Okagbue HI, Teixeira da Silva JA, Anake TA. Exploring the relationship between journal indexing and article processing charges of journals published by MDPI, the Multidisciplinary Digital Publishing Institute. *European Science Editing* 2020;46.
DOI: 10.3897/ese.2020.e54523

ORIGINAL ARTICLE

Exploring the relationship between journal indexing and article processing charges of journals published by MDPI, the Multidisciplinary Digital Publishing Institute

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DOI: 10.3897/ese.2020.e54523

Abstract
The Multidisciplinary Digital Publishing Institute (MDPI) is a prominent open access (OA) publisher that uses article processing charges (APCs) as its business model. Our objective was to determine the association between the APCs levied by MDPI journals and 1) their inclusion in Scopus and Web of Science databases or 2) their stature, as represented by their CiteScore (Elsevier's Scopus) and Impact Factor (awarded by Clarivate Analytics). Among the 227 journals published by MDPI, 51 had both IF and CiteScore; 107, only a CiteScore; and 84, neither IF nor CiteScore. The charges levied by the journals varied widely, from 0 to CHF 2000 (Swiss francs), the most frequent figure (159 journals) being CHF 1000, or about €930. The amount of APCs was found to be correlated to IF ($R^2 = 0.64$; $p < 0.001$; 107 journals) and also to CiteScore ($R^2 = 0.619$; $p < 0.001$; 53 journals). The charges levied by journals that had both IF and CiteScore were significantly higher than those charged by journals with neither IF nor CiteScore ($p < 0.05$). The charges were also correlated to the age of the journal: the more recently launched journals charged less than the older journals did.

***Keywords*:** Citations; CiteScore; Impact Factor (IF); MDPI; Scopus; Web of Science.

Introduction

The world of publishing is gradually moving towards open access (OA), a process centred on the ambitious Plan S,[1] which requires that all research supported by public grants be published only in OA journals. Except for diamond OA journals, which charge no publishing fees, gold OA requires authors to pay article processing charges (APCs) to have their articles published. Authors or the research institutions they are affiliated to or their funders usually pay the APCs, which vary widely depending on the publisher. Often authors pay the APCs themselves.[2] Two studies[3,4] found that APCs are not dependent on citation counts or numbers of articles published whereas another study[5] concluded that "from 2012 to 2018 higher APCs were actually associated with increased article volumes" for the Multidisciplinary Digital Publishing Institute (MDPI AG), BMC, Frontiers, and Hindawi. Currently, the largest 'whitelist' (ie, a list of journals recommended as safe to publish in or conforming to the principles of ethics of scholarly publishing) of OA journals is the Directory of Open Access Journals (DOAJ), although it faces several challenges.[6] An earlier study[7] estimated that 63% of the 11,836 DOAJ-indexed OA journals levied no APCs, and a later study[8] put the figure at 69.7%. In 2019, those numbers went up: Morrison[7] estimated that as of 26 November 2019, 73% of the 14,007 DOAJ-indexed OA journals were platinum OA.[9] Moreover, DOAJ-indexed OA journals with a high Impact Factor (IF; awarded by Clarivate Analytics) and published by such international publishers as Springer Nature, Elsevier, SAGE, and Taylor & Francis charged higher APCs than publishers from developing countries.[10]

MDPI publishes 227 OA journals, as shown on its website, and most of them collect APCs,[11] and this study sought to ascertain the association, if any, between APCs and coverage of MDPI journals in Web of Science (WoS) and Scopus.

Method

Selection of journals

To determine the link between the amount of APCs (expressed in Swiss francs, assuming 1 CHF to be €0.93) levied by a journal and its status and rank in the two indexing services, data on APCs, IFs, and CiteScores were retrieved from the publisher's website, WoS, and Scopus, respectively (Suppl. Table 1). Preliminary findings showed that 51 journals had an IF as well as a CiteScore, 107 had only CiteScore, 84 had neither an IF nor a CiteScore, and 68 are indexed in Emerging Sources Citation Index (ESCI). Both CiteScore and IF were extracted between 11 and 20 April 2020 and were mostly the same, whether as found in the respective databases or on the MDPI website. The data were subdivided into three groups or cases.

In Case 1, journals with an IF were removed, as were all those journals without a CiteScore, those with a 2019 CiteScore tracker, and those not indexed in Scopus. This screening left us with a set of 107 journals, all of which were indexed in Scopus and had a CiteScore. Note that some journals in this group, despite being indexed in Scopus, had an IF as well.

In Case 2, journals with a CiteScore were removed, as were those without an IF, those with a 2019 IF tracker, those indexed in ESCI, and those not indexed in WoS. This screening left us

Table 1. Descriptive statistics of article processing charges levied by MDPI journals indexed in Web of Science or Scopus or both

Statistic	Case 1 CiteScore (Scopus)	Case 2 Impact Factor (Web of Science)	Case 3 CiteScore and Impact Factor
Mean (Standard deviation)	1318 (413)	1664 (279)	1675 (276)
Median (25–75 percentile)	1200 (1000–1600)	1600 (1400–2000)	1600 (1425–2000)
Mode	1000	2000	2000
Kurtosis	–0.795	–0.481	–0.369
Skewness	0.225	–0.467	–0.517
Minimum	300	1000	1000
Maximum	2000	2000	2000
Normality	<0.001	0.002	0.001
Total	107	53	51

with a set of 53 journals, all of which were indexed in WoS and had an IF. Note that some journals in this group, despite being indexed in WoS and having an IF, had a CiteScore as well.

In Case 3, the following journals were removed: those not indexed in Scopus, those not indexed in WoS, those indexed in ESCI, those with neither a CiteScore nor an IF, and those tracked in 2019 for a Citescore or an IF. This screening left us with a set of 51 journals, which were indexed in Scopus and had a CiteScore and were also indexed in WoS and had an IF. The journals in each of these three categories are listed in Suppl. Table 2.

Statistical analysis

Descriptive statistics were used for summarizing the data. Minitab 17.0 (Minitab, State College, Pennsylvania, USA) was used for analysing Spearman's rank correlation, and the rank was then used for investigating the relationship between APCs and the two metrics. Using analysis of variance, we ascertained whether the differences among the means of the three cases were significant as assessed by the Kruskal Wallis test using SPSS ver. 23.0 (IBM, Armonk, New York, USA) at p <0.05. A *post hoc* analysis was conducted using the software package R and the Holm FWER (family-wide error rate) for calculating Conover p values.

CiteScore and IF, independent of their being indexed in ESCI.

As can be seen from Table 1, the mean APCs levied by Case 3 journals were greater than those levied by either Case 2 journals or by Case 1 journals; hence, on average, the APC for publishing in journals that have both IF and CiteScore were higher than those with only one of the two metrics.

The Spearman's rank coefficient for correlation between CiteScore and APCs for the 107 journals indexed in Scopus (Case 1) was 0.64 (p <0.0001), and that between IF and APCs for the 53 journals indexed in WoS (Case 2) was 0.67 (p <0.0001). In addition, partial correlation analysis for Case 3 journals showed that partial correlation between APCs and CiteScore, controlling for the IF, was 0.037 (p = 0.797); that between APCs and IF, controlling for CiteScore, was 0.347 (p = 0.014); and that between the CiteScore and IF, controlling for APCs, was 0.791 (p <0.001).

Journals from Case 3 (51 journals with CiteScore *and* IF) were subdivided into three categories based on their APCs (Table 2). The Kruskal Wallis test showed that APC levied by these journals were significantly different from those with either CiteScore (χ^2 = 13.203659; p = 0.001358) alone or IF alone (χ^2 = 17.407460; p = 0.000166).

Table 2. CiteScores and Impact Factors of journals categorized by the amount of article processing charges

		CiteScore			Impact Factor		
Article processing charges (Swiss francs)	**Number of journals**	**Q1 (25th percentile)**	**Q2 (median)**	**Q3 (75th percentile)**	**Q1**	**Q2**	**Q3**
1000–1500	15	2.04	2.37	2.85	1.76	2.05	2.79
1600–1800	22	2.45	2.90	3.83	2.26	2.56	3.36
2000	14	3.28	4.12	4.65	3.05	3.96	4.55

Results

A total of 159 of the MDPI OA journals collect APCs of CHF 1000 for each article; 62 journals collect less than or more than that sum, and only six levy no APCs at all (Table 1).[11] Journals (107) are indexed in Scopus, have a CiteScore, and some journals have an IF, so the focus of Case 1 is on CiteScore, independent of the IF. The focus of Case 2 is IF, independent of CiteScore, and the focus of Case 3 is journals with both

A *post hoc* analysis showed the pairs of groups that differed significantly from each other (p <0.05); more specifically, Case 3 journals differed significantly from those in the other two categories in terms of the two metrics, namely CiteScore and IF (Table 3).

Table 3. Differences between median article processing charges collected by journals that have either CiteScore or Impact Factor and those that have both.

	Group	1 p	2 p
Cite-Score	2	0.0297	
	3	**0.0004**	0.0443
IF	2	0.0103	
	3	**0.00002**	**0.0098**

Conover *p*-values were adjusted by the Holm FWER method. Group numbers are the same as those indicated in Table 2. Bold values indicate $p < 0.01$. Others have $p < 0.05$.

A significant negative Spearman's rank correlation coefficient was obtained between the amount of APCs and the age of the journal collecting that amount of APCs (−0.559, $p < 0.0001$).

Discussion

We investigated the association between APCs and the inclusion of MDPI journals in WoS, Scopus, or both because a weak positive correlation was found between APCs and Google h5 index for 89 journals indexed in multiple bibliometric databases.[12] A recent blog analysed the meteoric rise of the MDPI brand and how its APCs-driven business model has led to the remarkable growth of the journals and has also increased their market share.[13] Journals that were launched in 2020 charged lower APCs than those charged by the journals launched in 2011. It is thus evident that MDPI journals have adjusted their APCs over the years to reflect changes in the prestige that comes with being indexed by Wos and Scopus and the CiteScore or IF. (We chose CiteScore given its rising popularity.[14]) The present work also shows that MDPI has adopted a strategy similar to that adopted by BiomedCentral (BMC) namely to base the amount of APCs keeping in mind the metric and coverage by the two major indexing services; however, as the present study shows, MDPI has given greater weighting to IF in determining APC.[15] Technically, once a journal is awarded an IF, changes to the APCs levied by the journal reflect the new status conferred upon it by the award. The implication is that other metrics such as CiteScore and coverage by PubMed are used as stepping stones to IF. Consequently, APCs are revised if a journal scores low on IF or CiteScore or is dropped by the indexing services. Journals with an IF publish more articles than those without an IF, a policy that is similar to that followed by BMC journals.[16] Questions about the quality of peer review of the large number of articles that this economic model generates, as adopted by MDPI and publishers of other mega OA journal, continue to raised and generate mixed responses from the academia.[17]

In scholarly OA publishing, one concern is the potentially exploitative or excessive APCs.[18] Higher APCs imply higher earnings. In particular, academics are concerned about publishers raising the APCs if the IF goes up.[19] We found that APCs of MDPI's OA journals were strongly correlated to their IFs, suggesting that as the IF of an MDPI journal increases, its APCs also rise. If this is true, the potential ethical and exploitative implications of this trend need to be discussed in the light of the APCs *versus* IF or CiteScore trend for other member journals of OASPA (Open Access Scholarly Publishers Association).[20] One implication is that the APCs of MDPI journals change over the years—and the increase is determined mainly by the individual journal's IF or CiteScore and its coverage by WoS or Scopus. Academics from developing countries, who might not be able to pay the high APC, can apply for a waiver.[21,22] The driving force behind the willingness of academics (or their funders or universities), who may be erroneously convinced that such metrics are equated with 'quality', to pay sometimes incredibly high APCs is in the gaming of IF (and other metrics) in a cash-for-IF scheme.[23, 24] It can thus be argued that publishers that raise the APCs of their journals to correspond to the rank or metric (here, CiteScore or JIF) are simply responding to market demand rather than driving the market.

Lastly, it must be admitted that the present study has multiple limitations. First, it relies on a limited number of databases and metrics to determine whether an association exists between the metric and APCs, whereas APCs of MDPI journals may be being influenced by other factors. Secondly, the nexus between APCs and coverage by indexing services (and, consequently, the CiteScore or IF) was determined only for a single OA publisher, although it would be interesting to determine if similar associations exist for other stand-alone OA mega journals or OA publishers. Finally, given its rising prominence in the world of OA publishing, feedback from MDPI would be welcomed by academics who publish in MDPI journals.

Conflicts of interest

The authors declare no conflict of interest of relevance to this topic.

Disclaimer

The second author has published in several MDPI journals.

Author contributions

All three authors contributed equally to the intellectual discussion underlying this paper, literature exploration, writing, data collection and analysis and interpretation, reviews, and editing, and accept responsibility for the content of the paper.

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