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Research Article

The Influence of Funding on the Open Access Citation Advantage

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ABSTRACT

Some of the citation advantage in open access 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 biases. Several factors can affect the observed differences and 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. In this paper this hypothesis is tested. Thus, we studied the effect of funding on the publication modality and the citations received in more than 128 thousand research articles, of which 31% were funded. These research articles come from 40 randomly selected subject categories in the year 2016, and the citations received from the period 2016-2020 in the Scopus database. We found open articles published in hybrid journals were considerably more cited than those in gold open access journals. Thus, regardless of funding, articles under the hybrid gold modality are cite on average twice as those in the gold modality. Moreover, within the same publication modality, we found that funded articles generally obtain 50% more citations than unfunded ones. The use of open access repositories considerably increases citations, especially for those articles without funding. Thus, the articles in open access repositories are 50% more cited than the paywalled ones. There is citation advantage, excluding the gold modality, in more than 75% of the cases, and it is considerably greater among unfunded articles.

Keywords: Open access, Funded research bias, Gold OA, Green OA, Hybrid OA, Scholarly communication.

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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.[1] In the last years, more and more scientists are making their research results openly accessible to increase its visibility, usage, and citation impact.[2,3]

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.[4]

Thus, 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 (paywalled), in addition to self-archiving the pre-print or post-print paper in a repository.[5] *Hybrid Gold* 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.[6] And *Bonze OA* (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.[7]

Hybrid journals are a risk-free transition path towards full OA (gold), in contrast to starting new full OA journals or converting journals, since the subscription revenue remains.[4] However, the price level in the hybrid gold is typically around 3000 USD, which many authors and their institutions perceive as high.[8]

Since Lawrence proposed in 2001 the OA citation advantage, this postulate has been discussed in depth without an agreement being reach.[9] Furthermore, some authors are critical about the

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causal link between OA and higher citations, stating that the benefits of OA are uncertain and vary among different fields.[10]

Some of the citation advantage in open access 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 biases. 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.[11]

In this paper, this hypothesis is tested. Thus, based on citation data from the Scopus database, we provide longitudinal estimations of cites per article in all publication modalities: gold, hybrid gold, bronze, green, and paywalled. Moreover, we will answer the following questions: (1) Are OA research articles more highly cited than their paywalled counterparts? (2) Are there differences attributable to financing? (3) Which publication modality brings a greater citation advantage? (4) How does this citation advantage vary according to field and time?

Literature review

Many researchers 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,[12] philosophy, political science, electrical and electronic engineering, and mathematics,[13] physics,[5] biology and chemistry,[14] as well as civil engineering.[15]

However, this postulate has been discussed in the literature in depth without an agreement being reached.[9,16-20] 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.[10,21]

In the literature, authors set out three postulates supporting the existence of a correlation between OA and increased citations.[9,21-23] (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*). (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.

Some authors found evidence of selection bias in OA, but still estimated a statistically significant citation advantage even after controlling for that bias.[24,25] Regardless of the validity or generality of their conclusions, these studies establish that any analysis must consider the effect of time and selection bias.

At journal level, 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.[26] However, the economic model is not related to journal impact,[27,28] and articles are cited at a similar rate regardless of the distribution model.[28]

The OA citation advantage is not universally supported. Many studies have been criticized on methodological grounds,[10] and research using the randomized-control trial method failed to find evidence of an OA citation advantage.[29]

However, recent studies using robust methods have observed an OA citation advantage. The researchers used a complex statistical model to remove author bias and reported a small but meaningful 8% OA citation advantage.[30] In a massive sample of over one million articles and using field-normalized citation rates, the researchers described a 40% OA citation advantage.[31] Other paper reported a 19% OA citation advantage excluding the author self-selection bias and beyond the first years after publication.[32]

In a recent paper,[33] the authors 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.

METHODOLOGY

The database Scopus has new open access filters since the end of 2020, providing information on the modality of open access per article. With this new classification system, users can now filter their results or use specific open access tags, i.e., gold, hybrid gold, bronze, and green.

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

In this study, 40 subject categories in the Scopus database were randomly select. This is 12% of the subject categories (40 of 334) and 6.5% of the research articles in the Scopus database in 2016. They resulted 12 subject categories from Health Sciences, 7 from Life Sciences, 10 from Physical Sciences and Engineering, and 11 from Social Sciences and Humanities.

For each subject category, the "research articles" in the year 2016 and the citations received by such research articles in the period 2016-2020, were download from the Scopus database (April 28, 2021).

Table 1: Representativeness of the sample. Research articles in 2016 by funding and publication modality. Source: Scopus. All = Gold + Hybrid Gold + Bronze + Only Green + Paywalled.

Funding	Modality	Sample		Total Database
Funded Articles	Gold	4,713	4.8%	98,424
	Hybrid Gold	2,734	8.8%	31,009
	Bronze	7,134	8.2%	87,443
	Green	17,729	6.8%	260,903
	Only Green	7,796	7.9%	98,788
	Paywalled	17,298	5.3%	324,368
	All	39,675	6.2%	640,032
Unfunded Articles	Gold	11,128	5.8%	190,257
	Hybrid Gold	2,492	7.4%	33,545
	Bronze	7,746	6.6%	118,024
	Green	22,616	7.0%	325,127
	Only Green	10,127	9.2%	110,187
	Paywalled	57,495	6.4%	899,990
	All	88,988	6.6%	1,352,003
Total		128,663	6.5%	1,992,035

In relation to the representativeness of the sample, a total of 1,992,035 research articles were index in the Scopus database in 2016, of which 640,032 specifying a funding source (32.1%). During that same year, the selected 40 subject categories included 128,663 research articles, of which 39,675 were funded (30.8%). The representativeness of the sample by publication modality is shown in Table 1. Thus, the size of the sample over the total population, in number of research articles in 2016, varies according to publication modality between 4.8% and 9.2%.

RESULTS

The prevalence of the publication modality by funding, both in the sample and in the total database, is shown in Table 2. Thus, most of the research articles in the Scopus database in 2016 were paywalled, two out of three unfunded articles (67%) and half of the funded articles (51%). The use of open access repositories (green), is more widespread within the funded group (41%), compared to the group without funding (24%). The prevalence of the gold modality is quite similar, with only one percent point more in the case of funding. This is because some gold journals are also free of charge for the authors. However, the prevalence of the hybrid gold modality within the group with funding is double that of the group without funding. This is due to the authors must pay the publication costs under the hybrid gold modality.

The prevalence of funding by publication modality is shown in Table 3. Note most of the research articles in the Scopus database in 2016 were unfunded (68%), and only one out of three articles were funded (32%). The prevalence of unfunded articles rises to 73% in the paywalled modality. Although it may be surprising that in the gold modality the prevalence of unfunded articles is almost double that of those with financing, this is because, as already indicated, in the database two out of every three articles do not have financing. However, in the rest of the open access modalities, the proportion between both groups, with and without financing, is quite similar. This is even though, as already mentioned, the group without financing is much bigger in absolute value. Therefore, in the funded group there is a greater concern about offering open access to publications.

The prevalence of the publication modality in the sample by subject category and funding is shown in Figure 1. There are very important differences among subject categories, both in the prevalence of funding and in the open access modality. Thus, while in the humanities the prevalence of funding is around 5%, in the life sciences it exceeds 50% in some cases. Furthermore, while in some social sciences and humanities the prevalence of open access is below 20%, it reaches over 70% in some scientific disciplines.

Cites per article by funding and publication modality

The cites per article in 2016-2020 by funding, publication modality, and branch of knowledge are shown in Table 4. The mean is higher than the median in most cases. However, in life sciences just the opposite happens in some publishing modalities. In general, the highest citation averages are reach in life and health sciences, while the lowest citation averages are obtained in social sciences and humanities.

However, is between funding groups where the biggest differences exist. Thus, within the same modality, financed articles generally obtain 50% more citations than non-financed ones. The most cited modality is the hybrid gold and the least cited is the gold, well

Table 2: Prevalence of the publication modality by funding. Research articles in the sample and database in 2016. Source: Scopus. All = Gold + Hybrid Gold + Bronze + Only Green + Paywalled.

Funding	Modality	Sample		Total Database	
Funded Articles	Gold	4,713	11.9%	98,424	15.4%
	Hybrid Gold	2,734	6.9%	31,009	4.8%
	Bronze	7,134	18.0%	87,443	13.7%
	Green	17,729	44.7%	260,903	40.8%
	Only Green	7,796	19.6%	98,788	15.4%
	Paywalled	17,298	43.6%	324,368	50.7%
	All	39,675		640,032	
Unfunded Articles	Gold	11,128	12.5%	190,257	14.1%
	Hybrid Gold	2,492	2.8%	33,545	2.5%
	Bronze	7,746	8.7%	118,024	8.7%
	Green	22,616	25.4%	325,127	24.0%
	Only Green	10,127	11.4%	110,187	8.1%
	Paywalled	57,495	64.6%	899,990	66.6%
	All	88,988		1,352,003	

Table 3: Prevalence of funding by publication modality. Research articles in the sample and database in 2016. Source: Scopus. All = Gold + Hybrid Gold + Bronze + Only Green + Paywalled.

	Modality	Funded Articles		Unfunded Articles		Total
Sample	Gold	4,713	29.8%	11,128	70.2%	15,841
	Hybrid Gold	2,734	52.3%	2,492	47.7%	5,226
	Bronze	7,134	47.9%	7,746	52.1%	14,880
	Green	17,729	43.9%	22,616	56.1%	40,345
	Only Green	7,796	43.5%	10,127	56.5%	17,923
	Paywalled	17,298	23.1%	57,495	76.9%	74,793
	All	39,675	30.8%	88,988	69.2%	128,663
Total Database	Gold	98,424	34.1%	190,257	65.9%	288,681
	Hybrid Gold	31,009	48.0%	33,545	52.0%	64,554
	Bronze	87,443	42.6%	118,024	57.4%	205,467
	Green	260,903	44.5%	325,127	55.5%	586,030
	Only Green	98,788	47.3%	110,187	52.7%	208,975
	Paywalled	324,368	26.5%	899,990	73.5%	1,224,358
	All	640,032	32.1%	1,352,003	67.9%	1,992,035

below even the paywalled. Thus, articles under the hybrid gold modality are cited on average twice as those in the gold modality, and the green articles 50% more cited than the paywalled ones. Both evidences are remarkable. The first is justified because gold journals are younger than hybrids and, in most cases, do not have the prestige of the latter. The second is a measure of citation advantage in the open access repositories. Furthermore, these relationships are not dependent on funding.

The box diagram for the distribution of cites per article, according to funding and publication modality, is shown in Figure 2. In all publication modalities, cites per article for those in the funded group are clearly higher than the citations in the unfunded group. These average citations for the funded articles 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 in most cases larger than the median. This is because the distribution is asymmetric with a long tail on the right.

Regardless of funding, open articles published in hybrid journals were considerably more cited than those published in open access journals. Note that 75% of the articles published during 2016 in open access journals (gold) received an average number

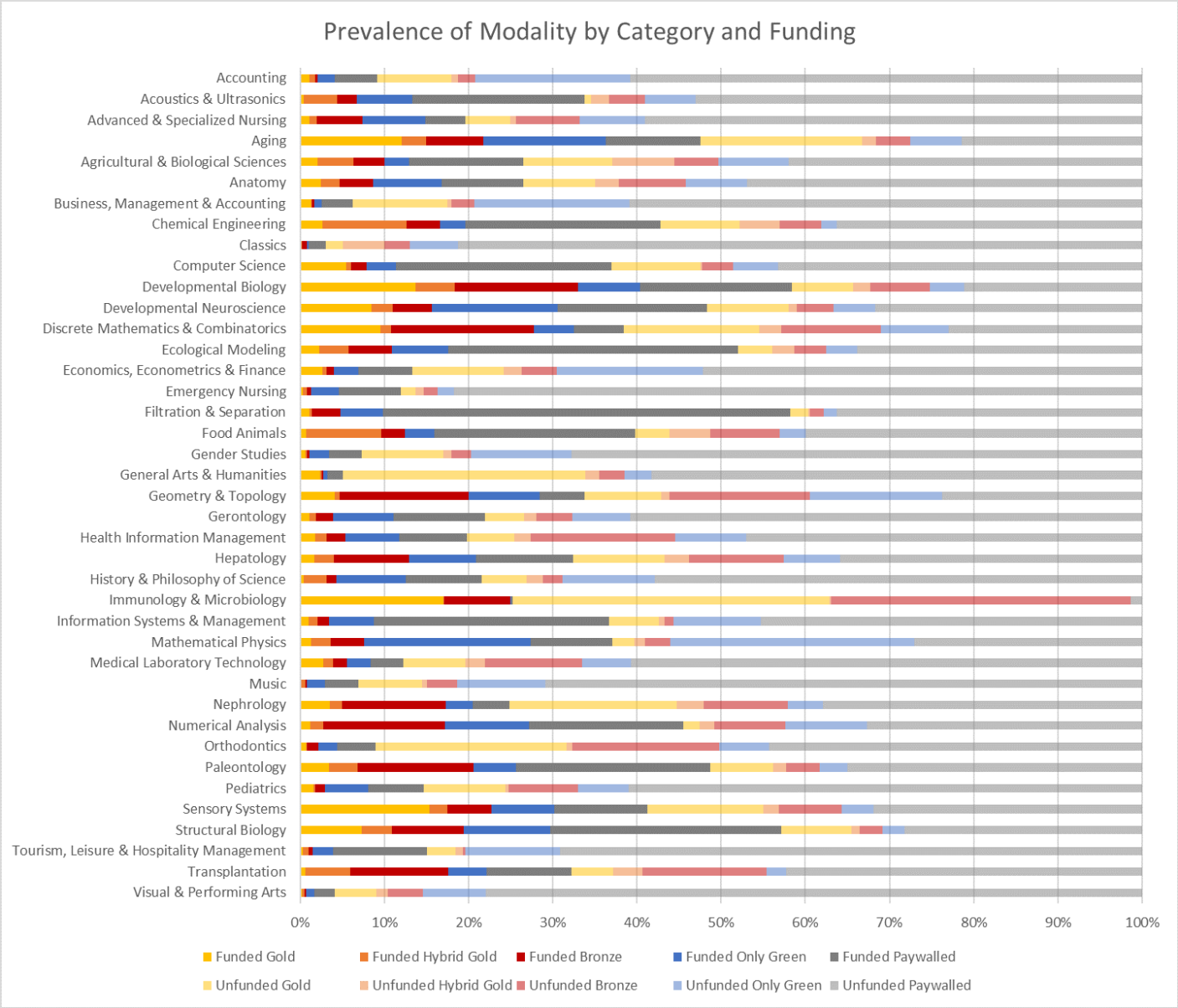

Figure 1: Prevalence of the publication modality by subject category and funding. Research articles in the sample in 2016. Source: Scopus.

of citations less than that received by the 25% least cited of open access articles in hybrid journals (hybrid gold). This is the case regardless of funding, so this evidence is strong. However, as mentioned before, gold journals are younger than hybrids and, in most cases, do not have now the prestige of the latter.

Except for open access journals (gold), the rest of open access modalities received more citations than paywalled articles. Moreover, the open access modality that receives more citations is the hybrid (hybrid gold). Both results are obtained regardless of funding, so this evidence is also strong.

In the group of unfunded articles, the average citation received by those deposited in open access repositories but published in the paywalled modality (only green), is greater than the average citation of all articles with versions in repositories (green). However, this does not happen within the group of those financed. This means that the use of open access repositories considerably increases the citations received, especially for those publications without funding.

The trend over time of cites per article by funding and modality is shown in Figure 3. Notice the increase in the number of citations over time to a large degree relates to the shape of the citation distribution. Thus, beyond this logical increase in the number of citations over first years after publication, no clear time effect observes in Figure 3.

Open Access citation advantage

The OA citation advantage (disadvantage if negative) for an OA modality (gold, hybrid gold, bronze, green, and only green) in a

Table 4: Cites per article in 2016-2020 by funding, publication modality, and branch of knowledge. Research articles in the sample in 2016. Source: Scopus.

		Health Sciences		Life Sciences		Physical Sciences and Engineering		Social Sciences and Humanities		Total	
Funding	Modality	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Funded	Gold	8.3	7.7	15.2	13.7	8.3	6.7	6.7	5.3	9.1	7.5
	Hybrid Gold	22.7	21.3	19.8	21.0	18.6	18.9	14.9	17.7	19.0	20.0
	Bronze	20.5	18.8	15.5	17.4	13.2	11.3	11.5	10.4	15.3	14.1
	Green	17.5	16.3	16.9	18.0	14.2	14.2	11.1	8.1	14.8	14.5
	Only Green	15.5	13.3	15.0	14.4	15.1	13.6	12.0	10.8	14.4	13.7
	Paywalled	11.4	10.9	12.0	12.9	12.4	11.5	9.5	8.4	11.2	10.7
Unfunded	Gold	5.3	4.7	11.4	11.7	6.8	6.1	3.7	3.5	6.3	5.7
	Hybrid Gold	16.1	15.2	15.1	13.8	13.3	8.7	9.3	8.1	13.4	12.2
	Bronze	17.3	11.8	11.9	11.0	7.3	5.0	5.4	4.7	10.6	7.9
	Green	11.3	10.5	11.6	11.3	9.7	9.7	7.3	6.7	9.9	9.8
	Only Green	11.4	9.6	11.1	10.6	11.3	11.2	8.5	7.8	10.5	9.5
	Paywalled	6.4	6.1	7.2	8.3	7.1	6.0	5.9	5.5	6.6	6.1

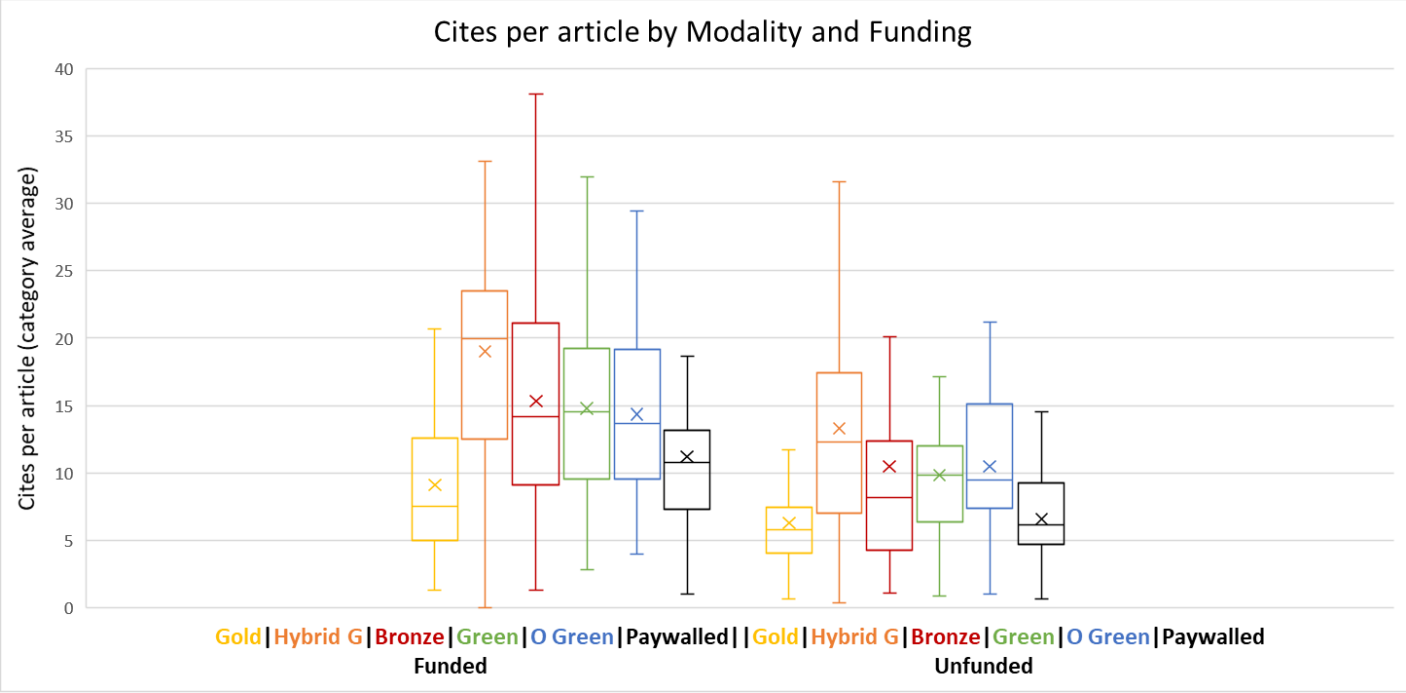

Figure 2: Box and whisker plot (without outliers) for the distribution of cites per article by funding and modality. Research articles in the sample in 2016 and cites in 2016-2020. Source: Scopus.

particular year, is defined in relation to the paywalled modality as the difference of citations. If cites per OA article in a particular modality is greater than cites per paywalled article, then the OA citation advantage of that modality is: (*Cites per OA-Cites per paywalled*) / *Cites per paywalled.*

However, if cites per OA article in a particular modality is less than cites per paywalled article, then the OA citation advantage (disadvantage because it is negative) of that modality is: (*Cites per OA-Cites per paywalled*) / *Cites per OA.*

The average OA citation advantage by funding, publication modality, and branch of knowledge is shown in Table 5. Notice

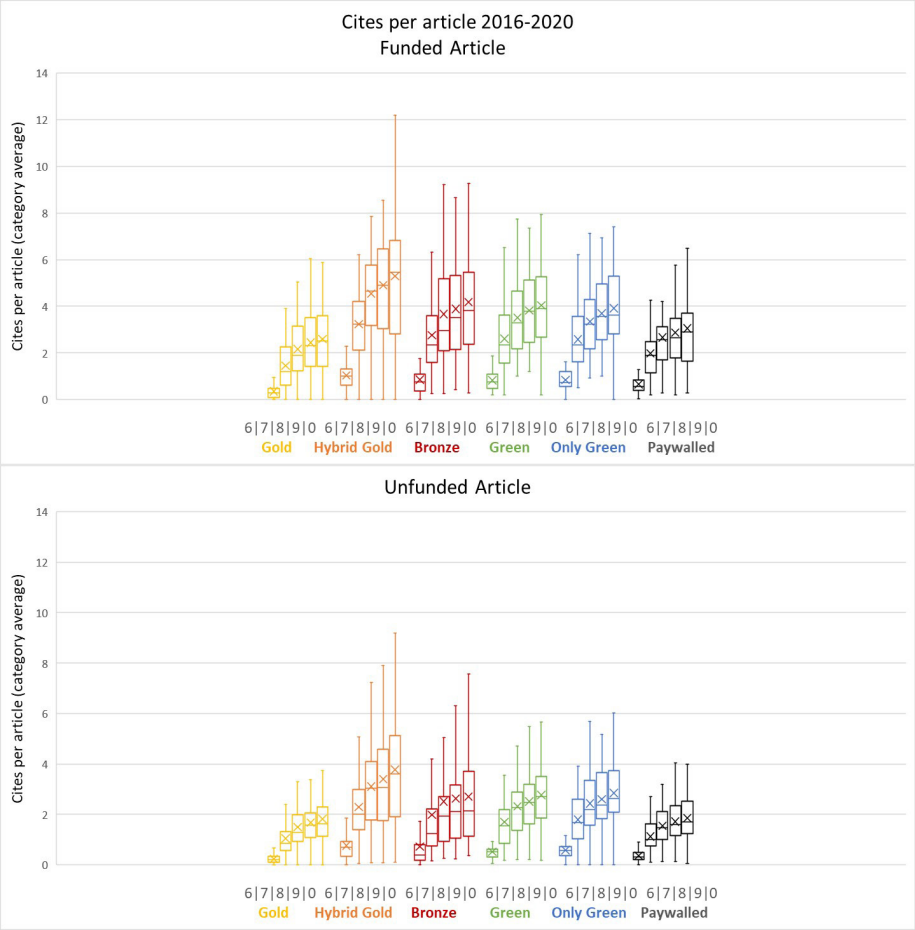

Figure 3: Trend of cites per article by funding and modality. Research articles in the sample in 2016 and cites in 2016-2020. Source: Scopus.

the outliers observed in the data distribution can skew the mean. Thus, the median is more robust measure of central tendency than the mean. Half of the articles have OA citation advantage above the median of the distribution and the other half below.

There are important differences between branches of knowledge. For the aggregate of all subject categories and excluding the gold modality, the average OA citation advantage varies in the funded group in the range 41–79%, with a median in 22–69%. In the unfunded group (excluding gold), the OA citation advantage varies in the range 72–124%, with a median in 42–80%.

The highest advantage reaches in hybrid gold, with 79% and 124% for funded and unfunded, respectively. Half of the categories analyzed present hybrid gold citation advantages greater than 69% for funded and 80% for unfunded articles. In green modality, the average OA citation advantage for funded and unfunded articles is 45% and 81%, respectively. Moreover, half of the categories present green citation advantages greater than 35% for funded and 50% for unfunded. In the only green modality, the average OA citation advantage is 47% for funded and 72% for unfunded articles, although half of the categories present advantages greater than 22% and 61%, respectively.

Thus, we can conclude that, excluding the gold modality where there is no OA citation advantage, the citation advantage of the other OA modalities in relation to the paywalled is on average greater than 50% increase in the group of unfunded articles. In half of unfunded articles (median), citation advantages were obtained above 80% in hybrid gold and 50% in green. However, in half of funded articles citation advantages were obtained above 69% and 35% for the hybrid gold and green, respectively.

The distribution of the OA citation advantage in relation to the modality and funding is shown in Figure 4. Note there are differences in OA citation advantage both between funding groups and among OA modalities. The OA citation advantage is clear for all open access modalities, except for the open access journals (gold) as mentioned. The data distribution, represented by the box and whisker, displaces toward the positive part of the vertical axis. Note the range of variation is considerably lower in the funded group. The median of the distribution is the inner line that divides the box into two parts, and the mean is the x symbol. Excluding the gold modality, there is a citation advantage in more than 75% of the cases (the 25th percentile is the bottom line of the box), although something less in the unfunded bronze group.

Table 5: OA citation advantage in 2016-2020 by funding, publication modality, and branch of knowledge. Research articles in the sample in 2016. Source: Scopus.

		Health Sciences		Life Sciences		Physical Sciences and Engineering		Social Sciences and Humanities		Total	
Funding	Modality	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Funded	Gold	-51%	-42%	49%	21%	-66%	-22%	-88%	-66%	-46%	-36%
	Hybrid Gold	93%	83%	76%	67%	59%	60%	86%	83%	79%	69%
	Bronze	80%	57%	40%	34%	14%	3%	24%	29%	41%	37%
	Green	55%	41%	58%	38%	27%	9%	42%	49%	45%	35%
	Only Green	38%	29%	24%	23%	37%	15%	82%	37%	47%	22%
Unfunded	Gold	-22%	-10%	172%	39%	0%	-4%	-63%	-27%	6%	-6%
	Hybrid Gold	190%	151%	152%	115%	84%	56%	72%	69%	124%	80%
	Bronze	164%	91%	188%	67%	-19%	-13%	13%	31%	81%	42%
	Green	81%	63%	181%	78%	42%	44%	54%	27%	81%	50%
	Only Green	88%	71%	39%	37%	62%	64%	82%	55%	72%	61%

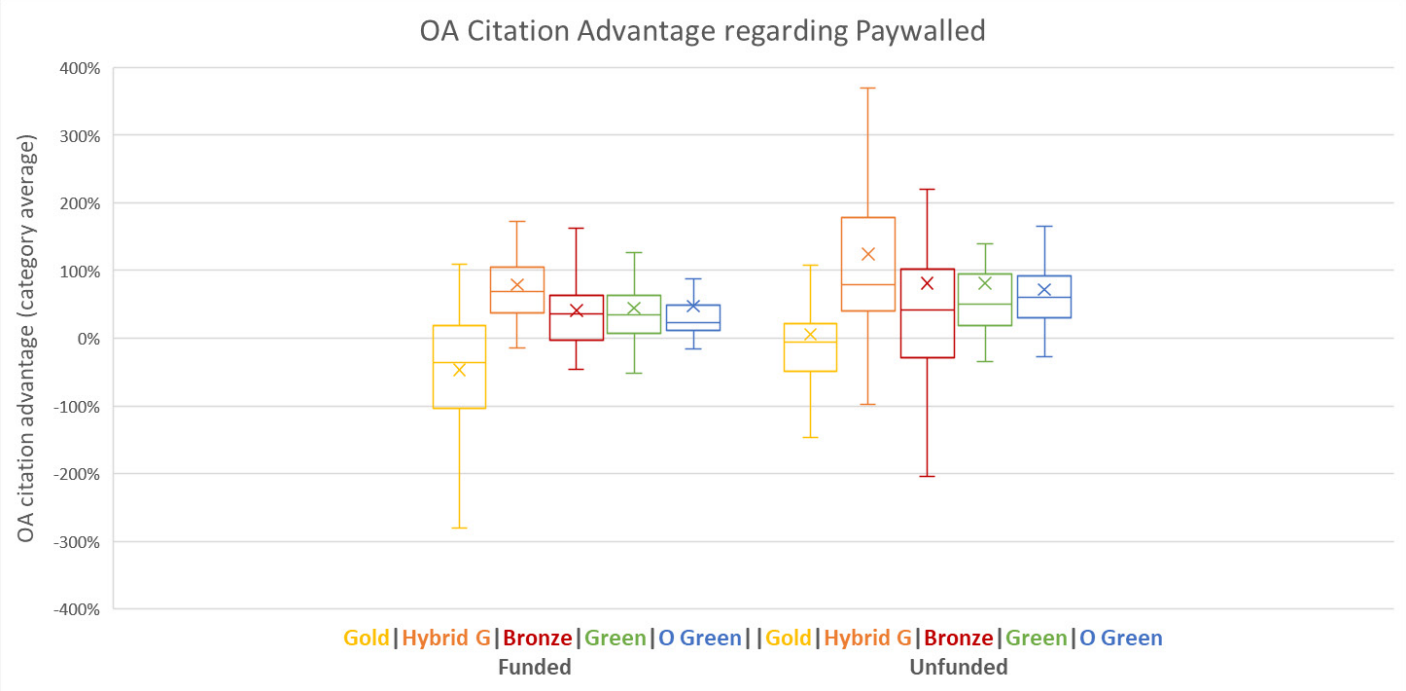

Figure 4: OA citation advantage by funding and modality. Research articles in the sample in 2016 and cites in 2016-2020. Source: Scopus.

The OA citation advantage is held in time (Figure 5). In the gold modality, and regardless of funding, although there is a clear citation disadvantage with respect to the paywalled option, this disadvantage decreases over time. However, in the hybrid gold and bronze modalities, where there is a clear citation advantage in relation to the paywalled, this advantage varies over time without a clear trend, and we can assume that it does not depend on time. The modalities in which the trend is more stable according to the median of the distribution are green and only green.

Finally, the OA citation advantage is consistent across subject categories and held in time (Figure 6). If we discard the lines further away, which are infrequent, a certain increasing trend can be observed in the gold modality, although most of the lines fall in the negative zone as already noted. There is great variability in the lines of the hybrid gold and bronze options. However, in general it seems that the citation advantage is held in time. In the green and only green groups, with some exceptions, the citation advantage is maintained over time.

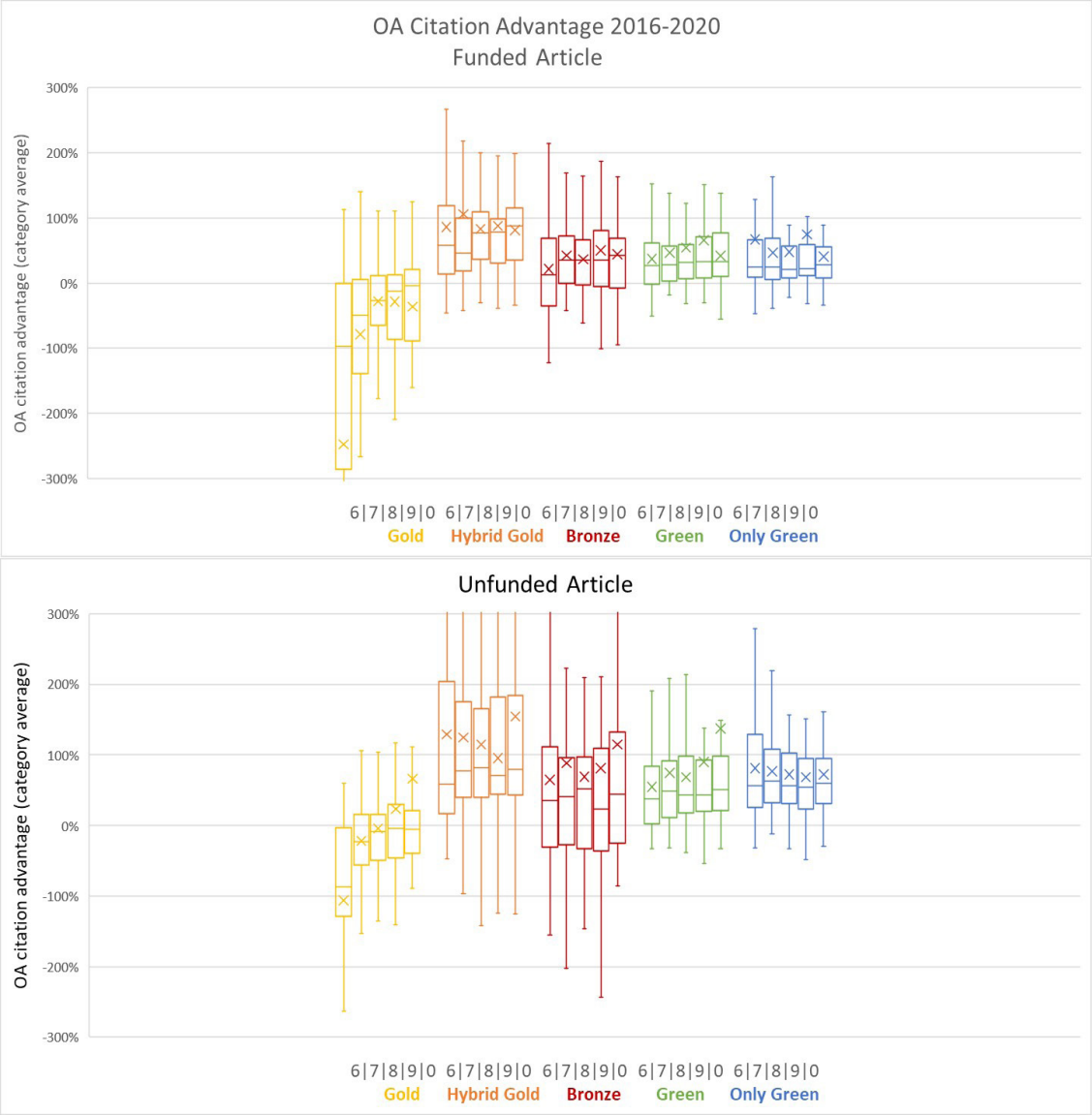

Figure 5: Trend of OA citation advantage by funding and modality. Research articles in the sample in 2016 and cites in 2016-2020. Source: Scopus.

CONCLUSION

The 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 context, we studied the effect of funding on the publication modality and the citations received in more than 128 thousand research articles, of which 31% were funded. These research articles come from 40 randomly selected subject categories in the year 2016, and the citations received from the period 2016-2020 in the Scopus database.

As main conclusion, we found that funded research articles are generally more cited than unfunded ones, but the open access citation advantage in relation to the paywalled modality is higher for the unfunded articles. This open access citation advantage is strong both across fields and over time and come mainly from hybrid gold modality and the author self-archiving in open access repositories (green).

To contextualize the results, we can mention that most of the research articles in the Scopus database in 2016 were unfunded (68%), and only one out of three articles were funded (32%). Moreover, most of them were paywalled, two out of three unfunded articles (67%) and half of the funded articles (51%). The prevalence of unfunded articles rises to 73% in the paywalled modality.

In the funded group there is a greater concern about offering open access to publications. Thus, the use of open access repositories (green) is more widespread within the funded group (41%), compared to the group without funding (24%). The prevalence of the gold modality is quite similar because some gold journals are also free of charge for the authors. However, the prevalence of

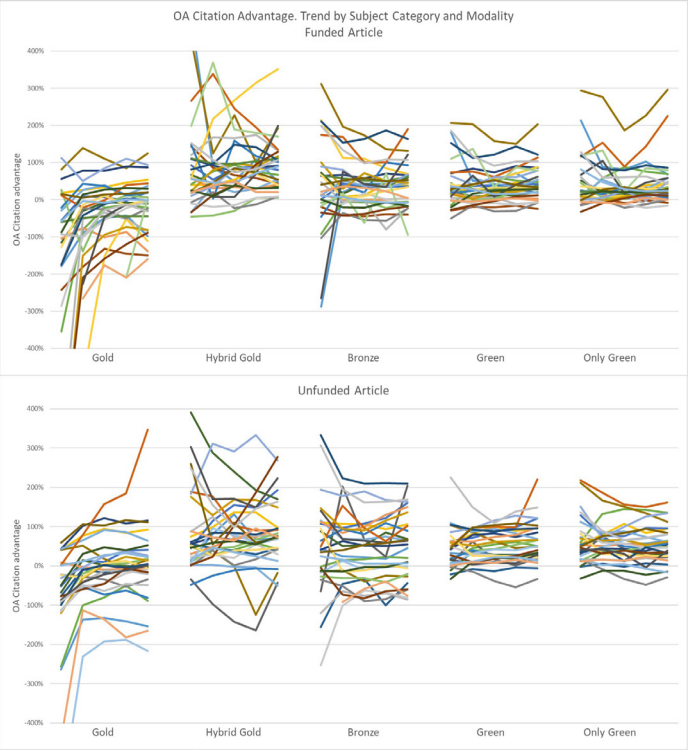

Figure 6: Trend of OA citation advantage by subject category, funding, and modality. Research articles in the sample in 2016 and cites in 2016-2020. Source: Scopus.

the hybrid gold modality within the group with funding is double that of the group without funding, motivated because the authors must pay the publication costs under the hybrid gold modality.

There are very important differences among subject categories, both in the prevalence of funding and in the open access modality. Thus, while in the humanities the prevalence of funding is around 5%, in life sciences it exceeds 50% in some cases. Furthermore, while in some social sciences and humanities the prevalence of open access is below 20%, it reaches over 70% in some scientific disciplines.

Interestingly, open articles published in hybrid journals were considerably more cited than those published in open access journals. Thus, articles under the hybrid gold modality are cited on average twice as those in the gold modality. Moreover, 75% of the articles published during 2016 in open access journals (gold) received an average number of citations less than that received by the 25% least cited of open access articles in hybrid journals (hybrid gold). This is the case regardless of funding, so this evidence is strong. However, it should be noted that gold journals are younger than hybrids and, in most cases, do not have now the prestige of the latter.

Within the same publication modality, we found that funded articles generally obtain 50% more citations than unfunded ones. The most cited modality is the hybrid gold and the least cited is the gold, well below even the paywalled. Moreover, the use of open access repositories considerably increases the citations received, especially for those articles without funding. Thus, the articles in open access repositories (green) are 50% more cited than the paywalled ones. This evidence is remarkable and does not depend on funding.

The OA citation advantage is clear for all open access modalities, except for the open access journals (gold) as mentioned. Excluding the gold modality, there is a citation advantage in more than 75% of the subject categories. Furthermore, the citation advantage of open access is considerably greater among unfunded articles. This result is strong both across fields and over time.

The highest advantage reaches in hybrid gold, with 79% and 124% for funded and unfunded, respectively. Half of the categories analyzed present hybrid gold citation advantages greater than 69% for funded and 80% for unfunded articles. In green modality, the average OA citation advantage for funded and unfunded articles is 45% and 81%, respectively. Moreover, half of the categories present green citation advantages greater than 35% for funded and 50% for unfunded. In the only green modality, the average OA citation advantage is 47% for funded and 72% for unfunded articles, although half of the categories present advantages greater than 22% and 61%, respectively.

Furthermore, we found that the OA citation advantage is consistent across subject categories and held in time. In the gold modality, and regardless of funding, although there is a clear citation disadvantage with respect to the paywalled option, this disadvantage decreases over time. However, in the hybrid gold and bronze modalities, where there is a clear citation advantage in relation to the paywalled, this advantage does not depend on time. Finally, the open access modalities in which the trend is more stable are green and only green.

There are some considerations in this regard. 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 biases. Several factors can affect the observed differences in citation rates. Selection bias can be one of them. The selection bias postulate suggests that authors choose only their most impactful studies to be open access.[21] The current study does not examine the cause of the observed citation advantage but does find that it exists in a very large sample that is representative of the general research literature.

AUTHORS' CONTRIBUTION

Pablo Dorta-González: conceptualization, literature search, data collection, data analysis, writing, review, and editing. María Isabel Dorta-González: conceptualization, data analysis, writing, review, and editing.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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