DE GRUYTER
OPEN

Research Paper

Contribution of the Open Access Modality to the Impact of Hybrid Journals Controlling by Field and Time Effects

Pablo Dorta-González[1†], María Isabel Dorta-González[2]

[1]University of Las Palmas de Gran Canaria, TiDES Research Institute, 35017 Las Palmas de Gran Canaria, Spain
[2]University of La Laguna, 38271 La Laguna, Spain

Citation: Dorta-González, P., & Dorta-González, M.I. (2022). Contribution of the open access modality to the impact of hybrid journals controlling by field and time effects. *Journal of Data and Information Science*, 7(2), 57–83. https://doi.org/10.2478/jdis-2022-0007

Received: Nov. 16, 2021
Revised: Jan. 23, 2022
Accepted: Feb. 18, 2022

Abstract

Purpose: Researchers are more likely to read and cite papers to which they have access than those that they cannot obtain. Thus, the objective of this work is to analyze the contribution of the Open Access (OA) modality to the impact of hybrid journals.

Design/methodology/approach: The "research articles" in the year 2017 from 200 hybrid journals in four subject areas, and the citations received by such articles in the period 2017–2020 in the Scopus database, were analyzed. The hybrid OA papers were compared with the paywalled ones. The journals were randomly selected from those with share of OA papers higher than some minimal value. More than 60 thousand research articles were analyzed in the sample, of which 24% under the OA modality.

Findings: We obtain at journal level that cites per article in both hybrid modalities (OA and paywalled) strongly correlate. However, there is no correlation between the OA prevalence and cites per article. There is OA citation advantage in 80% of hybrid journals. Moreover, the OA citation advantage is consistent across fields and held in time. We obtain an OA citation advantage of 50% in average, and higher than 37% in half of the hybrid journals. Finally, the OA citation advantage is higher in Humanities than in Science and Social Science.

Research limitations: Some of the citation advantage is likely due to more access allows more people to read and hence cite articles they otherwise would not. However, causation is difficult to establish and there are many possible bias. Several factors can affect the observed differences in citation rates. Funder mandates can be one of them. Funders are likely to have OA requirement, and well-funded studies are more likely to receive more citations than poorly funded studies. Another discussed factor is the selection bias postulate, which suggests that authors choose only their most impactful studies to be open access.

Practical implications: For hybrid journals, the open access modality is positive, in the sense that it provides a greater number of potential readers. This in turn translates into a greater number of citations and an improvement in the position of the journal in the rankings by

† Corresponding author: Pablo Dorta-González (E-mail: pablo.dorta@ulpgc.es, ORCID: 0000-0003-0494-2903).

impact factor. For researchers it is also positive because it increases the potential number of readers and citations received.

Originality/value: Our study refines previous results by comparing documents more similar to each other. Although it does not examine the cause of the observed citation advantage, we find that it exists in a very large sample.

Keywords Open access; Open science; Scholarly communication; Hybrid journals; Citation advantage

1 Introduction

Researchers are more likely to read and cite papers to which they have access than those that they cannot obtain. Thus, since the emergence of the world wide web, scientists and scholarly publishers have used different forms of Open Access (OA), a disruptive model for the dissemination of research publications (Björk, 2004). In the last years, more and more scientists are making their research results openly accessible to increase its visibility, usage, and citation impact (Dorta-González et al., 2017; 2020).

The common characteristic of all different forms of OA is that the primary source of communication of research results, the peer reviewed article, is available to anybody with Internet access free of charge and access barriers (Prosser, 2003).

There are four main OA modalities. *Gold OA* refers to scholarly articles in fully accessible OA journals. *Green OA* refers to publishing in a subscription or pay-per-view journal, in addition to self-archiving the pre- or post-print paper in a repository (Harnad et al., 2004). *Hybrid OA* is an intermediate form of OA, where authors pay scholarly publishers to make articles freely accessible within journals, in which reading the content otherwise requires a subscription or pay-per-view (Björk, 2017). And finally, *Delayed OA* refers to scholarly articles in subscription journals made available openly on the web directly through the publisher at the expiry of a set embargo period (Laakso & Björk, 2013).

As previously said, a hybrid journal is a traditional one, for which readers need a subscription or where readers can pay to view individual articles. However, the journal offers authors the possibility to open their individual article on condition of the payment of a price similarly than in a gold OA journal. The price level in the hybrid OA is typically around 3,000 USD, which many authors and their institutions perceive as high (Tenopir et al., 2017).

Hybrid journals are a risk free transition path towards full OA, in contrast to starting new full OA journals or converting ones, since the subscription revenue remains (Prosser, 2003). Thus, since Springer announced in 2004 the hybrid option "Open Choice" for their full portfolio of subscription journals, most big publishers

have adopted similar modalities and the number of journals offering the hybrid possibility has increased in recent years.

The vast majority of subscription journals from the leading scholarly publishers are nowadays hybrid. The number of journals offering the hybrid option has increased from around 2,000 in the year 2009 to almost 10,000 in the year 2016, and the number of individual articles in the same period has grown from an estimated 8,000 in the year 2009 to 45,000 in the year 2016 (Björk, 2017).

Since Lawrence proposed in 2001 the OA citation advantage, this postulate has been discussed in depth without an agreement being reached (Davis et al., 2008). Furthermore, some authors are critical about the causal link between OA and higher citations, stating that the benefits of OA are uncertain and vary among different fields (Davis & Walters, 2011).

In this paper, as novel contribution, we take a journal-level approach to assessing the OA citation advantage, while many others take a paper-level approach. This is because research articles in both publication modalities in the same hybrid journal and publication year, are quite similar in discipline and with a priori the same citation potential.

Thus, based on citation data from the Scopus database, we provide longitudinal estimations of cites per article in both publication modalities in hybrid journals. Moreover, we answer the following questions:

1. Are hybrid OA research articles more highly cited than their paywalled counterparts?
2. How does this difference vary according to field and time?

2 Theoretical framework on open access citation advantage

Many researchers, starting with Lawrence (2001), have found that OA articles tend to have more citations than pay-for-access articles. This OA citation advantage has been observed in a variety of academic fields including computer science (Lawrence, 2001), philosophy, political science, electrical & electronic engineering, and mathematics (Antelman, 2004), physics (Harnad et al., 2004), biology and chemistry (Eysenbach, 2006), as well as civil engineering (Koler-Povh, Južnič, & Turk, 2014).

However, this postulate has been discussed in the literature in depth without an agreement being reached (Davis et al., 2008; Dorta-González & Santana-Jiménez, 2018; Gargouri et al., 2010; González-Betancor & Dorta-González, 2019; Joint, 2009; Norris, Oppenheim, & Rowland, 2008; Wang et al., 2015). Furthermore, some authors are critical about the causal link between OA and higher citations, stating that the benefits of OA are uncertain and vary among different fields (Craig et al., 2007; Davis & Walters, 2011).

Research Paper

Kurtz et al. (2005), and later other authors (Craig et al., 2007; Davis et al., 2008; Moed, 2007), set out three postulates supporting the existence of a correlation between OA and increased citations. (1) OA articles are easier to obtain, and therefore easier to read and cite (*Open Access postulate*). (2) OA articles tend to be available online prior to their publication and therefore begin accumulating citations earlier than pay-for-access articles (*Early View postulate*). And (3) more prominent authors are more likely to provide OA to their articles, and authors are more likely to provide OA to their highest quality articles (*Selection Bias postulate*). Moreover, these authors conclude that early view and selection bias effects are the main factors behind this correlation.

Gaule and Maystre (2011) and Niyazov et al. (2016) found evidence of selection bias in OA, but still estimated a statistically significant citation advantage even after controlling for that bias. Regardless of the validity or generality of their conclusions, these studies establish that any analysis must take into account the effect of time (citation time window) and selection bias.

At journal level, Gumpenberger, Ovalle-Perandones, and Gorraiz (2013) showed that the impact factor of gold OA journals was increasing, and that one-third of newly launched OA journals were indexed in the Journal Citation Reports (JCR) after three years. However, Björk and Solomon (2012) argued that the economic model is not related to journal impact. This result has been confirmed by Solomon, Laakso, and Björk (2013), concluding that articles are cited at a similar rate regardless of the distribution model.

The OA citation advantage is not universally supported. Many studies have been criticised on methodological grounds (Davis & Walters, 2011), and a research using the randomized-control trial method failed to find evidence of an OA citation advantage (Davis, 2011).

However, recent studies using robust methods have observed an OA citation advantage. McCabe and Snyder (2014) used a complex statistical model to remove author bias and reported a small but meaningful 8% OA citation advantage. Archambault et al. (2014) in a massive sample of over one million articles and using field-normalized citation rates, described a 40% OA citation advantage. Ottaviani (2016) reported a 19% OA citation advantage excluding the author self-selection bias and beyond the first years after publication.

In a recent study, Piwowar et al. (2018) used three samples, each of 100,000 articles, to study OA in three populations: all journal articles assigned a DOI, recent journal articles indexed in Web of Science, and articles viewed by users of the open-source browser extension Unpaywall. They estimated that at least 28% of the scholarly literature is OA, and that this proportion is growing mainly in gold and hybrid journals. Accounting for age and discipline, they observed OA articles receive 18% more citations than average, an effect driven primarily by green and hybrid OA.

3 Methodology

Since the end of 2020, Scopus has new Open Access filters providing information on the type of open access per article. With this new classification system, users can now filter their results or use specific OA tags, i.e. gold, hybrid gold, green, and bronze (delayed).

The source of OA information in Scopus is Unpaywall, an open-source browser extension that lets users find OA articles from publishers and repositories (run by OurResearch, a non-profit organization).

In this study, four subject areas in the Scopus database, one in each branch of knowledge, are considered: Arts & Humanities; Economics, Econometrics & Finance; Medicine; and Physics & Astronomy.

We decided a priori to take four subject areas. This number was set so that both figures and tables could be displayed in the paper. The subject areas were selected based on the previous experience of the authors and trying to cover fields as diverse as possible.

For each of these subject areas, the "research articles" in the year 2017 from 50 hybrid journals, and the citations received by such research articles in the period 2017–2020, were downloaded from the Scopus database (April 8, 2021).

Only 2017 was taken as the year of publication (census) in order to have a citation window of at least three full years for all documents (a full window of three years plus the time elapsed during the year of publication). Note that in most areas the maximum of the distribution of citations is reached before the third year from its publication. Articles published at the beginning of 2017 accumulate their citations for almost four years, while those published at the end of 2017 accumulate their citations for just over three years. This consideration has no consequences on the results obtained since the publication under the hybrid open access modality is distributed uniformly among all the issues of the same year.

The 200 journals were randomly selected from those with share of OA papers in 2017 higher than some minimal value: 5% in Medicine, 4% in Arts & Humanities, 2% in Physics & Astronomy, and 2% in Economics, Econometrics & Finance. Said threshold was set based on the prevalence of the OA modality in each subject area, so that this percentage is higher in areas where the OA modality in hybrid journals is more widespread. This information is detailed in the dataset in Appendix.

A total of 2,020,793 "research articles" were published in the Scopus database in 2017, of which 69,093 were in hybrid journals under the OA modality (3.4%). During that same year, the selected four subject areas published 874,556 research articles, of which 33,796 were in hybrid journals with OA modality (3.9%).

The distribution by subject areas is show in Table 1. The hybrid OA prevalence is 4.6% in Medicine, 3.7% in Arts & Humanities, 2.7% in Physics & Astronomy, and 2.5% in Economics, Econometrics & Finance. The four subject areas represents 43.3% of the database in 2017 by including the largest (Medicine) and the fourth largest (Physics & Astronomy) subject areas. Moreover, the OA articles in hybrid journals in the four subject areas represent 48.9% of the database by including also the largest (Medicine) and the fourth largest (Physics & Astronomy) subject areas in hybrid OA articles.

Table 1. Description of the subject areas in the study.

Subject Area	Research Articles in 2017				
	OA Hybrid	%	Other modalities*	%	Total
Arts & Humanities	2,821	3.7%	74,458	96.3%	77,279
Economics, Econometrics & Finance	1,097	2.5%	43,376	97.5%	44,473
Medicine	23,243	4.6%	485,260	95.4%	508,503
Physics & Astronomy	6,635	2.7%	237,666	97.3%	244,301
Aggregate Areas	**33,796**	**3.9%**	**840,760**	**96.1%**	**874,556**
Scopus database	69,093	3.4%	1,951,700	96.6%	2,020,793
%	48.9%		43.1%		43.3%

*Paywalled modality in hybrid journals, paywalled journals, and OA journals

In the sample, the 62,608 research articles from 200 hybrid journals were analyzed. Of these, 8,043 research articles were published under the OA modality. This represents 23.8% of the total OA research articles published in hybrid journals in the subject areas considered (33,796). This information disaggregate by subject areas is show in Table 2. The areas that are overrepresented in the sample in relation to the OA, in relative terms, are Economics, Econometrics & Finance (49.3%) and Arts & Humanities (40.8%). However, in absolute terms, the total number of OA articles included in these two areas are lower than in Medicine and Physics & Astronomy, due to the larger size of the journals in the latter.

Table 2. Representativeness of the sample.

Subject Area	Research Articles in Hybrid Journals in 2017			
	Sample		Population	Sample %
	OA Hybrid	Paywalled	OA Hybrid	OA Hybrid
Arts & Humanities	1,151	5,759	2,821	40.8%
Economics, Econometrics & Finance	541	5,411	1,097	49.3%
Medicine	4,381	15,772	23,243	18.8%
Physics & Astronomy	1,970	27,623	6,635	29.7%
Total	**8,043**	**54,565**	**33,796**	**23.8%**

3 Results

3.1 Cites per article in hybrid journals by modality

About the correlation between variables (Table 3), as expected, the size of the journal does not correlate with any other variable. The OA prevalence in hybrid journals, this is the proportion of research articles under the OA modality, does not correlate with the position of the journal in the citation ranking (best CiteScore percentile). As a particular case, it does weakly and negatively in Arts & Humanities (-0.69), that is, the best-positioned journals in the citation ranking have a lower proportion of OA articles. This is due to some highly prestigious journals that are still in the initial stages of the hybrid publication model.

Table 3. Pearson's linear correlation coefficient.

	Best CiteScore Percentile 2017	Research Articles 2017	OA Prevalence	OA Cites per Article	Paywalled Cites per Article
Arts & Humanities					
Best CiteScore Percentile 2017	1.00	0.03	-0.69	0.50	0.57
Research Articles 2017	0.03	1.00	-0.21	0.30	0.42
OA Prevalence	-0.69	-0.21	1.00	-0.39	-0.40
OA Cites per Article	0.50	0.30	-0.39	1.00	0.81
Paywalled Cites per Article	0.57	0.42	-0.40	0.81	1.00
Economics, Econometrics & Finance					
Best CiteScore Percentile 2017	1.00	-0.16	0.07	0.60	0.57
Research Articles 2017	-0.16	1.00	-0.52	0.13	0.11
OA Prevalence	0.07	-0.52	1.00	-0.14	-0.12
OA Cites per Article	0.60	0.13	-0.14	1.00	0.85
Paywalled Cites per Article	0.57	0.11	-0.12	0.85	1.00
Medicine					
Best CiteScore Percentile 2017	1.00	-0.48	-0.22	0.29	0.34
Research Articles 2017	-0.48	1.00	-0.14	-0.18	-0.20
OA Prevalence	-0.22	-0.14	1.00	0.01	-0.02
OA Cites per Article	0.29	-0.18	0.01	1.00	0.97
Paywalled Cites per Article	0.34	-0.20	-0.02	0.97	1.00
Physics & Astronomy					
Best CiteScore Percentile 2017	1.00	0.12	0.00	0.33	0.52
Research Articles 2017	0.12	1.00	-0.35	0.03	0.15
OA Prevalence	0.00	-0.35	1.00	-0.17	-0.17
OA Cites per Article	0.33	0.03	-0.17	1.00	0.49
Paywalled Cites per Article	0.52	0.15	-0.17	0.49	1.00

Note: (a) The OA prevalence is the proportion of articles in the OA modality of the hybrid journal. (b) We use the term 'Best percentile' because a journal may be assigned to several subject fields and have different percentiles in each of them.

The OA prevalence either does not correlate with cites per article in the hybrid modalities. However, the position of the journal in the citation ranking (percentile) correlates weakly with cites per article in both hybrid modalities.

Note the only two variables that present high correlation, above 0.81 in three subject areas, are cites per article according to modality. That is, the higher cites per article in one modality, the greater in the other. Medicine highlight with a very high correlation (0.97). The exception is Physics & Astronomy, where the correlation reduces to 0.49.

As previously commented, there is a strong and positive linear correlation for cites per article in both hybrid modalities (see Figure 1). The coefficient of determination is generally high, with the exception of Physics & Astronomy. The hybrid journals with the greatest impact in one modality are also in the other. The bisector of the square, that is, the imaginary line that begins in the lower left corner and ends in the upper right corner of the square, separates the citation advantage for each modality. The bubbles below the bisector correspond to hybrid journals with citation advantage for the OA modality. Similarly, the bubbles above the bisector correspond to hybrid journals with citation advantage in the paywalled modality (citation disadvantage for the OA). Note in all the areas there is a majority of journals below the bisector, where the citation advantage corresponds to the OA hybrid modality. In fact, the regression line falls below the bisector in all cases, that is, the OA citation advantage in hybrid journals is observed even in the least squares estimate.

In relation to the OA prevalence, this is the proportion of articles in the OA modality of the hybrid journal, indicated through the size of the bubble in Figure 1, there is a tendency for big bubbles to gravitate around the origin. This is especially evident for Humanities and Physics. This means that hybrid journals with higher proportion of OA papers are usually cited less, which is in accordance with mostly negative correlation coefficients for these indicators in Table 3.

The box diagram for the average of cites per article in hybrid journals, according to modality and year of citation, is show in Figure 2. In all subject areas and each citation year, cites per article for those in the OA modality are clearly higher than the citations in the paywalled modality. These average citations for the OA modality are higher both in mean (indicated with the x symbol) and in quartiles of the distribution (box and whisker). Note that the mean of the distribution is considerably larger than the median. This is because the distribution is asymmetric with a long tail on the right.

The increase in the number of citations over time relates to the shape of the citation distribution in each subject area. Thus, for example, in Physics & Astronomy the maximum of the distribution reaches in the third year. Beyond this logical increase in the number of citations over years, no clear time effect observes in Figure 2.

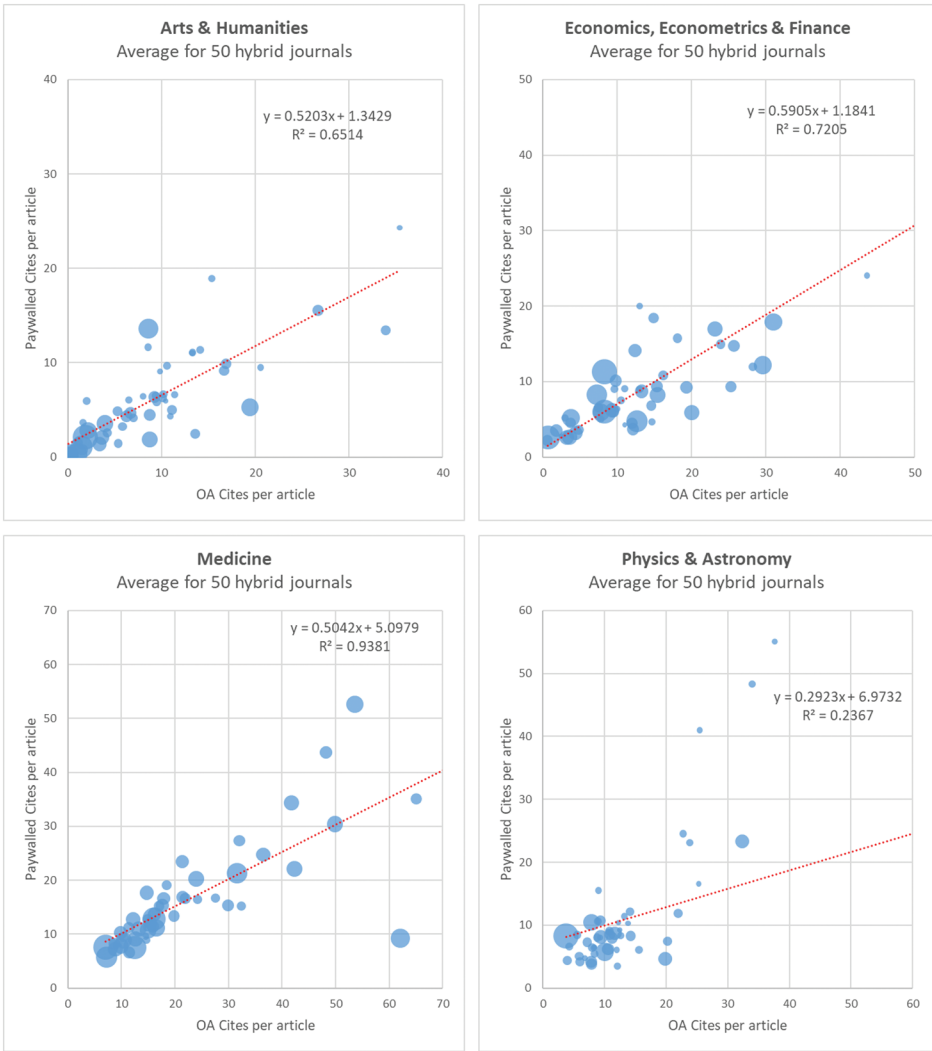


Figure 1. Scatter plot for cites per article in both hybrid modalities. Average across all citation years for the 200 hybrid journals in the sample. Bubble size proportional to OA prevalence.

3.2 Open Access citation advantage in hybrid journals

The OA citation advantage (disadvantage when it is negative) for a journal in a particular year, is defined in relation to the sign of the subtraction as follows. If cites per OA article is greater than cites per paywalled article, then the OA citation advantage is:

(Cites per OA - Cites per Paywalled) / Cites per Paywalled.

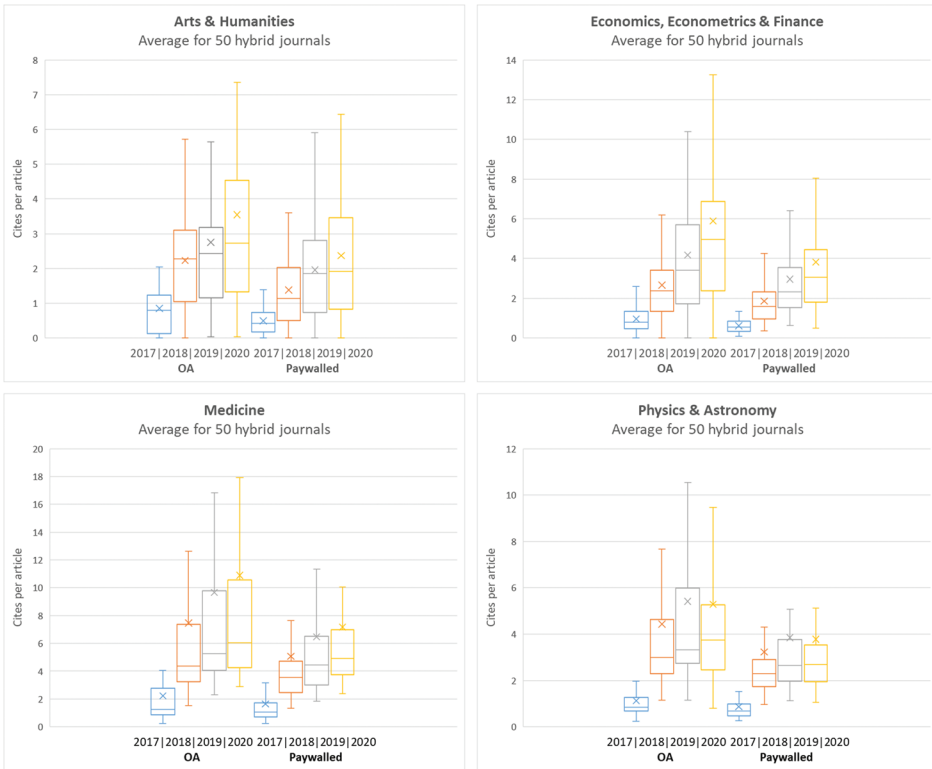


Figure 2. Box and whisker plot (without outliers) for the distribution of cites per article by hybrid modality and year of citation. Average in the citation years for the 200 hybrid journals in the sample.

However, if cites per OA article is less than cites per paywalled article, then the OA citation advantage (disadvantage because de result is negative) is:

(Cites per OA - Cites per Paywalled) / Cites per OA.

The OA citation advantage in relation to the journal percentile shows in Figure 3. There are differences in OA citation advantages between fields. For example, in Medicine there are few journals with a citation disadvantage for the OA, and in most cases the citation advantage is in the range 0–100%. However, in Economics, Econometrics & Finance the differences among journals are much greater and a big number of cases fall into the range from -100% to 200%. Note the only two highly disadvantaged journals have medium percentiles. A more detailed analysis will follow.

Figure 4 shows the OA citation advantage by subject areas, with and without outliers. Note the citation advantage of the OA modality in hybrid journals is clear for all subject areas. The data distribution, represented by the box and whiskers,

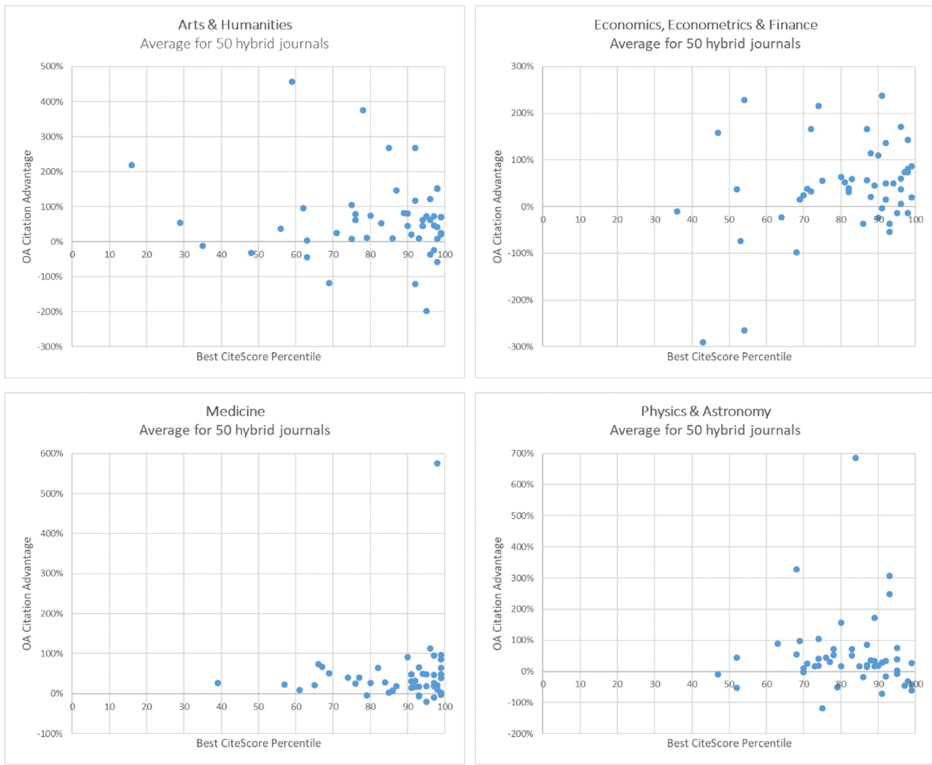
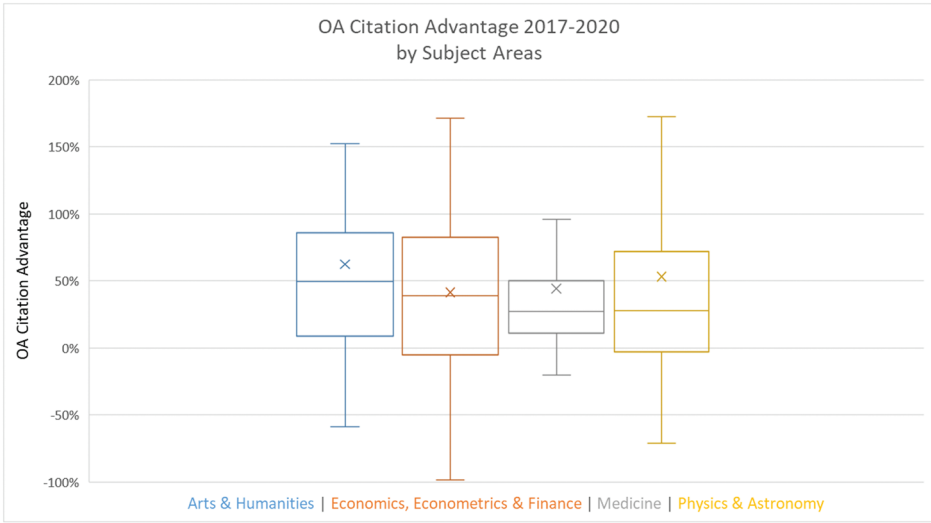


Figure 3. OA citation advantage in relation to the best CiteScore percentile. We use the term "Best percentile" because a journal may be assigned to several subject fields and have different percentiles in each of them.

displaces toward the positive part of the vertical axis. The median of the distribution (the inner line that divides the box into two parts) is in the range 25–50%, while the mean is in 40–60%. There is a citation advantage in more than 75% of the journals. Thus, the 25th percentile (the bottom line of the box) is located close to 0% in the worst case (Economics, Econometrics & Finance). Furthermore, the OA citation advantage is consistent across fields (Figure 4) and held in time (Figure 5).

There is OA citation advantage in 80% of hybrid journals (Table 4). In the remaining 20% there are OA citation disadvantage or there are no differences. The results are relatively stable both across fields and over time. The subject areas where the number of journals with OA citation advantage is higher are Medicine (88%) and Arts & Humanities (82%).

The average of the OA citation advantage (Table 5) increases with time in the area where the OA prevalence is highest (Medicine), but has a U-shape in the area where the OA prevalence is lowest (Economics, Econometrics & Finance).



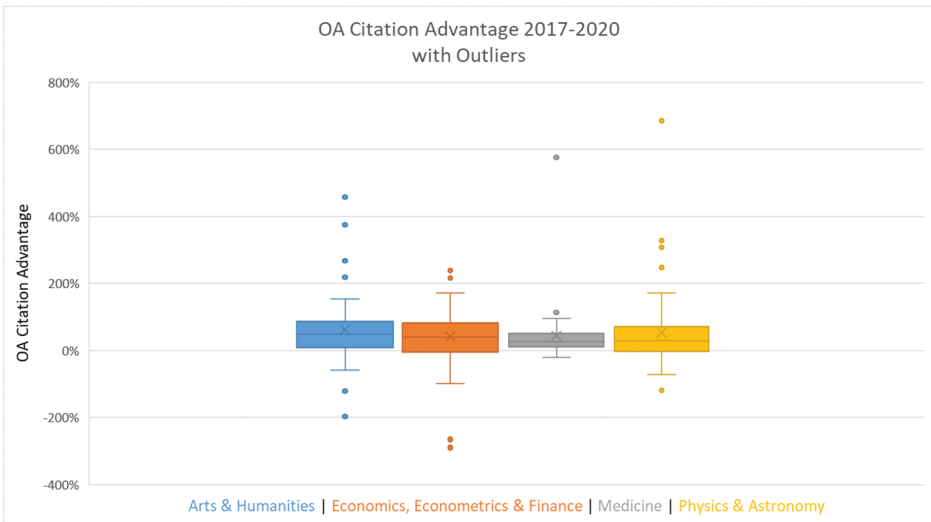


Figure 4. OA citation advantage by subject areas.

Table 4. Number of journals with OA citation advantage.

Subject Area	Number of Journals with OA Citation Advantage									
	2017		2018		2019		2020		2017–2020	
Arts & Humanities	33	66%	41	82%	40	80%	39	78%	41	82%
Economics, Econometrics & Finance	35	70%	38	76%	34	68%	40	80%	37	74%
Medicine	39	78%	43	86%	44	88%	40	80%	44	88%
Physics & Astronomy	38	76%	38	76%	35	70%	36	72%	37	74%
Aggregate areas	**145**	**73%**	**160**	**80%**	**153**	**77%**	**155**	**78%**	**159**	**80%**

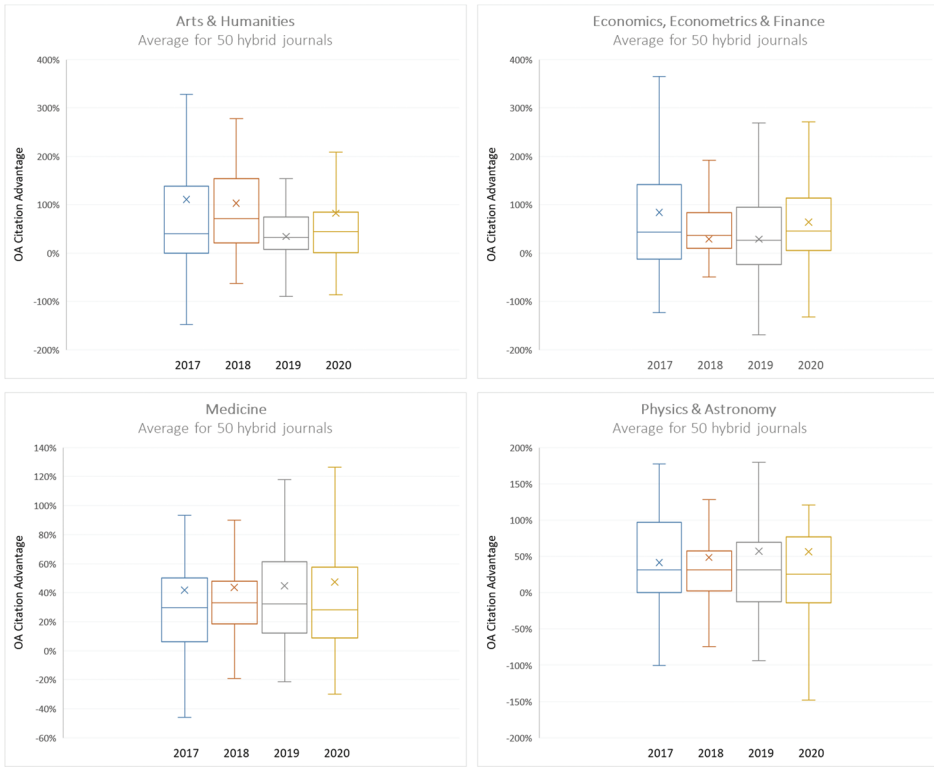


Figure 5. OA citation advantage along time.

Table 5. Mean of the OA citation advantage.

Subject Area	Mean OA Citation Advantage				
	2017	2018	2019	2020	2017–2020
Arts & Humanities	110.6%	102.8%	34.4%	82.5%	62.4%
Economics, Econometrics & Finance	83.9%	28.4%	28.8%	64.1%	41.4%
Medicine	41.7%	43.5%	44.7%	47.4%	44.3%
Physics & Astronomy	41.4%	48.6%	57.0%	56.3%	53.1%
Aggregate areas					**50.3%**

For the aggregate citations in 2017–2020, the average OA citation advantage varies in the range 41.4–62.4%, with a mean for the aggregate areas of 50.3%. The highest average reaches in Arts & Humanities, while the lowest observes in Economics, Econometrics & Finance.

The outliers observed in the data distribution can skew the mean. However, half of the journals have OA citation advantage above the median of the distribution (and the other half below). Thus, the median (Table 6) is more robust measure of central

tendency than the mean for data with such a high variance. The median OA citation advantage in 2017–2020 varies among fields in the range 26.9–49.4%, being 36.8% its value for the aggregate areas. The highest median reaches in Arts & Humanities, while the lowest observes in Medicine.

Table 6. Median of the OA citation advantage.

Subject Area	Median OA Citation Advantage				
	2017	2018	2019	2020	2017–2020
Arts & Humanities	38.9%	62.9%	31.8%	44.1%	49.4%
Economics, Econometrics & Finance	41.8%	37.9%	24.2%	45.8%	39.0%
Medicine	29.2%	32.1%	31.5%	28.0%	26.9%
Physics & Astronomy	30.5%	30.0%	30.7%	24.8%	27.9%
Aggregate areas					**36.8%**

Thus, we can conclude that the citation advantage of the OA modality in hybrid journals, in relation to the paywalled modality, is around 50.3% in average for the 200 journals and four years in the sample, and higher than 36.8% in half of the journals. Moreover, this OA citation advantage held in time. Finally, the highest OA citation advantage is observed in Arts & Humanities.

4 Discussion and conclusions

Access to academic literature is a current debate in the research community. Research funders are increasingly mandating OA dissemination while, at the same time, the growth in costs have led more and more university libraries to cancel some subscriptions.

In this paper, the "research articles" in the year 2017 from 200 hybrid journals in four subject areas, and the citations received by such articles in the period 2017–2020 in the Scopus database, were analyzed. The journals were randomly selected from those with share of OA papers higher than some minimal value. More than 60 thousand research articles were analyzed in the sample, of which 24% under the OA modality.

Interestingly, we found that in general, the citations per article in both hybrid modalities strongly correlate. The hybrid journals with the greatest impact in one modality are also in the other. The evidence for this result is weaker in the field of Physics. However, there is no correlation between the OA prevalence, this is the proportion of articles in the OA modality of the hybrid journal, and cites per article in any of the hybrid modalities.

We found that there is OA citation advantage in 80% of hybrid journals. This result is strong both across fields and over time. The number of journals with OA citation advantage is higher in Medicine (88%) and Humanities (82%).

We found that the average OA citation advantage increases with time in the field where the OA prevalence is highest (Medicine), but has a U-shape in the field with lowest OA prevalence (Economics). The average OA citation advantage in 2017–2020 varies among fields in the range 41–62%, with an aggregate mean of 50%. The highest average is obtained in Humanities, while the lowest is observed in Economics.

The median OA citation advantage in 2017–2020 varies in the range 27–49% according to fields, being 37% its value for the aggregate fields. The highest median is observed again in Humanities, while the lowest is obtained in Medicine.

Thus, we can conclude that the citation advantage of the OA modality in hybrid journals, in relation to the paywalled modality, is around 50% in average for the 200 journals and four years in the sample, and higher than 37% in half of the journals. Moreover, the OA citation advantage is consistent across fields and held in time. Finally, the OA citation advantage is higher in Humanities than in Science and Social Science.

There are some considerations in this regard. Some journals in the random sample have been cataloged by the Scopus database as Humanities, but are actually at the intersection with other areas. Notice that there are journals assigned to two different subject categories from two different areas. Indeed, these journals that employ scientific methods with applications to the Humanities receive more citations than pure humanistic journals. Therefore, the results obtained for this area must be taken with caution.

On the reliability of the data source, Unpaywall is indirectly used (through Scopus) to determine the publication modality in hybrid journals. Notice that Unpaywall is based on algorithms and not on indexing. This is the reason why, regardless of the discipline, the OA finder Unpaywall does not locate as many OA versions of journal articles as manual searches (Piwowar et al., 2018; Sergiadis, 2019).

Our study refines previous results by comparing documents more similar to each other, both in discipline and citation potential. Some of the citation advantage in the open access modality is likely due to more access allows more people to read and hence cite articles they otherwise would not. However, causation is difficult to establish and there are many possible bias. Several factors can affect the observed differences in citation rates. Funder mandates can be one of them. Funders are likely to have OA requirement, and well-funded studies are more likely to receive more citations than poorly funded studies (Aagaard, Kladakis, & Nielsen, 2020).

Another discussed factor is the selection bias postulate (Craig et al., 2007), which suggests that authors choose only their most impactful studies to be open access. Selection bias can occur in both paid open access journals (gold OA) and hybrid journals. This is due to researchers who have financial resources to publish their

results prioritize the publication in open access those papers that they consider may have a greater impact. The current study does not examine the cause of the observed citation advantage, but does find that it exists in a very large sample.

Author contributions

Pablo Dorta-González (pablo.dorta@ulpgc.es): Conceptualization (Equal), Formal analysis (Equal), Investigation (Equal), Methodology (Equal), Supervision (Equal), Validation (Equal), Writing—original draft (Equal), Writing—review & editing (Equal). María Isabel Dorta-González (isadorta@ull.edu.es): Data curation (Equal), Formal analysis (Equal), Investigation (Equal), Writing—original draft (Equal), Writing—review & editing (Equal).

References

Aagaard, K., Kladakis, A., & Nielsen, M.W. (2020). Concentration or dispersal of research funding?, *Quantitative Science Studies*, 1(1), 117–149.

Antelman, K. (2004). Do open-access articles have a greater research impact?, *College & Research Libraries*, 65(5), 372–382.

Archambault, E., Amyot, D., Deschamops, P., & Nicol, A., et al. (2014). Proportion of open access papers published in peer-reviewed journals at the European and world levels—1996–2013. Report for the European Commission. Available at https://digitalcommons.unl.edu/scholcom/8/

Sergiadis, A.D.R. (2019). Evaluating Zotero, SHERPA/RoMEO, and Unpaywall in an institutional repository workflow, *Journal of Electronic Resources Librarianship*, 31(3), 152–176.

Björk, B.C. (2004). Open access to scientific publications: an analysis of the barriers to change?, *Information Research*, 9(2), 170.

Björk, B.C. (2017). Growth of hybrid open access, 2009–2016, *PeerJ*, 5, e3878.

Björk, B.C., & Solomon, D. (2012). Open access versus subscription journals: a comparison of scientific impact, *BMC Medicine*, 10(1), 73.

Craig, I.D., Plume, A.M., Mcveigh, M.E., & Pringle, J., et al. (2007). Do open access articles have greater citation impact? A critical review of the literature, *Journal of Informetrics*, 1(3), 239–248.

Davis, P.M. (2011). Open access, readership, citations: a randomized controlled trial of scientific journal publishing, *FASEB Journal*, 25, 2129–2134.

Davis, P.M., Lewenstein, B.V., Simon, D.H., & Booth, J.G., et al. (2008). Open access publishing, article downloads, and citations: randomised controlled trial, *British Medical Journal*, 337(7665), 343–345.

Davis, P.M., & 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(3), 208–208.

Dorta-González, P., González-Betancor, S.M., & Dorta-González, M.I. (2017). Reconsidering the gold open access citation advantage postulate in a multidisciplinary context: an analysis of the subject categories in the Web of Science database 2009–2014, *Scientometrics*, 112(2), 877–901.

Dorta-González, P., & Santana-Jiménez, Y. (2018). Prevalence and citation advantage of gold open access in the subject areas of the Scopus database, *Research Evaluation*, 27(1), 1–15.

Dorta-González, P., Suárez-Vega, R., & Dorta-González, M.I. (2020). Open access effect on uncitedness: a large-scale study controlling by discipline, source type and visibility, *Scientometrics*, 124(3), 2619–2644.

Eysenbach, G. (2006). Citation advantage of open access articles, *PLoS Biology*, 4(5), e157.

Gargouri, Y., Hajjem, C., Larivière, V., & Gingras, Y., et al. (2010). Self-selected or mandated, open access increases citation impact for higher quality research, *PLoS ONE*, 5(10), e13636.

Gaule, P., & Maystre, N. (2011). Getting cited: does open access help? *Research Policy*, 40(10), 1332–1338.

González-Betancor, S.M., & Dorta-González, P. (2019). Publication modalities "article in press" and "open access" in relation to journal average citation, *Scientometrics*, 120(3), 1209–1223.

Gumpenberger, C., Ovalle-Perandones, M.A., & Gorraiz, J. (2013). On the impact of gold open access journals, *Scientometrics*, 96(1), 221–238.

Harnad, S., Brody, T., Vallières, F., & Carr, L., et al. (2004) The access/impact problem and the green and gold roads to open access, *Serials Review*, 30(4), 310–314.

Joint, N. (2009). The Antaeus column: does the "open access" advantage exist? A librarian's perspective, *Library Review*, 58(7), 477–481.

Koler-Povh, T., Južnič, P., & Turk, G. (2014). Impact of open access on citation of scholarly publications in the field of civil engineering, *Scientometrics*, 98(1033), 1033–1045.

Kurtz, M.J., Eichhorn, G., Accomazzi, A., Grant, C., et al. (2005). The effect of use and access on citations, *Information Processing & Management*, 41(6), 1395–1402.

Laakso, M., & Björk, B.C. (2013). Delayed open access: an overlooked high-impact category of openly available scientific literature, *Journal of the American Society for Information Science and Technology*, 64(7), 1323–1329.

Lawrence, S. (2001). Free online availability substantially increases a paper's impact, *Nature*, 411(6837), 521–521.

McCabe, M., & Snyder, C. (2014). Identifying the effect of open access on citations using a panel of science journals, *Economic Inquiry*, 52(4), 1284–1300.

Moed, H.F. (2007). The effect of open access on citation impact: an analysis of ArXiv's condensed matter section, *Journal of the American Society for Information Science and Technology*, 58(13), 2047–2054.

Niyazov, Y., Price. R., Vogel, C., Lund, B., et al. (2016). Open access meets discoverability: citations to articles posted to Academia.edu, *PLoS ONE*, 11(2), e0148257.

Norris, M., Oppenheim, C., & Rowland, F. (2008). The citation advantage of open-access articles, *Journal of the American Society for Information Science and Technology*, 59(12), 1963–1972.

Ottaviani, J. (2016). The post-embargo open access citation advantage: it exists (probably), it's modest (usually), and the rich get richer (of course), *PLoS ONE*, 11(8), e0159614.

Piwowar, H., Priem J., Larivière V., Alperin J.P, et al. (2018). The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles, *PeerJ*, 6, e4375.

Prosser, D. (2003). Institutional repositories and open access: the future of scholarly communication, *Information Services and Use*, 23(2), 167–170.

Solomon, D.J., Laakso, M., & Björk, B.C. (2013). A longitudinal comparison of citation rates and growth among open access journals, *Journal of Informetrics*, 7(3), 642–650.

Tenopir, C., Dalton, E., Christian, L., & Jones, M.K., et al. (2017). Imagining a gold open access future: attitudes, behaviors, and funding scenarios among authors of academic scholarship, *College & Research Libraries*, 78(6), 824–843.

Wang, X.W., Liu, C., Mao, W.L., & Fang, Z.C. (2015). The open access advantage considering citation, article usage and social media attention, *Scientometrics*, 103(2), 555–564.

Appendix: Dataset

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Arts and Humanities											
Anales de Literatura	29	Paywalled	20	43.5%	0	1	0	0	1	0.05	**53.8%**
Hispanoamericana		OA	26	56.5%	0	0	1	1	2	0.08	
Archaeological and	94	Paywalled	102	90.3%	86	157	202	217	662	6.49	**44.3%**
Anthropological		OA	11	9.7%	11	27	26	39	103	9.36	
Sciences											
Archaeology Ethnology	56	Paywalled	12	27.9%	0	2	5	6	13	1.08	**37.0%**
and Anthropology of		OA	31	72.1%	2	10	14	20	46	1.48	
Eurasia											
Archaeometry	99	Paywalled	64	88.9%	35	62	85	83	265	4.14	**69.1%**
		OA	8	11.1%	3	21	14	18	56	7.00	
Archives of Design	16	Paywalled	14	29.2%	0	1	2	1	4	0.29	**219.1%**
Research		OA	34	70.8%	1	8	12	10	31	0.91	
Archives of Sexual	91	Paywalled	197	94.7%	274	484	692	727	2,177	11.05	**20.1%**
Behavior		OA	11	5.3%	10	30	45	61	146	13.27	
Artnodes	69	Paywalled	11	47.8%	0	0	3	1	4	0.36	**-118.2%**
		OA	12	52.2%	0	0	1	1	2	0.17	
Attention Perception	94	Paywalled	177	88.9%	61	261	350	363	1,035	5.85	**61.7%**
and Psychophysics		OA	22	11.1%	22	52	69	65	208	9.45	
Behavior Research	95	Paywalled	132	82.0%	132	416	654	850	2,052	15.55	**71.9%**
Methods		OA	29	18.0%	52	163	225	335	775	26.72	
Bioethics	96	Paywalled	59	89.4%	39	109	111	112	371	6.29	**61.3%**
		OA	7	10.6%	11	21	23	16	71	10.14	
Biology and Philosophy	96	Paywalled	48	85.7%	21	51	68	100	240	5.00	**122.5%**
		OA	8	14.3%	15	28	25	21	89	11.13	
Brain and Cognition	92	Paywalled	96	93.2%	56	205	302	348	911	9.49	**116.8%**
		OA	7	6.8%	26	40	34	44	144	20.57	
Brain and Language	98	Paywalled	97	94.2%	62	241	267	310	880	9.07	**8.4%**
		OA	6	5.8%	2	19	18	20	59	9.83	
Cognition	99	Paywalled	222	91.0%	173	632	822	889	2,516	11.33	**24.3%**
		OA	22	9.0%	20	82	95	113	310	14.09	
Cognition and Emotion	86	Paywalled	141	91.0%	151	318	419	480	1,368	9.70	**9.0%**
		OA	14	9.0%	19	21	43	65	148	10.57	
Computers in Human	97	Paywalled	634	95.6%	715	2,976	5,094	6,609	15,394	24.28	**45.9%**
Behavior		OA	29	4.4%	39	207	344	437	1,027	35.41	
Contemporary British	87	Paywalled	19	70.4%	4	3	9	10	26	1.37	**146.6%**
History		OA	8	29.6%	5	9	5	8	27	3.38	
Cultural and Social	75	Paywalled	30	81.1%	3	4	4	12	23	0.77	**105.0%**
History		OA	7	18.9%	0	3	6	2	11	1.57	
Design Journal	35	Paywalled	45	9.9%	5	17	34	39	95	2.11	**-12.3%**
		OA	410	90.1%	3	136	259	373	771	1.88	
Ethical Theory and	76	Paywalled	41	69.5%	5	17	27	35	84	2.05	**79.0%**
Moral Practice		OA	18	30.5%	3	12	21	30	66	3.67	
Evolution and Human	96	Paywalled	79	91.9%	90	195	282	353	920	11.65	**-35.9%**
Behavior		OA	7	8.1%	6	17	16	21	60	8.57	
Gender Place and	97	Paywalled	97	92.4%	30	123	212	276	641	6.61	**72.1%**
Culture		OA	8	7.6%	1	20	20	50	91	11.38	

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Human Ecology	93	Paywalled	58	85.3%	14	56	107	103	280	4.83	**9.8%**
		OA	10	14.7%	1	12	13	27	53	5.30	
International Journal of Audiology	95	Paywalled	107	89.9%	44	151	233	209	637	5.95	**-197.7%**
		OA	12	10.1%	6	20	20	20	24	2.00	
International Journal of Transpersonal Studies	48	Paywalled	11	57.9%	12	1	10	8	31	2.82	**-32.6%**
		OA	8	42.1%	0	5	8	4	17	2.13	
Journal of Agricultural and Environmental Ethics	98	Paywalled	34	79.1%	6	35	63	56	160	4.71	**41.7%**
		OA	9	20.9%	14	11	17	18	60	6.67	
Journal of Archaeological Science	99	Paywalled	105	91.3%	107	275	350	429	1,161	11.06	**20.3%**
		OA	10	8.7%	17	32	44	40	133	13.30	
Journal of Archaeological Science Reports	80	Paywalled	379	95.9%	177	545	737	806	2,265	5.98	**74.6%**
		OA	16	4.1%	11	42	49	65	167	10.44	
Journal of Business Ethics	97	Paywalled	300	92.6%	345	953	1,772	2,610	5,680	18.93	**-23.5%**
		OA	24	7.4%	27	82	108	151	368	15.33	
Journal of Ethnic and Migration Studies	89	Paywalled	124	83.8%	126	213	338	457	1,134	9.15	**82.2%**
		OA	24	16.2%	49	79	103	169	400	16.67	
Journal of Intellectual and Developmental Disability	62	Paywalled	30	78.9%	15	31	34	54	134	4.47	**95.9%**
		OA	8	21.1%	8	17	23	22	70	8.75	
Journal of Medical Ethics	90	Paywalled	113	80.1%	82	200	218	221	721	6.38	**44.4%**
		OA	28	19.9%	28	69	70	91	258	9.21	
Journal of Memory and Language	98	Paywalled	88	87.1%	97	311	346	428	1,182	13.43	**152.6%**
		OA	13	12.9%	20	98	128	195	441	33.92	
Journal of Psycholinguistic Research	76	Paywalled	79	87.8%	15	42	54	93	204	2.58	**61.9%**
		OA	11	12.2%	8	12	13	13	46	4.18	
Journal of Religion and Health	98	Paywalled	163	93.7%	75	155	215	263	708	4.34	**151.2%**
		OA	11	6.3%	7	34	31	48	120	10.91	
Journal of Southern African Studies	59	Paywalled	59	85.5%	9	39	50	46	144	2.44	**457.2%**
		OA	10	14.5%	35	25	31	45	136	13.60	
Journal of the Acoustical Society of America	71	Paywalled	805	93.2%	322	1,364	1,850	1,642	5,178	6.43	**24.6%**
		OA	59	6.8%	28	120	167	158	473	8.02	
Journal of World Prehistory	98	Paywalled	5	41.7%	2	18	20	28	68	13.60	**-58.7%**
		OA	7	58.3%	6	17	16	21	60	8.57	
Law and Philosophy	78	Paywalled	12	63.2%	2	12	5	3	22	1.83	**375.3%**
		OA	7	36.8%	0	15	22	24	61	8.71	
Medical Humanities	85	Paywalled	81	88.0%	11	23	35	49	118	1.46	**268.2%**
		OA	11	12.0%	11	11	14	23	59	5.36	
Memory	75	Paywalled	123	92.5%	69	172	253	251	745	6.06	**7.3%**
		OA	10	7.5%	6	14	27	18	65	6.50	
Memory and Cognition	83	Paywalled	93	90.3%	47	149	185	239	620	6.67	**53.0%**
		OA	10	9.7%	12	23	23	44	102	10.20	
Neophilologus	63	Paywalled	35	81.4%	1	2	3	11	17	0.49	**2.9%**
		OA	8	18.6%	0	0	1	3	4	0.50	
Philosophia United States	63	Paywalled	105	84.7%	9	27	63	60	159	1.51	**-43.9%**
		OA	19	15.3%	0	3	6	11	20	1.05	
Philosophical Explorations	79	Paywalled	23	59.0%	4	15	28	35	82	3.57	**10.4%**
		OA	16	41.0%	2	17	22	22	63	3.94	

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Philosophical Studies	92	Paywalled	162	92.0%	46	113	192	238	589	3.64	**-121.3%**
		OA	14	8.0%	1	7	1	14	23	1.64	
Philosophy and Technology	92	Paywalled	14	56.0%	6	17	18	33	74	5.29	**268.1%**
		OA	11	44.0%	17	41	75	81	214	19.45	
Political Geography	99	Paywalled	72	83.7%	39	143	233	295	710	9.86	**70.9%**
		OA	14	16.3%	15	51	79	91	236	16.86	
Review of Philosophy and Psychology	94	Paywalled	33	80.5%	14	27	42	60	143	4.33	**44.2%**
		OA	8	19.5%	7	18	9	16	50	6.25	
Synthese	90	Paywalled	209	88.2%	42	139	203	290	674	3.22	**80.5%**
		OA	28	11.8%	19	38	47	59	163	5.82	
Economics, Econometrics & Finance											
Applied Economics	47	Paywalled	410	97.9%	98	336	561	752	1,747	4.26	**158.2%**
		OA	9	2.1%	10	21	19	49	99	11.00	
Applied Economics Letters	36	Paywalled	307	97.5%	71	157	286	332	846	2.76	**-10.2%**
		OA	8	2.5%	1	7	3	9	20	2.50	
Applied Health Economics and Health Policy	83	Paywalled	49	89.1%	21	74	84	114	293	5.98	**58.9%**
		OA	6	10.9%	9	10	22	16	57	9.50	
Computational Economics	72	Paywalled	54	91.5%	19	42	66	68	195	3.61	**32.9%**
		OA	5	8.5%	4	7	5	8	24	4.80	
Ecological Economics	92	Paywalled	266	92.4%	255	953	1,330	1,654	4,192	15.76	**14.8%**
		OA	22	7.6%	29	96	123	150	398	18.09	
Economic Geography	98	Paywalled	15	75.0%	15	64	89	100	268	17.87	**73.5%**
		OA	5	25.0%	7	24	52	72	155	31.00	
Economic Journal	91	Paywalled	105	87.5%	99	218	323	422	1,062	10.11	**-3.2%**
		OA	15	12.5%	9	29	49	60	147	9.80	
Economic Theory	68	Paywalled	59	86.8%	35	44	53	76	208	3.53	**-98.3%**
		OA	9	13.2%	7	1	3	5	16	1.78	
Economics Letters	53	Paywalled	390	95.6%	53	356	761	859	2,029	5.20	**-73.4%**
		OA	18	4.4%	5	11	14	24	54	3.00	
Economist Netherlands	43	Paywalled	10	52.6%	8	4	9	5	26	2.60	**-290.0%**
		OA	9	47.4%	4	0	2	0	6	0.67	
Empirical Economics	64	Paywalled	126	90.6%	27	133	173	241	574	4.56	**-23.4%**
		OA	13	9.4%	4	4	14	26	48	3.69	
Energy Economics	93	Paywalled	342	96.9%	333	1,352	2,193	2,966	6,844	20.01	**-53.9%**
		OA	11	3.1%	8	31	50	54	143	13.00	
Environmental and Resource Economics	81	Paywalled	95	84.8%	80	167	279	303	829	8.73	**52.3%**
		OA	17	15.2%	28	49	62	87	226	13.29	
European Journal of Health Economics	95	Paywalled	53	65.4%	55	98	130	156	439	8.28	**-13.7%**
		OA	28	34.6%	13	58	49	84	204	7.29	
Experimental Economics	94	Paywalled	35	83.3%	16	56	74	71	217	6.20	**49.8%**
		OA	7	16.7%	7	17	25	16	65	9.29	
Finance and Stochastics	87	Paywalled	20	62.5%	6	28	32	29	95	4.75	**166.7%**
		OA	12	37.5%	4	26	49	73	152	12.67	
Fiscal Studies	82	Paywalled	18	75.0%	11	20	29	47	107	5.94	**31.8%**
		OA	6	25.0%	6	6	13	22	47	7.83	
Food Policy	98	Paywalled	79	72.5%	49	203	312	398	962	12.18	**142.8%**
		OA	30	27.5%	60	160	269	398	887	29.57	

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Forest Policy and Economics	92	Paywalled	148	94.3%	198	447	518	604	1,767	11.94	**136.4%**
		OA	9	5.7%	29	60	87	78	254	28.22	
Global Policy	74	Paywalled	126	95.5%	72	123	172	218	585	4.64	**215.9%**
		OA	6	4.5%	12	19	28	29	88	14.67	
Globalizations	88	Paywalled	74	91.4%	73	121	146	163	503	6.80	**114.4%**
		OA	7	8.6%	5	25	28	44	102	14.57	
Internat Environmental Agreements Politics Law and Economics	91	Paywalled	37	80.4%	31	52	68	68	219	5.92	**237.9%**
		OA	9	19.6%	20	35	61	64	180	20.00	
International Journal of Agricultural Sustainability	80	Paywalled	43	87.8%	29	83	120	171	403	9.37	**63.6%**
		OA	6	12.2%	2	16	35	39	92	15.33	
International Journal of Game Theory	54	Paywalled	47	90.4%	9	31	30	33	103	2.19	**-265.2%**
		OA	5	9.6%	0	1	0	2	3	0.60	
International Journal of Production Economics	98	Paywalled	281	96.6%	331	1,284	2,207	2,930	6,752	24.03	**81.5%**
		OA	10	3.4%	7	80	121	228	436	43.60	
Journal of Common Market Studies	96	Paywalled	91	94.8%	70	198	256	298	822	9.03	**6.3%**
		OA	5	5.2%	4	15	8	21	48	9.60	
Journal of Development Economics	92	Paywalled	65	91.5%	32	138	213	319	702	10.80	**49.7%**
		OA	6	8.5%	4	17	34	42	97	16.17	
Journal of Econometrics	82	Paywalled	119	95.2%	67	155	269	403	894	7.51	**39.8%**
		OA	6	4.8%	8	10	15	30	63	10.50	
Journal of Economic Behavior and Organization	75	Paywalled	221	96.5%	53	266	463	635	1,417	6.41	**56.0%**
		OA	8	3.5%	4	18	16	42	80	10.00	
Journal of Economic Inequality	86	Paywalled	14	73.7%	2	12	30	29	73	5.21	**-37.2%**
		OA	5	26.3%	4	2	5	8	19	3.80	
Journal of Environmental Economics and Management	90	Paywalled	71	91.0%	85	259	392	571	1,307	18.41	**-23.9%**
		OA	7	9.0%	11	27	35	31	104	14.86	
Journal of International Economics	90	Paywalled	81	87.1%	30	142	225	349	746	9.21	**109.9%**
		OA	12	12.9%	9	38	71	114	232	19.33	
Journal of International Money and Finance	88	Paywalled	116	95.9%	52	187	316	499	1,054	9.09	**21.1%**
		OA	5	4.1%	5	7	16	27	55	11.00	
Journal of Public Economics	89	Paywalled	113	95.0%	47	184	333	449	1,013	8.96	**45.0%**
		OA	6	5.0%	7	15	18	38	78	13.00	
Journal of Risk and Uncertainty	82	Paywalled	11	52.4%	1	17	26	22	66	6.00	**38.3%**
		OA	10	47.6%	0	18	27	38	83	8.30	
Journal of the Academy of Marketing Science	99	Paywalled	45	90.0%	125	320	663	1,045	2,153	47.84	**20.0%**
		OA	5	10.0%	13	41	84	149	287	57.40	
Journal of the European Economic Association	98	Paywalled	31	86.1%	24	69	144	201	438	14.13	**-13.9%**
		OA	5	13.9%	1	16	18	27	62	12.40	
Labour Economics	69	Paywalled	78	92.9%	31	80	150	247	508	6.51	**15.2%**
		OA	6	7.1%	3	7	15	20	45	7.50	
Letters in Spatial and Resource Sciences	52	Paywalled	21	80.8%	2	9	22	22	55	2.62	**37.5%**
		OA	5	19.2%	3	2	2	11	18	3.60	
Marine Policy	96	Paywalled	304	90.2%	158	689	964	1,022	2,833	9.32	**171.2%**
		OA	33	9.8%	47	204	266	317	834	25.27	

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Public Choice	71	Paywalled	60	84.5%	14	36	57	83	190	3.17	**37.8%**
		OA	11	15.5%	2	8	18	20	48	4.36	
Quantitative Finance	87	Paywalled	109	95.6%	36	123	175	209	543	4.98	**56.6%**
		OA	5	4.4%	4	7	14	14	39	7.80	
Resources Policy	96	Paywalled	121	92.4%	88	369	594	755	1,806	14.93	**60.1%**
		OA	10	7.6%	8	46	94	91	239	23.90	
Review of Income and Wealth	72	Paywalled	56	88.9%	19	58	91	84	252	4.50	**166.7%**
		OA	7	11.1%	3	15	27	39	84	12.00	
Review of International Political Economy	99	Paywalled	27	79.4%	9	42	73	99	223	8.26	**86.8%**
		OA	7	20.6%	14	20	32	42	108	15.43	
Small Business Economics	96	Paywalled	80	80.8%	54	200	479	623	1,356	16.95	**36.6%**
		OA	19	19.2%	19	64	141	216	440	23.16	
Social Choice and Welfare	54	Paywalled	64	87.7%	29	56	79	72	236	3.69	**228.4%**
		OA	9	12.3%	14	23	29	43	109	12.11	
Technological and Economic Development of Economy	93	Paywalled	22	48.9%	27	63	82	76	248	11.27	**-36.5%**
		OA	23	51.1%	24	54	57	55	190	8.26	
Theory and Decision	70	Paywalled	50	83.3%	6	18	44	61	129	2.58	**24.0%**
		OA	10	16.7%	1	7	10	14	32	3.20	
World Development	97	Paywalled	252	88.1%	203	746	1,180	1,591	3,720	14.76	**74.1%**
		OA	34	11.9%	35	185	266	388	874	25.71	
Medicine											
Advances in Therapy	67	Paywalled	51	38.6%	26	111	113	133	383	7.51	**66.4%**
		OA	81	61.4%	68	254	358	332	1,012	12.49	
American Journal of Cardiology	82	Paywalled	626	94.0%	339	1,521	1,853	1,857	5,570	8.90	**64.9%**
		OA	40	6.0%	47	158	202	180	587	14.68	
American Journal of Preventive Medicine	97	Paywalled	237	79.5%	250	745	1,054	1,190	3,239	13.67	**18.4%**
		OA	61	20.5%	56	198	332	401	987	16.18	
American Journal of Tropical Medicine and Hygiene	66	Paywalled	414	83.6%	156	678	869	1,022	2,725	6.58	**73.3%**
		OA	81	16.4%	59	231	286	348	924	11.41	
Annals of Oncology	98	Paywalled	244	82.4%	572	2,345	3,436	4,319	10,672	43.74	**10.1%**
		OA	52	17.6%	183	656	875	791	2,505	48.17	
Annals of the Rheumatic Diseases	99	Paywalled	179	66.8%	917	2,359	3,031	3,113	9,420	52.63	**1.9%**
		OA	89	33.2%	593	1,378	1,364	1,437	4,772	53.62	
Antimicrobial Agents and Chemotherapy	92	Paywalled	751	85.2%	821	3,242	4,134	4,284	12,481	16.62	**31.7%**
		OA	130	14.8%	200	787	937	921	2,845	21.88	
Asian Pacific Journal of Tropical Medicine	93	Paywalled	47	30.7%	14	62	123	155	354	7.53	**-6.9%**
		OA	106	69.3%	26	163	245	313	747	7.05	
BMJ Online	98	Paywalled	186	59.6%	172	439	557	542	1,710	9.19	**575.7%**
		OA	126	40.4%	487	1,836	2,410	3,094	7,827	62.12	
Brain	98	Paywalled	178	74.8%	376	1,512	2,020	2,203	6,111	34.33	**21.6%**
		OA	60	25.2%	173	642	781	908	2,504	41.73	
Brain Structure and Function	93	Paywalled	200	78.1%	290	676	756	827	2,549	12.75	**-4.5%**
		OA	56	21.9%	67	182	210	224	683	12.20	
Breast Cancer Research and Treatment	77	Paywalled	298	83.0%	251	810	1,110	1,220	3,391	11.38	**39.7%**
		OA	61	17.0%	50	244	312	364	970	15.90	
British Journal of Dermatology	97	Paywalled	219	84.2%	473	833	994	1,059	3,359	15.34	**94.8%**
		OA	41	15.8%	133	317	358	417	1,225	29.88	

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Cancer Science	76	Paywalled	103	40.4%	26	307	456	527	1,316	12.78	**25.6%**
		OA	152	59.6%	184	646	765	845	2,440	16.05	
Cell Systems	91	Paywalled	51	54.8%	49	233	367	437	1,086	21.29	**48.3%**
		OA	42	45.2%	90	298	434	504	1,326	31.57	
Clinical Infectious Diseases	97	Paywalled	427	80.4%	842	2,640	3,269	3,264	10,015	23.45	**-9.9%**
		OA	104	19.6%	254	540	715	710	2,219	21.34	
Clinical Therapeutics	80	Paywalled	110	72.8%	98	191	273	294	856	7.78	**27.3%**
		OA	41	27.2%	25	96	140	145	406	9.90	
Diabetes Obesity and Metabolism	95	Paywalled	145	71.8%	285	815	911	918	2,929	20.20	**18.9%**
		OA	57	28.2%	164	407	401	397	1,369	24.02	
European Heart Journal	99	Paywalled	299	86.7%	1,035	2,633	3,219	3,599	10,486	35.07	**85.6%**
		OA	46	13.3%	302	769	925	998	2,994	65.09	
European Radiology	91	Paywalled	485	84.8%	568	1,784	2,014	2,111	6,477	13.35	**48.3%**
		OA	87	15.2%	132	448	546	597	1,723	19.80	
Health Policy and Planning	87	Paywalled	116	70.7%	90	200	292	448	1,030	8.88	**18.0%**
		OA	48	29.3%	47	108	169	179	503	10.48	
Human Brain Mapping	96	Paywalled	377	90.4%	384	1,402	1,876	2,061	5,723	15.18	**113.1%**
		OA	40	9.6%	76	289	434	495	1,294	32.35	
Human Molecular Genetics	91	Paywalled	322	80.7%	283	1,219	1,592	1,853	4,947	15.36	**14.7%**
		OA	77	19.3%	84	345	464	464	1,357	17.62	
Human Vaccines and Immunotherapeutics	57	Paywalled	211	75.6%	93	385	485	564	1,527	7.24	**23.1%**
		OA	68	24.4%	37	150	202	217	606	8.91	
Infection and Immunity	85	Paywalled	240	86.0%	207	687	868	915	2,677	11.15	**2.1%**
		OA	39	14.0%	43	98	150	153	444	11.38	
International Journal of Cancer	93	Paywalled	430	90.0%	578	1,880	2,275	2,441	7,174	16.68	**65.2%**
		OA	48	10.0%	67	341	420	495	1,323	27.56	
International Journal of Cardiology	69	Paywalled	1104	94.6%	1,024	2,893	3,223	3,478	10,618	9.62	**51.3%**
		OA	63	5.4%	89	220	273	335	917	14.56	
International Journal of Epidemiology	90	Paywalled	176	72.1%	291	820	1,270	1,500	3,881	22.05	**91.7%**
		OA	68	27.9%	187	575	893	1,220	2,875	42.28	
International Journal of Oncology	74	Paywalled	273	69.5%	195	750	890	1,094	2,929	10.73	**39.6%**
		OA	120	30.5%	102	427	595	673	1,797	14.98	
Journal of Allergy and Clinical Immunology	93	Paywalled	394	85.3%	1,241	2,946	3,189	3,393	10,769	27.33	**17.2%**
		OA	68	14.7%	276	582	654	667	2,179	32.04	
Journal of Antimicrobial Chemotherapy	95	Paywalled	439	89.8%	612	1,878	2,326	2,393	7,209	16.42	**47.6%**
		OA	50	10.2%	75	288	438	411	1,212	24.24	
Journal of Clinical Endocrinology and Metabolism	99	Paywalled	407	88.9%	438	1,987	2,582	2,746	7,753	19.05	**-3.2%**
		OA	51	11.1%	40	249	324	328	941	18.45	
Journal of Clinical Microbiology	86	Paywalled	269	81.0%	291	1,199	1,491	1,486	4,467	16.61	**8.0%**
		OA	63	19.0%	94	342	371	323	1,130	17.94	
Journal of Epidemiology and Community Health	94	Paywalled	95	66.9%	58	239	355	402	1,054	11.09	**49.4%**
		OA	47	33.1%	46	180	232	321	779	16.57	
Journal of Infectious Diseases	95	Paywalled	369	76.9%	508	1,648	2,129	2,246	6,531	17.70	**-20.1%**
		OA	111	23.1%	162	427	527	520	1,636	14.74	
Journal of Investigative Dermatology	98	Paywalled	280	87.2%	418	1,043	1,319	1,479	4,259	15.21	**11.6%**
		OA	41	12.8%	54	196	199	247	696	16.98	

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Journal of Neurology	84	Paywalled	204	82.6%	188	591	767	921	2,467	12.09	**27.9%**
		OA	43	17.4%	45	155	216	249	665	15.47	
Journal of the American College of Cardiology	99	Paywalled	235	85.1%	1,184	4,061	4,837	5,286	15,368	65.40	**48.3%**
		OA	41	14.9%	292	1,045	1,159	1,479	3,975	96.95	
Lancet	99	Paywalled	137	72.9%	1,904	6,006	7,701	8,435	24,046	175.52	**96.0%**
		OA	51	27.1%	829	3,994	5,907	6,819	17,549	344.10	
Leukemia	97	Paywalled	191	78.3%	602	1,305	1,346	1,473	4,726	24.74	**47.5%**
		OA	53	21.7%	202	529	603	600	1,934	36.49	
Magnetic Resonance In Medicine	92	Paywalled	419	88.4%	597	1,443	1,677	1,617	5,334	12.73	**17.1%**
		OA	55	11.6%	104	228	243	245	820	14.91	
Molecular Medicine Reports	39	Paywalled	904	49.7%	199	1,197	1,646	2,150	5,192	5.74	**26.0%**
		OA	915	50.3%	250	1,508	2,232	2,634	6,624	7.24	
Molecular Psychiatry	99	Paywalled	113	70.6%	397	862	1,041	1,136	3,436	30.41	**63.9%**
		OA	47	29.4%	283	592	714	754	2,343	49.85	
Oncology Reports	65	Paywalled	609	74.4%	431	1,595	2,104	2,555	6,685	10.98	**21.0%**
		OA	210	25.6%	108	656	917	1,108	2,789	13.28	
Pharmaceutical Biology	79	Paywalled	224	81.2%	161	549	718	879	2,307	10.30	**-4.8%**
		OA	52	18.8%	56	134	157	164	511	9.83	
Psychological Medicine	97	Paywalled	176	81.9%	204	664	938	1,166	2,972	16.89	**26.6%**
		OA	39	18.1%	41	210	253	330	834	21.38	
Quality of Life Research	86	Paywalled	240	85.1%	116	424	662	764	1,966	8.19	**6.4%**
		OA	42	14.9%	16	64	118	168	366	8.71	
Supportive Care in Cancer	61	Paywalled	333	88.6%	240	779	948	1189	3,156	9.48	**9.4%**
		OA	43	11.4%	31	97	139	179	446	10.37	
Surgical Endoscopy	91	Paywalled	604	92.9%	494	1,680	2,017	2,638	6,829	11.31	**30.6%**
		OA	46	7.1%	51	170	185	273	679	14.76	
Vaccine	99	Paywalled	631	73.4%	366	1,512	1,853	2,001	5,732	9.08	**38.8%**
		OA	229	26.6%	198	811	937	942	2,888	12.61	
Physics and Astronomy											
2d Materials	95	Paywalled	244	82.4%	552	1,486	1,764	1,881	5,683	23.29	**39.0%**
		OA	52	17.6%	155	463	548	517	1,683	32.37	
ACS Nano	99	Paywalled	1228	95.1%	2,938	15,752	20,346	20,317	59,353	48.33	**-42.5%**
		OA	63	4.9%	108	514	738	777	2,137	33.92	
ACS Photonics	95	Paywalled	371	95.4%	525	2,393	2,864	2,797	8,579	23.12	**3.1%**
		OA	18	4.6%	14	119	153	143	429	23.83	
Advanced Functional Materials	97	Paywalled	779	96.9%	2,219	11,199	14,744	14,737	42,899	55.07	**-46.3%**
		OA	25	3.1%	56	241	304	340	941	37.64	
Advanced Optical Materials	95	Paywalled	288	94.7%	402	1,814	2,404	2,444	7,064	24.53	**-7.8%**
		OA	16	5.3%	30	103	121	110	364	22.75	
Applied Physics B Lasers and Optics	78	Paywalled	248	86.4%	131	444	519	435	1,529	6.17	**71.8%**
		OA	39	13.6%	43	120	129	121	413	10.59	
Applied Physics Express	92	Paywalled	310	89.6%	230	909	1,146	1,048	3,333	10.75	**-15.5%**
		OA	36	10.4%	26	90	115	104	335	9.31	
Astronomical Journal	78	Paywalled	516	96.8%	781	2,803	2,558	2,392	8,534	16.54	**52.9%**
		OA	17	3.2%	23	103	143	161	430	25.29	
Astrophysical Journal Letters	93	Paywalled	513	94.6%	1,167	4,133	4,504	3,953	13,757	26.82	**307.5%**
		OA	29	5.4%	163	972	1,137	897	3,169	109.28	
Chaos	86	Paywalled	349	94.3%	293	1,007	1,258	1,138	3,696	10.59	**-18.3%**
		OA	21	5.7%	18	47	63	60	188	8.95	

Research Paper

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Chinese Physics C	98	Paywalled	163	74.1%	145	455	513	583	1,696	10.40	**-31.2%**
		OA	57	25.9%	64	147	124	117	452	7.93	
Communications in Mathematical Physics	99	Paywalled	235	89.4%	208	504	593	696	2,001	8.51	**27.5%**
		OA	28	10.6%	28	84	88	104	304	10.86	
European Physical Journal B	52	Paywalled	235	91.8%	64	290	312	310	976	4.15	**44.5%**
		OA	21	8.2%	14	35	43	34	126	6.00	
European Physical Journal D	47	Paywalled	301	91.8%	153	400	389	370	1,312	4.36	**-9.0%**
		OA	27	8.2%	18	37	31	22	108	4.00	
Experiments in Fluids	92	Paywalled	136	82.9%	50	283	431	419	1,183	8.70	**33.8%**
		OA	28	17.1%	23	90	95	118	326	11.64	
Japanese Journal of Applied Physics	76	Paywalled	681	96.3%	212	1,035	1,009	971	3,227	4.74	**43.7%**
		OA	26	3.7%	13	47	60	57	177	6.81	
Journal of Chemical Physics	88	Paywalled	1952	97.0%	1,490	5,331	5,794	5,381	17,996	9.22	**35.4%**
		OA	60	3.0%	55	211	241	242	749	12.48	
Journal of Computational Physics	85	Paywalled	684	95.3%	430	1,807	2,748	2,816	7,801	11.40	**16.0%**
		OA	34	4.7%	29	110	152	159	450	13.24	
Journal of Fluid Mechanics	89	Paywalled	736	93.3%	568	2,083	3,053	3,211	8,915	12.11	**16.5%**
		OA	53	6.7%	53	201	261	233	748	14.11	
Journal of Instrumentation	68	Paywalled	353	82.5%	124	483	542	492	1,641	4.65	**327.6%**
		OA	75	17.5%	148	494	489	360	1,491	19.88	
Journal of Magnetic Resonance	83	Paywalled	183	90.6%	135	462	508	411	1,516	8.28	**72.2%**
		OA	19	9.4%	13	66	98	94	271	14.26	
Journal of Nanoparticle Research	80	Paywalled	372	94.9%	119	593	812	733	2,257	6.07	**157.1%**
		OA	20	5.1%	9	62	116	125	312	15.60	
Journal of Nuclear Materials	87	Paywalled	531	96.4%	266	1,302	1,552	1,604	4,724	8.90	**19.7%**
		OA	20	3.6%	13	49	76	75	213	10.65	
Journal of Optics United Kingdom	70	Paywalled	336	91.8%	204	717	807	720	2,448	7.29	**-1.7%**
		OA	30	8.2%	23	69	61	62	215	7.17	
Journal of Physics A Mathematical and Theoretical	91	Paywalled	630	97.4%	546	1,199	1,203	1,153	4,101	6.51	**28.3%**
		OA	17	2.6%	12	51	36	43	142	8.35	
Journal of Physics Condensed Matter	80	Paywalled	770	96.4%	454	1,589	1,925	2,198	6,166	8.01	**16.3%**
		OA	29	3.6%	28	81	90	71	270	9.31	
Journal of Physics D Applied Physics	83	Paywalled	1095	94.4%	685	2,525	3,043	2,890	9,143	8.35	**51.3%**
		OA	65	5.6%	80	229	250	262	821	12.63	
Journal of Physics G Nuclear and Particle Physics	87	Paywalled	129	80.6%	115	336	281	317	1,049	8.13	**15.4%**
		OA	31	19.4%	16	55	99	121	291	9.39	
Journal of Quant Spectroscopy and Radiative Transfer	84	Paywalled	391	95.6%	503	1,097	1,090	1,149	3,839	9.82	**685.9%**
		OA	18	4.4%	54	309	472	554	1,389	77.17	
Journal of Statistical Physics	73	Paywalled	229	92.3%	94	323	366	379	1,162	5.07	**16.2%**
		OA	19	7.7%	18	32	25	37	112	5.89	
Journal of Synchrotron Radiation	95	Paywalled	76	69.1%	36	124	121	156	437	5.75	**74.4%**
		OA	34	30.9%	36	87	106	112	341	10.03	
Journal of the Acoustical Society of America	71	Paywalled	805	93.2%	322	1,364	1,850	1,642	5,178	6.43	**24.6%**
		OA	59	6.8%	28	120	167	158	473	8.02	

Journal	Best CiteScore Percentile 2017	Modality	Research Articles 2017	%	Cites 2017	Cites 2018	Cites 2019	Cites 2020	Total Cites	Cites per Article	OA Citation Advantage
Journal of the Physical	63	Paywalled	369	87.0%	152	481	508	390	1,531	4.15	**89.3%**
Society of Japan		OA	55	13.0%	27	149	144	112	432	7.85	
Journal of Thermal	70	Paywalled	793	93.3%	467	1,841	1,954	2,099	6,361	8.02	**9.8%**
Analysis and Calorimetry		OA	57	6.7%	40	145	161	156	502	8.81	
Measurement Science	77	Paywalled	460	95.2%	227	803	967	937	2,934	6.38	**29.5%**
and Technology		OA	23	4.8%	17	56	64	53	190	8.26	
Nano Letters	99	Paywalled	1086	96.1%	2,637	12,267	14,875	14,776	44,555	41.03	**-61.2%**
		OA	44	3.9%	64	337	367	352	1,120	25.45	
Nuclear Fusion	87	Paywalled	467	91.4%	637	1,663	1,723	1,518	5,541	11.87	**84.8%**
		OA	44	8.6%	87	270	295	313	965	21.93	
Nuclear Physics A	75	Paywalled	144	41.9%	192	332	337	329	1,190	8.26	**-119.2%**
		OA	200	58.1%	47	281	242	184	754	3.77	
Optical and Quantum	52	Paywalled	397	94.1%	217	821	787	799	2,624	6.61	**-53.0%**
Electronics		OA	25	5.9%	18	33	37	20	108	4.32	
Optical Engineering	74	Paywalled	616	88.3%	165	650	830	721	2,366	3.84	**105.4%**
		OA	82	11.7%	61	165	209	212	647	7.89	
Physical Review	91	Paywalled	402	95.7%	403	1,733	2,041	2,058	6,235	15.51	**-71.3%**
Applied		OA	18	4.3%	9	50	60	44	163	9.06	
Physical Review C	89	Paywalled	1008	96.9%	983	3,151	3,145	3,109	10,388	10.31	**33.7%**
		OA	32	3.1%	45	145	133	118	441	13.78	
Physics of Fluids	74	Paywalled	600	97.2%	260	1,500	2,365	2,117	6,242	10.40	**18.2%**
		OA	17	2.8%	9	46	88	66	209	12.29	
Physics of Plasmas	69	Paywalled	1317	96.3%	720	2,414	2,491	2,375	8,000	6.07	**97.2%**
		OA	51	3.7%	35	176	203	197	611	11.98	
Quantum Information	79	Paywalled	294	93.9%	154	593	921	813	2,481	8.44	**-51.3%**
Processing		OA	19	6.1%	10	22	34	40	106	5.58	
Review of Scientific	68	Paywalled	832	94.2%	271	1,256	1,499	1,509	4,535	5.45	**54.3%**
Instruments		OA	51	5.8%	35	101	143	150	429	8.41	
Soft Matter	93	Paywalled	2335	95.6%	591	2,256	2,645	2,638	8,130	3.48	**247.3%**
		OA	107	4.4%	105	379	408	402	1,294	12.09	
Solar Physics	74	Paywalled	166	87.4%	131	370	406	412	1,319	7.95	**41.1%**
		OA	24	12.6%	30	90	78	71	269	11.21	
Superconductor Science	90	Paywalled	259	93.5%	215	590	806	738	2,349	9.07	**18.8%**
and Technology		OA	18	6.5%	13	48	56	77	194	10.78	
Ultramicroscopy	89	Paywalled	209	92.5%	156	453	492	451	1,552	7.43	**172.5%**
		OA	17	7.5%	33	84	112	115	344	20.24	