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Original Article

Influence of open access journals on the research community in Journal Citation Reports

Sang-Jun Kim[1], Kay Sook Park[2]

Library, [1]Korea Research Institute of Bioscience and Biotechnology, [2]Electronics and Telecommunications Research Institute, Daejeon, Korea

Abstract

Purpose: The number of open access (OA) journals is rapidly increasing, and it is very important for librarians to understand the influence of OA journals on the research community. This study investigated the influence of the OA journals listed in Journal Citation Reports (JCR) based on various indicators.

Methods: The data for this study were prepared by combining the JCR 2014 to 2019 journal list with the number of hybrid OA articles obtained by searching the Web of Science. Each journal's JCR indicators and article processing charge were added. The influence of OA journals was compared according to OA type, whether they were published by large publishers, and whether they were top gold OA journals.

Results: Gold OA journals remained weaker in terms of JCR indicators than hybrid journals. However, the top 20 gold OA journals, accounting for 27.0% of all OA articles in JCR 2014 to 2019, were superior in all JCR indicators. The top three OA publishers (MDPI, BioMed Central, and Public Library of Science) showed potential for development despite concerns regarding poor journals. The top three subscription publishers were very active in OA publishing, but their actual share of hybrid OA articles (Elsevier, 5.1%; Springer, 10.1%; and Wiley, 12.4% in JCR 2019) was still insufficient.

Conclusion: Some gold OA journals showed high competitiveness and even the possibility for development beyond traditional journals. The transition of subscription journals to hybrid journals was found to be at the early stage. In light of these findings, librarians should continue monitoring the influence of OA journals.

Keywords

Gold open access journal; Hybrid journal; Journal Citation Reports indicator; Mega journal; Open access

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Correspondence to Sang-Jun Kim
sjkim@kribb.re.kr

ORCID
Sang-Jun Kim
https://orcid.org/0000-0002-1833-2236
Kay Sook Park
https://orcid.org/0000-0002-2771-4930

Introduction

***Background/rationale*:** As venues for scholarly communication, academic journals have contributed to the development of science and technology. In the traditional model, publishers sell journals to libraries for a subscription fee after acquiring the copyright of the article from the author, in exchange for publishing it in their journal and distributing it worldwide. Unlike traditional print journals, many e-journals have adopted the open access (OA) concept, allowing anyone free access and reuse of articles on the internet. The OA movement, which aims to promote OA to research, has been developed in two major directions: one is publishing articles that are OA from the time of initial publication (gold OA) with the author's agreement, and the other is sharing the articles before or after publication through self-archiving or institutional repositories (green OA). From the user's point of view, some articles are inside the paywall and require subscription fees, while others are outside the paywall and freely open to anyone.

Article processing charge (APC)-based gold OA journals published by new OA publishers are springing up everywhere, and even traditional subscription publishers are participating in this change with the new release of APC-based gold OA journals or the conversion of subscription journals to hybrid journals. Institutional budgets are increasing due to the APCs added onto the subscription fees. Many publishers have an opportunity to obtain more profits by combining the APC business model with the subscription business model. In this situation, librarians who are dissatisfied with high journal subscription fees have pushed for off-set agreements deducting the share of APCs already paid by authors from the subscription fee. In recent years, attempts have even been made to implement read-and-publish agreement, which based subscription fees combining APCs to expedite OA publishing [1]. Like this, authors, users, and publishers understand the OA movement from diverse aspects and put it into practice in specific ways.

OA journals are rapidly growing to a degree that may be sufficient to change the traditional academic publishing ecosystem. The OA movement is certainly a new change that librarians have experienced since the 2000s, when many print journals were converted to e-journals. Excellent gold OA journals are appearing despite controversies regarding the formal peer review system and several examples of predatory journals. Librarians need to investigate the real influence of gold and hybrid OA journals on the research community in order to provide better library services.

***Objectives*:** After a previous study on the general status of OA at the journal and article level [2], we had several questions such as "How strong is the influence of gold OA journals?", "Which are the most influential gold OA journals?", "How many subscription journals have been converted to hybrid journals?", and "Is there any difference in the influence of OA journals according to whether they are published by subscription or OA publishers?" To address these questions, this study conducted an in-depth analysis of OA journals in Journal Citation Reports (JCR) 2014 to 2019 based on JCR indicators and APCs. We compared OA journals' influence by OA type, whether they were published by large publishers, and whether they were top gold OA journals. Types of OA were defined in the same way as in the author's previous study [2]. The results of this study will provide useful information for librarians, researchers, and publishers who are interested in the future of OA publishing.

Methods

***Ethics statement*:** This was not a study with human subjects, so neither institutional review board approval nor informed consent was required.

***Study design*:** This was a literature database-based observational study.

***Data collection*:** In the author's previous study [2], the journal list in JCR 2014 to 2019 and the OA articles searched from the Web of Science were combined, and 9,575,780 articles in 12,449 journals were finally collected (Dataset 1). That is, the total number of articles in each journal was defined as the number of citable items in JCR, but the number of hybrid OA articles was defined based on the search results in Web of Science. To further investigate the influence of OA journals on the research community, this study added JCR indicators and the APC of each journal to the collected data. The JCR indicators used for the in-depth analysis were citations, the average journal impact factor percentile (AJIFP), impact factor, Eigenfactor score, and article influence score (AIS). However, the APC was collected for the top 10 subscription [3] and OA publishers [2] from February to April 2020, so the findings of this study do not reflect the APC of all JCR journals.

***Statistilal methods*:** This study was based on gold and hybrid OA journals and the articles therein; therefore, only descriptive statistics were presented. Data were tabulated and the proportions of the cells were calculated. The growth rate (%) was calculated in terms of the compound annual growth rate (CAGR).

Results

Characteristics of OA journals by OA type

As shown in Table 1, distinct patterns were found for the JCR indicators of journals by OA type. The annual number of arti-

Table 1. Comparison of JCR indicators across journals by OA type

OA type		Journal	APC[a] (USD)	Average JCR indicator					
				Article[b]	Citation[b]	AJIFP (%)	IF	ES	AIS
Gold OA	Without APC	317	-	68	363	31.9	1.365	0.00422	0.416
	With APC	1,323	2,243	184	496	37.5	1.831	0.00821	0.521
Hybrid OA	Large[c]	4,462	3,093	201	1,647	59.1	2.944	0.01516	1.000
	Small[c]	3,907	2,830	70	393	43.1	1.819	0.00359	0.667
Subscription only		2,440	-	66	247	28.7	1.288	0.00239	0.568
Total[d]		12,449	2,886	128	820	45.0	2.102	0.00797	0.744

JCR, Journal Citation Reports; OA, open access; APC, article processing charge; USD, US dollar; AJIFP, average journal impact factor percentile; IF, impact factor; ES, Eigenfactor score; AIS, article influence score.
[a]APC per journal was based on the authors' previous study [4] and some added journals; [b]The data were calculated per journal in JCR 2014 to 2019; [c]The large journals published more than 12 OA articles in JCR 2014 to 2019 and the small journals published fewer than 12 OA articles in 6 years; [d]Total journals in JCR 2014 to 2019.

Table 2. Comparison of the six major publishers of gold OA journals with JCR indicators

Publisher	APC[a] (USD)	Gold OA in 6 years			Average JCR indicator					
		Journal	Article	Citation	Article[b]	Citation[b]	AJIFP (%)	IF	ES	AIS
Elsevier	1,928	97	52,473	229,011	90	394	37.3	2.186	0.00552	0.574
Springer	2,380	104	172,335	526,598	276	844	38.8	2.478	0.01806	0.776
Wiley	2,420	65	44,254	143,655	114	368	48.2	2.852	0.00626	0.974
MDPI	1,509	71	210,910	257,865	495	605	36.2	1.566	0.00733	0.249
BMC	2,450	226	166,351	682,478	123	503	50.4	2.535	0.00760	0.782
PLoS	2,506	7	148,196	705,664	3,529	16,802	90.0	6.451	0.32631	3.304
Total of gold OA	2,118	1,640	1,587,002	4,631,496	264,500	771,916	36.5	1.744	0.00745	0.502

OA, open access; JCR, Journal Citation Reports; APC, article processing charge; USD, US dollar; AJIFP, average journal impact factor percentile; IF, impact factor; ES, Eigenfactor score; AIS, article influence score; BMC, BioMed Central; PLoS, Public Library of Science.
[a]APC per journal was based on the authors' previous study [4] and some added journals; [b]The data were calculated per journal in JCR 2014 to 2019.

cles per journal was 127 in JCR 2014 to 2018 [3], but increased to 128 in JCR 2014 to 2019. Most of the gold OA journals with APCs, which are published for commercial purposes, contained an average of 184 articles per year. However, it was interesting that large hybrid journals, which published more than 12 OA articles over the course of 6 years, published more articles than even the gold OA journals. In contrast, small hybrid journals that published fewer than 12 OA articles and subscription-only journals published fewer articles, corresponding to less than half of the annual articles per journal. All of the JCR indicators except for the AIS were higher for the gold OA journals without APCs, which are published for non-profit purposes, than for the subscription only journals; however, most of the indicators related to citations, including the number of articles per journal, were lower than those of other journal types and even lower than the overall average of JCR journals. Therefore, the gold OA journals without APCs had relatively low popularity. The average APC for the gold OA journals was lower than that of hybrid journals. Excluding the small hybrid journals, all JCR indicators in the large hybrid journals were significantly higher than those of other journal types, although the APC was expensive. With their relatively high popularity, they composed the core journals in the JCR. However, all JCR indicators were lower for the subscription-only journals than for the average of all JCR journals.

Influence of gold OA journals by publishers

Based on the number of gold OA articles [2], the top three publishers with a subscription model or an OA model were selected. Hybrid OA articles were counted together in the selection of the top three subscription publishers, but only gold OA journals were used to compare JCR indicators. Among the top three subscription publishers, Springer was the most active in OA publishing, while Elsevier remained relatively inactive (Table 2). Although Elsevier offered low APCs, it published the fewest OA articles per journal. Elsevier and Spring-

Table 3. Comparison of the top 20 mega-OA journals with JCR indicators

Journal	APC[a] (USD)	In 6 years		Average JCR indicator					
		Article	Citation	Article[b]	Citation[b]	AJIFP (%)	IF	ES	AIS
PLoS One	1,695	129,682	531,391	21,614	88,565	75.3	2.897	1.70429	1.051
Scientific Reports	1,870	96,924	175,381	16,154	29,230	84.1	4.533	0.62036	1.555
RSC Advances	958	50,375	102,302	8,396	17,050	65.5	3.224	0.22404	0.599
Nature Communications	5,380	24,357	162,206	4,060	27,034	94.9	11.879	0.79176	5.560
IEEE Access[c]	1,750	24,164	13,394	6,041	20,091	79.4	3.979	0.03705	1.118
Optics Express	1,842	18,959	100,455	3,160	16,743	82.8	3.422	0.20074	0.899
International Journal of Molecular Sciences	1,987	18,300	37,347	3,050	6,225	68.2	3.629	0.08654	0.840
Sensors	1,987	18,049	32,264	3,008	5,377	66.3	2.623	0.05214	0.544
Medicine	1,800	17,820	16,617	2,970	2,770	66.1	2.518	0.03831	0.860
Sustainability	1,789	17,004	11,996	2,834	1,999	42.3	1.886	0.01638	0.221
Molecules	1,987	14,507	29,823	2,418	4,971	61.3	2.861	0.05346	0.611
Biomed Research International	2,200	14,134	25,230	2,356	4,205	44.1	2.208	0.07477	0.588
BMJ Open	2,806	13,403	17,561	2,234	2,927	73.4	2.415	0.07535	1.010
Frontiers in Microbiology	2,950	12,705	25,217	2,118	4,203	77.6	4.124	0.07982	1.311
Energies	1,789	12,685	12,183	2,114	2,031	49.5	2.416	0.01906	0.482
International Journal of Environmental Research and Public Health	1,987	12,475	14,226	2,079	2,371	62.3	2.277	0.03464	0.697
Journal of High Energy Physics	Free	12,202	79,538	2,034	13,256	88.3	5.908	0.15957	1.187
Frontiers in Psychology	2,950	12,008	18,680	2,001	3,113	74.3	2.272	0.06995	0.958
Oncotarget[d]	3,400	10,808	7,434	3,603	14,867	81.2	5.512	0.04129	1.421
Materials	1,987	10,292	12,839	1,715	2,140	68.5	2.755	0.02342	0.672
Average[b]									
20 gold OA journals	2,269	27,043	71,304	4,507	11,884	67.4	3.463	0.21850	1.055
All gold OA journals	2,118	968	2,824	161	471	36.5	1.744	0.00745	0.502

OA, open access; JCR, Journal Citation Reports; APC, article processing charge; USD, US dollar; AJIFP, average journal impact factor percentile; IF, impact factor; ES, Eigenfactor score; AIS, article influence score.

[a]APC per journal was based on the authors' previous study [4] and some added journals; [b]The data were calculated per journal in JCR 2014 to 2019; [c]*IEEE* Access was based on JCR 2016 to 2019 since it was listed in JCR; [d]*Oncotarget* was based on JCR 2014 to 2016 as it was excluded from JCR.

er had a comparable average AJIFP to that of MDPI, so the largest three publishers did not yet have as favorable a reputation in gold OA journals as they had in subscription journals. Public Library of Science (PLoS) had the highest average number of OA articles and citations per journal with the fewest journals, even though it had the most expensive APC among the six publishers. PLoS also overwhelmed the other publishers regarding the remaining four JCR indicators, suggesting the success of its OA journals. MDPI and Springer had the next highest average numbers of OA articles and citations per journal. MDPI published the largest amount of OA articles with the lowest APC, and was the least competitive in the four JCR indicators excluding Eigenfactor score.

Mega-gold OA journals in OA publishing

The top 20 gold OA journals, which published more than 10,000 OA articles over the course of 6 years, were as follows, in descending order: *PLoS One, Scientific Reports, RSC Advances, Nature Communications, IEEE Access*, and *Optics Express*, and so on (Table 3). These journals, which exert a major influence on the research community, are mega-OA journals that were newly created for OA publishing, and accounted for 27.0% of all OA articles in JCR 2014 to 2019. In particular, the top 20 gold OA journals were superior in all JCR indicators,

Table 4. Articles and AJIFP of the seven gold open access journals in Journal Citation Reports' rank Q1

Journal[a]	Article						AJIFP (%)					
	2014	2015	2016	2017	2018	2019	2014	2015	2016	2017	2018	2019
PLoS One	30,040	28,114	22,077	20,328	17,879	11,244	85.1	83.3	77.3	77.3	65.9	62.7
Scientific Reports	3,931	10,642	20,517	24,809	17,152	19,873	92.1	89.7	85.2	82.0	79.0	76.8
Nature Communications	2,788	3,192	3,534	4,316	5,058	5,469	95.6	96.0	96.1	96.1	93.5	92.3
IEEE Access[b]	-	1	420	2,221	6,537	14,985	-	-	78.7	81.5	81.7	75.6
Optics Express	3,306	3,321	2,905	3,061	3,063	3,303	89.1	85.0	82.1	80.3	79.5	80.9
Frontiers in Microbiology	650	1,435	2,015	2,503	3,177	2,925	77.7	81.7	79.6	75.0	76.3	75.2
Journal of High Energy Physics	2,002	2,079	1,861	1,942	2,138	2,180	90.7	87.5	91.4	87.9	84.5	87.9

AJIFP, average journal impact factor percentile.
[a] *Oncotarget* was not included as it was excluded since Journal Citation Reports 2017; [b] *IEEE Access* began to be listed since Journal Citation Reports 2016.

overwhelming all other gold OA journals, and even had higher values for these indicators than the large hybrid journals, which were traditional journals with high authority and a long reputation. Table 3 shows the influence of the 20 mega-gold OA journals, which lead the domain of OA publishing, based on JCR indicators. Some of the APCs were somewhat expensive, but became cheaper (2,096 US dollars on average) when the exceptionally expensive *Nature Communications* was excluded. Therefore, the top 20 gold OA journals demonstrated excellence in both academic influence and economics. In terms of the average AJIFP, eight journals were ranked in Q1 and nine journals in Q2.

Regarding the challenges of gold OA journals published by subscription publishers, Springer tried a very expensive APC for *Nature Communications*; in contrast, society publishers such as the Royal Society of Chemistry, Institute of Electrical and Electronics Engineers, and Optical Society of America started carefully with lower APCs. Looking closely at the seven gold OA journals (excluding *Oncotarget*) ranked in Q1 in terms of their average AJIFP, six journals (excluding *PLoS One*) continuously remained in Q1 for 6 years (Table 4).

OA publishing of the top three subscription publishers

The top three subscription publishers, including Elsevier, Springer, and Wiley, were analyzed for 6 years (Table 5). For non-OA articles, which readers access through subscription fees, the CAGR of Elsevier and Springer was higher than that of all JCR journals, but Wiley had a lower CAGR. In contrast, for hybrid OA articles, the CAGR of Elsevier and Springer was lower than that of all JCR journals, but Wiley showed a very high CAGR, with an actively increasing number of hybrid OA articles even though it started slightly later. Among the top three subscription publishers, Wiley had the highest share of hybrid OA articles in 2019, whereas Elsevier remained passive, with the lowest share (Fig. 1).

Discussion

Key implications for gold and hybrid OA journals

OA publishing is proceeding in two main directions: gold OA journals as a new business model and hybrid journals combined with the existing subscription model. The JCR indicators were used for an in-depth analysis of the influence of these OA journals. Most old and well-known subscription journals have shifted to the hybrid model, while 23% of journals still remained subscription-only. The large hybrid journals showed excellent results for all JCR indicators, which is why authors were willing to pay a high APC to publish their articles in those journals. However, the large hybrid journals published more articles per journal than average, and it can be assumed that they were just adding the OA articles from a business perspective, rather than trying to convert subscription articles to the OA articles. Consequently, they were becoming somewhat mega-hybrid journals. Therefore, the publishers first converted highly influential journals into hybrid journals, for which authors were paying the APC as worthwhile.

Gold OA journals with a short publication history were still weaker in academic influence than hybrid journals. However, many top gold OA journals were superior in most JCR indicators and were in a higher position than even the large hybrid journals. These gold OA journals were favored by researchers and achieved a strong reputation in a short time through their enormous influence on the research community. If competitive gold OA journals continue to be launched, they may change the traditional journal ecosystem more quickly. Therefore, the journals of OA publishers showed both the potential for development beyond traditional peer-reviewed journals

Table 5. Articles in the subscription journals of the top three publishers

Publisher	Article type	2014	2015	2016	2017	2018	2019	CAGR (%)
Elsevier	Hybrid-OA	10,270	11,779	13,470	14,897	17,535	22,236	16.7
	Hybrid-subscription	333,023	347,923	360,162	372,530	401,139	413,415	4.4[a]
	Subscription only	3,018	2,247	2,396	2,619	2,772	2,695	
	Subtotal	346,311	361,949	376,028	390,046	421,446	438,346	4.8
Springer	Hybrid-OA	8,735	10,326	14,567	14,282	16,542	20,680	18.8
	Hybrid-subscription	139,278	143,225	146,360	150,124	155,875	159,062	2.3[a]
	Subscription only	25,315	25,645	25,415	25,743	26,620	25,474	
	Subtotal	173,328	179,196	186,342	190,149	199,037	205,216	3.4
Wiley	Hybrid-OA	971	2,336	5,836	7,520	10,424	19,662	82.5
	Hybrid-subscription	132,682	133,121	132,626	141,043	146,759	137,892	0.3[a]
	Subscription only	3,762	3,561	739	697	803	811	
	Subtotal	137,415	139,018	139,201	149,260	157,986	158,365	2.9
All JCR	Hybrid-OA	37,239	45,143	63,043	69,796	82,952	114,687	25.2
	Hybrid-subscription	1,044,272	1,064,530	1,080,155	1,109,276	1,156,331	1,158,155	1.7[a]
	Subscription only	161,254	164,254	161,250	160,537	160,720	155,184	
	Total	1,242,765	1,273,927	1,304,448	1,339,609	1,400,003	1,428,026	2.8

CAGR, compound annual growth rate; OA, open access; JCR, Journal Citation Reports.
[a]The data were calculated by adding hybrid-subscription and subscription only.

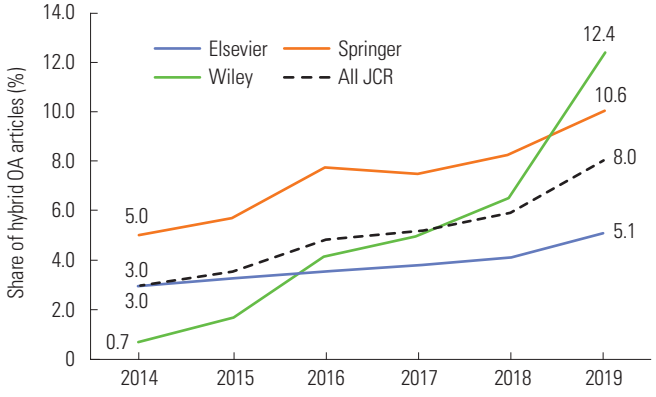

Fig. 1. Share of hybrid open access (OA) articles in the subscription journals of the top three publishers. JCR, Journal Citation Reports.

and concerns posed by poor-quality journals, besides their contribution to the growth of OA articles. If gold OA journals maintain the advantage of a traditional peer-review system with a long turnaround time, rather than a formal peer review system with a short turnaround time, their potential for development will be great. Gold OA journals have more advantages over traditional subscription journals in terms of the rapid circulation of research articles without any barrier to users, and the fact that they do not impose budgetary burdens on libraries.

Changing subscription agreements based on the growth of OA articles

Institutions sign subscription contracts for subscription journals, including hybrid journals. As the number of hybrid OA articles increases, it is time to reflect upon whether it makes sense for commercial publishers to raise their subscription prices every year. On the whole, the CAGR for hybrid OA articles was much higher than that of non-OA articles. The share of hybrid OA articles published by the top three publishers gradually increased over 6 years. This means that the share of non-OA articles decreased, undermining the purported rationale for the steep increase of journal subscription prices. Therefore, one may ask whether there was any other reason why the journal subscription prices of these publishers increased every year beyond the CAGR of JCR articles or the general inflation rate. Thus, the subscription agreement model needs to change, since double-dipping in the subscription prices provides support for off-set or read-and-publish agreements [1].

In OA publishing, the dominance of large journal publishers is also growing [5]; however, their influence remains limited. This trend has important implications for the negotiation of subscription prices with the top three publishers.

***Conclusion*:** Librarians are involved in the entire process of journal use, including the rational use of the subscription

budget, delivering articles to researchers, and recommending appropriate journals for submitting articles. In this study based on JCR indicators, the actual influence of OA journals on the research community was documented. Some gold OA journals were highly competitive in terms of JCR indicators, and even showed the potential to develop beyond traditional journals with high authority and a long reputation. Moreover, the top three subscription publishers published a rapidly increasing number of hybrid OA articles during the 6-year period analyzed in this study. In this situation, librarians need to expand journal services to include valuable OA journals by specifically grasping the trends and influence of OA journals.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Data Availability

Data are available from the author upon reasonable request.

Dataset 1. List of journal type with the APC and number of articles in Journal Citation Reports 2014 to 2019

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