage, and Taylor & Francis. The aim of this paper is to provide a comprehensive analysis of OA publishing from 2008 to 2020, using two data sources with different coverage (Basson et al., 2022): Dimensions and Web of Science.

## Methods

This paper uses two data sources: Dimensions and Web of Science. Traditionally, Web of Science and Scopus have been the two most widely used databases for bibliometric analyses. However, during the last few years some new scholarly databases have come up. Singh et al. (2021) find that the Web of Science is the most selective and Dimensions is the most exhaustive database in terms of the journal coverage, which could represent the high-end and full scholarly publishing market respectively.

Dimensions is a platform that identifies OA using the digital object identifiers (DOIs) registered by Crossref. Dimensions includes all scholarly papers published in journals listed in the Directory of Open Access Journals (DOAJ), indexed PubMed Central as well as other repositories, but excludes papers from social-networking platforms (e.g., ResearchGate, Sci-Hub, etc.). Dimensions (Herzog et al., 2020) provides the open-access status of over 100 million scholarly documents. In this study, 10,810,444 journal articles published between 2008 and 2020, and their publishing information (journal title, OA status, publishers, etc.) were retrieved from Dimension. In order to analyze the APCs charged by publishers, only Hybrid and Gold OA that charge APCs were investigated in this study although OA consists of other formats (Diamond, Bronze, Green, etc.).

We matched the Dimension data to the Web of Science (WoS) database, which includes the Science Citation Index Expanded, the Social Science Citation Index and the Arts and Humanities Citation Index, annually index documents published in about 12,000 journals, covering all areas of research. Publications indexed by WoS are considered to be the core scientific literature with a high impact and are exclusively used in research assessment in many countries. Additionally, the bibliographic data provided by WoS allows for detailed analysis of disciplinary comparison, global contribution, and research impact of OA publishing.



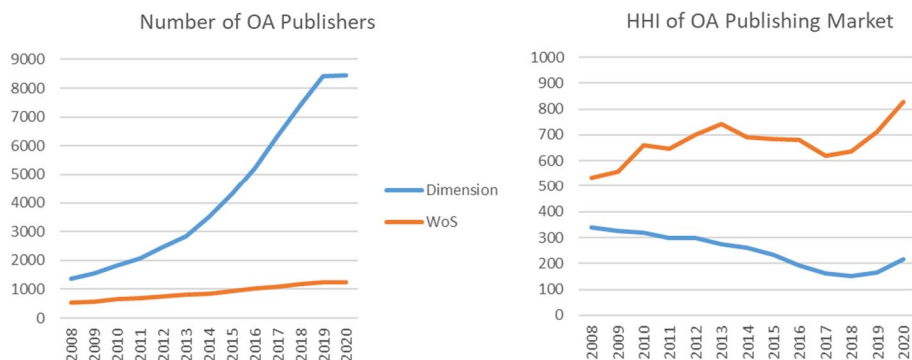
**Fig. 1** Number and percentage of open access papers, by open access status, Dimensions and Web of Science (2008–2020)

To conduct a financial investigation of the OA publishing market, a list of APCs of major academic publishers was collected from various sources, including publisher websites, journal websites, DOAJ, and others. Since the OA publishing market is dynamic with new journals emerging and publishers changing APC prices occasionally, it was difficult to track APCs prior to 2017 or APCs charged by small publishers. However, the study managed to compile a complete list of APCs for the top 5 commercial publishers in scholarly publishing, namely Elsevier (2017–2020), Springer-Nature (2010–2020), Wiley-Blackwell (2011–2020), Taylor & Francis (2012–2020), and Sage Publications (2010–2020). Additionally, all APCs for OA papers (both Hybrid and Gold) published in 2020 were collected for market analysis.

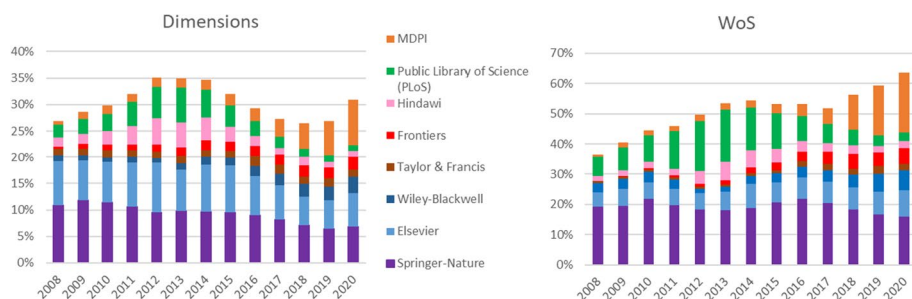
It is important to note that publishers offer different rates, discounts, and conditions as they charge APCs. However, the regular APC rate was used in this study since the different conditions could not be distinguished. Additionally, since APC payment information is not always available, the study assumed that the first author would pay the APCs, although this is not always the case. The study also assigned OA papers to different countries based on first authorship when conducting country-level comparisons to avoid inflated co-authorship due to international collaborations.

## Results

Figure 1 presents the evolution of OA publishing since 2008. The number of OA papers has increased almost tenfold, from 193,892 in 2008 to 1,930,895 in 2020, with a Compound Annual Growth Rate (CAGR) of 21.11%. Similarly, the number of OA papers indexed by WoS has also increased from 65,434 in 2008 to 640,169 in 2020 with a CAGR of 20.93%. The percentage of OA papers has also been increasing over the years, from 10.81% in 2008 to 47.77% in 2020, while the proportion of OA papers indexed by WoS has increased from 6.47% to 32.43% in the same period. The percentage of Gold OA papers has also seen a rise in both the general OA market (indexed by Dimension) and the high-end OA market (indexed by WoS), increasing from 73.04% to 85.31% and 69.98% to 78.21% respectively.



**Fig. 2** Market concentration of the OA publishing, Dimensions and Web of Science (2008–2020)



**Fig. 3** Market share of major OA publishers, Dimensions and Web of Science (2008–2020)

## Market concentration by volume

As the OA publishing market continues to expand, an increasing number of new publishers are entering the fray. As illustrated in Fig. 2, the number of OA publishers has risen dramatically from 1368 in 2008 to 8442 in 2020. This trend is mirrored in the high-end OA publishing market indexed by WoS, where the number of publishers has risen from 532 in 2008 to reach a historical high of 1251 in 2019 before slightly declining to 1247 in 2020.

We applied the Herfindahl–Hirschman index (HHI),<sup>1</sup> commonly used to measure market concentration in business, to the concentration of OA publishing. The decreasing HHI shown in Fig. 2 suggests that the OA publishing market has become more competitive. However, a different trend is observed in the high-end OA publishing market (indexed by WoS), as the HHI has been increasing, particularly since 2017. This indicates a shift in market concentration in the high-end OA market.

<sup>1</sup> The formula of HHI is.

$$HHI = \sum_{i=1}^n Si^2$$

where  $Si$  is the market share of a given publisher  $i$ , and  $n$  is the number of publishers in the market.



**Fig. 4** Market concentration of the OA publishing in different domains (2008–2020, Indexed by WoS)

Signs of a changing market concentration are also observed in Fig. 3, which presents the specific market share of major OA publishers.<sup>2</sup> These publishers include both the traditional commercial publishing houses (Elsevier, Springer-Nature, Wiley-Blackwell, Taylor & Francis) and the emerging OA publishers (Frontiers, MDPI, Hindawi,<sup>3</sup> and PLoS). With the increasing volume of OA publications, these OA publishers have maintained a stable market share in OA market and been gradually increasing their shares in high-end market (i.e., WoS), from 39.07% in 2008 to 66.05% in 2020. The sizeable increase of MDPI is noticeable for both WoS and Dimensions; in the latter, it increased its number of OA publications from 1514 in 2008 to 165,330 in 2020, and became the largest OA publisher of the world.

<sup>2</sup> Ranked by both the number of OA publications and the number of OA publications indexed by Dimension and WoS respectively. These eight publishers are listed as the top 10 publishers in all four rankings.

<sup>3</sup> Hindawi is an independent publisher during the period of investigation (2008–2020) in this study although it was acquired by Wiley-Blackwell in January 2021.

**Table 1** Number of papers and associated revenue, by major OA publisher (2020, indexed by dimensions)

Publisher	Number of papers	Market share by papers (%)	Revenue (USD) <sup>a</sup>	Market share by revenue (%)
MDPI	165,330	8.56	262,832,932	15.22
Springer-Nature	132,571	6.87	328,393,991	19.02
Elsevier	122,390	6.34	214,511,802	12.42
Wiley	58,120	3.01	149,878,144	8.68
Frontiers	48,208	2.50	133,779,440	7.75
Taylor & Francis	25,656	1.33	51,465,861	2.98
Hindawi	24,267	1.26	44,131,565	2.56
PLOS	19,638	1.05	34,459,290	2.00
...	...	...	...	...
Total	1,930,895	100	1,726,786,904	100

<sup>a</sup>The APC revenue is calculated by 569,207 out of 640,169 OA papers (88.92%) while the APC information in the rest of OA papers is not available or missing

The market concentration also varies by domain.<sup>4</sup> As Fig. 4 indicates, the OA publishing market in all domains has become more concentrated. The increases in Herfindahl–Hirschman Index (HHI) values are relatively small in Social Sciences and Life Sciences & Biomedicine, whereas in Physical Sciences and Technology, they have doubled. Notably, since 2016, there have been radical increases in the HHI values. In the period of four years (2016–2020), the HHI values for Physical Sciences (518 to 1614) and Technology (572 to 1629) have more than tripled. These values indicate that the OA publishing markets in Physical Sciences (1614) and Technology (1629) are not highly competitive but rather moderately concentrated, as defined by U.S. Department of Justice (2018).

### Market concentration by revenue

Scholarly publishing is one of the most profitable businesses (Larivière et al., 2015), and the market share of this industry can also be measured in terms of sales or revenues. In 2020, a total of 1,930,895 Open Access (OA) papers were published and indexed by Dimensions, generating \$1,726,786,904 (USD) in Article Processing Charges (APCs). According to Table 1, MDPI had the largest share of OA papers (8.56%) and the second-largest share of OA revenues (15.22%), while Springer-Nature generated the most OA revenues (19.02%) by producing 6.87% of OA papers in 2020, followed by Elsevier (6.34% in papers, 12.42% in revenues), Wiley-Blackwell (3.01% in papers, 8.68% in revenues), and Frontiers (2.50% in papers, 7.75% in revenues). Notably, top OA publishers held higher market shares when measured by revenue than when measured by the volume of products.

<sup>4</sup> Web of Science Research Areas (SU) are used here. They consist of 5 major domains (Arts & Humanities, Social Sciences, Life Sciences & Biomedicine, Physical Sciences, and Technology), which are assigned at the journal level.

**Table 2** Number of papers and associated revenue, by major OA publisher (2020, Indexed by WoS)

Publisher	Number of papers	Market share by papers (%)	Revenue (USD) <sup>a</sup>	Market share by revenue (%)
MDPI	125,299	19.57	245,031,128	19.53
Springer-Nature	101,003	15.78	228,404,605	18.20
Elsevier	57,060	8.91	123,551,079	9.85
Wiley	40,759	6.37	126,145,202	10.05
Frontiers	34,055	5.32	98,608,690	7.86
PLOS	19,638	3.07	34,459,290	2.75
Hindawi	19,273	3.01	40,018,950	3.19
Taylor & Francis	14,953	2.34	32,949,140	2.63
...	...	...	...	...
Total	640,169	100	1,254,775,669	100

<sup>a</sup>The APC revenue is calculated by 569,207 out of 640,169 OA papers (88.92%) while the APC information in the rest of OA papers is not available or missing

**Table 3** Market concentration of OA publishing market by revenue across disciplines (2020, indexed by WoS)

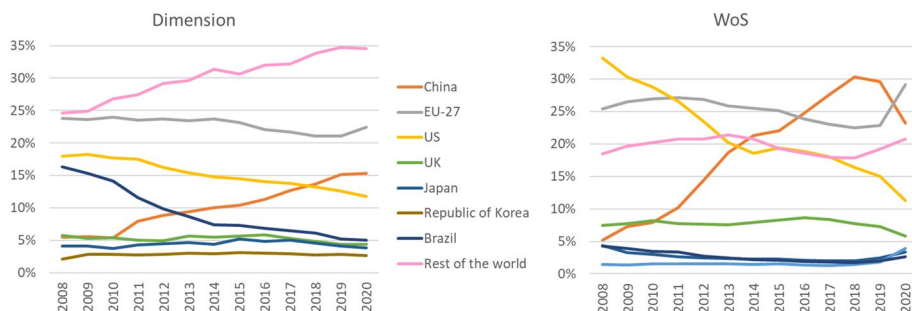
Discipline	Revenue (USD)	HHI by revenue	Number of papers	HHI by volume
Life Sciences and Biomedicine	\$715,670,236	1071	355,401	934
Physical Sciences	\$251,234,004	3229	155,519	1614
Technology	\$190,336,184	2635	129,246	1629
Social Sciences	\$91,622,462	1230	33,356	1024
Arts and Humanities	\$5,912,783	1553	7057	689

These eight major OA publishers accounted for almost 70.63% of total revenues, despite producing only 30.92% of the products in the market.

In the high-end OA publishing market, a total of 640,169 OA papers were published and indexed by Web of Science (WoS), generating \$1,254,775,669 (USD) in Article Processing Charges (APCs). According to Table 2, MDPI had the largest share of OA papers (19.57%) and OA revenues (19.53%), followed by three traditional commercial publishers: Springer-Nature (15.79% in papers, 18.20% in revenues), Elsevier (8.81% in papers, 9.85% in revenues), and Wiley-Blackwell (6.49% in papers, 10.05% in revenues), which also held higher market shares when measured by revenue than by the volume of products. These eight major OA publishers generated almost 71.45% of total revenues by producing 61.23% of all products in the market. Consequently, the Herfindahl–Hirschman Index (HHI) of the OA publishing market, when measured by revenue, is 1025, compared to 829 when measured by volume.

Similar trends can be observed in the market concentration measures at the discipline level. For instance, in 2020, 127 publishers produced 7057 OA papers in Arts and Humanities. Springer-Nature was the largest publisher in Arts and Humanities, producing 1419 papers (20.11%), followed by Taylor & Francis (691, 9.79%), and MDPI (620, 8.79%). As only 25 out of the 127 publishers charged APCs while the rest offered free OA, the OA





**Fig. 5** The Share of major source countries in terms of the number of papers in OA publishing, Dimensions and Web of Science (2008–2020)

publishing market in Arts and Humanities was moderately concentrated, with an HHI of 1553 when measured by revenue. As demonstrated in Table 3, the HHIs measured by revenue were higher than those measured by volume in all five domains. An oligopoly OA publishing market ( $HHI > 2500$ ) was observed in Physical Sciences ( $HHI = 3229$ ) and Technology ( $HHI = 2635$ ).

### Market concentration by source

Concentration is also observed at the national level. In 2020, the market for OA publications indexed by Dimension showed contributions from 202 countries, an increase from 177 in 2008. However, a significant portion of OA publications were from major source countries such as the European Union, China, US, UK, Japan, Brazil, and Korea. These countries accounted for two thirds of the general OA market (Dimension) share, and 80% of the high-end OA market (WoS) share. The European Union was found to be the largest source region and China the largest source country for OA publications. This trend is consistent with the overall trend in scholarly publishing, where China's share has been increasing at the expense of the decreasing share of the US and European Union. Notably, China's share in the high-end OA publishing market (WoS) decreased in 2020, which could be attributed to China's science policy reform aimed at limiting the number of OA publishing. (Shu et al., 2022) (see Fig. 5).

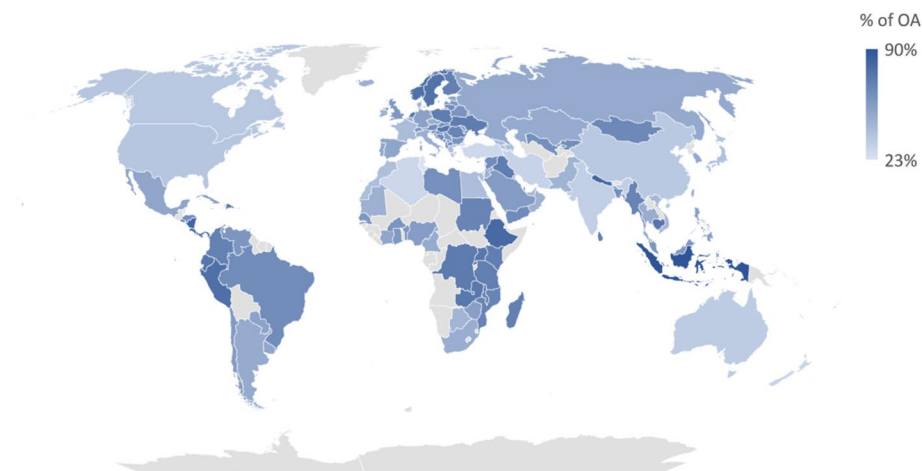
The introduction of article processing charges (APCs) may have created a new barrier for authors from developing countries, who may struggle to afford APCs. Table 4 illustrates that in 2020, the majority of revenue for OA publishing (79.81% for general OA publishing and 82.51% for high-end OA publishing) came from major source countries, with the rest of the world contributing 20% or less. Figure 6 provides a global map showing the ratio of OA publications to all publications at the country level. In 2020, 47.77% of all publications worldwide were open access. Although the European Union (55.34%), China (35.21%), and the US (36.57%) were the top three contributors to OA publishing, China and the US published a smaller proportion of OA papers compared to the world average of 47.77%. In contrast, scholars from some Global South countries published a higher proportion of OA papers, regardless of charging APCs or not, than the world average.<sup>5</sup> For

<sup>5</sup> Only the countries with at least 100 publications in 2020 were ranked.

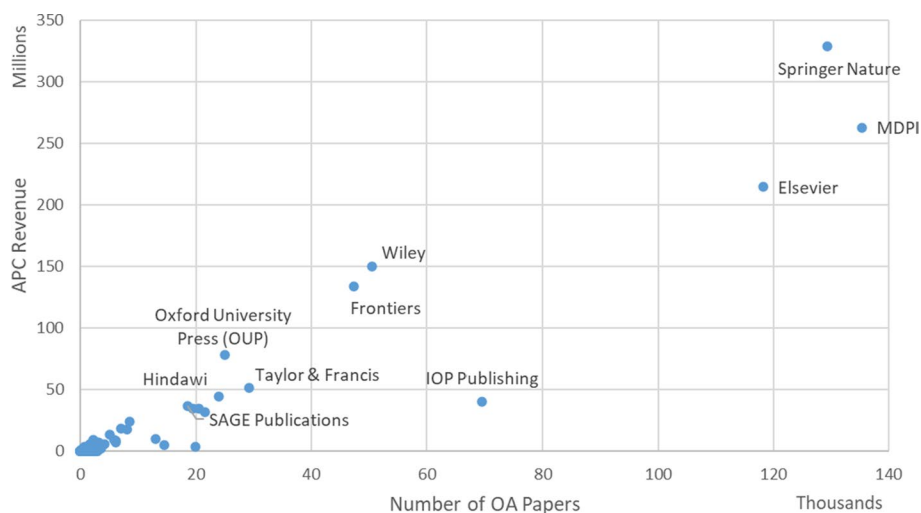


**Table 4** List of the major source countries and their APC payment (2020)

Country/Region	Dimension			Web of Science		
	Number of OA papers	Amount of APCs paid (USD)	Share of APCs paid (%)	Number of OA papers	Amount of APCs paid (USD)	Share of APCs paid (%)
EU-27	259,297	\$511,251,441	29.96	165,650	\$405,062,553	32.28
China	177,213	\$319,285,910	18.71	132,134	\$276,145,043	22.01
US	136,218	\$275,669,975	16.15	64,155	\$160,877,677	12.82
UK	50,570	\$120,760,972	7.08	32,955	\$93,507,913	7.45
Japan	44,057	\$64,494,892	3.78	19,103	\$42,021,246	3.35
Republic of Korea	30,715	\$45,894,543	2.69	22,013	\$41,687,910	3.32
Brazil	57,831	\$24,515,222	1.44	14,830	\$16,068,887	1.28



**Fig. 6** Global map of OA publishing ratio (2020)



**Fig. 7** Overview of the OA publishing market (2020, Indexed by Dimension)

instance, Indonesia had the highest proportion of OA papers (90.35%), followed by Nicaragua (81.85%), Nepal (81.29%), Ethiopia (80.40%), and Costa Rica (78.26%). On the other hand, Tunisia (22.65%), Turkey (27.80%), and Algeria (28.35%) had the lowest shares of OA publications in 2020.

**Table 5** Market portfolio of the major OA publishers by volume (2020)

Publisher	Dimension		WoS	
	Gold	Hybrid	Gold	Hybrid
MDPI	157,193	8137	118,018	0
Springer-Nature	96,978	35,593	52,322	32,166
Elsevier	77,439	44,951	21,894	32,356
Wiley	25,776	32,344	12,971	27,556
Frontiers	48,167	41	31,938	0
OUP	16,544	9676	3570	5032
Taylor & Francis	21,553	4103	7782	3176
Hindawi	23,987	279	18,248	0
SAGE	15,113	6856	6824	5742
IEEE	19,898	756	18,037	756
PLOS	19,638	0	19,638	0
...	...	...	...	...
Total	1,647,241	283,654	404,181	165,026

## Discussion

Compared to traditional subscription-based publishing, OA publishing allows publishers to generate revenue during the production process rather than the sales process by charging APCs. This reduces operating costs and the risk of unsold copies, while also lowering the market entry threshold (Crow, 2009). While OA publishing has been considered as a solution to the oligopoly of scholarly publishing (Pinfield et al., 2014; Spezi et al., 2017; Wilbanks, 2006), our findings reveal that it may not be the case, and that OA publishing is increasingly concentrated, especially in the high-end market.

## The invisible hand

Although the low market entry threshold has allowed many competitors to appear in the OA publishing market, traditional commercial publishing houses have used their advantageous publishing resources to regain a dominant position in the market. As shown in Fig. 7, these traditional commercial publishing houses (Springer-Nature, Elsevier, Wiley-Blackwell) and some early-entry OA publishers (MDPI, Frontiers, Hindawi) have emerged as dominant publishers in terms of volume and revenue, leading the OA publishing market from a competitive to an oligopolistic market.

In traditional subscription-based publishing market, commercial publishing houses use product differentiation and price strategies to increase sales and market share (Shu et al., 2018). Based on their reputation and visibility in the traditional academic publishing market, these commercial publishing houses are able to establish their new OA journals as more easily recognized and respected by academia compared to new journals published by newer or less well-known publishers. Additionally, they are able to charge higher APCs than other publishers due to their established brand and perceived higher quality (Solomon & Björk, 2012) since the demand for OA publishing is price-inelastic (Khoo, 2019; Yuan et al., 2020). In addition, they offer Hybrid OA—generating revenue from the same article twice

**Table 6** Market portfolio of the major OA publishers by revenue (2020, indexed by dimension)

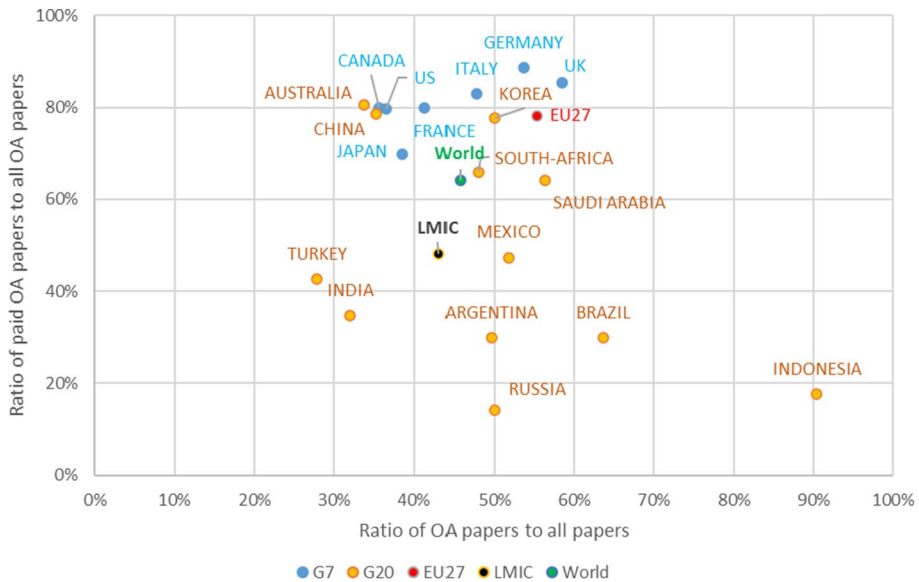
Publisher	Hybrid		Gold		Total (USD: million)
	Revenue (USD: million)	Average APC	Revenue (USD: million)	Average APC	
MDPI	14.41	1771	248.43	1953	262.83
Springer-Nature	149.20	3484	179.20	2073	328.40
Elsevier	113.48	2583	101.03	1361	214.51
Wiley	98.02	3440	51.85	2354	149.88
Frontiers	0.15	3663	133.63	2826	133.78
OUP	33.48	3326	44.59	2972	78.06
Taylor & Francis	26.40	2850	25.06	1261	51.47
Hindawi	0.61	2202	43.52	1844	44.13
SAGE	15.30	2735	21.06	1632	36.36
IEEE	1.25	1827	33.36	1683	34.61
PLOS	–	–	34.46	1757	34.46
...	...	...	...	...	...
Total	607.24	2412	1119.54	1226	1726.79

**Table 7** Market portfolio of the major OA publishers by revenue (2020, indexed by WoS)

Publisher	Hybrid		Gold		Total (USD: million)
	Revenue (USD: million)	Average APC	Revenue (USD: million)	Average APC	
MDPI			245.03	2076	245.03
Springer-Nature	100.98	3240	127.43	2435	228.40
Elsevier	91.12	2816	32.43	1481	123.55
Wiley	94.83	3441	31.32	2414	126.15
Frontiers			98.61	2919	98.61
OUP	18.53	3683	9.69	2713	28.22
Taylor & Francis	13.67	2899	19.28	1759	32.95
Hindawi			40.02	2076	40.02
SAGE	14.82	2580	14.29	2094	29.10
IEEE	1.35	1788	31.00	1719	32.35
PLOS			34.46	1755	34.46
...	...	...	...	...	...
Total	459.00	2781	805.14	1973	1254.78

with little additional cost; and the APCs of Hybrid OA are higher than ones of Gold OA since most of Hybrid OA papers are published in those prestige journals (Björk & Solomon, 2014).

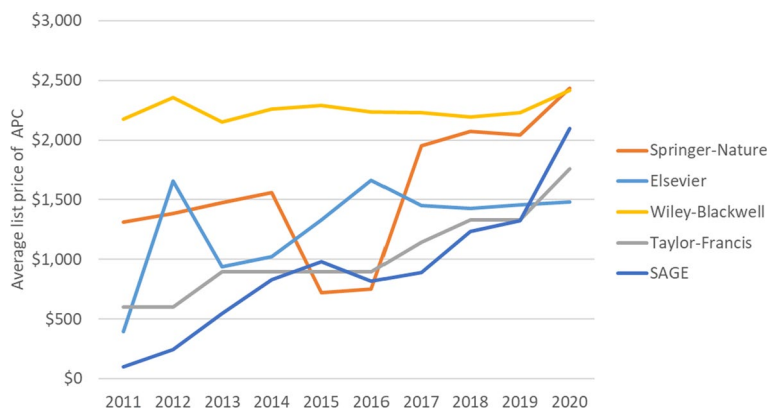
As a result, these traditional commercial publishing houses have diverse market portfolio comparing with other OA publishers. As Table 5 shows, these top traditional academic



**Fig. 8** Authors' publishing preference on OA publishing by country (2020, indexed by Dimension)

publishers, including Springer-Nature, Elsevier, Wiley-Blackwell, Taylor & Francis, Oxford University Press (OUP), and Institute of Electrical and Electronics Engineers (IEEE) offer both Hybrid OA and Gold OA, while new OA publishers such as MDPI, Frontiers, Public Library of Science (PLoS), and Hindawi only focus on the Gold OA. The diverse market portfolio can help to improve market performance and increase market profits. For example, although MDPI published more OA papers than Springer-Nature in 2020, Springer-Nature generated more revenue as it published more Hybrid OA (See Table 6). This is especially evident in the high-end market (indexed by WoS) as the ratio of Hybrid OA papers to Gold OA papers is 0.41, which is much higher than the its counterpart in the general OA market (0.17).

Table 6 indicates that the average APCs in Hybrid OA (\$2412) is almost double than its counterpart in Gold OA (\$1226). It is surprising that some societies charged higher APCs than commercial publishers as OUP charged higher average APC rate in Gold OA (\$2972) than other publishers. It means that both commercial publishers and non-for-profit publishers (societies) adopt the same income model and marketing strategy in the OA publishing market, and the market will be more concentrated because of the “Matthew Effect”. Major OA publishers differentiate the market using different pricing strategies. As Table 7 shows, the average APCs in the high-end market (indexed by WoS) are higher than the general OA market, in both Gold OA and Hybrid OA. These major publishers capitalize on their existing high-end portfolio by implementing elevated APCs to maximize their profits. Meanwhile, they introduce or acquire numerous new OA journals with low or even zero APCs, aiming to expand their market share. Consequently, the competitive landscape in the OA market shifts, resulting in the struggle of many smaller OA publishers to sustain themselves amidst the formidable competition posed by these industry giants. This transformation gradually shapes the OA market into an oligopoly.



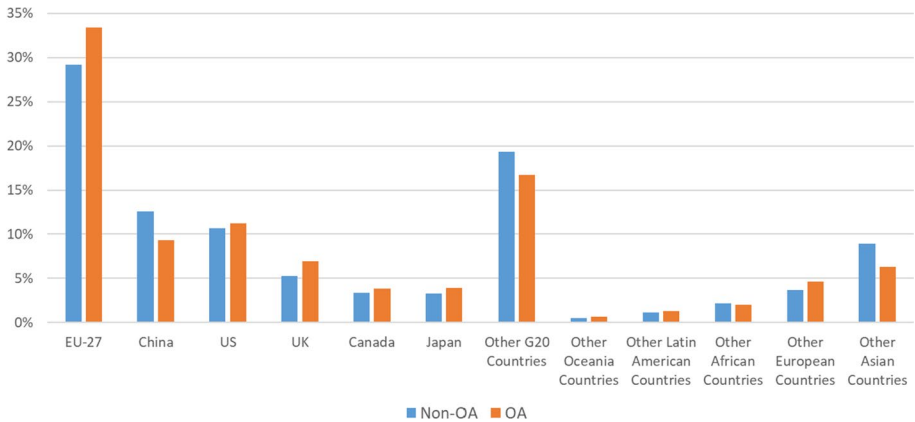
**Fig. 9** The change of average listing price of Gold OA APCs among major publishers (2011–2020)

## New paywall

OA publishing enables researchers to access scientific literature without facing paywalls or access barriers. (Budapest Open Access Initiative, 2002). However, when the cost of knowledge dissemination is transferred from readers to authors, the incurred high APCs may prevent authors from developing countries from publishing their research in OA journals (Brainard, 2021; Cox, 2020), which builds a new paywall in scholarly communication.

Although some publishers offer the APC waivers for authors from low-income countries, the offer is often more symbolic than practical. While most OA publishers offer waivers for low-income countries (defined by World Bank), complex and strict waiver conditions make it difficult for researchers from these countries to publish their research in an OA journal with APCs. In 2020, only 57,771 out of 1,930,895 OA papers were eligible for the APC waivers and the waived APCs only accounted for 2.33% of total OA revenue generated by publishers. Previous studies indicate that scholars from developing countries struggle with the unaffordable APCs (Cox, 2020; Krauskopf, 2021; Pavan & Barbosa, 2018). Those findings are confirmed here (Fig. 8) which displays the publishing preferences of authors from different countries, as indicated by the ratio of OA papers (X-axis) to all papers and the ratio of paid OA papers to all OA papers (Y-axis). The results show that although authors from low- and middle-income countries (LMICs) and some G20 developing countries, such as Indonesia, Mexico, and Brazil, wish to make their research open access, they tend to prefer free OA rather than paid OA. Specifically, in 2020, 90.36% of Indonesian papers were published in OA, but only 17.63% of them were published in OA journals that charge APCs. Conversely, authors from the European Union and G7 countries are more inclined to pay and publish their research findings in OA journals that charge APCs.

Indeed, current OA mandates promoted by Plan S attribute to a huge demand in OA publishing market, which could lead to the inflation of APCs considering scholarly publication is a price-inelastic product (Khoo, 2019; Shu et al., 2018). Figure 9 tracks the average list price of Gold OA APCs among five major publishers between 2011 and 2020, and presents an increase of list prices, especially in recent three years. Since scholarly publications are usually linked to research evaluation, authors and their funders would like to publish their research in high prestige journals when paying the APCs, implying higher visibility and influence in exchange for the money paid.



**Fig. 10** Share of citations to OA and non-OA papers published in 2015

OA mandates have created a significant demand for OA publishing, which may lead to an increase in APCs. This is concerning because scholarly publishing is considered a price-inelastic product, as noted by Khoo (2019) and Shu et al. (2018). Figure 9 illustrates the average list price of Gold OA APCs from five major publishers between 2011 and 2020, showing a noticeable increase in recent years. Given that scholarly publications play a crucial role in research evaluation, authors and funders often prefer to publish their research in high-prestige journals that require APCs, providing greater visibility and impact in exchange for the money spent (Estakhr et al., 2021). This also produce a highly inelastic demand for Hybrid OA so that publishers could charge higher APCs for Hybrid OA than Gold OA, even over 10,000 USD for an OA paper (Else, 2020).

## What solutions?

Despite promises associated with OA, library materials expenditures<sup>6</sup> among Association of Research Libraries (ARL) members have not decreased since 2007 (Association of Research Libraries (2009–2019)). Unsurprisingly, the combination of both subscription and publishing costs increases the global cost of publishing (Johnson et al., 2016; Pinfield et al., 2016). For some universities in China, the sum of incurred APCs is even higher than the cost of their journal and database subscription (Shu et al., 2022). Such high cost for OA publishing has been noticed by China’s administrators, which results in the new policy limiting the use of research funding on paying APCs in China (Ministry of Education of China & Ministry of Science & Technology of China, 2020; Ministry of Science & Technology of China, 2020). Some Chinese universities even exclude all OA papers published by MDPI, Frontiers and Hindawi from research assessment (Predatory Reports, 2023).

Without the paywall, OA publications get more visibility as they are freely accessible, which leads to the higher research impact in terms of the number of citations received than non-OA publications (Lawrence, 2001; Lewis, 2018). However, the coverage of readership

<sup>6</sup> The library material expenditure consists of journal subscription, book and monograph purchase, electronic resource subscription and other expenditures; journal subscription accounts for the largest portion in the library material budget.



and the global impact of OA publication are still limited as researchers from low- and middle-income countries don't contribute as much as expected citations to OA publications (Smith et al., 2017). Although Simard et al. (2022) find that low-income countries cite more OA papers than high-income countries when all OA types are included, a different result is found in this study as only Gold and Hybrid OA are considered. When investigating the citations (5-year after publication) to OA and non-OA papers published in 2015, as shown in Fig. 10, the shares of citations to OA papers were higher than the shares of citations to non-OA papers among European, North American authors while authors from the rest of the world did not cite more OA papers. It is confirmed that OA publishing fails to reduce the cost of knowledge dissemination and disseminate knowledge broadly.

## Conclusion

OA was a revolution in scholarly communication, and was expected to replace the subscription-based model. However, this expectation has not been fulfilled as large commercial publishing houses have gained increasing control over the OA publishing market, which is moving towards an oligopoly market. The situation appears to be irreversible, given the acquisition of Hindawi by Wiley-Blackwell and the joint ownership of Springer-Nature and Frontiers.

While we do not question the good intentions behind OA mandates such as Plan S, those may have inadvertently given significant leverage to large commercial publishers. Those publishers have started to exert their market power and interfere with scholarly communication, as exemplified by the creation of questionable journals (Oviedo-García, 2021) to forcing journal to retract critical papers (Macháček & Srholec, 2021).

The concept of the author-paid model raises some concerns. As the creators of knowledge, researchers are required to pay Article Processing Charges (APCs) to publish their research, which seems like a form of “knowledge tax” even though knowledge is not a taxable commodity. While the funders may cover the APCs, researchers who lack funding or work in developing countries are left to pay the “knowledge tax” themselves or forfeit the opportunity to publish their work in OA format. This creates a potential scenario where academic freedom is restricted, and science becomes a game of wealth, as was warned by some scholars (Beall, 2013).

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## Declarations

**Conflict of interest** The authors declare that there is no conflict of interests.

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