

Zhang, Xijie; Grebel, Thomas; Budzinski, Oliver

Working Paper

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Ilmenau Economics Discussion Papers, No. 145

Provided in Cooperation with:

Ilmenau University of Technology, Institute of Economics

Suggested Citation: Zhang, Xijie; Grebel, Thomas; Budzinski, Oliver (2020) : The prices of open access publishing: The composition of APC across different fields of sciences, Ilmenau Economics Discussion Papers, No. 145, Technische Universität Ilmenau, Institut für Volkswirtschaftslehre, Ilmenau

This Version is available at:

<https://hdl.handle.net/10419/225259>

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Ilmenau Economics Discussion Papers, Vol. 26, No. 145

**The Prices of Open Access Publishing: The Composition
of APC across Different Fields of Sciences**

Xijie Zhang, Thomas Grebel & Oliver Budzinski

Oktober 2020

Institute of Economics

Ehrenbergstraße 29
Ernst-Abbe-Zentrum

D-98 684 Ilmenau

Phone 03677/69-4030/-4032

Fax 03677/69-4203

<https://www.tu-ilmenau.de/wpo/forschung/>

ISSN 0949-3859

The Prices of Open Access Publishing: The Composition of APC across Different Fields of Sciences

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Abstract

Modern media technologies paved the way to the open access movement. Instead of the traditional academic subscription and publishing model, which allowed few big publishers to charge excessive publishing fees, the open access model raises the hope for a fair system, where scientific content is freely accessible and thus the dissemination of research work becomes possible at little cost. However, previous literature pointed out that big publishers seem to be able to preserve their market power when going from the subscription-based model to the open access model. In this paper, we take a closer look at the differences across disciplines. The publication routines in Social Sciences, Physical Sciences, Life Sciences and Health Sciences differ to a substantial extent. On these grounds, we test whether there are also differences in the explanations for the article processing charges (APC) across these disciplines. For doing so, we combined various data sources such as the dataset of the “Directory of Open Access”, the “OpenAPC Initiative” and the “CiteScore Metrics”. Our regression results show that the differences across the four fields in terms of publication habits and endowment levels allow publishers to exploit their market power to different extents.

1. Introduction

In principle, the process of publishing scientific articles is the same across all scientific disciplines. After a quality check – ensured by the traditional peer-review process – the journal decides if an article can be published. Since the publishing process is a simple routine and authors, reviewers and editors are barely paid for their contributions to the scientific publication process, one may conclude that production cost should not differ much between publishers either, and neither should prices for accessing published research work. One reason why prices differ, as publishers may argue, is that journals enjoy different levels of reputation. To publish an article in a reputed journal also yields reputation to respective authors – and reputation, not the least, is what researchers eventually seek for (Bergstrom, 2001; Grebel, 2011; Smith, 2018). Accordingly the publishers can charge higher APCs.

Another reason for differences in prices may be rooted in a certain degree of market power in the scientific publishing market. Primarily libraries but also remaining subscribers pay more and more for accessing scientific journals. For dominant publishers, academic publishing has become a profitable business in recent decades (Delamothe & Smith, 2004). Considerable merger and acquisition activities in the publishing market have aided big publishers to increase their market power and their pricing strategy of bundling famous journals with less famous ones tends to facilitate re-allocating rents from buyers to the publishers (McCabe, 2002; McCabe, 2004; Solomon & Björk, 2012b).

Not even the era of digitalization, which has made the open access (OA) movement possible, seems to diminish publishers' market power, despite its production cost reducing effect in the publication process (Budzinski, et al., 2020). The Budapest Open Access Initiative in 2001 (Tennant, et al., 2016; Piwowar, et al., 2018) started to pursue the idea to make scientific knowledge freely accessible. To set this into practice, the payment procedure needed also a new design. Instead of subscribers paying subscription fees, it will be authors, or libraries to which they are associated with, that pay so-called article processing charges (APC)¹, i.e. the price for OA publishing. However, the implicit hope that this technical change comes with a reduction in publishing cost for them has not yet been satisfied. Publishers started to adjust to this change by adapting their business model. Two strategies emerged: first, the creation of new journals, explicitly devoted to open access publishing (the so-called gold-OA journals) and, second, the development of hybrid OA options offering authors to choose between the

¹ There is a considerable number of journals financially supported by academic institutes like universities and societies, which very often are free of charges. As our study focus is on the APC, these cases are excluded from the analysis.

subscription model or the OA model on the level of every single paper to be published. Thus, by pursuing the latter strategy, publishers could skim the cream of both the subscription model and the OA model. Parts of the articles in hybrid journals would remain subscription based, whereas articles for which authors opted for the OA model became freely available. The hybrid model is mainly employed by incumbent publishers and hybrid journals manage to charge higher APC than their gold OA counterparts (Morrison, et al., 2015; Pinfield, et al., 2016; 2017) ; Budzinski, et al., 2020).

The variance in APC between journals is large. This holds true also among journals of big publishers. Many studies have been conducted to disentangle the different drivers of APC (Hagenhoff, et al., 2008; Solomon & Björk, 2012a; Romeu, et al., 2014; Wang, et al., 2015; Pinfield, et al., 2016; Pinfield, et al., 2017; Schönfelder, 2018; Budzinski, et al., 2020; Yuen, et al., 2019). Reputation is one of the most frequently investigated explanatory variable. Usually proxied by journal impact factor, it takes a positive impact on APC (Schönfelder, 2018; Budzinski, et al., 2020). The largest share in APC, as Schönfelder (2018) and Budzinski, et al., (2020) show, accrues to the hybrid business model. Especially established big publishers are able to charge significantly higher APC.

In contrast to previous studies, which merely controlled for the heterogeneity between disciplines within their estimation strategy, we focus explicitly on the APC differentials between disciplines. Despite the same fundamental structure, different scientific disciplines follow quite different publication regimes in detail. Some disciplines experience abundance of funding opportunities while others have difficulty in doing so (Solomon & Björk, 2012a; 2012b; Tenopir, et al., 2017). As a consequence, publishers with market power could try to acquire a greater share in the respective discipline's disposability of funds. A further difference lies in the availability of outlets. Some disciplines have a higher number of publication slots available in journals than in others (Buchheit, et al., 2002). Furthermore, some disciplines value preprints more for the sake of visibility, in contrast to disciplines focusing exclusively on peer-reviewed journal articles (Fry, et al., 2016). Also, importantly, not all disciplines are dominated by established and/or for-profit publishers/journals in the same way, which eventually affects APCs. Particularly in smaller disciplines non-profit publishers are prevalent (Dewatripont, et al., 2007; Gargouri, et al., 2012). All these differences, as we hypothesize, create specific conditions for incumbent publishers to adjust their rent-seeking behavior accordingly, which will also reflect in the differences in APCs across disciplines.

In order to provide a preliminary picture, we will focus on the four main subject fields provided by Scopus which is also widely used in the literature, namely Health Sciences, Life Sciences, Physical Sciences and Social Sciences (for classification details, see Appendix 1). We will compare the difference in APC levels across these four groups. Then we test the influence of market power on APC levels. The dataset is assembled from three main sources: The Directory of Open Access Journals (DOAJ), the “OpenAPC Initiative”, and the “CiteScore Metrics” of Scopus. In addition, we complete the data with information about publisher profit types and the foundation year of the publisher.

In the next section, we motivate the hypothesis we derive. Section three provides details on the data and methodology. Results are discussed in section four, followed by the limitations of our study and a conclusion in section five.

2. Objectives and Hypotheses

The objective of this study is to test, to what extent established publishers exploit their market power by raising the APC above basic production cost in the four selected disciplines.

Research question: How does market power contribute to APC differences across discipline fields?

Many studies report that there is an obvious variance of APCs across disciplines. Journals from Life and Health Sciences appear to be levying the highest APC and Social Sciences seems to be offering the most favorable price for OA publishing (Hagenhoff, et al., 2008; Solomon & Björk, 2012a; Solomon & Björk, 2012b; Björk & Solomon, 2015; Schönfelder, 2018). The reasons behind this variance can be manifold, but results from previous studies suggest that market power should play a considerable role in determining APC levels (Schönfelder, 2018; Budzinski, et al., 2020). Suppose the market of academic publishing is sufficiently competitive and publishers do not possess much market power within an individual subject field, then APC should be around the level of the production cost of publishing. With digitization, the production process of a scientific article should be similar across disciplines, which means that prices (APCs) should be around the same level as well, while taking all remaining drivers of APC into account such as differences in reputation. If they nevertheless differentiate their APC levels, publishers have market power and exploit it to maximize their profits.

Since Health Sciences and Life Sciences enjoy access to higher resources funding, inter alia, publication prices (like submission fess but also like APCs), the authors from these fields may

display a higher willingness-to-pay, followed by Physical Sciences (Solomon & Björk, 2012a). Conversely, authors of Social Sciences have significantly less financial support, which forces them to prefer cheaper publication opportunities. In other words, they have a lower willingness-to-pay. Generally, publishing in a peer-review OA journal has two benefits: one is the prestige arising from such a journal; the other is the potentially high visibility thanks to free access (boosting citations). Both the prestige of the publication outlet and the number of citations of one's work are important career mechanisms in science. Most of prestigious journals delivering high reputation are incumbent outlets, having been in the market long before the OA movement started, because reputation-building takes time (Suber, 2002; Liu, 2005). As a consequence, the more prestigious journals are usually paid-hybrid-OA – and the more expensive ones as former studies found reputation to be a driving-factor for APC (Solomon & Björk, 2012a; Solomon & Björk, 2012b; Wang, et al., 2015; Pinfield, et al., 2017; Schönfelder, 2018). Thus, publishing OA in journals offering high reputation in general incurs considerable costs to the authors. By contrast, publishing with the closed-access option, authors still enjoy the journals' prestige but without bearing any cost.

The disadvantage of publishing with the subscription-only-access option – the danger of low visibility – may be alleviated by freely available preprints (a form of free open access). These are earlier versions of papers published in peer-reviewed journals, usually without the latest review-based changes and not in the journal-style edition. One of their functions is to bridge the time-consuming process of peer-reviewed publication (which can take several years) and create an immediate availability of newest research – though having not yet passed the (often lengthy) quality control mechanisms of peer-review (so-called *working papers* or *discussion papers*). However, preprints may also alleviate the disadvantage of publishing with the subscription-only-access option: if, at the end of the process, a publication in a subscription-based accessible prestigious journal co-exists with a freely available preprint, then reputation and visibility can be achieved without the authors having to pay a high (APC) price. Thus, the combination of closed-access publication and free preprint may be an imperfect substitute for OA publishing in the eyes of authors. At the same time, the preprints also represent an alternative for readers wanting access to the papers, which should lower the market power of the journal publishers.

In the context of this study, it is important to consider that preprint practices differ across disciplines. Scholars in some disciplines of Social Sciences favor preprints and even cite preprints in their papers (Whitley, 2000; Fry, et al., 2016). By contrast, in Health and Life Sciences, articles are only published in peer-review journals and remain invisible before

(Whitley, 2000; Fry, et al., 2016). Hence, while the combination of preprints and closed-access journal publications may represent an acceptable option from the perspective of Social Sciences authors, the expensive OA option of a prestigious journal may be seen as an important and necessary enhancement of the closed-access option for scholars in Health Sciences and Life Sciences – particularly given the good availability of (external) funding for APCs. If established publishers extract supracompetitive rents due to market power, APCs should be observed the highest in Health Sciences and Life Sciences and lowest in Social Sciences due to the field-specific situations. Market power should have the strongest impact on APCs in Health Sciences and Life Sciences, whereas it should be lowest in Social Sciences.

Hypothesis: Market power has a higher impact on APCs in Health Sciences and Life Sciences than in Physical Sciences and Social Sciences.

3. Data and Method

To test our hypothesis, we conduct multivariate regressions, taking the following variables into account: market power (as our prime interest), journal reputation, citations, number of articles per journal, profit types (non-profit/for-profit), and publisher age. We construct market power from two variables, namely hybrid and big publisher. As pointed out, a hybrid journal is a journal that offers a gold-OA publishing option, while keeping the traditional subscription model as a default. As reported, hybrid journals, which usually belong to incumbent publishers, charge higher APCs in their OA option than gold journals (Morrison, et al., 2015; Pinfield, et al., 2016; 2017). Due to indirect network effects, when looking at the publishing market as a two-sided market (Jeon & Rochet, 2010; Armstrong, 2015; McCabe & Snyder, 2007; 2018), authors respond more elastically to the price for OA publishing than readers for accessing an article (stronger indirect network effect from authors to readers than vice versa). Thus, the publisher as a platform would actually like to charge readers and cross-subsidize authors. Consequently, the ability to extract rents from the market is more limited in the OA model.

Additionally, with open access, for-profit publishers cannot enjoy excess rents by subscription bundles anymore. Publishers enjoying market power experiences incentives to keep as many authors and readers in the old system as possible. Introducing a hybrid version allows for offering authors a choice to stick to the old, closed-access model or pay for getting OA. The incentive for the publisher is then to set APCs on a high level in order to (i) push authors back into the closed-access model and (ii) reap revenues from those authors (or their financial

backers) displaying a high willingness-to-pay in order to compensate for the loss of supracompetitive rents. Thus, established publishers may keep their revenue stream up while, at the same time, hampering the attractiveness of OA publishing. By contrast, publishers of gold OA journals need to earn all their revenues through OA and cannot afford to restrict their offers to authors with a high willingness-to-pay (as long as they cannot price-discriminate between authors according to their individual willingness-to-pay). Therefore, we consider hybrid journals as publishers' attempt to sustain their market power (Budzinski et al., 2020). This should be the case also for the top five publishers above all. Across all disciplines, they own more than 45 per cent of the total number of articles according to the data of "CiteScore Metrics Scopus".² Market concentration in a field also is a relevant factor in driving APCs. However, it also is a fixed effect in the respective disciplines, for which we employ dummies. Including the fields as dummy variables, we could explain more variance in APCs than with market concentration. This is also one of the findings in Budzinski et al. (2020).

To proxy reputation, as one of the further drivers of APC, we use the Source-Normalized Impact per Paper (SNIP) from Scopus. In order to see the field-specific effects of market power, interaction terms of each field with hybrid and each field of big publishers are added, e.g. *Health Sciences x hybrid*, *Health Sciences x big publishers*. Journal reputation (SNIP), citation, number of articles, and publisher age are cardinal variables. Hybrid (hybrid or gold), big publishers (big or not), profit type (for-profit or non-profit) are dichotomous variables. Fields are four dummy variables (Health Sciences, Life Sciences, Physical Sciences, and Social Sciences).

In the following, we briefly describe the three datasets we use from DOAJ, "OpenAPC Initiative" and Scopus.

DOAJ

From DOAJ, we extract the information of the OA type gold, the publisher and the APC of gold OA journals. DOAJ is an online gold OA journal directory (<https://doaj.org/>). It is a cross-sectional journal-level dataset with 13,436 entries. Hence, all data entries are considered as the most updated information. Any journal found in DOAJ is counted as a gold OA journal. Entries with no APC or zero APC are excluded. After excluding the data, there are 3,547 titles left. As DOAJ is a global repository, APCs are registered with different currencies. We employ the Purchasing Power Parity (PPP) from the Organization for Economic Co-operation and Development (OECD) to convert APC into USD.

² This is the count of big publishers according to the CiteScore Metrics Scopus database from 2011 to 2018.

“OpenAPC Initiative”

From the “OpenAPC Initiative”, we obtain the information about the kind of OA journal (hybrid vs. gold) and the value of APC. The “OpenAPC Initiative” is an open source project collecting APC information offered by participating universities and research institutions (<https://www.intact-project.org/openapc/>). It is located at Bielefeld University Library, supported by German Research Foundation and the Federal Ministry of Education Research. By 2019, it contains information of 81,293 articles from 2005 to 2019 contributed by 241 universities and institutes. Unfortunately, the “OpenAPC Initiative” does not provide a balanced panel although the database contains repeated cross sections. In order to produce a journal-level cross-sectional data of 2018, the mean APC is calculated. We converted APCs from originally EUR into USD using PPP from OECD.

“CiteScore Metrics Scopus”

We keep the information of SNIP, number of articles, citations and subject fields from “CiteScore Metrics Scopus”. The data is downloaded from Scopus’ website (<https://www.scopus.com/sources>). It is a panel data of 52,531 journals from 2011 to 2018. Since we have to turn the longitudinal data into a cross section in the year of 2018, we take the mean of SNIP, the number of articles and citations are summed up. If there is any unmatching information of publishers, we select the latest and the most frequent information. Finally, 25,006 observations remain.

“Profit type and publisher age”

The information of publisher profit types and the years of establishment are collected manually from publishers’ websites. Publisher age is calculated by deducting the establishment year with 2018.

Finally, we merge the data of DOAJ, “OpenAPC Initiative” and “CiteScore Metrics Scopus” by ISSN, the information of publisher profit types and the foundation year of publishers by the publisher information. After merging the different data sources, the final database includes 2,887 titles.

In order to perform our analysis, we firstly run four separate regressions for each of the four fields to see how the variables of market power perform in each field. Secondly, we run the combined model by including the four fields as dummy variables. Thirdly, to see the marginal effects of market power in different subject fields, we add another model where we interact the variable market power with the four subject fields, respectively.

4. Results

Table 1. Descriptive statistics.

	Obs.	Mean	Std. Dev.	Min.	Max.
APC	2,887	2,162.97	1,314.41	12	7,501.93
SNIP	2,837	1.09	0.72	0	8.75
Hybrid	2,887	0.60	0.49	0	1
Age	2,565	134.54	89.78	6	500
For-profit	2,571	0.83	0.38	0	1
Citations	2,887	8,675.4	25,324.8	0	469,880
No. of articles	2,887	2,678.8	5,538.2	1	124,290

Table 1 shows the descriptive statistics. Since we collected the information about age and profit orientation of publishers from their websites, we had to exclude publishers without a searchable website from our study. The average APC of our dataset is 2,163 USD. The minimum is 12 USD while the most expensive outlet reaches 7,502 USD showing a big variance in the APCs among journals. The mean SNIP is 1, the difference between the highest score and the lowest is 8.75. The gap between highest ranked journal and lowest is almost 9 scores. On average every article in the dataset is cited once, but there are also journals included which articles are never cited (0) and others which articles are cited on average almost 9 times. The publishers range from 6 years old to 500 years old with an average of 135 years old, which demonstrates that most of the publishers in our data are not that young. Citations and number of articles are the sum of the years 2001 to 2018. Both of them contain huge variance, too. In our dataset, 60 per cent of the titles are hybrid journals and 83 per cent are for-profit journals. Commercial publishers and big publishers seem to take up the majority of the journals.

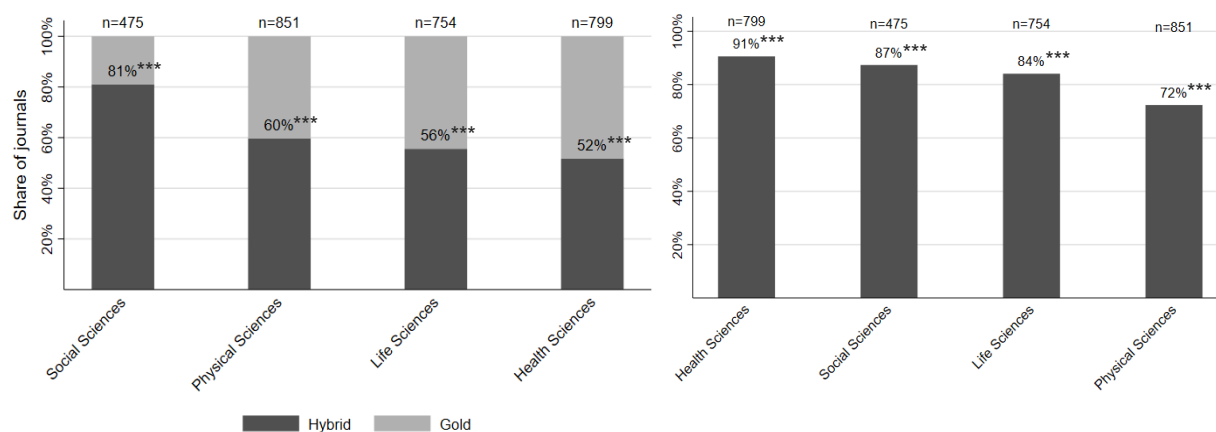
Table 2. ANOVA of APC, SNIP, age, citations and number of articles by subject fields.

	Social Sciences	Life Sciences	Physical Sciences	Sci-ences	Health Sciences	Sci-ences	F-Stat.
N	475	754	851		799		
APC	1,958.7	2,359.5	2,005.6		2,276.8		15.76***
SNIP	1.03	1.06	1.2		1.03		14.13***
Age	155.4	136.2	128.0		126.6		10.45***
Citations	1,425.5	10,741.2	13,058.2		6,396.9		25.89***
No. of articles	867.1	2,871.2	3,853.2		2,333.5		31.95***

***p<0.001, ** p<0.01, * p<0.05

Note: the numbers in the table represent mean APC, SNIP, age, citations and number of articles within each subject field.

The means of APC, SNIP, publisher age, citations and number of articles in each discipline are presented in Table 2. Life Sciences charges the highest APC, followed by Health Sciences and Physical Sciences, while Social Sciences comes in the last place., which is consistent with the study of Solomon and Björk (2012a), who report that Life Sciences and Health Sciences enjoy lavish grants and funding resources. Physical Sciences demonstrates the highest SNIP, which does not comply with the description in previous studies, which, for example, claim that Health Science performs best in SJR (Miguel, et al., 2011; Ennas & Di Guardo, 2015) and JCR (Giglia, 2010; Gumpenberger, et al., 2013). Physical Sciences have the most citations and number of articles in 8 years, which goes in the same direction as SNIP. The average age of publishers is more or less the same across fields with the exception of Social Sciences having publishers about 20 years older than the others.



Note: ***p<0.001, ** p<0.01, * p<0.05

a.

b.

Fig. 1. Shares of hybrid journals (a.) and for-profit journals (b.) in four subject fields.

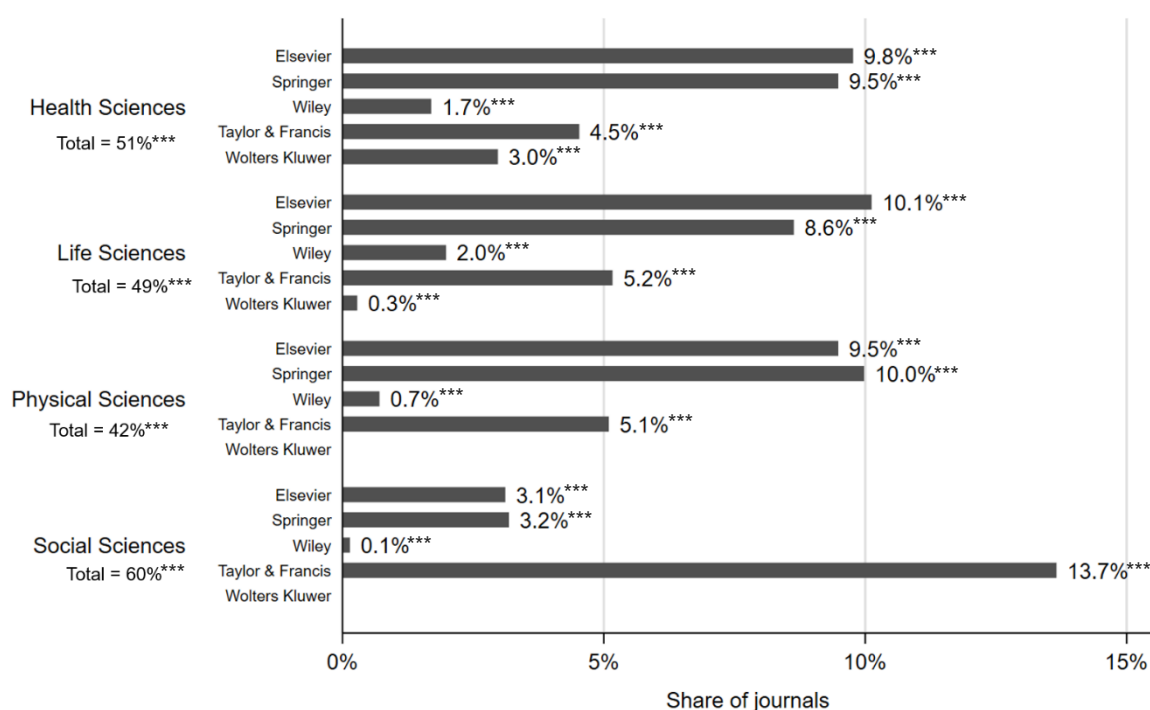
Table 3. Shares of hybrid journals in for-profit journals.

	For-profit Gold	Hybrid	Total
Social Sciences	42 12%***	318 88%***	360 100%
Life Sciences	235 42%***	331 58%***	566 100%
Physical Sciences	239 44%***	308 56%***	547 100%
Health Sciences	308 47%***	348 53%***	656 100%
Total	824 39%	1,305 61%	2,129 100%

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

With 81 per cent, Social Sciences has the largest share of hybrid journals, followed by Physical Sciences with a share of 60 per cent (see Fig. 1a), Life Sciences and Health Sciences with a bit less but still above 50 per cent. By contrast, shown in Fig. 1b, Health Sciences has the highest share of for-profit journals, which is 91 per cent. The lowest with a share of 72 per cent is Physical Sciences. The shares of hybrid journals and for-profit journals seem to be quite close in Social Sciences (81 per cent and 87 per cent, respectively) and Physical Sciences (60 per cent and 72 per cent, respectively). Both the share of hybrid journals and the share of for-profit journals across four discipline fields are examined with Chi² Test, and both have the p-values less than 0.1 per cent, which means both shares are significantly different across four fields.

In order to see, if the journals employing the hybrid model and the ones belonging to for-profit publishers overlap, we make a cross-table of discipline fields by OA models among for-profit journals (shown in Table 3). The majority of for-profit journals are using hybrid OA model in all four fields. As it is indicated in Fig. 1, the biggest overlap is in Social Sciences which accounts for 88 per cent. The significant result of a Chi² Test means the shares of for-profit journals applying hybrid model are significantly different across four fields.



Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. The percentages of the left-hand side are calculated based on the samples in each field respectively, while the percentages on the right-hand side are based on the total sample.

Fig. 2 Shares of journals belonging to the big publishers in each field.

Fig. 2 displays the compositions of the top five publishers in each subject field. On the left-hand side, we depict the shares of journals belonging to the top five publishers within each field (calculated within the observations of each field), on the right-hand side, the shares belonging to each top five publisher and each field respectively (the numbers of the bar labels are calculated based on the total observations of big publishers). Hence, we have 20 subgroups (5 publishers x 4 fields). All the shares are examined with χ^2 Test ($p < 0.001$) and it shows the shares of journals owned by top five publishers are significantly different across four fields, as well as the shares of journals belonging each big publisher differ significantly across four fields. On the left-hand side, Social Sciences has the highest share of journals belonging to the big publishers (60 per cent), which might also be the case, because this discipline has the highest share of hybrid journals. This result, at first glance, appears to be in conflict with the existing literature of Larivière et al. (2015), who, however, focus on academic journals in general rather than on OA publishing. Regarding the shares of journals belonging to the 20 subgroups (see right-hand side in Fig. 2), the highest share are taken by journals of Taylor & Francis in Social Sciences (13.7 per cent). The journal portfolios of Springer and

Elsevier are quite similar. Both hold journals distributed evenly across Life Sciences, Health Sciences and Physical Sciences, with around 10 per cent each. Wiley and Wolters Kluwer own fewer journals than the remaining three big publishers. Wiley concentrates mostly on Health Sciences and Life Sciences. Wolters Kluwer is a company providing diversified services in various industries but only focuses on the clinical area when it comes to research. We did not find any journals in Physical Sciences or Social Sciences from this publisher.

Table 4. Correlation matrix.

	APC	SNIP	Hybrid	Big publishers	Age	Citations	No. of article	For-profit
APC	1.00							
SNIP	0.41*	1.00						
Hybrid	0.62*	0.30*	1.00					
Big publishers	0.35*	0.12*	0.31*	1.00				
Age	0.26*	0.13*	0.23*	0.22*	1.00			
Citations	0.23*	0.32*	0.19*	-0.04	0.04*	1.00		
No. of article	0.17*	0.15*	0.18*	-0.04	0.02	0.77*	1.00	
For-profit	-0.07*	-0.20*	-0.12*	0.50*	-0.32*	-0.24*	-0.20*	1.00

Note: * denotes the p-value is at least less than 0.05.

Compatible with the research of Budzinski et al. (2020) and Schönfelder (2018), the variables impact factor (SNIP), hybrid, and big publishers positively correlate with APC (see Table 4). Age, citations and the number of articles all show positive relationships with APC as well. However, for-profit seems to be negatively correlating with APC and hybrid, even though the coefficients are rather small, -0.07 and -0.12, respectively. The connection between citations and big publishers, as well as the relation between number of articles and big publishers are not significant. The strongest correlation in Table 4 is between citations and the number of articles (0.77).

Six regression models are presented in Table 5. The first four models are regressions run for each field individually, i.e. Social Sciences (SS), Life Sciences (LS), Physical Sciences (PS) and Health Sciences (HS), having sample sizes of 408, 662, 750 and 697. Model 1 to 4 are using sub-samples of each field. Model 5 (Four fields) and Model 6 (With interaction terms) use the pooled sample including the four discipline dummies. In order to see the marginal effects of market power in each field, we include the interacted variables in model 6. In the models with the discipline dummies (model 5 and 6), Social Sciences serves as the base category.

Table 5. Regression table.

	1	2	3	4	5	6
	SS	LS	PS	HS	Four fields	With interaction terms
Hybrid	1,202*** (153.31)	1,402*** (82.38)	1,138*** (75.70)	1,177*** (81.40)	1,216*** (44.56)	1,110*** (148.21)
Big publishers	374.9*** (130.34)	470.5*** (101.88)	449.1*** (100.16)	483.6*** (89.99)	397.4*** (52.05)	21.46 (105.01)
LS x Big pub.						1,081*** (109.88)
PS x Big pub.						421.6*** (79.04)
HS x Big pub.						994.9*** (78.54)
Life Sciences					820.0*** (61.18)	
Physical Sciences					336.1*** (61.06)	
Health Sciences					822.2*** (60.73)	
SNIP	-128.5 (118.58)	297.2*** (72.25)	154.7*** (44.75)	636.2*** (61.74)	378.8*** (29.07)	368.1*** (29.03)
For-profit	-1,077*** (217.87)	223.6 (142.46)	42.66 (110.70)	-321.3* (164.01)	-26.59 (72.16)	-102.6 (75.39)
Citation	0.142*** (0.04)	0.013*** (0.00)	0.003** (0.00)	-0.004 (0.01)	0.003*** (0.00)	0.004*** (0.00)
No. of article	-0.330*** (0.10)	-0.029* (0.02)	-0.002 (0.01)	0.031 (0.02)	-0.0002 (0.01)	-0.0003 (0.01)
Publisher age	1.836*** (0.65)	1.140** (0.49)	1.092** (0.46)	0.770 (0.49)	1.555*** (0.25)	1.312*** (0.26)
Constant	1,663*** (280.02)	695.9*** (166.63)	798.0*** (129.34)	986.7*** (186.92)	126.8 (98.52)	596.2*** (167.53)
Observations	408	662	750	697	2,517	2,517
R-squared	0.316	0.518	0.435	0.531	0.450	0.459
R2 (adj)	0.304	0.513	0.430	0.526	0.448	0.455

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Note. Since coefficients of the interaction terms field x hybrid are not significant, they are not shown on the table.

As mentioned, we interpret market power with the influence of two variables, hybrid and big publishers. Hybrid displays a positive effect across all the models and turns out as the strongest effect among all the variables. In the case of Life Sciences, hybrid has the biggest impact on APCs. Authors pay about 1,402 USD (see model LS) more in comparison to a gold OA journal. Looking at Model 6, a hybrid journal charges 1,110 USD more for OA publications than a gold journal, on average. However, the field-specific marginal effect of hybrid is not significant. It means that hybrid has the strongest impact on APC across all fields with no discrimination.

The publication fee, as suggested by the literature, is the lowest in Social Sciences (compare model 5). Health Sciences and Life Sciences exhibit the highest mean APC with 822 USD and 820 USD more than Social Sciences, respectively. The average APC of Health Science is 949 USD ($822+127=949$ USD) and Life Sciences is 947 USD ($820+127=947$ USD).

The impact of big publishers is significant throughout model 1 to model 5. Looking at the four fields separately, a journal from one of the top five publishers (i.e. Elsevier, Springer, Wiley, Taylor & Francis, and Wolters Kluwer) in Social Sciences tends to bring up the APC by 375 USD (see model 1), which refers to 60 per cent of the journals in Social Sciences (see Fig. 2), while in Health Sciences, it would become 51 per cent of the journals requesting 484 USD more when compared to the rest (see model 4 and Fig. 2). Including all fields, journals owned by top five big publishers are 397.4 USD more expensive (see model 5). From Model 6, we can see the marginal effect of big publishers in each field. Journals of big publishers charge the most in Health Sciences and Life Sciences, 1,591 USD ($995+596=1,591$ USD) and 1,677 USD ($1,081+596=1,677$ USD), respectively. In Physical Sciences, big publishers are still able to charge 422 USD more compared to the base category, i.e. Social Sciences no big publisher. To conclude, market power, as proxied by the variables hybrid and big publishers, plays the biggest role in Health and Life Sciences, the lowest in Social Sciences. In other words, the differences across the four fields in terms of publication habits and endowment levels allow publishers to exploit their market power to different extents.

5. Discussion and Conclusions

The study investigates whether publishing giants adjust their market power-based rent-seeking strategies according to the special circumstances in different disciplines, in particular (i) different willingness-to-pay by authors because of differences in discipline endowment (funding) and (ii) the relevance of the visibility of journal articles because of the (non-) existence of (imperfect) substitutes for access (preprints). The results suggest that Health Sciences and Life Sciences, i.e. the fields with the highest financial endowments and a lack of substitutes for accessing non-OA papers, display the highest APC levels, whereas Social Sciences, i.e. a field with a lower willingness-to-pay and widespread use of preprints shows significantly lower prices. Thus, the discipline-specific effect of market power on APCs is the smallest in Social Sciences and the strongest in Health Sciences and Life Sciences, supporting our hypothesis. In addition, we could show – in line with the existing literature – that the strategy to amend the traditional subscription-based model with an OA option, i.e. to create so-called

hybrid journals, pays off for established publishers. They seem to be able to convey their market power from the traditional to the new world of digital publication.

To what extent powerful publishers can score supracompetitive rents depends, *inter alia*, on some features of the publishing markets in the respective disciplines. For instance, publishers with market power manage to exploit the superior funding opportunities that exist in some disciplines. In Health Sciences and Life Sciences, researchers receive substantially more financial support compared to Social Sciences. This implies that academic authors in these fields can at least partly pass the market power rents levied on them by publishers through to the funding institutions. This pass-through possibility increases the willingness to pay expensive APCs of authors in these fields. Moreover, in these fields, researchers also lack good substitutes for paid-OA publishing when it comes to creating visibility of and access to their work. Particularly in Social Sciences, the preprint culture limits the market power of the publishers because other researchers may use an imperfect substitute to accessing the journal article.

As our empirical exercise shows, in spite of roughly homogeneous production costs of publishing OA journals across publishers, which we believe to be a legitimate assumption, APC to be paid by libraries/authors vary significantly across disciplines and publishers, which to a large extent can be attributed to their market power – even when controlling for reputation.

This insight should be considered when designing the institutional framework for this market. Due to the buyers in the old model being mostly university libraries and due to authors being predominantly university researchers – both with a significant share of public funding (although differing across countries) – taxpayer money plays an important role in this market. If governments and regulators want to promote OA publishing of scientific insights, they will likely look to support authors from public research organizations to pay APCs – as it is already happening or being negotiated in many countries. However, while this may succeed in triggering more authors to choose the OA option in hybrid journals, it also makes authors less price sensitive: if someone else pays the price, the willingness-to-pay by the authors increases. Thus, financial support for authors publishing in hybrid OA journals also contributes to prolonging and maintaining supracompetitive rents for commercial academic publishers. The question is, then, whether taxpayers really should finance rents and profits of academic publishers.

So, do the goals of promoting OA publishing and preventing market power rents in the market for academic publishing contradict each other (creating a dilemma situation)? A way forward

could be to support authors in paying APCs for gold OA journals as well as for journals of non-for-profit academic publishers. The first do not look to recover lost rents from the old model and experience stronger incentives to respond to competitive pressure, also because they often cannot build upon a persistent reputation advantage. The second look more for covering their costs than for creating profits. And in contrast to the large majority of gold OA journals, some journals from non-commercial academic publishers actually enjoy high reputation. Financial support for OA options of commercial academic publishers could then be limited to what the other two types charge. Another avenue would be to erode the reputation advantage that many hybrid journals enjoy vis-à-vis gold OA journals by helping the latter to build up competitive reputation. With roughly equal reputation (across journal types, not necessarily across journals), authors are more likely to go for the better prices, i.e. lower APCs, creating an effective competition. However, this may be a long process and it is rather unclear how this may work in detail. Similarly, the academic communities who provide non-paid-for input to this market as authors, editors and reviewers anyway, may engage stronger in developing and publishing online-only academic journals without commercial interest. In the digital online world, moreover, alternative forms of peer-reviewed outlets and repositories may create new competitive pressure for traditional types of academic journals.

So far, the insights we gained in this study lead us to conclude that the transformation toward open access publishing fails to change relevant deficits of the old system when creating a new system, in which scientific knowledge is publicly accessible without any pay walls and barriers. Big publishers remain powerful also in the new world of open access publishing and there is indication that they are able to leverage their market power into the new system, perhaps even corroborated by taxpayer money.

Acknowledgement

We thank Jens Wolling for valuable comments to an earlier version of this paper.

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Appendix 1

The classification of disciplines to fields according to Scopus

Fields	Disciplines
Health Sciences	Medicine Nursing Veterinary Dentistry Health Professions
Life Sciences	Agricultural and Biological Sciences Biochemistry; Genetics and Molecular Biology Immunology and Microbiology Neuroscience Pharmacology; Toxicology and Pharmaceutics
Physical Sciences	Chemical Engineering Chemistry Computer Science Earth and Planetary Sciences Energy Engineering Environmental Science Materials Science Mathematics Physics and Astronomy
Social Sciences	Arts and Humanities Business; Management and Accounting Decision Sciences Economics; Econometrics and Finance Psychology Social Sciences

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