

## Open access journals & article processing charges 2011 - 2021

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## Abstract

This study examines trends in open access article processing charges (APCs) from 2011 – 2021, building on a 2011 study by Solomon & Björk (2012). Two methods are employed, a modified replica and a status update of the 2011 journals. Data is drawn from multiple sources and datasets are available as open data (Morrison et al, 2021). Most journals do not charge APCs; this has not changed. The global average *per-journal* APC increased slightly, from 906 USD to 958 USD, while the *per-article* average increased from 904 USD to 1,626 USD, indicating that authors choose to publish in more expensive journals. Publisher size, type, impact metrics and subject affect charging tendencies, average APC and pricing trends. About half the journals from the 2011 sample are no longer listed in DOAJ in 2021, due to ceased publication or publisher de-listing. Conclusions include a caution about the potential of the APC model to increase costs beyond inflation, and a suggestion that support for the university sector, responsible for the majority of journals, nearly half the articles, with a tendency not to charge and very low average APCs, may be the most promising approach to achieve economically sustainable no-fee OA journal publishing.

## Introduction

Open access (OA), the free online dissemination of scholarly works with little or no restrictions on downstream use, is broadly recognized as the optimal approach to dissemination. Major funding agencies now typically require OA to funded research. As of April 2021, the Registry of Open Access Repository Mandates and Policies (ROARMAP) (n.d.) lists over a thousand OA policies in 5 continents. Since the Budapest Open Access Initiative (BOAI, 2002), two major approaches to achieving OA have been recognized, author self-archiving and OA publishing. Achieving sustainable OA scholarly publishing requires transition of underlying support from the demand (purchase / subscription) to the supply side (support for production). Crow (2009) identified nine supply side models. This article focuses on one of these models, journal article processing charges (APCs), acknowledging that this model is used by a minority of OA journals.

A full review of the literature in this area is beyond the scope of this article. A meta-search of our university library for “open access” and “article processing charges” yields over 5,000 results, over 1,000 of which are published since 2019. The unique contribution of this study is a longitudinal comparison of APC trends through an update of a 2011 study of APCs by Solomon and Björk published in *JASIST* in 2012, using two methods: a modified replication of the 2011 study and an update of the 2011 dataset. The remainder of this section highlights the most relevant works, all of which provide both context and data used in this study.

Solomon & Björk (2012) described APCs as a central funding mechanism for OA journals. They gathered APC data and 2010 article counts for 1,190 journals that were listed in DOAJ in 2011 and indicated use of APCs and used weighting of journals from smaller publishers to estimate results for the full set of 1,370 APC charging DOAJ journals. Major findings include a global average APC of 906 USD calculated over journals and 904 USD calculated over articles, with a range of 8 – 3,900 USD. Lower pricing was associated with journals from developing countries, higher pricing with high impact factor journals from developed countries. Journals in biomedicine had the highest article counts and the highest APCs; professional publishers had higher APCs than journals published by societies, universities, or researchers.

Morrison et al. (2019a, b) is an OA longitudinal survey of over 19,000 journals that includes the 2011 Solomon & Björk (2012) dataset, additional data from DOAJ on an annual basis from 2015 (including non-charging as well as APC journals) and publication fee data obtained from publisher websites for 2015 – 2019. Of the 19,000 journals, only journals found in the DOAJ 2021 dataset are included in this study. Morrison et al. emphasize that many OA journals do *not* charge APCs. While the global average APC in 2019 was found to be 908 USD, almost identical to the 2011 global average, the authors found that the average masked a more complex picture. For example, journals that were included in the 2011 sample were found to have increased in price by 50%, pricing trends on a per-journal basis suggested a mixed picture of prices increasing, decreasing, or remaining the same, and the “tendency to charge or not to charge, how much is charged and whether prices are increasing or decreasing varies considerably by journal, publisher, country of publication, language and currency”.

Crawford (2020) reports on early 2020 APC (charging and non-charging) data of journals listed in DOAJ in 2020, a total of 13,948 journals, and 2019 article counts for these journals. Due to DOAJ journal additions and deletions from 2020 to 2021, not all journals in this dataset were matched in DOAJ 2021 and vice versa. Crawford reports that the global average APC was 1,023 USD “and probably less”, and that while most journals do not charge APCs, the majority of articles were published in APC-charging journals. Crawford breaks down pricing by publisher category, country of publisher, and subject.

The OpenAPC (n.d.) group has automated collation of payment data for easy online data manipulation and visualization by APC payers on a per-article, per-journal, per-payer and per-year basis.

## Method

Two methods are used for this update, a modified replica of the 2012 study and an update of the original dataset. Two base datasets were created, DOAJ 2021+ and 2011 – 2021 APCs. DOAJ 2021+ involves merging of data from a DOAJ (2021) metadata set downloaded Jan. 5, 2021, and selected data based on journal matches from Morrison et al. (2019a, b), Crawford (2020), and OpenAPC (n.d.), JCR (2019) and Scopus (2021). Zhao, Borges & Morrison (2021) document clean-up and standardization of the DOAJ metadata in preparation for this study. 2011 -2021 APCs is an update of Solomon & Björk’s (2012) dataset, merging data from DOAJ 2021+, publisher websites, and other sources. Both datasets will be released as open data, omitting proprietary JCR and Scopus data. An August 29, 2011 DOAJ metadata set collected by the authors for a different study was used to compare DOAJ numbers and APC charging status from 2011 – 2021.

### Method 1. 2021 modified replication of 2011 Solomon and Björk study

The journals listed in DOAJ as of Jan. 5, 2021 and their DOAJ metadata (15,690 journals), downloaded on Jan. 5, 2021, forms the base for this study. Additional data for this set of journals was merged from the open datasets of Morrison et al. (2019b), Crawford (2020), JCR (2019) and Scopus (2020). The resulting dataset (DOAJ 2021 plus) will be released as open data, with the proprietary JCR and Scopus data removed. The 2011 data on which the Solomon and Björk (2012) article, while not originally published as open data (less common at that time), was provided to the authors and is used in both methods.

APC status (charging and non-charging) and amount was determined using data from DOAJ (2021) for 3,548 journals added to DOAJ as of 2019 or later and 3,363 journals last updated in DOAJ 2019 or later for a total of 6,911 journals for which we used DOAJ APC status and amount data or 44% of the 15,690 journals listed in DOAJ. APC status and amount is derived from Crawford (2020) for 6,128 journals (39%)

(data gathered from publisher websites early 2020) and Morrison et al. (2019) for 2,626 journals (17%) (data gathered from publisher websites in 2019). There were 25 titles for which DOAJ data dated 2018 or earlier was the only information available. It is estimated that APC status and amount dates from 2019 – early Jan. 2021 for about 95 – 99% of the 15,690 journals. The lack of precision reflects uncertainty about whether a DOAJ “last update” date reflects updating of APC status and amount or is limited to other updates such as corrections of URLs, journal or publisher name changes or corrections. The charging / non-charging status and near full sample, made possible by DOAJ advances and the open datasets of Crawford & Morrison, goes beyond the sampling employed by Solomon and Björk (2012).

Pricing analysis, including calculation of central tendencies and price bands by journal and by article, follows the method used by Solomon and Björk (2012) with minor differences in sampling. Solomon and Björk’s per-journal and per-article price analysis is based on a weighted sample of 1,090 of 1,370 APC journals listed in DOAJ in 2011. Our per-journal price analysis reflects a full sample of the 4,368 journals for which we were able to identify a specific APC amount of 2019 or later; our per-article analysis is limited to 3,662 journals for which 2019 article counts are available from Crawford’s (2020) sample which does not include journals with no articles published in 2019 or journals added to DOAJ in 2020 or 2021. Figures follow the same pattern used by Solomon and Björk (2012) to facilitate comparison. The comparison of 2011 and 2019 articles by price band incorporates re-analysis of 2011 data as provided by Solomon and Björk (2012). Article counts are for 2010 (from Solomon and Björk (2012) data) and 2019 (Crawford, 2020), while APC pricing is for 2011 and 2019 – 2021. Currency conversion to USD was based on the XE currency conversion service data for Jan. 5, 2021.

Publisher size and type are both based on DOAJ metadata and are challenging to assess for several reasons. Professional publishers, whether not-for-profits like Ubiquity Press and Public Library of Science or commercial publishers such as Elsevier or SpringerNature, are relatively easy to identify. However, assessing the full size of a publisher requires identifying and collating imprints. SpringerNature includes Springer Open, BioMedCentral, and Nature. Sciendo is owned by DeGruyter. Hindawi was recently purchased by Wiley. Many journals do not necessarily *have* a publisher. DOAJ “publisher names” sometimes such variations as journal title or the name of an editor. Variations in publisher names are common, and typos are common, as explained in Zhao, Borges & Morrison (2021). To assess publisher size, a new column was created to list standardized publisher names to the extent that we were able to identify these.

Publisher type was determined based on a combination of publisher name in DOAJ (e.g. known publishers, variations of “university” or “society”) and DOAJ “society or institution” metadata. Journals that listed the journal name or member of the editorial board as the publisher were considered independent.

APC by impact factor follows a simplified method as compared with Solomon and Björk (2012). Journals were divided into high and low impact based on dividing into the upper and low half based on CiteScore (Scopus) and overall rank (JCR).

It was not possible to replicate the subject analysis due to major changes in DOAJ metadata in the interim. Our subjects are based on the DOAJ primary subject area and results are only roughly comparable.

To minimize complexity, the DOAJ 2021 plus dataset is referred as DOAJ 2021 plus although the actual data is from 2019 – 2021 and citation data (JCR and Scopus) reflects earlier citations.

## Method 2. 2011 dataset update: current status and trends

The 2011 data on which the Solomon and Björk (2012) article forms the base for this study. Data on current status, (e.g. whether the journal is still active, open access, and APC charges, and the amount in the original currency) was obtained from the DOAJ 2021+ dataset created for the modified replication study described above, with additional data from Morrison et al. (2019), publisher websites, CLOCKSS, and web searches for journals and publishers. JCR 2010 data (not included in the original provided by Solomon and Björk) was added for the impact factor analysis. The dataset 2011 – 2021 APCs will be released as open data, without the proprietary JCR data.

Inflation rates are based on the website U.S. Inflation Rate Calculator (n.d.) as of April 2021.

## Results

### Modified replication of the Solomon and Björk 2011 study

#### Overall growth and charging trends in open access journals 2011 – 2021

The following Table 1 *DOAJ Journals and APC charging status comparison 2011 – 2021* shows changes in the number of journals listed in DOAJ overall and by APC charging status. In August 2011, 6,946 journals were listed in DOAJ; of these, 68% did not charge APCs. In January 2021, 15,690 journals were listed in DOAJ; 73% did not charge APCs (70% when factoring in other data sources, Morrison et al. (2019) and Crawford (2020)). This illustrates that DOAJ net growth (journals added – journals deleted) reflects more than doubling in a decade. DOAJ metadata on charging status has changed to a straightforward no / yes; in 2011 there was a “conditional” option. The number of journals with “Yes” to charging status in 2021 includes 4,368 journals for which a specific amount was identified and 159 journals for which a specific amount was not identified (80 journals using per-page rather than per-article charges, 58 new journals indicating an APC model but not yet charging, 19 journals indicating charges without specifying an amount, 1 journal charging “by publishing unit”, and 1 journal that negotiates fees with conference organizers).

DOAJ Journals and APC charging status comparison 2011 - 2021						
APC charging status	DOAJ metadata 2011		DOAJ metadata 2021		DOAJ 2021 plus other sources	
	# journals	% journals *	# journals	% journals	# journals	% journals <sup>1</sup>
No	4,745	68%	11,399	73%	11,050	70%
Yes	1,840	26%	4,291	27%	4,527	29%
Information missing	236	3%			70	0.4%
Conditional	112	2%				
Blank (2011) / Other (2021)	13	0.2%			43	0.3%
Total DOAJ journals	6,946		15,690		15,690	

<sup>1</sup> percentages do not add up to 100% due to rounding error

Table 1. DOAJ Journals and APC charging status comparison 2011 - 2021

The 4,368 journals for which a specific APC amount dating from 2019 – 2021 could be identified are included in the APC analysis. Per-article analysis is based on a subset of 3,662 of these journals for which a 2019 article count by Crawford (2020) was available. Table 2 below *Article processing charges in U.S. dollars 2019 – 2020 with summary statistics presented by journals and articles* lists the central tendencies including range, average (mean), median and mode by journal and article. The range of APCs was <1 – 5,200 USD (a few journals have APCs of less than 1 USD after currency conversion). The per-journal average APC is 958 USD while the per-article average APC is 1,626, suggesting that authors are more likely to choose to publish in more expensive journals.

<i>Article processing charges in U.S. dollars 2019 – 2020 with summary statistics presented by journals and articles</i>			
	By journal	By article published in 2019	By journal revenue <sup>1</sup>
Average (Mean)	958	1,626	222,813
Median	650	1,051 <sup>2</sup>	21,850
Standard Deviation	955	946 <sup>3</sup>	1,247,151
Minimum	<1 <sup>4</sup>	<1 <sup>4</sup>	<1 <sup>4</sup>
Maximum	5,200	5,200	35,885,386
Count	4,368 journals	501,950	3,662 journals
<sup>1</sup> Revenue calculated only for journals for which we have a 2019 article count (3,662 journals)			
<sup>2</sup> This is the mean of the median size journals (published 1,189 articles in 2019)			
<sup>3</sup> Only includes journals for which we have a 2019 article count (3,662 journals)			
<sup>4</sup> These are journals from developing countries with very low fees that translate into less than one USD			

Table 2. - *Article processing charges in U.S. dollars 2019 – 2020 with summary statistics presented by journals and articles*

The following Table 3 *Journals by price band 2021* and figure 1 *# journals per APC price band in USD 2021* illustrates the number of journals per APC size category in 2021. The largest price band is the smallest APC price range (0 – 500 USD). There are substantial numbers of journals in the price bands from 500 – 2,500 USD and smaller numbers of journals in the higher price categories.

<b>Journals by price band 2021</b>	
APC in USD	# journals
0 - 500	2,037
501 - 1,000	607
1,001 - 1,500	476
1,501 - 2,000	548
2,001 - 2,500	436
2,501 - 3,000	145
3,001 - 3,500	83
3,501 - 4,000	19
4,001 - 4,500	4
4,501 - 5,000	1
5,001 - 5,200	12
<b>Total</b>	<b>4,368</b>

Table 3 Journals by price band 2021

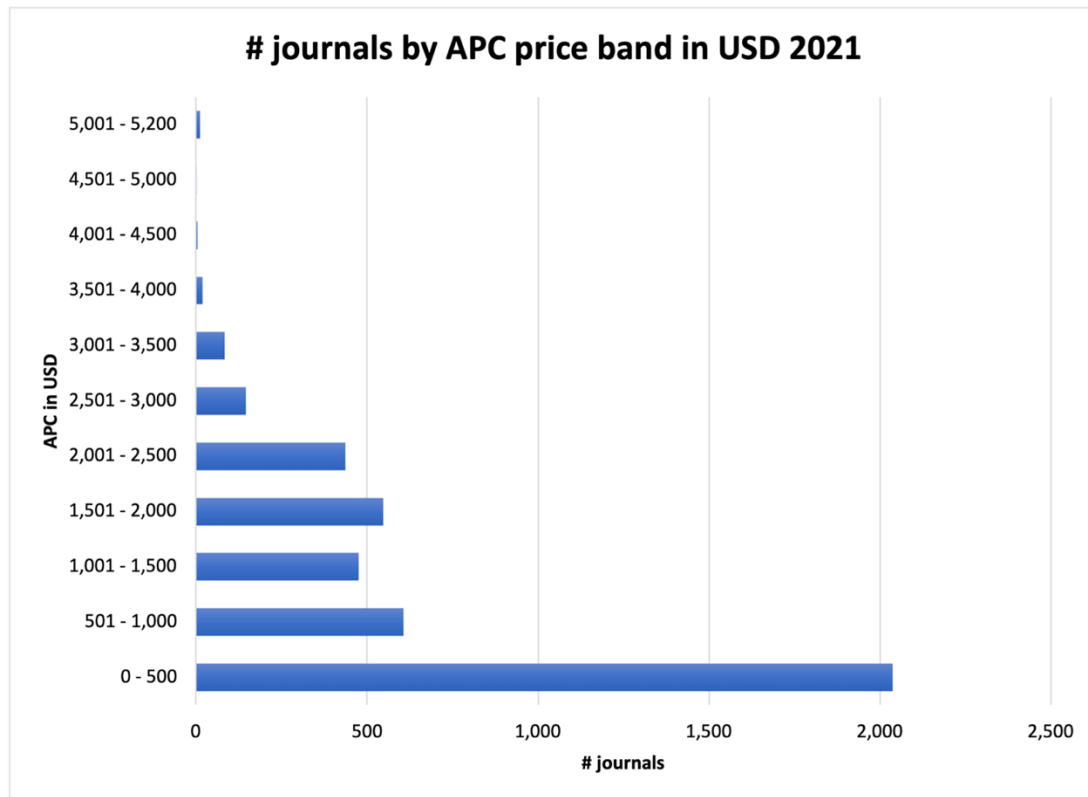


Figure 1 Journals per APC price band in USD 2021

Figure 2 *2019 article counts by APC price band in USD* below illustrates the number of articles published in 2019 per APC price band. This chart is based on the 3,662 journals for which we have a specific APC amount and a 2019 article count from Crawford (2020).

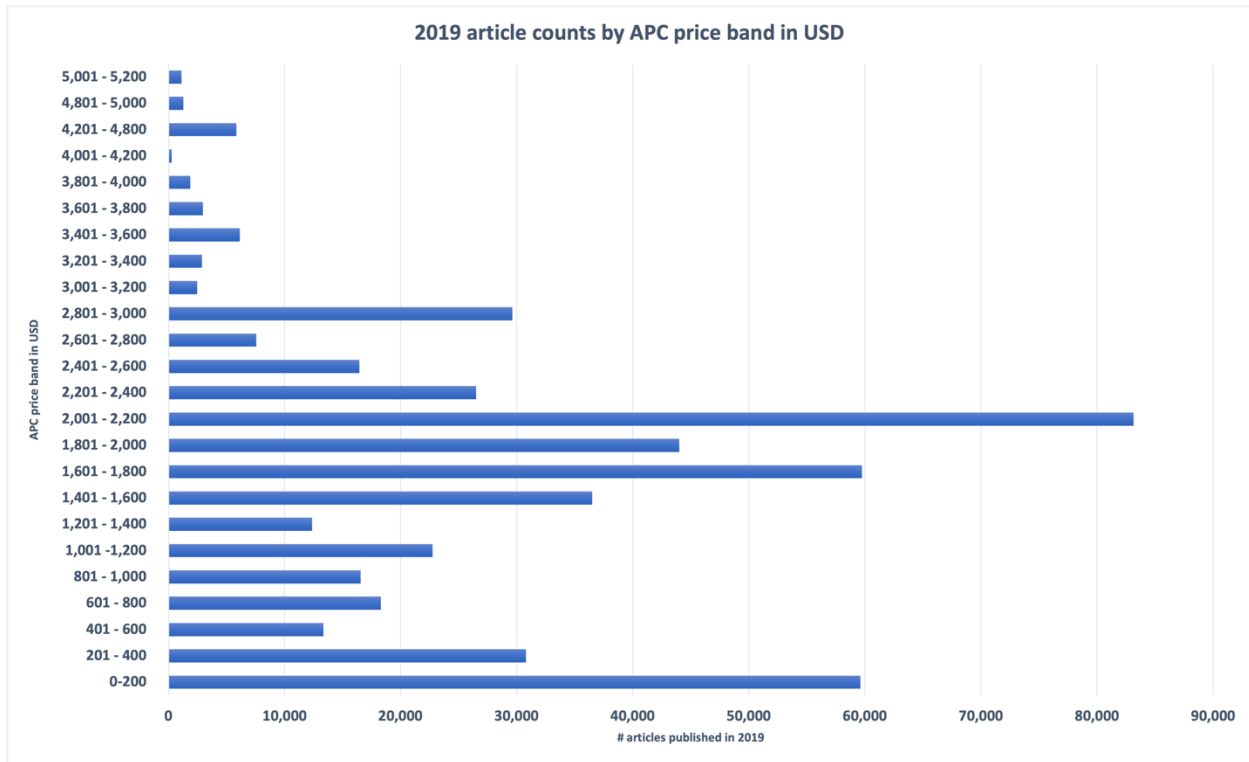


Figure 2. 2019 article counts by APC price band in USD

The following figure 3 *% of articles by APC price band in USD 2010 and 2019* illustrates a pattern of change during this time frame. Note that while APC pricing is from 2011 and 2019 – 2021, article counts are from 2010 and 2019. The upper end of the APC price bands is more than a thousand dollars higher than in 2011. 2010 article percentages peak at 1,801 – 2,000 USD. 2019 article percentages peak at 2,001 – 2,200. The percentage of articles at APC price bands above the peak is higher in 2019 than in 2010. This suggests a trend of price increases. The % of 2010 articles at the very lowest price band is likely understated due to Solomon & Bjork’s weighting of smaller journal publishers; the trend towards lower prices for smaller publishers is evident in 2019 as presented below in the section on publisher size.

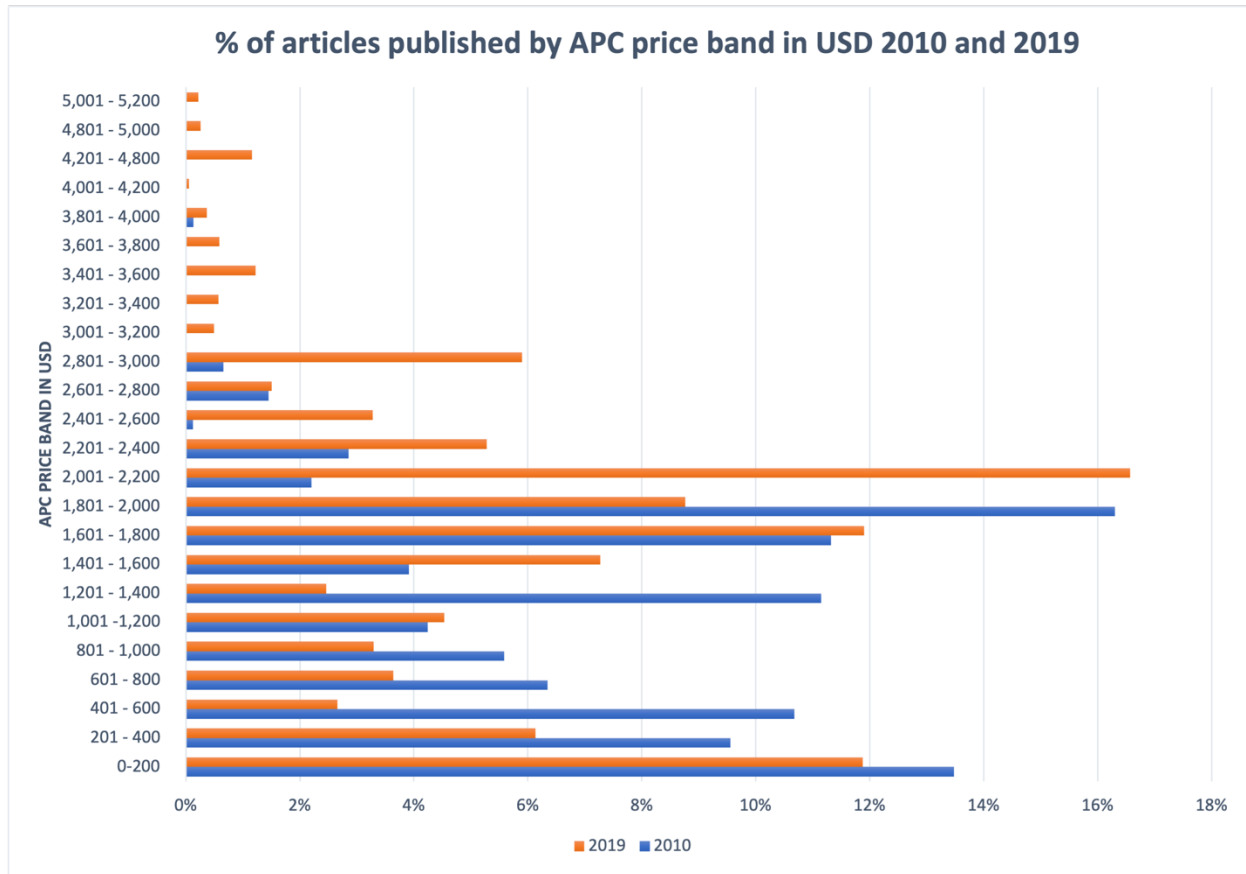


Figure 3 % of articles by APC price band in USD 2010 and 2019

### Journals and APC by publisher size

The following Table 4 *DOAJ 2021: journals and average APC (USD) by publisher size* illustrates a long tail effect. Most publishers are small, and most journals are published by small publishers. Of the 6,804 publishers identified, 5,305 or 78% publish only one journal. 6,640 or 98% publish 10 journals or less. About one third of journals (34%) are published by very small publishers with only 1 journal, two thirds (34 + 29 = 63%) by publishers with 2 – 10 journals and 85% by publishers with 25 journals or fewer. Of the publishers with more than one journal, many publish both no-fee and APC journals. The average APC is noticeably lower for journals by small publishers (<400 USD for 1 – 10 journals) and higher for larger publishers (> 1,000 USD for 26 or more journals), with publishers of 11 – 25 journals in between at about 800 USD.

DOAJ 2021: journals and average APC (USD) by publisher size								
Publisher size by # of journals	# publishers	# journals	# no-fee journals	# APC journals	# other journals	Average APC in USD	% of no-fee journals <sup>1</sup>	% of all journals
1	5,305	5,305	4,358	926	21	306	39%	34%
2- 10	1,335	4,550	3,617	908	25	396	33%	29%
11 -25	114	1,823	1,441	376	6	799	13%	12%
26 - 50	33	1,136	761	364	11	1,116	7%	7%
51 - 100	7	523	210	309	4	1,644	2%	3%
101 - 200	3	479	39	437	3	1,640	0.4%	3%
200 +	7	1,874	624	1,207	43	1,456	6%	12%
Total	6,804	15,690	11,050	4,527	113			
<sup>1</sup> percentages do not add up to 100% due to rounding error								

Table 4. DOAJ 2021: journals and average APC (USD) by publisher size

Relative publisher size varies by journal and by articles. Elsevier is the largest publisher in this dataset by number of journals (386), while MDPI is the largest publisher by number of articles published in 2019 (104,948). A few publishers rank highly by number of articles published with a low journal count, reflecting publication of journals that publish a large number of articles (both traditional and OA megajournals). For example, Public Library of Science (PLOS), publisher of the pioneer OA megajournal PLOS ONE, ranks 6<sup>th</sup> by number of articles (19,632 articles), with only 7 journals, while IEEE, a traditional society publisher in engineering, a field where journals that publish articles in the thousands per year is common, ranks 9<sup>th</sup> with 16,233 articles in only 5 journals. Although as shown by Table X. *DOAJ 2021: journals and average APC (USD) by publisher size* above, larger publishers *tend* to publish journals with higher average APCs, the publishers with the highest APCs are not necessarily the largest publishers by either journal or article. Elsevier, the largest publisher by number of journals and second largest by number of articles, ranks 50<sup>th</sup> by average APC. The National Institutes of Health Research (NIHR) Journals library has the highest average APC of 4,086 USD with only 5 journals and 154 articles. 8 of the most expensive publishers are in the biosciences. Full data is available in the open datasets *Publisher size by # journals*, *Publisher size by # articles*, and *Publisher by average APC* (the 3 datasets include the same data, organized for reader convenience).

### Publisher type

The following Table 5 *Publisher type analysis* illustrates the size of publishers by type by the number of journals, number of articles published in 2019, broken down by no-fee and APC journals, and the average APC in USD. Universities stand out as having published the largest number of journals, 9,330 or 63% of the 14,764 with an identified publisher type, an even higher percentage of the no-fee journals, 7,857 or 75% of the 10,463 no-fee journals, the second highest number of articles published in 2019, and a low average APC of 234 USD, a quarter of the overall average. The commercial sector published the largest portion of articles, 312,770 or 39% of the 810,358 articles, and was the only publisher type that published more APC than no-fee journals, 275 or 18% of the commercial sector journals were no-

fee, likely due to sponsor-partners such as societies and universities. The society or institution type had the highest average APC in USD at 1,606. The commercial, society, nonprofit, and university press types all had above-average APCs. Some publisher types had low numbers of journals (government and institute), hence caution is recommended in interpreting the results.

Publisher type analysis					
Publisher type	# journals	# articles 2019	# no fee journals	# APC journals	Average APC (USD)
Commercial	1,850	312,770	275	1,575	1,511
Government	55	2,779	50	5	657
Independent	206	7,243	186	20	194
Institute	72	358	61	11	132
Nonprofit	79	22,923	41	38	1,038
Society	2,246	144,865	1,414	832	1,180
Society or Institution	440	24,483	221	219	1,606
University	9,330	275,709	7,857	1,473	234
University Press	486	19,228	358	128	1,370
Total	14,764	810,358	10,463	4,301	986

Table 5. Publisher type analysis

Figure 4 below % of DOAJ 2021 journals with / without APC by publisher type illustrates the relative contribution of journals by publisher type by APC and non-APC journals. The university sector stands out in production of journals, particularly in the no-fee category.

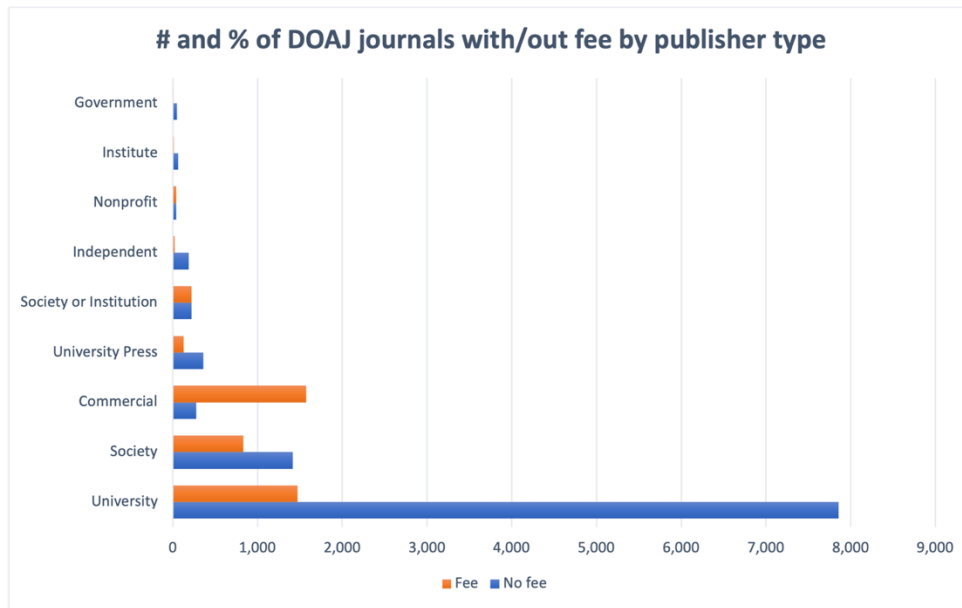


Figure 4 % of DOAJ 2021 journals with / without APC by publisher type

### Average APC in USD by impact factor category

The Table 6 *DOAJ 2021 yes / no status, Scopus & JCR below* shows the number of journals and APC status listed in DOAJ according to whether the journals are listed in JCR, Scopus, or neither. Many journals are listed in both JCR and Scopus. 70% of the 15,690 journals listed in DOAJ 2021 are not listed in either JCR or Scopus. 10% of DOAJ journals are listed in JCR. 28% of DOAJ journals are listed in Scopus. This analysis illustrates a higher tendency for journals listed in JCR or Scopus to charge APCs; 72% of journals listed in JCR charge APCs and 45% of journals listed in Scopus, compared to 19% of journals not listed in either JCR or Scopus.

DOAJ 2021 yes / no status, Scopus & JCR						
Not JCR or Scopus			JCR Journals		Scopus Journals	
APC?	# journals	% journals	# journals	% journals	# journals	% journals
No	8,947	81%	461	28%	2,411	55%
Yes	2,122	19%	1,170	72%	1,996	45%
Total	11,069	100%	1,631	100%	4,407	100%

Table 6 DOAJ 2021 yes / no status, Scopus & JCR

The Table 7 *Average APC in USD by impact factor* below was developed by dividing journals in half based on impact status as measured by JCR rank or Scopus CiteScore (a count of citations). Average APC was calculated for the subset of journals for which a specific APC amount was identified. The per-article amount was determined by multiplying APC by article count from Crawford (2020), where available, and dividing the total by the number of articles. This Table demonstrates much higher APCs for journals listed in either JCR or Scopus and higher APCs for high vs. low impact journals, by journal and by article. For APC journals not listed in either Scopus or JCR, the per-journal average is 561 USD compared to 2,709 USD for high impact journals listed in JCR by article.

Average APC in USD by impact factor					
	Not in Scopus or JCR	Scopus low impact	Scopus high impact	JCR low impact	JCR high impact
By journal	561	916	1,685	1,231	2,133
By article	649	1,054	1,658	1,803	2,709

Table 7 Average APC in USD by impact factor

Figure 5 Average APC in USD by impact factor below illustrates the same data.

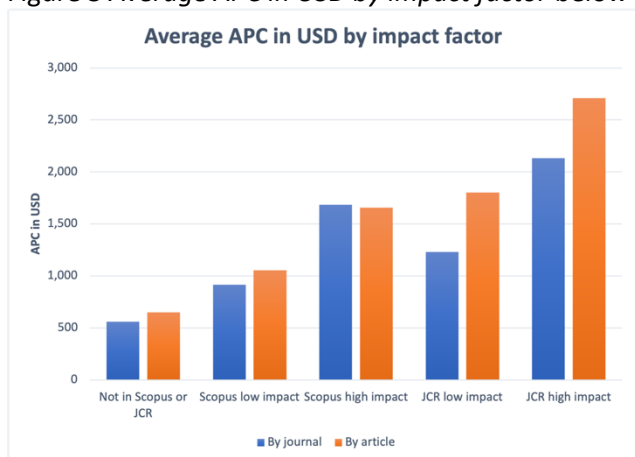


Figure 5 Average APC in USD by impact factor

### APC status and average by subject

DOAJ subject metadata has changed considerably since 2011. For this reason, this portion of the replica study is less comparable with the 2011 study than other results. The subject in Table 8 Subject Analysis below was determined by the main subject heading in DOAJ. For example, specific branches of medicine are included in the subject “Medicine”. The APC journals used for this analysis are the 4,368 journals for which we were able to identify an APC of a specific amount. Per-article APC is derived from the 3,662 journals for which we have both an APC and a 2019 article count. All subjects have more no-fee than APC journals, while the percentage of no-fee and fee varies considerably. This is illustrated in figure 6 below, *No Fee and APC journals by subject*. In Language and Literature there are 1,006 no-fee journals and only 78 APC journals. The average APC by journal or by article varies considerably by subject. For example, Education, History, and Social Sciences’ average APCs by journal are a fraction of the overall average, while Medicine and Science are above the average.

Subject analysis						
DOAJ Primary Subject	# journals	# articles published in 2019	# no fee journals	# APC journals	Average APC in USD (journal)	Average APC in USD (article)
Agriculture	738	33,319	397	337	519	851
Auxiliary sciences of history	103	1,952	91	12	532	506
Bibliography. Library science. Information resources	150	3,309	143	7	264	297
Education	1,505	41,512	1,205	292	235	376
Fine Arts	434	9,817	394	37	508	457
General Works	295	10,406	260	33	408	413
Geography. Anthropology. Recreation	817	28,128	636	178	831	1,163

<b>History</b>	432	9,672	416	15	164	377
<b>Language and Literature</b>	1,093	24,691	1,006	78	192	290
<b>Law</b>	540	10,464	485	47	406	530
<b>Medicine</b>	3,347	291,940	1,698	1,626	1,373	1,753
<b>Military Science</b>	33	935	29	3	22	24
<b>Music</b>	48	731	43	5	453	218
<b>Naval Science</b>	21	1,247	15	5	329	449
<b>Philosophy. Psychology. Religion</b>	798	21,920	684	109	402	1,634
<b>Political science</b>	376	8,268	334	37	293	370
<b>Science</b>	1,519	148,106	797	710	1,122	1,967
<b>Social Sciences</b>	1,686	43,413	1,355	321	365	419
<b>Technology</b>	1,755	144,605	1,062	675	977	1,591
<b>Total</b>	15,690	834,435	11,050	4,527	958	1,662

Table 8. Subject analysis

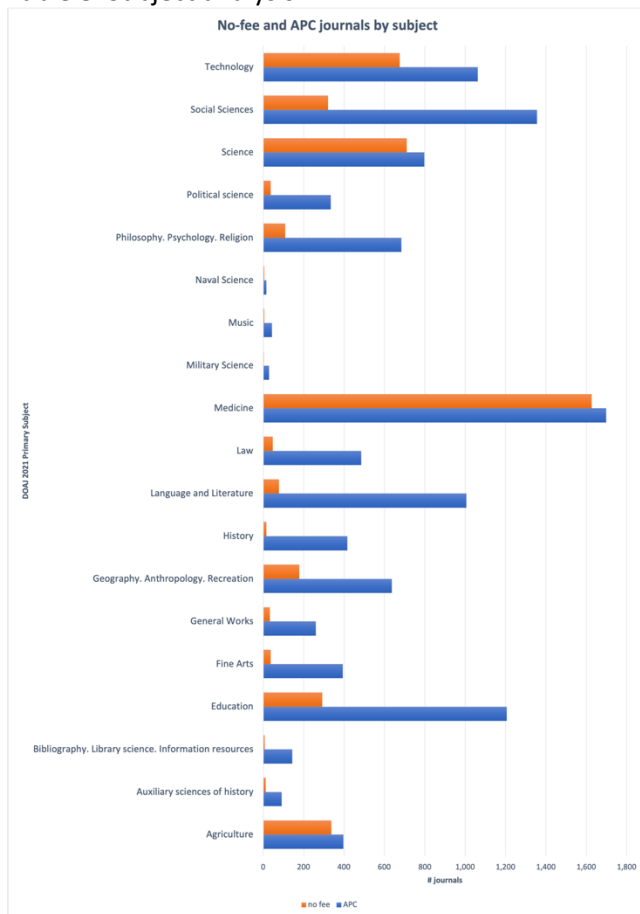


Figure 6. No-Fee and APC journals by subject

The average APC by article often varies considerably from the per-journal price. This is illustrated in figure 7 below *Average APC per subject by journal and article*. A higher per-article APC indicates that authors are choosing to publish in more expensive journals. Medicine stands out as having the highest number of journals and articles and the highest average APC by journal, while Science has the highest average APC per article.

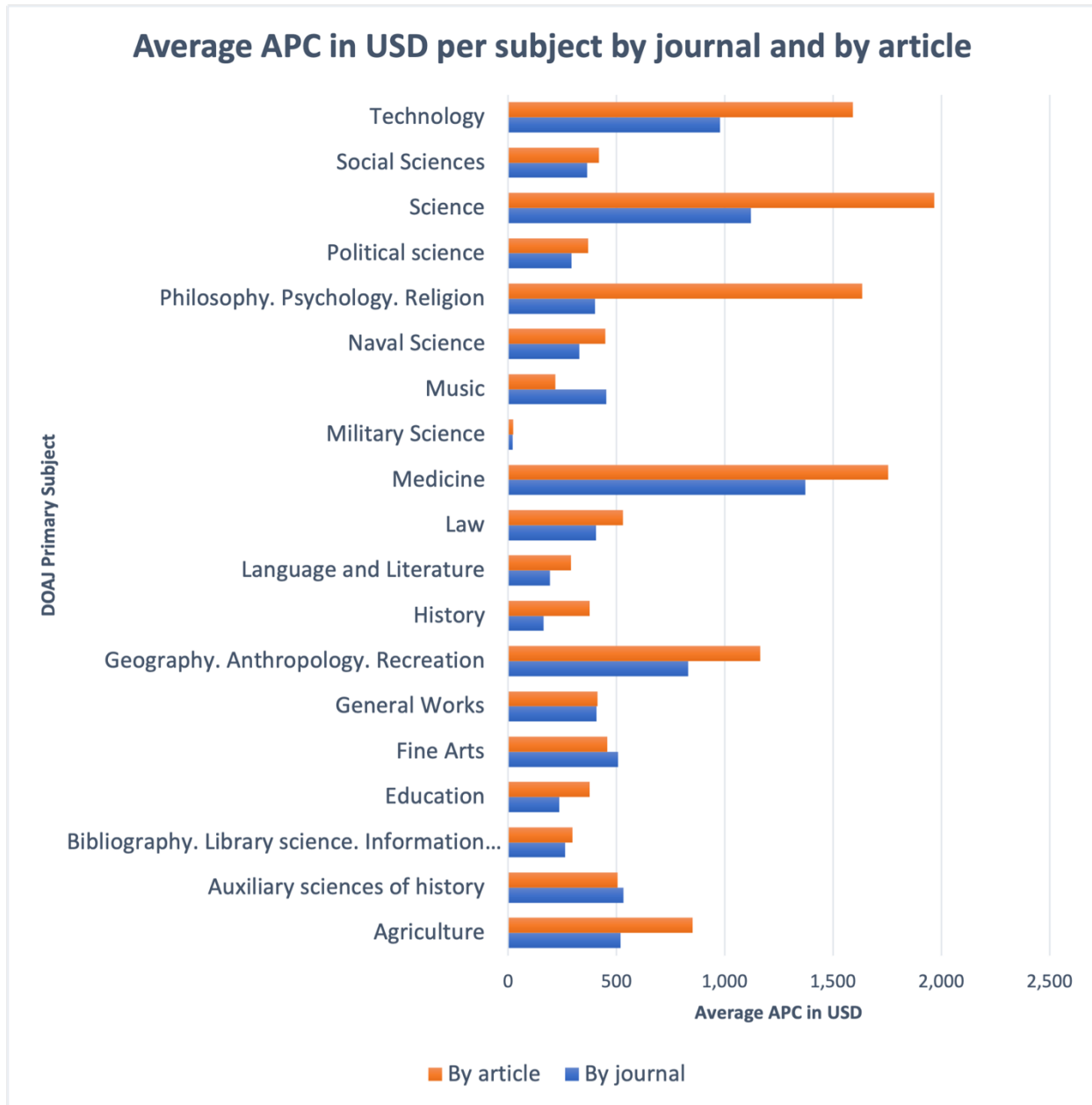


Figure 7 Average APC per subject by journal and article

### Current status and trends of 1,090 journals studied by Solomon & Björk (2012) in 2011

The majority of these journals (755 or 69%) are still active, open access, and fee-charging. 274 journals (25%) have ceased publication. 11 journals are active and open access but no longer fee-charging. One publisher (Kamla-Raj) is now subscription-based, and 2 journals are now hybrid (some articles open access, others by subscription only). The following Table 9 *2021 status of 2011 OA APC journals* details the current status of all 1,090 journals.

2021 status of 2011 OA APC journals		
Status	# journals	% journals
Active, OA, fee	755	69%
Active, OA, no fee	11	1%
Ceased publication	274	25%
Hybrid	2	0%
Inactive	3	0%
Predecessor	4	0%
Subscription journal / publisher	9	1%
Title not found	32	3%
Total	1,090	

Table 9 *2021 status of 2011 OA APC journals*

One startling result was the finding that more than half the journals are no longer listed in DOAJ as of 2021, as illustrated in the following Table 10 *DOAJ inclusion status of 2011 APC journals*.

DOAJ inclusion status of 2011 APC journals		
Listed in DOAJ 2021?	# journals	% journals
No	578	53%
Yes	512	47%
Total	1,090	

Table 10 DOAJ inclusion status of 2011 APC journals

Of the 578 journals no longer listed in DOAJ, 254 are still active, open access and fee charging. Of these, 251 are published by publishers that are no longer represented in DOAJ; these are listed in the *Publishers No Longer in DOAJ* appendix.

The following Table 11 *2011 and 2021 APC comparison: 718 journals for which 2011 and 2021 APC data is available* shows the central tendencies for both years and the breakdown by DOAJ journal inclusion / exclusion in 2021. The average APC of this set of journals increased from 1,109 USD to 1,459 USD, a 32% increase that is well beyond the inflation rate in this time frame. DOAJ inclusion / exclusion showed different patterns. The average APC of journals included in DOAJ in 2021 show a much higher increase to

an average of 1,800 USD, a 62% increase, while journals not listed in DOAJ in 2021 showed an average price *decrease* to 772 USD, a 30% decrease.

<b>2011 and 2021 APC comparison: 718 journals for which 2011 and 2021 APC data is available</b>				
<b>2021 APC (USD)</b>	<b>2011 APC (USD)</b>	<b>2021 APC (USD) All journals</b>	<b>2021 APC (USD) Journals listed in DOAJ 2021</b>	<b>2021 APC (USD) Journals not listed in DOAJ 2021</b>
Average (Mean)	1,109	1,459	1,800	772
Median	1,000	1,588	1,958	599
Mode	1,610	1,958	1,958	960
Lowest	13	1	45	1
Highest	3,900	4,200	4,200	4,171

Table 11. 2011 and 2021 APC comparison: 718 journals for which 2011 and 2021 APC data is available

The status and APC of 176 journals included in the 2011 dataset of 1,090 journals that are also listed in the 2010 JCR is displayed in the Table *2021 status of 2011 OA APC journals listed in JCR 2010*. APC was calculated for all the JCR journals, and separately by the top and bottom half of the JCR journals by JCR rank, as illustrated in the following Table *2021 status of 2011 OA APC journals listed in JCR 2010*. In contrast with the full dataset, almost all the JCR journals are active, OA, and fee charging (99%) and still listed in DOAJ 2021 (99%)?

<b>2021 status of 2011 OA APC journals listed in JCR 2010</b>		
Status	# journals	% journals
Active, OA, fee	174	99%
Active, OA, no fee	1	1%
Predecessor	1	1%
Total	176	100%

Table 12 2021 status of 2011 OA APC journals listed in JCR 2010

Table 13 below illustrates that almost all the OA APC journals listed in JCR 2010 are listed in DOAJ 2021.

<b>Listed in DOAJ 2021?</b>	# journals	% journals
No	1	1%
Yes	175	99%
Grand Total	176	100%

Table 13 JCR 2010 journals: listed in DOAJ 2021?

Not surprisingly, higher ranked journals have a higher mean (average) and median APC as illustrated by the following Table *2021 APC in USD of OA APC journals listed in JCR 2010*.

<b>2021 APC in USD of OA APC journals listed in JCR 2010</b>			
	All journals	Top half by rank	Bottom half by rank
Mean	2,032	2,301	1,776
Median	2,135	2,247	2,029
Mode	2,302	1,866	2,302
Lowest	62	1,075	62
Highest	4,200	4,200	3,119

Table 14 2021 APC in USD of OA APC journals listed in JCR 2010

### Meta-analysis: the “average” APC and price changes 2011 – 2021

Table 15 *Meta-analysis: variations in APC trends 2011 - 2021 by sample* below illustrates wide variation in average APC trends from 2011 – 2021 depending on the sampling method. A % change from 2011 of 100% means no change in price. Below 100% means a reduction in price, above 100% means an increase in price. A % change of 136% is a 36% increase in price. A % change of 200% is a doubling of price; 300% is a tripling of price. The baseline inflation is 114%; any price increase below this amount is below inflation, any price increase above this amount is above the inflation rate. The highest price increases are associated with JCR high impact journals. Journals listed in DOAJ 2021 in the upper half of JCR ranking had an average APC more than double the baseline (235% change); the per-article average APC for this group of journals is triple the baseline (300% change), illustrating that the higher priced high impact journals are attracting more content. Higher average APCs are more evident based on articles, an 80% increase in average APC compared to 2011 (180% change). These numbers contrast with the overall average APC change from 906 to 958 USD, a 6% increase that is below the inflation rate. The only group of journals that showed an average price decrease were journals in DOAJ 2021 that are not listed in JCR or Scopus.

The 2011 dataset update section in the Table above starts with a baseline of 1,109 USD, in contrast to the original 906 USD. This means that the average 2011 APC of journals still active and charging APCs in 2021 was 22% higher than the average of all journals from that sample. From this baseline, the highest price increase is again associated with JCR higher impact journals; journals in the upper half of rankings from JCR 2010, on average, doubled their average APC from 2011 – 2021 (207% change). On average, this group of journals, starting from the 22% higher baseline, increased their APCs an average of 32%. Higher price increases were evident for journals listed in DOAJ in 2021 (62% increase), and inclusion in JCR 2010, with even the lower half of journals by rank showing a 60% increase. The only group of journals that decreased in average APC was journals no longer listed in DOAJ; this group showed a 30% average price decrease (70% percentage change).

Data from the OpenAPC (2021) project is included for contrast. 290 institutions share their data on APC payments in a standard format to allow for manipulation and visualization of the entire dataset. As of May 13, 2021, the average APC for 124,245 articles paid by members was 1,942 EUR. Using XE currency converter as of May 13, 2021, this converts to 2,344.58 USD. This amount, reflecting actual payments, is higher than any other sample.

<b>Meta-analysis: variations in APC trends 2011 - 2021 by sample</b>				
	<b>Per-journal average APC (USD)</b>	<b>% change from 2011</b>	<b>Per-article average APC (USD)</b>	<b>% change from 2011</b>
<b>Baseline: 2011 Solomon &amp; Björk (2012)</b>	<b>906</b>		<b>904</b>	
<b>Baseline: inflation 2011 - 2021</b>		<b>114%</b>		<b>114%</b>
<b>2021 DOAJ modified replication</b>				
2021 DOAJ all	958	106%	1,626	180%
2021 DOAJ not in Scopus or JCR	561	62%	649	72%
2021 DOAJ Scopus low impact	916	101%	1,054	117%
2021 DOAJ Scopus high impact	1,685	186%	1,658	183%
2021 DOAJ JCR low impact	1,231	136%	1,803	199%
2021 DOAJ JCR high impact	2,133	235%	2,709	300%
<b>2011 Dataset update</b>				
<b>Baseline: 2011 APCs of active APC journals in 2021</b>	<b>1,109</b>			
2021 APC 2011 dataset update all	1,459	132%		
2021 APC 2011 dataset update in DOAJ 2021	1,800	162%		
2021 APC 2011 dataset update not in DOAJ 2021	772	70%		
<b>2021 APC 2011 dataset journals in JCR 2010</b>				
2021 APC 2011 dataset journals in JCR 2010 all	2,032	183%		
2021 APC 2011 dataset journals in JCR 2010 top half by rank	2,301	207%		
2021 APC 2011 dataset journals in JCR 2010 bottom half by rank	1,776	160%		
<b>OpenAPC: average APC payment (290 institutions, 124,245 articles; converted to USD from 1,942 EUR)</b>	<b>2,344</b>			

Table 15 Meta-analysis: the “average” APC and price changes 2011 – 2021

Figure 8 *2011 – 2021 average APC change in comparison with inflation* below illustrates the wide variation in pricing trends demonstrated by selecting different samples. While most indicators are well above the inflation rate, a few indicators are below the inflation rate, and one is nearly identical to the inflation rate.

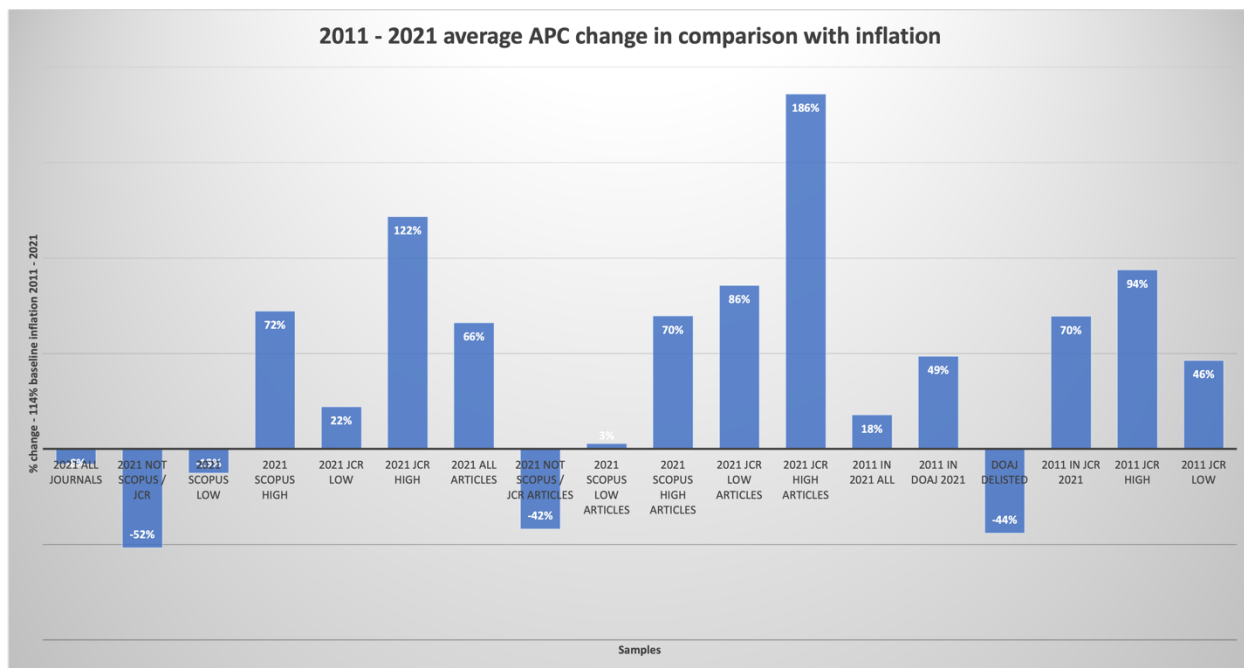


Figure 8 2011 – 2021 average APC change in comparison with inflation

## Discussion

### Change and growth in open access journal publishing and charging trends 2011 – 2021

One of the most startling findings of this study is the finding that over half the 1,090 APC-charging DOAJ journals studied by Solomon & Björk (2012) in 2011 are not listed in DOAJ 2021. While most of this change is explained by journals that have ceased publication and publishers that are no longer listed in DOAJ, this is not likely to be of comfort to authors who chose to pay APCs and selected journals based on their inclusion in DOAJ, and/or readers who previously found content through DOAJ and can no longer find it through this source.

A business strategy of some of the pioneer commercial open access journal publishers (BioMedCentral, Hindawi, Bentham Open) involved creating a wide range of journals, then continuing to publish successful titles and discontinuing unsuccessful ones. This would explain the large number of journals that have ceased publishing, but it does not address the questions of ongoing access to this material through DOAJ as a source. To achieve full functionality as a trusted list and link to OA material, DOAJ or another service would need to provide links to ceased as well as active journals.

The de-listing of publishers from DOAJ may reflect a variety of factors. DOAJ does not explain why journals are publishers are de-listed. However, there is some evidence suggesting potential reasons for de-listing. In 2014, DOAJ initiated a get-tough policy, requiring journals to re-apply for inclusion and more strictly applying the DOAJ inclusion criteria. Publishers may have failed to re-apply or may not have met the stricter criteria for inclusion. One small former OA publisher, Kamla-Raj, has switched to a subscriptions model. DOAJ de-lists journals with low activity levels; this would impact smaller journals, for example journals associated with conferences that do not meet every year. Given the correlation between small journals and a tendency to charge no or low APCs, relying on DOAJ may have a negative impact on scholarly OA journal publishing arising from this criteria for inclusion. In the case of one of the

publishers, OMICS, questionable publishing practices may explain DOAJ exclusion, as illustrated by the order of a U.S. federal district court to pay \$50.1 million USD “to resolve FTC charges that they made deceptive claims about the nature of their conferences and publications, and hid steep publication fees” (U.S. Federation Trade Commission, 2019).

In spite of weeding ceased journals and journals published by de-listed publishers, DOAJ’s net growth from 2011 – 2021 more than doubled and the percentage of charging and non-charging journals has remained fairly steady, with the majority of journals (70%) not charging and about 27% charging.

#### APC pricing trends 2011 – 2021

The APC meta-analysis might be useful in a research methods course as a means of illustrating how misleading the apparently straightforward task of determining pricing trends based on average price over time can be, and how easy it can be to present a deceptive picture based on selective inclusion of data that shows the trend one prefers to emphasize. For example, a commercial publisher seeking to sell their business would likely prefer data illustrating rising price trends, while an OA advocate wishing to convince a university to support OA might prefer to emphasize the large numbers of no-fee journals.

The global average per-journal APC has increased at a rate below inflation, while other indicators such as the average per-article APC and the average APC of journals included in the 2011 sample indicate price rises far beyond inflation. Comparison of per-journal pricing in 2011 and 2021 shows that the average masks a more complex scenario where most prices are rising, while some remain the same and others decrease. Pricing trends are quite different when assessed by original currency.

The tendency to charge APCs as well as the average APC varies quite a bit by subject. This is similar in 2021 and 2011, however variation in DOAJ subject classification does not permit subject-by-subject comparison between the two time frames. The finding that particular subjects, particularly science, technology, and medicine, are more likely to charge APCs and to charge higher APCs is similar to what Solomon & Björk reported in 2012. Our results show a similar pattern to those of Crawford (2020); for example, Crawford found that the percentage of articles in no-APC journals is relatively low in medicine, science, and technology, and high in languages & literature. Differences in results can be accounted for by a difference in emphasis on journals in our study, and articles in Crawford’s study, as well as overlapping but not identical subject categories; for example, we use DOAJ’s Science and Fine Arts categories, while Crawford has Medicine and “Other Science” and no fine arts category.

The weight of evidence strongly suggests an overall trend of rising prices well beyond inflation rates as OA journals become established and are successful in attracting content. This is supported by higher price rises based on the 2011 sample as compared with the DOAJ 2021 sample, and higher pricing associated with inclusion in DOAJ and/or higher rank in JCR or Scopus. Our price band analysis illustrating a trend towards higher price bands since 2011 also supports an hypothesis of rising prices. We note a shift in a spike at the 1,801 – 2,000 USD price band in 2011 to a spike in the 2,001 – 2,200 USD price band in 2021; this is similar to the finding of Crawford (2020, p. 8-9) that there has been an explosion in publishing in higher priced journals, with 59% of revenue going to journals with prices at or above 2,000 USD, nearly double our finding of the global average APC of 958 USD. A tendency of authors to select higher priced journals is also supported by our finding of a higher average of 1,626 USD as calculated on a per-article basis (nearly identical to the 1,673 USD calculated on a per-article basis by Crawford (2020, p. 4), and the finding that OpenAPC (2021) payers pay an average of 2,344 USD, higher than any of our samples. A trend of price rises beyond inflation may be cause for celebration by APC-

charging publishers but should be cause for concern for APC payers including libraries, universities and research funding agencies.

The weight of evidence also suggests a functional and functioning economical OA alternative for those who pay directly or indirectly for scholarly journal publishing, as universities (as distinct from university presses) stand out as having the most OA journals, publishing close to the highest number of OA articles in spite of producing smaller journals than some of the other sectors, contributing the bulk of non-APC journals and when APCs are charged, having pricing well below the other sectors. Crawford (2020, p. 20) similarly found that the majority of articles are published by universities and colleges. This evidence complements the findings of Bosman et al. (2021); this major survey, prepared for the members of cOAlitionS of 1,619 “diamond” or no-fee OA journals that are financially supported by Research Performing Organizations (primarily universities) (p. 117), 40% of which are owned by universities (p. 79). 60% of these journals reported annual per-journal costs, including in-kind support, of under 10,000 USD / EUR, and half of these reported annual costs of under 1,000 USD / EUR (p. 110). Our findings that the majority of journals and articles are published by universities, that universities are particularly well represented among no-fee journals, and that on average university journals with APCs had average APCs a fraction of the overall average, are consistent with the findings of Bosman et al. (2021). There is considerable overlap of this sector with the “long tail” finding that the vast majority of OA journals are published by very small publishers, with 1 journal being the largest category; Bosman et al. (2021, p. 103) report that the 1,619 journals survey are published on 783 different domain names.

As Bosman et al. (2021, p. 102) report, the “diamond” sector of open access is disadvantaged with respect to indexing. These journals are less well represented in DOAJ, Scopus, and Web of Science (from which the JCR impact factor is derived), partially due to lack of staff and partially due to the indexes’ tendency to focus on inclusion of English language and well-funded journals, creating a vicious circle. The recommendations arising from this study (Becerril et al., 2021) suggest a way forward out of the vicious cycle by providing support targeted to funders, Research Performing Organizations (universities), societies, and OA infrastructure services.

#### Limitations and further research

Both the 2011 and 2019-2021 datasets are drawn from the Directory of Open Access (DOAJ). While DOAJ is the most comprehensive vetted list of fully open access journals, the extent of DOAJ comprehensiveness is unknown and there is evidence to suggest that it represents only a fraction of the fully OA journals. Bosman et al. (2021, p. 7) estimate that there are about 29,000 “diamond” or no-fee OA journals, and only about a third of them are listed in DOAJ. Shi (2020) reports that a Chinese Open Access Aggregator makes about 10,000 OA journals available; these journals are not reflected in DOAJ. Other limitations associated with DOAJ are exclusion of journals that some would consider open access, such as hybrid subscriptions-open access journals, journals with free access to back issues, and journals that publish less frequently, for example journals associated with conferences that are held every other year. The quality of DOAJ metadata is another limiting factor, as is illustrated by the challenges of identifying publishers and publisher size based on variations in publisher name input and typos. Identifying a single per-journal APC represents a simplification of what is actually a complex variable, as variations in pricing based on such factors as author ability to pay, length and quality of wordsmithing, and society or institutional membership are common, and there is a growing tendency for large payers such as library consortia to negotiate one fee with publishers for journal subscriptions and OA to the works of their own authors. Combining datasets from different sources, developed by groups of researchers with similar but not identical methods, inevitably introduces some apples and oranges

comparison type errors. We are confident however that in spite of these limitations some firm conclusions can be drawn and directions suggested for further research. Further studies of APC trends should focus on price band analysis, per-country, per-currency, and/or per-publisher trends rather than global average APC, while further studies of economic models for OA might be better aimed at the potentially more economical university or research performing organizations sectors.

One promising framework for research to support this sector was developed by the Library Publishing Coalition, a group of about 80 primarily North American university libraries founded in 2014 to share best practices and expertise. The Library Publishing Coalition Research Committee (2020) has published a research agenda identifying 6 priority areas for research (assessment, labor, accessibility, non-traditional research outputs, peer review and partnerships), with specific research questions and resources identified for each one.

## Conclusions

The APC business model is used successfully by a minority of fully open access journals, and is more common in particular subject areas, particularly science and medicine. The fact that half the APC charging journals listed in DOAJ in 2011 are no longer listed in DOAJ in 2021 demonstrates that a journal's APC model and/or inclusion in DOAJ are not indicators of stability. Journals from the 2011 dataset that are still publishing showed price increases well beyond inflation rates, suggesting that an APC market could replicate the inelastic market long observed with subscription journals. Impact factor, measured by relative JCR or Scopus ranking, correlates with higher APCs. While the per-journal global average APC has increased at less than the rate of inflation, the per-article global average APC has increased at a rate far beyond inflation, and price band analysis indicates an overall concerning trend of price increases. Meanwhile, more OA journals and articles are published by universities (as distinct from university presses) than any sector, and this sector is associated with a greater tendency not to charge APCs, and when APCs are charged, to charge much lower fees than other sectors. This is a model worthy of further exploration.

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**Average APC in USD by publisher type and size (per-journal and per-article) Appendix**

The following Table *Average APC in USD by publisher type and size (per-journal and per-article)* shows the breakdown by publisher type and size by number of journals for the journals for which we have an identified APC amount. The average APC is given on a per-journal and per-article basis, and the number of journals and articles the data is based on is provided. The per-journal pricing reflects the whole set of journals while the per-article pricing is limited to journals for which we have a 2019 article count. The number of journals for government and institute publishers is very low (5 and 11 respectively) in comparison to the other types of publishers. The university press category did not include any publishers with more than 100 journals. Note that the average APC per journal and the average APC per article tends to vary considerably in almost all categories, with the exception of categories with very small journal numbers. The smallest publishers tend to have the lowest APCs in their type category across all categories, but there are exceptions and patterns are not consistent.

<b>Average APC in USD by publisher type and size (per-journal and per-article)</b>					
<b>Publisher type</b>	<b>Publisher size by # journals</b>	<b>Average APC per journal (USD)</b>	<b>average APC per article</b>	<b># journals</b>	<b># articles</b>
Commercial	1	683	1,953	32	2,533
Commercial	2 - 10	835	1,202	81	6,055
Commercial	11 - 25	1,603	1,952	95	16,411
Commercial	26 - 50	1,358	2,324	63	30,615
Commercial	51 - 100	1,759	2,546	217	42,892
Commercial	101 - 200	1,600	1,930	215	16,827
Commercial	200 +	1,519	1,935	803	7,256
<b>Commercial</b>	<b>All</b>	<b>1,511</b>	<b>1,987</b>	<b>1506</b>	
Government	1	115	149	2	202
Government	2 - 10	1,018	3,000	3	33
<b>Government</b>	<b>All</b>	<b>657</b>		<b>5</b>	
Independent	1	202	241	19	2,054
Independent	2 - 10	40	40	1	80
<b>Independent</b>	<b>All</b>	<b>194</b>	<b>233</b>	<b>20</b>	
Institute	1	126	n/a (no article counts)	9	
Institute	2 - 10	131	287	2	92
<b>Institute</b>	<b>All</b>	<b>132</b>	<b>287</b>	<b>11</b>	
Nonprofit	1	1,158	1,246	2	231

Nonprofit	2 - 10	1,608	1,734	14	20,361
Nonprofit	26 - 50	524	1,364	16	965
<b>Nonprofit</b>	<b>All</b>	<b>1,038</b>	<b>1,712</b>	<b>32</b>	
Society	1	446	728	237	15,173
Society	2 - 10	1,159	1,521	112	25,254
Society	11 - 25	1,696	1,782	48	20,081
Society	26 - 50	1,161	2,213	41	1,934
Society	51 - 100	1,622	2,068	4	1,153
Society	101 - 200	1,759	1,906	143	12,457
Society	200 +	1,490	1,537	219	15,568
<b>Society</b>	<b>All</b>	<b>1,180</b>	<b>1,523</b>	<b>804</b>	<b>15,568</b>
Society or Institution	1	464	837	13	1,244
Society or Institution	2 - 10	316	296	13	1,451
Society or Institution	11 - 25	2,564	2,686	9	732
Society or Institution	26 - 50	2,083	2,224	33	1,236
Society or Institution	51 - 100	800	800	2	
Society or Institution	101 - 200	1,443	1,649	49	3,679
Society or Institution	200 +	1,849	1,833	69	5,272
<b>Society or Institution</b>	<b>All</b>	<b>1,606</b>	<b>1,644</b>	<b>188</b>	
<b>Unidentified</b>	<b>All</b>	<b>438</b>	<b>536</b>	<b>226</b>	
University	1	186	236	474	25,589
University	2 - 10	137	205	552	22,569
University	11 - 25	164	365	206	9,001
University	26 - 50	692	893	116	3,717
University	51 - 100	174	241	28	1,323
University	101 - 200	2,009	1,404	12	381
University	200 +	554	397	57	4,164
<b>University</b>	<b>All</b>	<b>234</b>	<b>296</b>	<b>1445</b>	
University Press	1	433	311	10	1,085
University Press	2 - 10	283	315	21	1,138
University Press	11 - 25	193	258	14	241
University Press	26 - 50	1,886	1,912	27	904
University Press	51 - 100	1,991	2,760	56	8,248
<b>University Press</b>	<b>All</b>	<b>1,370</b>	<b>2,174</b>	<b>128</b>	
<b>All types</b>	<b>All</b>	<b>986</b>			

Table X Average APC in USD by publisher type and size (per-journal and per-article)

**Publishers No Longer in DOAJ appendix**

Publishers in DOAJ 2011 not 2021	# journals
Academic and Business Research Institute	7
Academic Journals	8
Academy & Industry Research Collaboration Center (AIRCC)	21
Advanced Research Journals	3
AstonJournals	5
Bentham Open	72
Canadian Center of Science and Education	20
e-Century Publishing Corporation	6
Engg Journals Publications	3
European Journals, Inc.	3
Internet Scientific Publications, LLC	8
Kamla-Raj Enterprises	9
Maxwell Science Publication	11
OMICS Publishing Group	20
Scholarlink Resource Centre	3
Sciedu Press	4
Scientific Research Publishing	48
Total	251