



# Open Access Mega-Journals: Quality, Economics and Post-publication Peer Review Infrastructure

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## Abstract

As the publishing industry evolves towards the predominant open access (OA) model, publishers are establishing OA journal power-houses, the OA mega-journals (OAMJs), which are wide in scope, with larger-than-usual editor boards, and that pump out large numbers of papers. OAMJs are thus able to accommodate a surge in submissions, or transfers from other journals within the same publisher's fleet. OAMJs represent a simple but effective publishing model that can also be an effective business model. We question whether the peer review system is robust enough to accommodate for effective post-publication peer review in OAMJs. As examples, we examine *Scientific Reports*, *PLOS One*, *Heliyon*, *F1000Research*, *PeerJ*, and *BMJ Open*, as well as a possible developing OAMJ, *eLife*, for clues to the dynamics of OAMJs and the possible links to quality control via peer review or post-publication peer review. We also take a closer look at the economics of OA publishing that might be driving the expansion of the OAMJ market.

**Keywords** Article processing charge · Economics · Journal cascades · Marketing · OAMJ · Open access · Spam · Transparency

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## Introduction to the Nature of APCs in Open Access

### 1. APCs within the OA publishing model

The open access (OA) movement, while gradually fulfilling the promise of making information open to a wider range of academics and society in general, has become, to some extent, unscrupulously exploited by low-tier “predatory” entities that might offer weak or no quality control in the form of peer review, editorial oversight and post-publication peer review (PPPR). This exploitation is not limited to such “predatory” entities since established, indexed and ranked<sup>1</sup> journals have exploited their market dominance to, in a free market, set the price of open knowledge, via article processing charges (APCs) based on a perceived value, as part of a branding campaign that is dominating academic publishing, rather than on the actual value of open science. That surcharge on open knowledge comes in the form of two fees, in the gold (hybrid) OA model, in which the author (or their institute or funder) pays a fee for a paper to be OA while their institute may also subscribe to the journal. The gold OA model are subscription-based journals with the option to make papers OA, at a cost.

The premium on knowledge has reached such incredulous proportions that, according to at least one UK source, the average cost of an OA APC is now around 1700 £GB (or about 2250 US\$ using March 2019 exchange rates), with APCs more than tripling in value between 2013 and 2016, with the largest benefactors being Elsevier BV, Wiley-Blackwell, Springer Nature, Public Library of Science (PLOS), Informa UK Ltd., and others, including Frontiers Media SA,<sup>2</sup> which was a controversial listing as a “predatory” OA publisher by Jeffrey Beall in his equally controversial blacklists [37].

It can thus be argued that the gold OA model, which extracts APCs from authors, their institutes or their funders, is a profitable business model. This may be the reason why the EU publishing market, designated as Horizon 2020,<sup>3</sup> is seeking to make the gold OA model its standard. Does the value of such APCs correspond to the actual value of that knowledge, or is a “pay to publish or perish” model becoming established [1]?

### 2. The birth and expansion of open access mega-journals

It is within this exploitative APC-based gold OA model that the OA mega-journals (OAMJs) were born, in which regular OA journals evolved into large OA

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<sup>1</sup> For simplicity sake, we only refer to the most gamed metric, the Clarivate Analytics journal impact factor (JIF) [30, 42], when we use the term “rank” in this paper.

<sup>2</sup> <https://scholarlycommunications.jiscinvolve.org/wp/2017/08/23/article-processing-charges-in-2016/>; in this survey, there are several limitations that might not reflect a global trend: (1) UK-based; (2) assessment across 11 institutions; 38 publishers assessed.

<sup>3</sup> <https://ec.europa.eu/programmes/horizon2020/>.

journals with a wide scope and sound peer review [52]. The first such model evolved after the start of the OA movement, with *PLOS ONE*, in 2006, where it dominated the volume of OAMJs until at least 2013.<sup>4</sup> In the OAMJ model, a broad journal title is assigned, topic-specific editors are recruited in typically large editor boards, many offering their services for free,<sup>5</sup> as do peer reviewers, which increases the profitability of the gold OA model [45]. The increasing volumes of submissions may place some pressure on editors or publishers to have relatively higher acceptance rates, since an acceptance reflects an APC, and an APC reflects revenue and/or profit. The publishers of some OAMJs, such as PLOS, claim that they do not make profit since they are a non-profit organization. Others such as *eLife*, which we consider to be a developing OAMJ using some of the characteristics of OAMJs listed by Björk [6], are financially supported by independent research-related organizations, and by an APC set at a level intermediate to that of some of the highest APC-charging OA journals. Others yet, like *Heliyon*, are published by Elsevier, a for-profit publisher. There is somewhat wide variation as to what constitutes an OAMJ.

Over the years, the *PLOS ONE* OAMJ thrived and became the market leader, both in terms of volumes of submissions, and also in terms of revenues generated from its APCs. Other publishers, most likely eyeing the success of this publishing model, initiated their own OAMJs, such as Nature Publishing Group's *Scientific Reports*, which overtook *PLOS ONE* as the OAMJ market leader in the first quarter of 2017,<sup>6</sup> and Elsevier's *Heliyon*, which serves as an OAMJ, accepting regular direct submissions, and also as a cascade journal, accepting papers that are rejected by other Elsevier OA and non-OA journals. The Springer Nature (at that time, Springer Science + Business Medium) equivalent to *Heliyon* was *Springer Plus*<sup>7</sup> but that OAMJ shut down operations in June 2016 precisely when a JIF was supposed to be assigned. The stated reason by Springer Nature for the termination of this OAMJ was that it was too broad.<sup>8</sup> In the absence of *Springer Plus*, SpringerOpen<sup>9</sup> flourished and any of the OA journals on that platform has the potential to evolve into an OAMJ if there is sufficient growth in volume, popularity and JIF. Springer Transfer<sup>10</sup> serves as Springer Nature's management tool to pass rejected papers from a

<sup>4</sup> <https://creativecommons.org.nz/2013/10/open-access-megajournalcrearnals-have-they-changed-every-thing/>.

<sup>5</sup> *eLife*, which is financially supported by the Howard Hughes Medical Institute, the Max Planck Society, and the Wellcome Trust, and which charges a publishing fee (APC) of US\$ 2500 per paper, pays its Editor-in-Chief, three Deputy Editors, 39 Senior Editors and almost 300 Reviewing Editors for their time <https://elifesciences.org/inside-elifeb6365b76/setting-a-fee-for-publication>.

<sup>6</sup> <https://scholarlykitchen.sspnet.org/2017/04/06/scientific-reports-overtakes-plos-one-as-largest-megajournal/>.

<sup>7</sup> <https://springerplus.springeropen.com/>.

<sup>8</sup> <https://springerplus.springeropen.com/about/springerplus-faqs> ("Ultimately, we felt that *SpringerPlus* covered too wide a range of disciplines, from the natural sciences to engineering and the social sciences. These are very different research communities, with very different needs when submitting or transferring manuscripts, and a one-size-fits-all journal is not the solution.")

<sup>9</sup> <https://www.springeropen.com/>.

<sup>10</sup> <https://www.springer.com/gp/authors-editors/journal-author/the-springer-transfer-desk>.

Springer Nature journal into alternative journals by the same publisher, including SpringerOpen and the Biomed Central OA journal fleet.

Other noticeable OAMJs include *BMJ Open*, and possibly journals within the Frontiers stable, such as *Frontiers in Plant Science*, which has multiple sub-sections, or themes, all under the same umbrella, boasting to be the most cited plant science OA journal.<sup>11</sup> The OAMJ status of Frontiers' OA journals might be contested by some. There are a number of other up-and-coming OAMJs,<sup>12</sup> many of which are in a phase of establishment. One example is Wolter Kluwers' *Medicine*, which saw a decrease in citations since 2015 despite a growth in submissions, primarily from China, potentially lowering, or weakening, the bibliometric profile of this OAMJ [54]. For simplicity sake, given the complexity of this topic, in this paper we focus only on select OAMJs, some of which have dominated the conversation, others that have grabbed media headlines, or others that merit wider analysis and discussion, or that might be in a nascent phase of becoming an OAMJ, such as *eLife*. We recognize that a large journal (traditional print or subscription-based) most likely displays similar properties to an OAMJ [6], in terms of size, broad theme, and number of submission and published papers, such as Elsevier's *The Lancet*, but the largest difference would lie in the fact that OAMJs derive their sustainability from APCs and may thus pose unique ethical or economic challenges, as we discuss later, that the traditional print/subscription model does not.

## Does Gaming Metrics and Cashing in on the Impact Factor Drive the APC Market?

The gaming of metrics in academic publishing is one consequence of academia's commercialization [30]. Some nations, such as in China, where researchers are often handsomely rewarded for publishing in high Clarivate Analytics JIF journals, the reward is often proportional to the JIF score [47]. Consequently, researchers in countries such as China frequently observe the JIF of a journal as a first selection factor for submission [31], followed by secondary factors such as OA, or price of APCs. Academics might ignore the latter to determine its financial viability, especially if their institute pays for the APC. This pay-to-publish culture, however, may stimulate unhealthy competition, cheating, and fake peer review [32]. Some OAMJs, such as *Scientific Reports*, have a high JIF relative to other OAMJs, such as *PLOS ONE*. Therefore, paying an APC of US\$1760 at *Scientific Reports* would be a financially viable decision, given its lower APC and higher JIF than the APC at *PLOS ONE*, which is US\$2900. Publication in a higher JIF OA journal does not necessarily guarantee more citations [11]. However, relative to the financial rewards based

<sup>11</sup> <https://blog.frontiersin.org/2017/06/28/quality-impact-journal-analysis-frontiers-in-plant-science/>.

<sup>12</sup> [https://en.wikipedia.org/wiki/Mega\\_journal](https://en.wikipedia.org/wiki/Mega_journal).

on the JIF/APC ratio, i.e., impact of the journal (journal JIF) per \$ of APC paid [9], this factor might not be important in academic gaming.<sup>13</sup>

OAMJ represent a potentially profitable model by supplementing more topic-specific OA or hybrid OA journals, attracting a wider set of academics, and also improving publishers' profit margin. Increasing competition among OAMJs may have caused the shrinking output and profits of OAMJs like *PLOS ONE*<sup>14</sup> whose staff was downsized by its parent publisher PLOS.<sup>15</sup> It is important to assess growth in OAMJs, in terms of number of submissions, number of papers published and APCs. An analysis of 11 OAMJs showed an average 14.9% growth between 2014 and 2015 [53]. Stephen Pinfield, in a *Times Higher Education* op-ed, noted how low rejection rates form an integral part of the OAMJ business model, claiming that *PLOS ONE* published 65–70% of its submitted papers.<sup>16</sup> There is a risk that CiteScore might also be gamed similarly to the JIF [46].

## Quality Control in OAMJ Peer Review: Are There Any Distinguishing Features?

Academic publishing may be facing a crisis, as may reproducibility, according to Randall and Welsler [21], including academics who may feel that they are being exploited, and this is being caused by a wide range of factors, independent of reproducibility [48]. PPPR is an effective strategy to identify flaws in the published literature [41], and the correction of the erroneous literature [43]. PPPR is not restricted to traditional print or OA journals, but also affects OAMJs. Scandals in OAMJs tend to be accentuated by science watchdogs [29]. A few examples include the near recycling of a retracted paper back into *PLOS ONE*,<sup>17</sup> mass editorial resignations from *Scientific Reports*,<sup>18</sup> constant negative profiling of Frontiers,<sup>19</sup> or a plagiarism scandal at *F1000Research*.<sup>20</sup>

Buriak [10] suggested a drop in scholarly quality in OAMJs as a result of an increase in the volume of submissions. However, is this concern valid provided that a pool of peers and editors can be found to handle this surge in volume? This large demand explains why the editor boards of some OAMJs can number thousands of academics. Is this model financially sustainable, even if the quality of publishing

<sup>13</sup> As a hypothetical example, a “cost per journal JIF” of \$2900 APC for a JIF=2.0 journal would be rewarded less than a publication in a journal with JIF=4.0 journal that charges an APC of \$400.

<sup>14</sup> <https://scholarlykitchen.sspnet.org/2016/01/06/plos-one-shrinks-by-11-percent/>; <https://scholarlykitchen.sspnet.org/2017/11/27/plos-reports-2016-financial-loss/>.

<sup>15</sup> <http://blogs.plos.org/plos/2018/04/plos-update/>.

<sup>16</sup> <https://www.timeshighereducation.com/blog/mega-journals-future-stepping-stone-it-or-leap-abys>.

<sup>17</sup> <https://forbetterscience.com/2018/01/22/plos-one-publishes-near-copy-of-retracted-jbc-paper-sans-coauthor-carlo-croce/>.

<sup>18</sup> <https://retractionwatch.com/2018/03/20/over-a-dozen-board-members-resigned-after-a-journal-refus-ed-to-retract-a-paper-today-its-retracted/>.

<sup>19</sup> <https://forbetterscience.com/?s=Frontiers>.

<sup>20</sup> <http://www.translationalethics.com/2017/06/02/recapping-the-recent-plagiarism-scandal/>.

drops? The OAMJ model might be unsustainable because it is beyond the financial reach of academics in poorer nations [13]. The CEO of protocols.io, Lenny Teytelman, claimed that an increase in the number of published papers represents sustainability, and that it is a fallacy that OAMJs represent a weak peer review model.<sup>21</sup> These issues need wider debate and analyses.

Our interpretation of Wakeling et al. [55] is that editorial policies at OAMJs state that the decision to publish an article is based on its scientific or technical soundness, implying that OAMJs might employ less rigorous peer review than that which is used by traditional journals. In this case, it is then reasonable to expect more retractions to emerge from these journals in the near future, and if this happens, this will certainly have a negative impact on the reputation of these journals, which is likely to discourage authors from submitting to OAMJs, an issue that Wakeling et al. [55] draw to the attention of readers. As a consequence, their long-term sustainability is likely to face major threats [55]. To prevent a reputational crisis, OAMJs need to improve both pre-publication peer review and PPR. This could involve inviting verified trustworthy and competent peer reviewers or editors, even if that requires a financial investment in rewarding them for their efforts, an approach used by *eLife*. Reputational damage carries an additional weighting factor, the JIF. Thus, OAMJs that rely heavily on their JIF to sustain their reputation, and their business model, and which thus are heavily dependent on specific competitive academic markets will suffer a greater reputational blow than JIF-free OA journals, such as DOAJ-indexed OA journals, that might not be so dependent on APCs for their survival such as society-based OA journals. Even so, the DOAJ faces considerable challenges to ensure that its “whitelisted” OA journal fleet conforms to best publishing practices and that the DOAJ itself displays transparency related to inclusions and exclusions, funding and decision-making that is independent of its member publishers and financial sponsors [44].

OAMJs could also consider an approach taken by Scienceroot which aims “to leverage the decentralizing power of blockchain technology and incentivizing power of cryptoeconomics to solve the biggest problems with the status quo”. One of the problems Scienceroot aims to solve is the “no reward for the authors or reviewers” through the use of cryptoeconomics.<sup>22</sup> However, although the use of blockchain can be employed to reward reviewers’ efforts with crypto currencies, it is still in its infancy and some have cautioned against its use, solely, to make “magical and sparkly” headlines [14]. This topic merits greater exploration, especially with the explosion in cryptocurrencies in recent years.

The reviewing system that OAMJs employ shifts the assessment of novelty, importance and interest to readers, by relying on article level metrics (ALMs).

<sup>21</sup> <https://www.protocols.io/groups/protocolsio/news/megajournals-megamyths> (“The past decade has conclusively established that this model is welcome, needed, and sustainable. Just look at the explosion in the number of articles published in megajournals”; “Megajournals do not do peer review (or, they do “peer review light”). That’s a malicious myth which seems to have been intentionally spread by several authors of the publisher-funded Scholarly Kitchen. See “How a sustained misinformation campaign by Scholarly Kitchen attacked PLOS ONE’s rigorous peer review.””).

<sup>22</sup> <https://www.scienceroot.com/#science>.

*PLOS ONE* ALMs are “quantifiable measures that incorporate both academic and social metrics to document the many ways in which both scientists and the general public engage with published research”.<sup>23</sup> These ALMs are presented on the metrics tab of every published article, and they include the number of views, downloads (save), citations and shares on social media. However, this is not enough to ensure the requirements for novelty and importance, because ALMs can easily be manipulated or gamed by authors, their friends and/or their institutions [19]. Clearly, there are no reliable indicators that guarantee that whoever downloads, views or shares an article is going to read it or use in an academic context. Therefore, improving the quality of published articles and protecting the reputation of any journal requires an efficient use of tools that can promote PPPR, such as inviting competent peer reviewers to initiate the PPPR process, or the use of recommendations or ratings [4], as well as the publication of comments alongside published articles. For instance, recommending an article may signal its novelty or importance, especially if a comment is posted with that recommendation that describes the article’s strengths. In addition, a negative comment signals a weakness that could highlight a serious flaw.

*PeerJ*, *F1000Research* and *BMJ Open* use open peer review (OPR), which generally removes the element of bias generally associated with hidden peer reviewers in traditional peer review, allows peer reviewers to be more accountable for what they have stated or advised, and makes the publishing process more transparent, an essential aspect of open science. However, OPR has a number of challenges that need to be overcome for it to be considered an important model of peer review [39].

## How is Post-publication Peer Review Integrated into OAMJs?

To answer this question, we examined a publication in several OAMJs. The assumption is that an OAMJ incorporates PPPR if it provides a tool for readers to initiate a discussion or to post comments, registered or non-registered (i.e., anonymously), after the articles are published. Our examination revealed the following: *PLOS ONE* allows readers to post comments on each article; *eLife* uses open annotations, in collaboration with Hypothesis,<sup>24</sup> so that authors, reviewers and readers can make comments<sup>25</sup> by highlighting important sections of articles and engaging with online discussions. *Scientific Reports*, *Heliyon* and *F1000Research* integrate PPPR by allowing comments for each paper, *PeerJ* allows readers to ask questions or report problems with articles while *BMJ Open* handles readers’ responses whose publication is at the absolute discretion of *BMJ*.<sup>26</sup> There appears to be, at least for these OAMJs, a solid infrastructure for this aspect of open science. In a comparison between pre-publication peer reviews of four high-ranking medical journals and

<sup>23</sup> <https://www.plos.org/article-level-metrics>.

<sup>24</sup> <https://web.hypothes.is/>.

<sup>25</sup> <https://elifesciences.org/for-the-press/81d42f7d/elife-enhances-open-annotation-with-hypothesis-to-promote-scientific-discussion-online>.

<sup>26</sup> <http://bmjopen.bmj.com/content/8/3/e019700.responses>.

PPPR in *F1000Research*, major differences were found: short and positive comments were features of PPPR in *F1000Research*<sup>27</sup> compared to pre-publication peer reviews in medical journals. These findings suggest that although 12 non-affiliated *F1000Research* reviewers had a long and distinguished publication record (based on their average *h*-index, which was 18.7), they made very little effort to improve the paper.<sup>28</sup>

Nonetheless, our examination proposes that PPPR is an inherent characteristic of OAMJs. Indeed, if PPPR is a crucial instrument that is being used to correct the literature published in traditional journals, it is of greater importance to maintaining the integrity of publications in an OAMJ whose peer review is based on “technical or scientific soundness” and does not extend to the assessment of novelty of a manuscript, its importance and interest, and is thus perceived to be less rigorous by readers and authors, at least according to Wakeling et al. [55]. An argument by Spezi et al. [25] suggests that the approach of OAMJs to quality control, at least in terms of novelty, importance and interest, represents a paradigm shift from a pre-publication peer review assessment of these aspects to a post-publication, ALM-based assessment of these parameters. If so, then the case can be made that PPPR by verified, named or anonymous peer reviewers is an essential element that should be incorporated into an OAMJ’s reviewing system. This is not always the case. The retraction of an article published in *PLOS ONE* [57] experienced a delay in issuing the retraction even though the retraction notice states: “Following publication of this article [...], the authors requested its retraction due to errors in the data analyses. A member of *PLOS ONE*’s Editorial Board confirmed that the statistical analyses were not done correctly and as such the conclusions of the article have been called into question” [50]. The delay in issuing this retraction indicates that the efficiency of PPPR was compromised. This ailment has affected all journals, OA and non-OA, OAMJs or not [2, 3], and in this context, it can be argued that any OAMJ that does not promote PPPR would be a paper mill meant exclusively to harvest APCs.

## Preprints and the Link to OAMJs

Examining the *F1000Research* FAQs page<sup>29</sup> reveals a curious question of whether *F1000Research* is a preprint server. Indeed, there are similarities. *F1000Research* publishes all articles without peer review, as the formal peer review is initiated by authors after publication. In addition, authors can, albeit in rare situations, decide to “discontinue peer review” and submit their manuscripts to another journal. Although *F1000Research* uses a unique peer review process, and not all OAMJs use the *F1000Research* model, but a comparison between OAMJs and preprints should

<sup>27</sup> One could argue that the review process *F1000Research* implements does not meet the threshold of PPPR, since pre-publication peer review is absent [51].

<sup>28</sup> <https://scholarlykitchen.sspnet.org/2013/03/27/how-rigorous-is-the-post-publication-review-process-at-f1000-research/>.

<sup>29</sup> <https://f1000research.com/faqs>.



be outlined. *F1000Research* defines a preprint server as “a repository for pre-publication draft versions of full papers that are often subsequently submitted to journals for peer review and publication”, while *PeerJ* defines its preprint as “a draft of an article, abstract, or poster that has not yet been peer-reviewed for formal publication”.<sup>30</sup> So where does one draw the line between a preprint and a published<sup>31</sup> article that undergoes peer review after publication? This is a question that is worthy of further exploration and debate especially that the sustainability of OAMJs depends on their reputation and how researchers perceive the quality of the literature published in this venue. Readers are however, cautioned that several risks may exist with preprints, and that are not often discussed, or exposed [33–36, 38]. One of the new concerns about preprints is that they might be used by OAMJs as “nets” to “catch” new submissions, where each submission represents a potential APC-based income. Therefore, “deals” between OAMs such as *PLOS ONE* and *bioRxiv*<sup>32</sup> might be frowned upon, because they may undermine the free flow of information and authors’ choice of publishing venue.

## The Economics and Market of OAMJs

The OAMJ is a new type of publishing business model with the aim of publishing a large volume of OA articles and revenue generated from APCs. It is considered to be a sector of the gold OA market that was growing fast but has shown signs of a slow-down recently [16]. However, it is still a very small component of the overall market of published articles accounting for approximately 2% of 3 million articles published per year. According to Björk [7, 8], 58,007 articles were published in 2017 by 19 OAMJs, with *Scientific Reports* and *PLOS ONE* accounting for 77% of this market. Plume and van Weijen [20] noted that a total of 2.4 million articles were published in 2013, rising at an annual rate of 3% prior to 2003, but at a much faster rate from 2003 to 2013, at 6.7% per annum. Hence the share, measured as the number of published articles, of the total market by OAMJs is at least 2% based on Björk’s 2018 list. We believe that this might be an underestimate since other OAMJs—actual or potential—were not included, such as the BMC Series, *Oncotarget*, *Frontiers in [...]*, *Zootaxa*, Hindawi’s *The Scientific World Journal*, and *Optics Express*, some of which were considered by Ware and Mabe [56] as OAMJs. The OAMJs in the Björk [7, 8] study constitute at least 6.4% of the share of OA (down from 20% in 2015; [56]), if one assumes that 30% (up from 12% in 2015) of all articles are published in OA journals (vs [16]).<sup>33</sup>

<sup>30</sup> <https://peerj.com/preprints-search/>.

<sup>31</sup> The term “published” should, *sensu lato*, indicate the release of information into the public, and in that sense, *F1000Research* represents and uses the term accurately, as do preprint servers; many other publishers incorrectly associate “published” with having been peer reviewed.

<sup>32</sup> <https://www.cshl.edu/plos-cshl-enter-agreement-enable-preprint-posting-biorxiv/>.

<sup>33</sup> STM 2018 report states, on page 136: “Several dedicated studies looking at levels of OA in the years 2014–2016 have also returned figures for OA content in the region of 30%, while others report substantially higher figures, in excess of 50% in some cases (see Table 1)”.

**Table 1** Article processing charges (APC) of some main open access mega-journals (OAMJ). (Last accessed: April 4, 2019)

Journal	APC	URL
BMJ Open	£1350	<a href="https://bmjopen.bmj.com/pages/authors/#article_publishing_charges">https://bmjopen.bmj.com/pages/authors/#article_publishing_charges</a>
eLife	US \$2500	<a href="https://submit.elifesciences.org/html/elifesciences.html#fees">https://submit.elifesciences.org/html/elifesciences.html#fees</a>
F1000Research	up to 1000 words (short article) US \$150 1000-2500 words (medium article) US \$500 over 2500 words (long article) US \$1000	<a href="https://f1000research.com/for-authors/article-processing-charges">https://f1000research.com/for-authors/article-processing-charges</a>
Heliyon	US \$1250	<a href="https://www.heliyon.com/faq/#Openaccessandpayment">https://www.heliyon.com/faq/#Openaccessandpayment</a>
PeerJ	US \$0-US \$1095	<a href="https://peerj.com/benefits/reduced-cost-publishing/">https://peerj.com/benefits/reduced-cost-publishing/</a>
PLOS ONE	US \$1495	<a href="http://journals.plos.org/plosone/">http://journals.plos.org/plosone/</a>
SAGE Open	currently US \$480, discounted from the full rate of US \$800	<a href="https://uk.sagepub.com/en-gb/mst/sage-open/journal202037">https://uk.sagepub.com/en-gb/mst/sage-open/journal202037</a>
Scientific Reports	£1290 (UK) US \$1790 (The Americas, China and Japan) €1490 (Europe and rest of the world)	<a href="http://www.nature.com/srep/about/article-processing-charges">http://www.nature.com/srep/about/article-processing-charges</a>

Five dominant oligopolistic companies, Reed-Elsevier, Wiley-Blackwell, Springer Nature, Taylor & Francis/Informa, and Wolters Kluwer, published more than 50% of all academic papers in 2013 [17]. Do OAMJs pose a serious threat, in terms of being a disruptive innovation, to this oligopolistic publishing establishment [58]? According to the Larivière et al. study, Elsevier profits and profit margins showed a general upward trend from 1991 to 2013 with a US\$ 2 billion profit in 2013, but high profit margins were also observed for the other big publishers. Barriers to entry allow firms in oligopolistic markets to make positive economic profits.<sup>34</sup> For example, the “big 5” publishers sell their subscriptions to a captured market of academic libraries with rates that increase over time. Economic profits are positive (i.e., there are excessively high profit margins) because of the peculiar nature of the publishing market in which the authors who submit their manuscripts, the peers who review these papers, and the editors who oversee the entire quality control chain, are mostly not financially compensated, as would be the case with most other goods supplied in markets where a company would have to pay for the inputs it uses to produce the goods or service, in this case the published paper.<sup>35</sup> These important resources into the production of scholarly publishing, without compensation, results in a low marginal cost of production and with high fixed costs. As a result, economies of scale evolve and only a few firms supply the market demand. The few firms that do not face competition from the outside may collude to increase the price of journal subscriptions. A price will be set which will exceed the already peculiar low marginal cost of production resulting in economic profits but at the societal cost of market distortions and economic inefficiencies.

The OA movement, and within it, the OAMJs, can be perceived as a threat to the “big” publishers if they lose market power which would result in bringing down their profit margin and economic profits. The OA movement can be considered an innovative disruption to the market power of these oligopolistic firms.<sup>36</sup> However, as the OA movement was gaining momentum and increasing its market share, Beall released controversial blacklists of “potentially, probable or possible predatory” OA publishers and journals (i.e., 2012-2017) to somehow cast doubts on the uprising of the OA movement and caused chaos [28], slowing down its path to innovatively disrupt the establishment.

<sup>34</sup> Economic profit is defined as revenue minus all costs including the opportunity cost of the shareholders’ investment into the firm. Hence, positive economic profits means the firms are making above-normal profits.

<sup>35</sup> According to the 2015 STM report by Ware and Mabe, the global cost of peer review is estimated at £1.9 billion annually. This translated to an estimate of £1200 per paper [22] or US\$1656 (April 30, 2018 exchange rate: 1 £GB = 1.38 US\$; <https://www.xe.com/>). Houghton et al. [15] estimated a higher true cost of peer review at £1400 per paper or US\$1932 (April 30, 2018 exchange rate). These hidden costs are not far from the average APC being charged by OAMJs. These are full costs and include reviewers’ time.

<sup>36</sup> Christensen [12] coined the term “innovative disruptions” as events that cause turmoil in an established market causing profound and permanent changes in the structure. Examples include Google, Apple, Uber and AirBnB. For innovative disruptions see: <http://www.claytonchristensen.com/key-concepts/>.

There are multiple factors that allow an OAMJ to publish a large volume of scientific articles [25]. One important factor is being online, as opposed to the constraints print-based publishing faces, resulting in economies of scale; having a broad scope and subject area; very high acceptance rates in the range of 50–70% [6] with relatively rapid publication, moderate APCs [6], and a peer review process that is based on scientific reliability and not on significance, novelty and relevance [26], three aspects that Spezi et al. [26] believe shift review from the “wisdom of the expert” to the “wisdom of the crowd”. We believe that the subjective nature of significance, novelty and relevance is most likely best left for PPPR to decide.

Leaving aside technology and innovation, why have OAMJs established themselves in this growing market and are a growing sector? What has been somewhat overlooked is the huge market of rejected papers that have emerged from the traditional peer review process that focuses on significance, novelty, relevance and scientific soundness. This more rigorous but also more subjective peer review process should show up as lower acceptance rates for non-OA journals relative to OA journals, including OAMJs. Sugimoto et al. [27] indeed found significantly higher acceptance rates for OA journals relative to non-OA journals, where most acceptance rates in non-OA journals ranged from 30 to 40%. With approximately 3.1 million articles being published in 2017<sup>37</sup> and with an overall average acceptance rate of 50%, this implies that there is an equal sized uncaptured market of another 3 million articles that have been rejected and hence have not yet found a publishing home, i.e., orphan papers. Such papers can be considered as system overflow, or “excess”, which OAMJs relieve, by absorbing them in a profitable and easy way [18]. Some of these rejected papers require no revisions, some minor revisions, while others need major revisions before they can get published. Even very weak scientific papers, but that are novel, can be revised and resubmitted. In addition to rejected papers that are trying to find a publishing outlet, new articles are ready to enter the market to try and find a home. With an estimated 7–8 million researchers around the world [16] and rising,<sup>38</sup> the volume of research and articles produced is bound to increase further. Where will they find a home?

It is reasonable to assume that many of the 3 million rejected manuscripts are significant, novel, and relevant, while many others are only scientifically sound. However, in this pool, there are evidently manuscripts that are flawed. OAMJs have entered the publishing market to capture some of this untapped market of scientifically sound work. How many OAMJs would be needed to capture this market? Only 120 OAMJs of the size of *Scientific Reports* or *PLOS ONE* would be able to absorb this entire lucrative market of rejected papers.

Given the size of this untapped market, the same can be said about the evolution of deceptive publishers and journals who will publish anything for a low APC

<sup>37</sup> Assuming a 6.7% continued growth starting from 2.4 million articles published in 2013.

<sup>38</sup> This number might be a large underestimate of the real number of academics that publish. According to ResearchGate, an academic social networking site, there are currently in excess of 15 million academics: <https://www.researchgate.net/about>.

without peer review<sup>39</sup> in order to capture some of this market of rejected papers. Beall [5] listed five OAMJs as potentially predatory OAMJs, *British Journal of Science*, *International Journal of Current Research*, *International Journal of Science and Advanced Technology*, *International Journal of Sciences*, and *World Journal of Science and Technology*, but it is unclear what criteria Beall used to classify them as “mega”. At least two of these OAMJs are still publishing, and thus their publishing operations were not disrupted by Beall’s blacklisting. However, the same cannot be said of the other OAMJs, which may have suffered irreparable and irrevocable reputational damage by Beall’s blacklisting. This certainly constitutes a risk given the flaws associated with blacklists [49].

What evidence is there that OAMJs evolved to capture the market of papers that have been rejected? Given that manuscripts are assessed only for scientific soundness and worthiness and not for novelty, importance and relevance, they will probably be found in such a market of rejected papers whose authors are trying to find a publishing outlet. There is evidence that many rejected papers are resubmitted to OAMJs. Solomon [24] provided evidence that just under 50% of the papers published in *BMJ Open*, *PeerJ*, *PLOS ONE* and *Sage Open* were previously rejected papers by other journals.<sup>40</sup> Solomon [24] also found that a quarter of the published articles were preliminary findings but that these OAMJs attracted experienced international scholars who placed importance on journal quality and the rapid review and publication process. More importantly, there is evidence that article cascading is happening with *BMJ Open* where editors of other BMJ journals recommend that their authors submit their rejected papers to *BMJ Open*, and also with *PLOS ONE*<sup>41</sup> [24]. This is a pattern that has been observed for Elsevier’s *Heliyon* and also for the now-defunct *Springer Plus* [52].

Are OAMJs profitable? Table 1 shows the current cost of publishing in some main OAMJs, the range of which averages between US\$480 and US\$2500. Comparing the current APCs to the average (US\$1300) previously reported [6] indicates that the business model of OAMJs is likely to generate positive economic profits. This is not surprising if one considers the low operating costs, and the non-financial compensation of authors, peers and editors (except for peer and editor compensation in *eLife*). In competitive markets, positive economic profits provide a signal for other companies to enter the market. As new companies enter the OAMJ market, competition should intensify, APCs may fall, and one would expect positive economic profits of existing companies to evaporate. For example, when *PLOS ONE* was launched

<sup>39</sup> We assume that there are also publishing entities that will publish anything for a zero APC without peer review or with weak peer review, with the sole objective of increasing their volume of published literature and profile. Such publishers take a slice of the orphan papers, depriving other legitimate publishers from collecting potential APCs. Such unscholarly players thus also represent a financial threat.

<sup>40</sup> However, Solomon does not examine how many papers the other journals published that were previously rejected by yet other journals and hence one cannot argue that OAMJs publish lower quality work because there is no control group against which quality can be compared.

<sup>41</sup> “PLOS ONE’s instructions for authors indicates the publisher will help in transferring manuscripts from one PLOS journal to another but encourage authors to carefully consider which PLOS journal would be most appropriate for their manuscript before submission.” (p. 6).

in 2006 it published 138 articles and peaked in 2013 at 31,404 articles; in 2013, *PLOS ONE* occupied 83% of the total number of published research articles among the 19 OAMJs listed by Björk [7, 8]. This successful market penetration (and dominance) of *PLOS ONE* was a signal for established publishers to enter the market. Nature launched *Scientific Reports* in 2011, publishing 208 articles or 1.4% of the OAMJ market, but by 2013 it increased its share to 6.6% [7]. In 2017, according to Björk, the “Big Two” in this OAMJ market are *Scientific Reports* publishing the most articles (24,077) and occupying 41.5% of this mega-market, while *PLOS ONE* is now the second biggest occupying 35.3% of the market (20,098 articles) [8]. The third largest OAMJ in terms of market share of OAMJ publications is *Medicine*, occupying only 4.7% but has shown a growth rate of 833% since it converted from a single-subscription journal in 2014 to an OAMJ in 2017. As a subscription-based journal, it published 29 journals in 2013 prior to switching to the OAMJ model [7, 8]. However, Björk excluded *Oncotarget* from his list of OAMJs, but it would in fact occupy third place by capturing 8% of the total articles published by the OAMJs in Björk’s list.<sup>42</sup> In addition, the Frontiers series and other OAMJs are absent from Björk’s list of journals, probably because they did not satisfying his primary criteria of what is a mega-journal. Given the current structure of the two journals that occupy 77% of the OAMJ market share, or with still few companies occupying a large segment of this relatively new market, it is still far from the competitive outcome which indicates that it fits within the oligopolistic market (a few firms controlling the market) with barriers to entry, even in this OAMJ market. As one innovative way to capture orphan papers and thus a larger slice of the OAMJ market, *PeerJ*, as a way to lure more academics to its preprint, reduced its APCs from \$1095 to zero for a limited period, creating instant demand.<sup>43</sup>

## Up-and-Coming OAMJs Vying for Market Space

Cell Press’ *iScience*,<sup>44</sup> which launched in late 2017, may be seeking a slice of this profitable OAMJ market, to capture some of those rejected papers. No one really knows how this market will evolve in the future, but it is certainly in a phase of disruptive innovation.<sup>45</sup> For example, Africa has become a curious neo-colonialist academic battle ground for the preprint and OAMJ markets. Elsevier’s *Scientific African*,<sup>46</sup> a proposed new OAMJ for the African continent that employs the *f1000Research* technological platform, was launched on March 26, 2018, while The Center for Open Science, central in the academia’s reproducibility battle, launched

<sup>42</sup> <http://www.scimagojr.com/journalsearch.php?q=19900191708&tip=sid&clean=0>.

<sup>43</sup> <https://scholarlykitchen.sspnet.org/2018/03/09/peerj-waives-apc-pivots/>.

<sup>44</sup> <https://www.cell.com/iscience/home>.

<sup>45</sup> According to Christensen, disruptive innovation “describes a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors.” See: <http://www.claytonchristensen.com/key-concepts/>.

<sup>46</sup> <https://www.journals.elsevier.com/scientific-african/>.

AfricArxiv.<sup>47</sup> These projects, and what they represent to the OA movement in Africa, have been discussed in greater detail by Teixeira da Silva et al. [40]. Another example is the launch of the first university-based OAMJ, *UCL Open: Environment*,<sup>48</sup> hosted by University College London, and launched in February of 2019. The aim, as we predicted above, seems clear: APCs.<sup>49</sup> *JAMA Network Open*<sup>50</sup> launched in May of 2018, with their site on medical sciences. At the time of launch, Rivara et al. [23] stated, relative to a 2017 prediction: “we estimate that more than 17,000 research manuscripts will be submitted to *JAMA* and the 11 specialty journals and approximately 1500 will be published”, suggesting that 15,500 orphan papers were candidates for absorption by *JAMA Network Open*. With a \$3000 APC,<sup>51</sup> *JAMA Network Open* is well on the road to profitability.

## Conclusions

If one considers that *PLOS ONE* has been around since near the start of the OA movement, then it can be argued that the concept of an OAMJ is neither new, nor novel. However, considering that the OA market is now facing stronger competition, and PLOS competitors have seen that this business model can be profitable, in part because gaming the JIF may be attracting more paying Chinese authors [53], as in the OAMJ *Medicine* [54]. This possibility is real, especially given Björk and Solomon’s [9] hypothesis that journals with a better quality to APC ratio tend to attract more authors. It is therefore reasonable to expect that most OA publishers, or publishers with an OA fleet, even those that focus on thematic journals, may turn towards an OAMJ to boost revenues. The concern of diversifying the market with broad titles that all cater for an identical pool of academics, is that, given the current incentives structure in science and science publishing, most likely the vast majority might aim for the OAMJ with the highest JIF (as this would give the greatest financial and professional rewards), and then cascade down the JIF ladder as their paper gets rejected and resubmitted. However, a survey of 2128 authors who published in *BMJ Open*, *PeerJ*, *PLOS ONE* or *SAGE Open* showed that the JIF was more important for authors who published in *PLOS ONE* than *BMJ Open* authors [24]. In this climate, does the OAMJ model provide any new, viable, or even sustainable incentives to the publishing industry? Are OAMJs simply using tools to attract academics to their OAMJs, or to steer them away from competing publishers, by offering a transfer service such as *SpringerPlus* or *Heliyon* in the case of Springer Nature or Elsevier, respectively.

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<sup>47</sup> <https://osf.io/preprints/africarxiv?platform=hootsuite>.

<sup>48</sup> <https://ucl.scienceopen.com/>.

<sup>49</sup> <https://ucl-about.scienceopen.com/article-processing-charges/>.

<sup>50</sup> <https://sites.jamanetwork.com/jamanetworkopen/index.html>.

<sup>51</sup> <https://jamanetwork.com/journals/jamanetworkopen/pages/instructions-for-authors>.

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