

# 1 Disclosing funding sources for open 2 access publication fees: the Open APC 3 initiative

4 Najko Jahn<sup>1</sup> and Marco Tullney<sup>2</sup>

5 <sup>1</sup>Bielefeld University Library, Bielefeld University, Bielefeld, Germany

6 <sup>2</sup>German National Library of Science and Technology (TIB), Hannover, Germany

## 7 ABSTRACT

8 Publication fees in open access publishing hold a prominent place on the agenda of researchers, policy-  
9 makers, and academic publishers. This paper contributes to the evolving empirical basis on open access  
10 funding. It describes the Open APC initiative, in which German universities and research organizations  
11 share their expenditures for publication fees. As method, the initiative uses existing open data tools to  
12 aggregate and disseminate institutional spending on open access publication fees. In total, 29 German  
13 research organizations self-reported funding of 6,279 open access journal articles, which amounted to  
14 8,039,339 €. The average payment for each article was 1,280 €, and the median payment 1,209 €. Our  
15 data-set comprises only 53 articles in hybrid journals. With an indexing coverage of 99 %, the findings  
16 reveal that the DOI agency CrossRef provides both comprehensive bibliographic coverage of the funded  
17 open access journal literature and disambiguated names of journal titles and publishing houses. We  
18 show that authority control of these bibliographic information is particularly relevant for the comparative  
19 study of the economical effects of open access publishing.

20 Keywords: Open access, open access journal, scholarly publishing, publication fees, article processing  
21 charges, science policy

## 22 INTRODUCTION

### 23 General Background

24 The rise of open access journals matches the increasing relevance of publication fees in academic  
25 publishing (Davis and Walters, 2011; Laakso and Björk, 2012; Pinfield, 2015). To cover these fees, also  
26 referred to as article-processing charges (APC), authors tend to make use of funding that grant agencies or  
27 academic institutions provide (Suber, 2012). Yet, how and to what extent these research support activities  
28 are effective in terms of the number of supported articles and associated costs remains under debate.

29 The analysis of APC spending is difficult. The total spending is fragmented across the budgets of grant  
30 agencies, research institutions, and libraries, or is covered by personal budgets. Asking 9,645 authors  
31 from various disciplines how they financed publication fees, a comprehensive survey in 2010 revealed  
32 that the majority of the respondents had access to research funding or institutional support to cover these  
33 charges. By contrast, 12 % paid publication fees individually (Dallmeier-Tiessen et al., 2011). These  
34 findings are consistent with that of other studies, adding that sources of funding mostly exists in higher  
35 income countries, mainly to support research articles in the bio- and physical sciences (Solomon and  
36 Björk, 2011). Personal budgets, on the other hand, are likely used to cover low price publication fees  
37 (Björk, 2015; Solomon and Björk, 2011).

38 Another key problem in this regard is that funding for open access journals using publication fees  
39 lacks transparency because the parties involved - authors, universities, funders, publishers - neither  
40 release information on who pays for what nor the costs of publishing (Björk and Solomon, 2014), a  
41 situation similar to the lack of transparency regarding journal subscriptions (Lawson and Meghreblian,  
42 2015). Empirical studies examining publication fees so far obtained price estimates by surveying  
43 authors (Dallmeier-Tiessen et al., 2011), or from journal websites. Using the latter method, two studies  
44 investigating journals across a broad range of disciplines calculated similar price averages that ranged  
45 between 904 \$ (Solomon and Björk, 2012) and 923 \$ (Walters and Linvill, 2011), as well as considerable

price variances across journals and publishers. Accordingly, Solomon and Björk (2012) suggested to cluster fully open access journal using publication fees into several groups. In descending order, these are high-impact journals, followed by biomedicine journals from commercial publishers, large multi-disciplinary journals, and mid-price journals from commercial publishers covering a large spectrum of disciplines. Lower priced journals were published by academic societies and by publishers from low-income countries.

Nevertheless, it remains unclear which factors contribute to pricing in academic publishing. Generally, these might include article processing, impact, rejection rates, management and investment, and profit margins (Noorden, 2013). While fixed prices for individual articles are common, agreements between publishers and institutions can lead to discounts, and publishers sometimes waive publication fees for authors from low-income countries (Björk and Solomon, 2012; Lawson, 2015c). Other factors leading to variable pricing schemes include submission or page charges (Björk and Solomon, 2012).

Hybrid journals substantially add to this complexity of open access funding (Kingsley, 2014; Pinfield et al., 2015). These journals, allowing articles to be published immediately as open access after a charge was paid, rely both on subscriptions and publication fees as revenue sources. Although the uptake of open access through hybrid journals was described as lower and more expensive compared to that of fully open access journals (Björk and Solomon, 2014; Solomon and Björk, 2012), this model has gained attention through recent science policies, notably because of open access policies from the UK (Pinfield, 2015).

To address these problems of fragmented spending on publication fees and of in-transparency about what was being paid, some European research funders and research performing institutions have recently begun to disclose their payment for publication as open data. To our knowledge, the first research funders providing such data were the Wellcome Trust (Kiley, 2014) and the Austrian Science Fund FWF (Reckling and Kenzian, 2014). The not-for-profit company Jisc followed by collecting data from UK universities (Lawson, 2015b). Disclosed as publicly available spreadsheets, these data-sets self-report what was being spent along with bibliographic information, including title, journal and publisher, and a persistent identifier to the publisher's version. Curatorial efforts focused on the disambiguation of publisher and journal titles as well as on detecting duplicates and persistent identifiers to the full text including the Digital Object Identifier (DOI) (Neylon, 2014; Woodward and Henderson, 2014). Parts of Jisc's cost data was examined by Pinfield et al. (2015). Although the average spending on publication fees remained stable across the universities, they found large price variances, as well as a varying number of articles UK universities supported between 2007 - 2014, confirming earlier studies that collected price information from journal websites.

## **Central funding for publication fees in Germany**

This paper focuses on how much German universities and research organisations spent on open access publication fees. In Germany, the Deutsche Forschungsgemeinschaft (DFG), the largest German research funder, has strongly influenced how universities manage institutional support for these charges. Before the DFG started to pay for centrally funded publication fees on a pro rata basis through its "Open-Access Publishing" program in 2011, only a few central funds existed (Eppelin et al., 2012). This is similar to the situation described in Canada (Hampson, 2014) or the UK (Pinfield and Middleton, 2012). The DFG has enforced a set of criteria grantees have to comply with (Fournier and Weihberg, 2013), leading to similar implementations for open access supporting across German universities. These criteria exclude sponsoring of articles in hybrid journals and the funding of articles whose publication fee exceeds 2,000 €<sup>1</sup>. Grantees agree not only to pay for APCs but also to find ways to improve the handling of those financial transactions. This includes central invoicing schemes and memberships, among others, agreed between university libraries and publishers that, in many cases, lead to discounts (Fournier and Weihberg, 2013).

Research institutes outside of universities, e.g. those institutes organised in the Fraunhofer-Gesellschaft, Helmholtz-Gemeinschaft, Leibniz-Gemeinschaft, and Max-Planck-Gesellschaft, are not eligible for this DFG funding program. But in response, some organizations have adopted similar processes to support authors. The Max-Planck-Gesellschaft operates their long-lasting open access activities, including handling spending and publisher agreements centrally, through the Max Planck Digital Library (Schimmer et al., 2013; Sikora and Geschuhn, 2015), while the Leibniz-Gemeinschaft set up a dedicated open access fund in 2016.

<sup>1</sup>Guidelines for the funding program can be found here: [http://www.dfg.de/formulare/12\\_20/](http://www.dfg.de/formulare/12_20/)

The evolving institutional support structures to cover open access publication fees has led to calls for an unified approach towards supporting open access journal publishing in Germany. The Allianz der Wissenschaftsorganisationen<sup>2</sup>, a science policy board representing all major research organisations in Germany, marked price transparency as one way to sustain an “adequate open access publication system” (Bruch et al., 2015). Reflecting Austrian and UK initiatives to share institutional spending on open access publication fees as open data, as well as professional discussions on open access publishing, Bielefeld University Library began to openly share its payment of publication fees in May 2014. After engaging with the working group “Electronic Publishing” of the Deutsche Initiative für Netzwerkinformation (DINI)<sup>3</sup>, other German institutions joined under the umbrella of the Open APC initiative soon after.

## Research question

The aim of the study was to examine how much German universities and research organisations spent on open access publication fees until 2015. Using self-reported cost data from the Open APC initiative, the analysis focused on the amount that was being spent on publication fees, and compared these expenditures with data from related Austrian and UK initiatives, both in terms of size and the proportion of articles being published in fully and hybrid open access journals. We also asked how thoroughly self-reported articles were indexed in Crossref, a DOI minting agency for scholarly literature, and analysed how institutional spending per articles was distributed over publishers and journal titles.

## METHODS AND MATERIALS

We analysed self-reported cost data released by the Open APC initiative on May 13, 2016<sup>4</sup> to assess institutional spending on open access publication fees in Germany. In addition to administrative data about the amount paid per article including value added tax, the reporting institution, and the year of invoicing, we used information about whether an article was published in a fully open access journal or in a hybrid journal as well as the DOI reported in the data-set.

We fetched bibliographic metadata for each article from Crossref on May 19, 2016, on the basis of the reported DOIs. Although the Open APC initiative gathered metadata representing publishers and journals from Crossref as well, this information was retrieved at the time when the participating institutions submitted their expenses. The Open APC initiative kept track of the date when these data-sets were submitted with Git, a version control system, increasingly used for enabling reproducible research (Ram, 2013), and made this information available via GitHub to be transparent over time. However, during these data collection activities Crossref had regularly updated metadata to represent ongoing mergers of publishing houses. A prominent example in this regard was the merger of the two large publishing houses Springer Business + Media and Nature Publishing Group announced on May 6, 2015, that operated as Springer Nature at the time of our study. To reflect these dynamics in academic publishing, we decided to retrieve updated metadata from Crossref for the whole Open APC data-set instead of re-using the historical publisher and journal information contained in the Open APC data-set.

As a client, we used the R package rcrossref (Chamberlain et al., 2016), developed and maintained by the rOpenSci initiative<sup>5</sup>, to access Crossref’s REST API<sup>6</sup>. We requested the XML-based format `application/vnd.crossref.unixsd+xml` in which full and abbreviated journal titles as well as the ISSN media types, the International Standard Serial Number used to identify journals, were distinguished. It also contained normalised publisher information, thus avoiding confusion about naming of publishing houses other studies were faced with when working with self-reported data (Woodward and Henderson, 2014). In cases where no bibliographic information could be obtained, we used the Open APC values. Because Crossref was not the only registration agency for DOIs, but also the agencies DataCite and Medra minted DOIs for scholarly work, we furthermore obtained the DOI agency for each article with the help of the rcrossref client.

Data collection also involved obtaining cost data from related open data initiatives. To compare self-reported spending on open access journal articles by Germany universities and research organisations with that of other initiatives, we consulted the openly available data-sets from the the Austrian Science

<sup>2</sup>[http://www.dfg.de/en/dfg\\_profile/alliance/index.html](http://www.dfg.de/en/dfg_profile/alliance/index.html)

<sup>3</sup><http://dini.de/english/ag0/e-pub0/>

<sup>4</sup><https://github.com/OpenAPC/openapc-de/tree/v2.4.3>

<sup>5</sup>rOpenSci: <https://ropensci.org/>

<sup>6</sup>[https://github.com/CrossRef/rest-api-doc/blob/master/rest\\_api.md](https://github.com/CrossRef/rest-api-doc/blob/master/rest_api.md)

147 Fund FWF (Reckling and Rieck, 2015; Rieck et al., 2016), Jisc (Lawson, 2015a, 2016) and the Wellcome  
 148 Trust (Kiley, 2015, 2016). For analysis, we obtained the overall publication fee spending on both fully  
 149 and hybrid open access journal articles. In the case of FWF, we gathered the cost information from the  
 150 accompanying spending reports. We used the spreadsheet data to calculate Wellcome Trust's and Jisc's  
 151 spending, and converted the prices from GBP to € in accordance with the average foreign exchange  
 152 reference rates provided by the European Central Bank. Our comparison of the open data initiatives  
 153 focussed on the last two years 2014 and 2015. Because Wellcome Trust's spending was reported for  
 154 the financial periods 2013 - 2014 and 2014 - 2015, we referred to the average exchange rates of the full  
 155 two-year period as we could not determine the actual invoicing dates from the data. We excluded articles  
 156 from the analysis for which either cost information or journal type was missing. In the case of Jisc's  
 157 2014 data (Lawson, 2015a), for instance, we excluded spending on 2,812 publications that amounted to  
 158 4.861.772 € from the analysis because no publication type was given in the data-set.

159 The data collection methods of the Open APC initiative and those of the other initiatives differed in  
 160 some aspects. For instance, whereas the DOI was a mandatory element in the Open APC data template that  
 161 the participating institutions were required to report, in the Wellcome Trust data a publication identifier  
 162 was added as part of the automated compliance checks. Our first screening of the data-sets revealed  
 163 that some articles lacked a DOI. For this reason, and as our main focus was institutional funding for  
 164 publication fees in Germany, we decided to only compare German APC spending with that reported by  
 165 other initiatives. We did not compare the distribution of spending over publishers and journal titles, or the  
 166 indexing coverage in Crossref.

## 167 RESULTS

### 168 Cost Data

169 After excluding payments being made for non-journal articles as well as articles invoiced in 2016, we  
 170 retrieved 7,417 open access journal articles 30 German universities and research institutions financially  
 171 supported between 2005 and 2015. As illustrated in Figure 1, payments made for open access journal  
 172 articles increased over the years. While one institution supported 5 articles in 2005, the majority shared  
 173 their expenditure from 2013 onwards. With 1,999 articles, the year 2015 was best represented in our  
 174 data-set. However, the data-set contained 27 institutions that contributed their cost data for 2015 at the  
 175 time of this analysis, suggesting a time lag between payments made and reporting these spending to the  
 176 Open APC initiative.

#### 177 Figure 1: Growth of Open APC Initiative

178 Among all articles, fees amounted to 9,627,537 € including VAT, the average payment was 1,298 €  
 179 and the median value 1,231 €. Figure 2 presents the distribution of institutional spending on publications.  
 180 We observed that 6,996 (94%) of the publication fees were paid in accordance with the DFG price cap of  
 181 2,000 €. Most payment on publications ranged between 1,000 - 1,250 €.

#### 182 Figure 2: Distribution of institutional spending on publication fees by German research organ- 183 isations

#### 184 Figure 3: Institutional spending on publication fees by German research organisations per year

185 Figure 3 presents the large price variations. Publication fees that were paid by the German universities  
 186 and research organisations ranged between 40 € and 7,419 € (SD 486). However, the average price paid  
 187 varied somewhat during the period 2011 and 2015 (1239 - 1423 €). Average publication fee spending per  
 188 article in Germany was 1,298 (Median = 1,231 €, SD = 486 €).

189 The number of APC payments per institutions varied considerably (see Table 1). With 2,856 reported  
 190 articles, the Max Planck Society contributed 39 % of the overall submissions. By contrast, several  
 191 universities that only recently begun to set up support structures for fee-based open access journal articles  
 192 reported low numbers of payments.

#### 193 Table 1: Institutional spending on open access publications (in €)

### 194 Comparison of related cost data-sets

195 Table 2 compares Open APC spending data with that of the Austrian FWF, as well as with Jisc's and  
 196 Wellcome Trust's expenditure. Prices were converted according to the average Euro exchange rate of the  
 197 examined periods, and gathered for both fully and hybrid open access journals. The comparison reveals  
 198 that the Open APC initiative lacked cost information about hybrid journals, whereas the related Austrian  
 199 and UK open data initiatives could report a large share of spending on these journals between 2014 and

200 2015. This situation presumably reflected the importance of the DFG as funding source for publication  
 201 fees in Germany. The DFG funding policy excluded support for publications in hybrid journals. Over the  
 202 years 2005 – 2015, 3 out of 30 German universities and research institutions reported 60 hybrid journal  
 203 articles to the Open APC initiative, representing 0.81 % of the overall supported article volume. In terms  
 204 of the number of supported articles and the amount being spent on publication fees, by contrast, the Open  
 205 APC data-set provided the most comprehensive price information for fully open access journals compared  
 206 to what the Austrian and UK initiatives had reported.

207 Comparison of average prices suggests that publishing in hybrid journal was more expensive than  
 208 in fully open access journals. Price differences between these two categories were also reported earlier,  
 209 indicating that prices for fully open access journals were typically lower (Pinfield et al., 2015; Solomon  
 210 and Björk, 2012). In 2014 and 2015, the mean price for fully open access journals calculated from all  
 211 data-sets was below the DFG price cap of 2,000 €.

## 212 **Crossref indexing**

213 To identify publication fee spending on the article-level, as well as to gather bibliographic metadata, DOIs  
 214 were a mandatory part of the Open APC initiative's data collection activities. The participating institutions  
 215 reported DOIs for 7,373 out of 7,417 articles. Using these DOIs, we retrieved additional metadata from  
 216 Crossref for 7,346 publications, representing 99 % of the total article volume. Articles for which no  
 217 metadata could be obtained, were registered with the DOI agency DataCite (10 articles) or Medra (two  
 218 articles). For eight articles, our parser could not gather the XML resource, although these publications  
 219 were registered with Crossref at the time of our study. Seven DOIs reported to the Open APC initiative  
 220 did not resolve.

## 221 **Cost data by publisher and journal**

222 We used the DOI to automatically fetch publisher and journal names for each article from the Crossref  
 223 REST API. Table 4 shows the top ten publishers in terms of payments made that represented 92 % of  
 224 the overall spending on publication fees. In total, payments were made to 139 publishing houses. In  
 225 comparison with data from the UK, some open access publishers have a greater share on total spending.  
 226 Pinfield et al. (2015), for instance, reported remarkably lower numbers for the open access publishers  
 227 MPDI, Copernicus, and Hindawi.

### 228 **Table 2: Publication fees paid per publisher (in €)**

229 Most of publication fee spending in Germany was on articles published in Springer Nature journals,  
 230 most likely profiting from the merge with the open access publisher BioMed Central in 2008, and that  
 231 between the well-established publishers Springer Science + Business Media and Nature Publishing Group  
 232 in 2015. Using the Crossref-Member-ID instead of the publisher name, we were able to differentiate  
 233 between journals formerly published by Springer Science + Business Media and Nature Publishing Group.  
 234 In terms of articles, the majority of payments made were for publications in journals formerly associated  
 235 with Springer Science + Business Media. Springer Science + Business Media journals accounted for 2,027  
 236 articles, representing 94% of the overall Springer Nature article volume in the Open APC data, and 92 %  
 237 in terms of the amount being spent. Median publication fee spending slightly differed between Springer  
 238 Science + Business Media (1,355 €) and Nature Publishing (1,386 €). However, price variation was  
 239 higher for Nature Publishing journals (SD = 848€) compared with that of the former Springer Science +  
 240 Business Media titles (SD = 313 €).

241 In contrast to Springer Nature, other well-established publishing houses such as Elsevier and Wiley-  
 242 Blackwell rank lower in our analysis. Table 2, furthermore, illustrates the price variations across and  
 243 within publishers, which confirms earlier findings (Pinfield et al., 2015; Solomon and Björk, 2012).

### 244 **Table 3: Publication fees paid per journal (in €)**

245 Prices also varied within single journals. Based on the number of articles paid for, Table 3 illustrates  
 246 the top ten out of 732 journals. Payments to these journals represent 45 % of the overall expenditure. The  
 247 multidisciplinary journal PLOS ONE and the journals New Journal of Physics, Atmospheric Chemistry  
 248 and Physics Discussions and Frontiers in Psychology, all of which publish contributions from all branches  
 249 of their respective discipline, were also well represented in the Open APC data-set. In general, an  
 250 estimated 14 out of more than 10,000 journals registered in DOAJ in 2015 accounted for up to 15–20 %  
 251 of all articles published in fully open access journals (Björk, 2015) In the case of Atmospheric Chemistry  
 252 and Physics Discussions, the large price range can be explained by the fact that this journal charges per  
 253 page and also takes the submission's file format into consideration.

## DISCUSSION

In Germany, institutional spending on publication fees charged by open access journals has increased over the years. These findings are consistent with the general trend of publication fees as revenue source for open access publishing (Davis and Walters, 2011; Laakso and Björk, 2012; Pinfield, 2015). They also reflect the increasing importance of providing central support to cover these charges (Fournier and Weihberg, 2013; Kingsley, 2014). Similar to investigations of the expenditure on publication fees at an institutional level in the UK (Pinfield et al., 2015), spending size varies across the German universities and research organisations included in the Open APC initiative. With a proportion of 39 % of the overall number of articles, the Max Planck Society, a large non-university research organisation, supported most open access journal articles. This likely reflects the centralised library support at the Max Planck Society where the Max Planck Digital Library has managed large open access agreements with publishers over the last decade (Schimmer et al., 2013, Sikora and Geschuhn (2015)) leading not only to a large number of supported articles but also to an advantage in monitoring and thus being able to report on this data. Many universities and research organisations, on the other hand, reported a remarkably lower number of supported articles.

To answer data curation issues while unifying spending data raised by UK initiatives, re-using DOIs to gather bibliographic metadata from Crossref is a promising approach. In our study, Crossref thoroughly indexed open access journal articles disclosed in the Open APC data-set, providing publisher and journal titles for 99 % of the overall article volume. Making use of metadata from Crossref, therefore, reduces the extensive validation work of bibliographic information provided that the DOI is made available in the cost data, a requirement needed to be addressed also in other fields of the quantitative study of scholarly communication (Haustein, 2016). Drawing on Crossref would also increase the comparability of cost data to prepare future negotiations with publishers on open access agreements, because Crossref's metadata reflects the current landscape of academic publishing in terms of ongoing mergers of publishing houses or name changes. Comparative studies of publication fee spending using data on the article-level would also benefit from such an approach.

This study is limited in some respects. One is that we cannot assess whether publishers and journals granted publication fee discounts because the Open APC initiative, dedicated to make self-reporting easy by using a minimal data schema, does not track this kind of information. However, large price ranges of particular journals suggests that varying pricing schemes are in place, an observation also made earlier (Solomon and Björk, 2012, Pinfield et al. (2015)). Adding to this complexity, it is likely that some institutions only paid parts of the publication fee. Take for instance the journal *Nature Communication*. Charges reported to the Open APC initiative ranged between 2000 €, the DFG price cap, and 4,403 €. Although such payments made from several budgets are a proposed strategy to sustain publication funds at German universities (Fournier and Weihberg, 2013), these pro rata amounts cannot be identified as such within the Open APC data, leading to a possibly flawed representations of publication fee spending in Germany. In another case, one university included its contributions to the SCOAP<sup>3</sup> consortia and presumably divided the sum by the articles published by their authors in SCOAP<sup>3</sup>-covered journals.<sup>7</sup> This is very arbitrary, since the mean APC for an institution can only be determined after the end of a full 3-year funding cycle.

It must also be noted that reporting to the Open APC initiative is voluntary. Therefore, not all institutions in Germany that provide central funding of publication fees contribute cost data to this initiative. In a qualitative survey, asking why German institutions are reluctant to share their cost data through the Open APC initiative, one institution feared that increase in transparency would allow publishers to adjust prices in their favour. Others pointed out that the workload to produce such a data-set could be too extensive (Deppe, 2015). As no complete registry of institutional open access funds or similar support structures exists, we cannot assess the number of non-participants in Germany.

Our analysis of how institutional spending per articles was distributed over publishers and journal titles indicates that open access publishing is heterogeneous and concentrated at the same time. While we were able to identify 139 individual publishing houses that were supported by the German universities and research organizations, the distribution is highly skewed. 92 % of open access publication fee spending went to ten publishers, being consistent with a observed high concentration of few publishers in current academic publishing (Larivière et al., 2015). However, our study could not confirm that publications

---

<sup>7</sup>26

in open access journals owned by traditional publishing houses account for most of the spending on publication fees as observed by Pinfield et al. (2015). Rather, open access publishers such as Public Library of Science (PloS), Copernicus or MPDI rank higher in our study than in the analyses of cost data in the UK.

One possible explanation why traditional publishers are less well represented in our study, is the lack of cost information about hybrid open access journals. 99 % of the overall article volume German universities and research organisations financially supported were published in fully open access journals. This presumably reflects the DFG funding policy which excludes the support of articles published in hybrid open access journals through many university open access funds. However, reviewing self-reported cost data from funders or countries that also support hybrid open access journals or open access books, we observe smaller proportions of payments in favour of articles in fully open access journals. Because open access publication fee spending is fragmented, it remains open to speculation whether authors affiliated with universities and research organisations simply avoided opting for open access when publishing in hybrid journals for political or economical reasons, or used other budgets for these fees—budgets that did not report data to the Open APC initiative. This could support a key operational idea of the initiative: having organisations report on spendings they have made, which might work better when done through organisation-wide funds.

## CONCLUSION

## ACKNOWLEDGMENT

We thank Andrea Hacker and Ada-Charlotte Regelman for valuable comments on the first draft of this paper. We also thank Christoph Broschinski, Vitali Peil, and Dirk Pieper, the members of the DINI working group “Electronic publishing”, and all data contributors<sup>8</sup> of the Open APC initiative.

## REFERENCES

- Björk, B.-C. (2015). Have the ‘mega-journals’ reached the limits to growth? *PeerJ* 3, e981. <http://doi.org/10.7717/peerj.981>.
- Björk, B.-C., and Solomon, D. (2012). Pricing principles used by scholarly open access publishers. *Learned Publishing* 25, 132–137. <http://doi.org/10.1087/20120207>.
- Björk, B.-C., and Solomon, D. (2014). How research funders can finance APCs in full OA and hybrid journals. *Learned Publishing* 27, 93–103. <http://doi.org/10.1087/20140203>.
- Bruch, C., Deinzer, G., Geschuhn, K., Haetscher, P., Hillenkoetter, K., Kress, U., et al. (2015). Positions on creating an Open Access publication market which is scholarly adequate : Positions of the Ad Hoc Working Group Open Access Gold in the priority initiative “Digital Information” of the Alliance of Science Organisations in Germany. Ad-hoc-Arbeitsgruppe Open-Access-Gold der Schwerpunktinitiative “Digitale Information” der Allianz der deutschen Wissenschaftsorganisationen. <http://doi.org/10.2312/allianzao.009>.
- Chamberlain, S., Boettiger, C., Hart, T., and Ram, K. (2016). *rcrossref: Client for Various ‘CrossRef’ APIs*. Available at: <https://CRAN.R-project.org/package=rcrossref>.
- Dallmeier-Tiessen, S., Darby, R., Goerner, B., Hyppolae, J., Igo-Kemenes, P., Kahn, D., et al. (2011). Highlights from the SOAP project survey. What Scientists Think about Open Access Publishing. Available at: <http://arxiv.org/abs/1101.5260>.
- Davis, P. M., and Walters, W. H. (2011). The impact of free access to the scientific literature: a review of recent research. *Journal of the Medical Library Association* 99, 208–217. <http://doi.org/10.3163/1536-5050.99.3.008>.
- Deppe, A. (2015). *Ansätze zur Versteigerung von Open-Access-Publikationsfonds.*, ed. K. Umlauf Institut für Bibliotheks- und Informationswissenschaft. Available at: <http://nbn-resolving.de/urn:nbn:de:kobv:11-100234262>.
- Eppelin, A., Pampel, H., Bandilla, W., and Kaczmirek, L. (2012). Umgang mit Open-Access-Publikationsgebühren – die Situation in Deutschland in 2010. *GMS Medizin — Bibliothek — Information*. 12. <https://doi.org/10.3205/mbi000240>.

<sup>8</sup><https://github.com/OpenAPC/openapc-de#contributors>

356 Fournier, J., and Weihberg, R. (2013). Das Förderprogramm “Open Access Publizieren” der Deutschen  
 357 Forschungsgemeinschaft. Zum Aufbau von Publikationsfonds an wissenschaftlichen Hochschulen in  
 358 Deutschland. *Zeitschrift für Bibliothekswesen und Bibliographie* 60, 236–243. [http://doi.org/10.](http://doi.org/10.3196/186429501360528)  
 359 [3196/186429501360528](http://doi.org/10.3196/186429501360528).

360 Hampson, C. (2014). The Adoption of Open Access Funds Among Canadian Academic Research  
 361 Libraries, 2008-2012. *Partnership: The Canadian Journal of Library and Information Practice and*  
 362 *Research* 9. <http://doi.org/10.21083/partnership.v9i2.3115>.

363 Haustein, S. (2016). Grand challenges in altmetrics: heterogeneity, data quality and dependencies.  
 364 *Scientometrics*. <http://doi.org/10.1007/s11192-016-1910-9>.

365 Kiley, R. (2014). Wellcome Trust APC spend 2012-13: data file. [http://doi.org/10.6084/](http://doi.org/10.6084/m9.figshare.963054.v1)  
 366 [m9.figshare.963054.v1](http://doi.org/10.6084/m9.figshare.963054.v1).

367 Kiley, R. (2015). Wellcome Trust open access (OA) spend and compliance monitoring: 2013-14.  
 368 <http://doi.org/10.6084/m9.figshare.1321361.v5>.

369 Kiley, R. (2016). Wellcome Tust/COAF spend on open access publishing (article processing charges)  
 370 - 2014-15. <http://doi.org/10.6084/m9.figshare.3118936.v1>.

371 Kingsley, D. A. (2014). Paying for Publication: Issues and Challenges for Research Support Services.  
 372 *Australian Academic & Research Libraries* 45, 262–281. [http://doi.org/10.1080/00048623.](http://doi.org/10.1080/00048623.2014.945135)  
 373 [2014.945135](http://doi.org/10.1080/00048623.2014.945135).

374 Laakso, M., and Björk, B.-C. (2012). Anatomy of open access publishing: a study of longitudinal  
 375 development and internal structure. *BMC Medicine* 10, 124. [http://doi.org/10.1186/1741-](http://doi.org/10.1186/1741-7015-10-124)  
 376 [7015-10-124](http://doi.org/10.1186/1741-7015-10-124).

377 Larivière, V., Haustein, S., and Mongeon, P. (2015). The Oligopoly of Academic Publishers in the  
 378 Digital Era. *PLOS ONE* 10, e0127502. <http://doi.org/10.1371/journal.pone.0127502>.

379 Lawson, S. (2015a). APC data for 25 UK higher education institutions - 2014. [http://doi.org/](http://doi.org/10.6084/m9.figshare.1305596.v5)  
 380 [10.6084/m9.figshare.1305596.v5](http://doi.org/10.6084/m9.figshare.1305596.v5).

381 Lawson, S. (2015b). Article Processing Charges Paid by 25 UK Universities in 2014. *Journal of Open*  
 382 *Humanities Data* 1. <http://doi.org/10.5334/johd.2>.

383 Lawson, S. (2015c). Fee Waivers for Open Access Journals. *Publications* 3, 155–167. [http:](http://doi.org/10.3390/publications3030155)  
 384 [//doi.org/10.3390/publications3030155](http://doi.org/10.3390/publications3030155).

385 Lawson, S. (2016). APC data for 27 UK higher education institutions in 2015. [http://doi.org/](http://doi.org/10.6084/m9.figshare.1507481.v4)  
 386 [10.6084/m9.figshare.1507481.v4](http://doi.org/10.6084/m9.figshare.1507481.v4).

387 Lawson, S., and Meghreblian, B. (2015). Journal subscription expenditure of UK higher education  
 388 institutions. *F1000Research*. <http://doi.org/10.12688/f1000research.5706.3>.

389 Neylon, C. (2014). Wellcome Trust Article Processing Charges by Article 2012/13. [http://doi.](http://doi.org/10.6084/m9.figshare.964812.v3)  
 390 [org/10.6084/m9.figshare.964812.v3](http://doi.org/10.6084/m9.figshare.964812.v3).

391 Noorden, R. V. (2013). Open access: The true cost of science publishing. *Nature* 495, 426–429.  
 392 <http://doi.org/10.1038/495426a>.

393 Pinfield, S. (2015). Making Open Access work. *Online Information Review* 39, 604–636. [http:](http://doi.org/10.1108/oir-05-2015-0167)  
 394 [//doi.org/10.1108/oir-05-2015-0167](http://doi.org/10.1108/oir-05-2015-0167).

395 Pinfield, S., and Middleton, C. (2012). Open access central funds in UK universities. *Learned*  
 396 *Publishing* 25, 107–117. <http://doi.org/10.1087/20120205>.

397 Pinfield, S., Salter, J., and Bath, P. A. (2015). The “total cost of publication” in a hybrid open-access  
 398 environment: Institutional approaches to funding journal article-processing charges in combination with  
 399 subscriptions. *Journal of the Association for Information Science and Technology*. [http://doi.org/](http://doi.org/10.1002/asi.23446)  
 400 [10.1002/asi.23446](http://doi.org/10.1002/asi.23446).

401 Ram, K. (2013). Git can facilitate greater reproducibility and increased transparency in science.  
 402 *Source Code for Biology and Medicine* 8, 7. <http://doi.org/10.1186/1751-0473-8-7>.

403 Reckling, F., and Kenzian, M. (2014). Austrian Science Fund (FWF) Publication Cost Data 2013.  
 404 <http://doi.org/10.6084/m9.figshare.988754.v4>.

405 Reckling, F., and Rieck, K. (2015). Austrian Science Fund (FWF) Publication Cost Data 2014.  
 406 <http://doi.org/10.6084/m9.figshare.1378610.v14>.

407 Rieck, K., Haslinger, D., Meischke-Ilic, S., Kirindi-Hentschel, Ü., and Reckling, F. (2016). Austrian  
 408 Science Fund (FWF) Publication Cost Data 2015. [http://doi.org/10.6084/m9.figshare.](http://doi.org/10.6084/m9.figshare.3180166.v1)  
 409 [3180166.v1](http://doi.org/10.6084/m9.figshare.3180166.v1).



410 Schimmer, R., Geschuhn, K., and Palzenberger, M. (2013). Open Access in Zahlen: Der Umbruch in  
 411 der Wissenschaftskommunikation als Herausforderung für Bibliotheken. *Zeitschrift für Bibliothekswesen  
 412 und Bibliographie* 60, 244–250. <http://doi.org/10.3196/186429501360532>.

413 Sikora, A., and Geschuhn, K. K. (2015). Management of article processing charges – challenges for  
 414 libraries. *Insights: the UKSG journal* 28, 87–92. <http://doi.org/10.1629/uksg.229>.

415 Solomon, D. J., and Björk, B.-C. (2011). Publication fees in open access publishing: Sources of  
 416 funding and factors influencing choice of journal. *Journal of the Association for Information Science and  
 417 Technology* 63, 98–107. <http://doi.org/10.1002/asi.21660>.

418 Solomon, D. J., and Björk, B.-C. (2012). A study of open access journals using article processing  
 419 charges. *Journal of the Association for Information Science and Technology* 63, 1485–1495. <http://doi.org/10.1002/asi.22673>.

420 Suber, P. (2012). *Open Access*. MIT Press. Available at: [https://mitpress.mit.edu/  
 421 books/open-access](https://mitpress.mit.edu/books/open-access).

422 Walters, W. H., and Linvill, A. C. (2011). Bibliographic index coverage of open-access journals in  
 423 six subject areas. *Journal of the Association for Information Science and Technology* 62, 1614–1628.  
 424 <http://doi.org/10.1002/asi.21569>.

425 Woodward, H. M., and Henderson, H. L. (2014). Report for Jisc Collections on total cost of owner-  
 426 ship project: Data capture and process. Information Power Ltd. Available at: [https://www.jisc-  
 427 collections.ac.uk/Global/News%20files%20and%20docs/IPL-Jisc-Total-Cost-  
 428 of-Ownership-Data-Capture-Report.pdf](https://www.jisc-collections.ac.uk/Global/News%20files%20and%20docs/IPL-Jisc-Total-Cost-of-Ownership-Data-Capture-Report.pdf).

429