



# A longitudinal comparison of citation rates and growth among open access journals



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## ABSTRACT

The study documents the growth in the number of journals and articles along with the increase in normalized citation rates of open access (OA) journals listed in the Scopus bibliographic database between 1999 and 2010. Longitudinal statistics on growth in journals/articles and citation rates are broken down by funding model, discipline, and whether the journal was launched or had converted to OA. The data were retrieved from the websites of SCIMago Journal and Country Rank (journal/article counts), JournalM3trics (SNIP2 values), Scopus (journal discipline) and Directory of Open Access Journals (DOAJ) (OA and funding status). OA journals/articles have grown much faster than subscription journals but still make up less than 12% of the journals in Scopus. Two-year citation averages for journals funded by Article Processing Charges (APCs) have reached the same level as subscription journals. Citation averages of OA journals funded by other means continue to lag well behind OA journals funded by APCs and subscription journals. We hypothesize this is less an issue of quality than due to the fact that such journals are commonly published in languages other than English and tend to be located outside the four major publishing countries.

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## 1. Introduction

About 20 years ago it became feasible to distribute digital versions of scholarly journals over wide area networks. Digital distribution dispenses with the incremental costs of printing and delivery, enabling dissemination of scientific publications at no charge while funding the “first copy costs” of publication via other means. A core concept of open access (OA) journal publishing is a transition from subscription fees to alternative ways of funding publication (BOAI, 2002). OA has challenged the established business models and stakeholder relationships in the scientific publishing industry, the implications of which have been debated and benefits argued at length (see e.g. Suber, 2012; Willinsky, 2006).

Since the early 1990s OA journal publishing has been growing at a far faster rate than traditional subscription journal publishing. This has been particularly true in the Scientific Technical and Medical (STM) fields (Laakso et al., 2011). However OA publishing currently makes up only a small fraction of the total scholarly literature. An estimated 340,000 articles a year are published in OA journals almost evenly split between journals charging an Article Processing Charge (APC) to fund publication and journals that do not (Laakso & Björk, 2012).

There is a great deal of misinformation concerning OA publishing which is often disparaged as lower quality than traditional subscription publishing (Butler, 2008). It is difficult to measure the quality of scholarly journals. Despite their

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weaknesses citation rates are often used as a proxy for quality due to lack of a better universal metric (Kurmis, 2003; Rossner, Van Epps, & Hill, 2007). Björk and Solomon (2012) recently compared two-year citation averages from the Journal Citation Reports (JCR) for subscription journals, OA journals funded by APCs, and OA journals funded by other means. After controlling for journal age, the study found that OA journals funded by APCs had roughly equivalent citation averages as their subscription counterparts. The section below provides a more in depth discussion of the research on the growth of OA journals and the extent they are cited in the scholarly literature.

### 1.1. Previous research

#### 1.1.1. Development of open access

Tracking the status and longitudinal development of OA publishing has been an active area of research and has been studied through via a diverse set of methodological approaches. Some studies have provided estimates for OA development by drawing random samples of articles from bibliographic databases published in a specific year and then verified the availability of the articles through OA journal list matching or by attempting to obtain full texts of articles on the web (e.g. Björk, Roos, & Lauri, 2009; Gargouri, Larivière, Gingras, Carr, & Harnad, 2012). Due to the nature of such methods, these studies have often included measurement of both OA journal publishing and OA self-archiving.

Most OA development studies have been based on exploring OA prevalence in a specific bibliographic database or citation index by identifying which journals in the index are OA and using annual article counts as the basis for the calculations. Most such studies have based measurements on data from either one or some combination of the following databases: Scopus, Journal Citation Report (JCR), Ulrichs, and the Directory of Open Access Journals (DOAJ). A persistent problem that OA development studies have faced is the lack of readily available article count data for the majority of OA journals, leading to laborious manual data collection, or sampling-based studies (Björk et al., 2009; Laakso & Björk, 2012; Laakso et al., 2011).

So far there have been no studies based on complete article and journal counts in the Scopus database either for individual years or longitudinally across a number of years. The most robust measurements available so far are estimations by Laakso et al. (2011) and Laakso and Björk (2012) which were based on sampling around 10% of the DOAJ population of journals and extrapolating the results. The overlap between inclusion of journals in DOAJ and Scopus enabled some estimation for OA growth to be made to other indexes by proxy. Expanding the sampling to include the whole Scopus database would enhance the precision of the findings.

#### 1.1.2. Open access and citation averages

The first systematic study of the citation impact of OA journals was reported by McVeigh (2004). McVeigh identified 239 OA journals included in the JCR and documented the distribution across subject fields and origin country. She identified the citation rate within their respective disciplines. The study found the distribution of OA journals was slightly skewed toward the lower end of the overall distribution. It should be noted that the majority of the identified journals were old and established journals where the publisher had decided to make the digital version freely available, rather than journals that were launched as OA journals.

In a study covering open access journals with JCR impact factors, Giglia (2010) combined JCR data covering the years 2007 and 2008 to data extracted from the DOAJ. She found 5.3% of the journals indexed in the 2008 Science JCR were OA and 1.5% of the journals in the 2008 Social Science JCR were OA. Giglia also studied the relative level of the impact factors for the OA journals within their fields. Fifty-four percent of the OA journals within the science JCR were in the top half, compared to 38.6% for the social sciences. Since the data covered only two consecutive years there was little opportunity for a longitudinal analysis but the author was able to draw some comparisons with the McVeigh's earlier study. Giglia's results clearly demonstrated that regions like Latin America and Asia had a higher share of OA journals.

Miguel, Chinchilla-Rodríguez, and de Moya-Anegón (2011) used the comprehensive Scopus index as a basis for exploring multiple aspects related to OA, including prevalence and impact. The authors found that the share of OA-journals in Scopus was 9% in 2010. In addition to DOAJ data, the authors collected data from the Sherpa/Romeo database covering publisher OA policies and found that an additional 32% of journals explicitly allowed self-archiving manuscripts often termed "green" OA. The authors studied the average citation impact of OA journals (gold OA), green OA, and non-OA journals using citation indicators comparable to JCR impact factors calculated based on Scopus citation data. The citation averages of journals with green OA policies were around 50% higher than OA journals however citation averages for OA journals were comparable to non-OA journals. Their study confirmed the very uneven regional distribution of high quality OA journals already visible in McVeigh's and Giglia's studies.

Björk and Solomon (2012) reported on the most comprehensive study so far on the relative citation levels of OA journals compared to non-OA journals. The study included both JCR and Scopus data and the comparisons were conducted on the journal as well as the level of individual articles. The results show that OA journals are lagging slightly behind subscription journals but the differences can largely be explained by country of origin and the age of the journal with OA journals founded in the last decade having impact factors roughly equal to subscription journals of the same age.

Gumpenberger, Ovalle-Perandones, and Gorraiz (in press) was the first study to conduct a systematic longitudinal analysis of citation rates for OA journals. The authors used Ulrichs, DOAJ and the 2010 edition of JCR. They analyzed the distribution of OA titles over disciplines, countries and publishers. The longitudinal analysis was limited to the 50 journals with the highest

impact factors. Additional information was extracted from SCIMago (2007) and the CWTS Journal Indicators (2013) websites. This enabled the study of the evolution of three different impact measures: IF, SJR and SNIP. Overall the citation impact for the vast majority of the 50 titles grew during the period 2001–2010. It is somewhat difficult to generalize the results since approximately half (24) of these top OA-titles were published by the two leading biomedical publishers BioMedCentral and PLoS. The study did also not compare OA journal citation averages with non-OA journals.

## 1.2. Study aims

The aims of the study are to:

1. Document the growth of OA journals and the articles they contain in the Scopus database between 1999 and 2010.
2. Compare Source-Normalized Impact per Paper Version 2 (SNIP2) Citation Averages for OA journals with that of subscription journals during the period 1999–2010.

Scopus is the world's largest abstract and citation database containing records of approximately 18,500 peer-reviewed journals. The selection process for journals included in the Scopus database is transparent, objective and relies on external peer-review (Kähler, 2010). As such the Scopus database provides a valuable frame of reference to assess the growth and citation averages of established OA journals that meet a basic set of quality standards.

From around 1999 onwards OA has become a viable and increasingly established form of scholarly publishing, growing in two distinct ways. First, OA publishing has grown by existing subscription journals making their digital versions freely available (converted OA journals). Secondly, OA publishing has grown through the creation of new journals that were OA from their birth (born OA journals). Since converted OA journals in many cases were listed in Scopus prior to their conversion to OA, it is important to determine the conversion date to accurately assess the true growth of OA during this period.

Professional OA publishers such as BioMed Central and the Public Library of Science also launched during this period. Most are using APCs as a funding model and appear to be moving toward a dominant role in OA scholarly publishing. Another aim is to assess citation rates for journals funded by APCs, those funded by other means and subscription journals. We also compare converted versus born OA journals in terms of their growth in citations. Since citation rates vary markedly by discipline the study uses Source-Normalized Impact per Paper Version 2 (SNIP2) statistics as a measure of citation rates (Moed, 2010). Since professional OA publishing has largely been concentrated in biomedicine, journals are broken in to those in the health sciences and those in other fields. We felt the number of OA journals outside the health sciences, particularly before 2005, is too small to further subdivide.

## 2. Dataset and methodology

The study combined data from multiple sources to explore the outlined research aims. This section documents what data were collected from which sources, how it was integrated, and what purpose each type of data served for fulfilling the aims of the study.

Through direct collaboration with Scopus, the SCIMago Journal and Country Rank website (SCIMago, 2007) provides free access to journal level information contained in the Scopus database. It is possible to download a spreadsheet with the latest year's summarized data, currently 2011, from the SCIMago website. It is also possible to display citation averages, article counts and other statistics for individual journals from 1999 through 2011 based on various search criteria including the International Standard Serial Number (ISSN) (SCIMago help page, 2013). After obtaining the ISSN for the journals in Scopus from the downloadable spreadsheet, we developed software that automated the process of searching the SCIMago database by ISSN and capturing a digital copy for each journal of the full set of information displayed on the site for the years 1999–2011. The software extracted the statistics for each year including article counts and the country in which the journal was published. The data were captured on July 26 and 27, 2012. The data from 2011 appeared not to be complete in the SCIMago database at the time of query and was not used in the study.

Elsevier, owner and operator of the Scopus database, provides a regularly updated openly available spreadsheet with information about the journals included in Scopus. The spreadsheet includes the ISSN as well as detailed data about the journal discipline (Elsevier, 2012). Using the ISSN for each journal we were able to merge this data with the data captured from the SCIMago website.

Source-Normalized Impact per Paper (SNIP) provides a measure of the citation impact of a journal that takes into account and attempts to correct for the fact that citations are more common in some fields than others (Moed, 2010). A revised version of SNIP, SNIP2 is freely available for the journals in Scopus for each year inclusive of 1999–2011 (JournalMetrics, 2013). While journal citation averages are available on the SCIMago website, we felt SNIP2 statistics provide a better means of comparing citation rates for journals across disciplines. ISSN was used to merge SNIP2 data from the JournalMetrics website with SCIMago, discipline data retrieved from the Elsevier website and DOAJ data described below. Since journals publish different numbers of articles, we weighted the SNIP2 value for each journal by the number of articles published in a given year, in essence giving the citation rate for each article published that year an equal value in calculating averages for SNIP2 statistics.

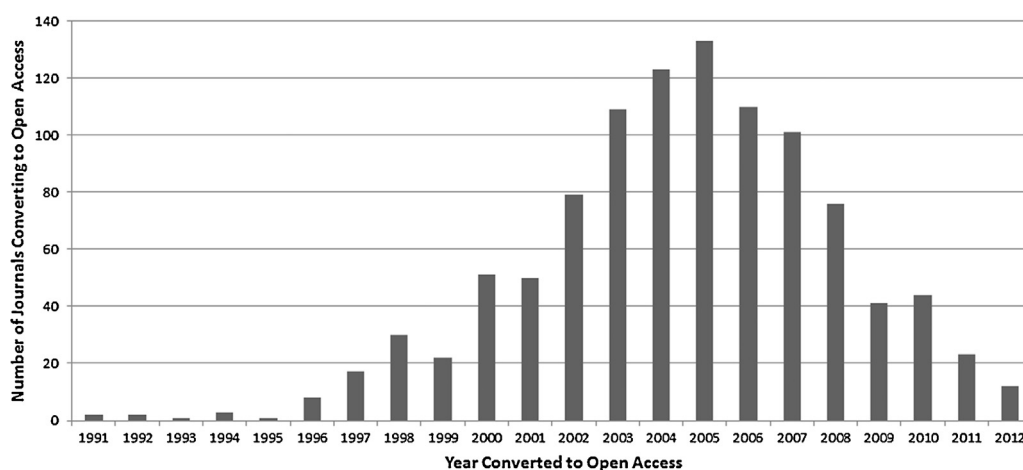


Fig. 1. Number of journals in Scopus converting to open access between 1991 and 2012.

The DOAJ provides the most comprehensive list of open access journals currently available. Along with a variety of other descriptive data the DOAJ metadata includes an indicator of whether the journal charges APCs and a date for when the journal was included in the DOAJ. A continuously updated spreadsheet containing data for all journals included in the DOAJ can be freely downloaded from the DOAJ website (DOAJ, 2012). Data for this study was downloaded on August 9, 2012 and integrated into the rest of the collected dataset by ISSN. If a journal was not listed in the DOAJ it was assumed to be subscription based.

Since journals that converted to OA may have been indexed in Scopus prior to when digital versions of their articles became freely available, we felt it necessary to attempt to determine which journals were converted and if so, the year their digital content became freely available. The DOAJ dataset includes a self-reported start year however our own experience as well as others suggests these dates are often inaccurate (Sotudeh & Horri, 2007). To determine if a journal converted to OA and if so, when, we identified all Scopus indexed journals listed in the DOAJ and reviewed their websites, seeking an indication of if they were converted OA journals and if so at what point in time. In many cases it was not immediately clear if a journal was born OA or converted and if so the conversion year. In such cases we used a set of assumptions in assigning a journal as born or converted and the conversion year. These are given in Appendix I.

The coding was done by two of the investigators, DS and ML. The consistency of the coding was assessed by both investigators coding 30 randomly selected journals. In 28 cases the determination as to whether a journal was born OA versus converted from a subscription journal was consistent. In 6 of the 10 journals that were determined by both investigators to be converted, the dates of conversion were consistent. Of those where the investigators differed, 3 were within 2 years of each other. In one case they differed by 7 years. The discrepancy was due to 1 of the investigators inadvertently failing to follow the coding guidelines outlined in Appendix I.

### 3. Results

There were 18,854 journal records in the spreadsheet containing the 2011 data downloaded from the SCIMago website. Our software was able to capture data from 18,245 or 97% of the journals. We were able to match 18,133 or well over 99% of these journals from SCIMago with data describing the journals provided by Scopus. Since the SNIP2 scores from the JournalM3trics site were exactly parallel with the data from the SCIMago site, all 18,133 had SNIP2 data merged in to the dataset. Since not all journals had SNIP2 data available for each year in the study, the number journals with data in a particular year varied.

A total of 2012 or 11% of the journals were found in the DOAJ and assumed to be OA journals as of 2012. Of these journals, 742 or 4.1% charged APCs according to self-report data from the DOAJ, 1168 or 6.4% did not and 99 or 0.5% lacked information on the source of funding. Nine hundred and thirty-one journals or 5.1% of the total sample were determined to be born OA and 1064 or 5.8% were determined to be converted. It was not possible determine the origin for 17 of the journals listed in the DOAJ.

Fig. 1 presents the dates that the converted journals began making their articles freely available online. While a few journals began making their digital versions freely available during the mid-1990s, the number grew rapidly after the turn of the century peaking around 2005 and tailing off since then.

Table 1 presents the type of journal: subscription, born OA and converted to OA by the location of the journal, in one of the four major publishing countries (USA, Great Britain, the Netherlands and Germany) versus the rest of the world. Nearly three quarters of the subscription journals are published in these four large publishing countries while journals that were

**Table 1**  
Type of journal by location.

	Large publishing countries	Other countries
Subscription	11,785 72.5%	4463 27.5%
Launched open access	484 52.0%	447 48.0%
Converted open access	130 12.2%	934 87.8%

**Table 2**  
Number of journals of each type in Scopus citation database by year.

Type of journal	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
<b>Other disciplines</b>												
OA W/O fee	35	41	54	72	97	109	133	163	210	271	354	439
OA with APC	10	14	18	25	32	35	38	50	64	84	114	142
Subscription	4106	4185	4289	4422	4768	5078	5242	5726	6055	6387	6896	7479
<b>Health sciences</b>												
OA W/O fee	33	49	72	104	138	166	198	238	310	371	446	541
OA with APC	14	21	35	83	117	160	187	210	264	294	334	431
Subscription	4268	4422	4574	4693	4882	5048	5174	5418	5639	5869	6160	6392

OA W/O fee – open access journals without an article processing fee.

OA with APC – open access journals with an article processing fee.

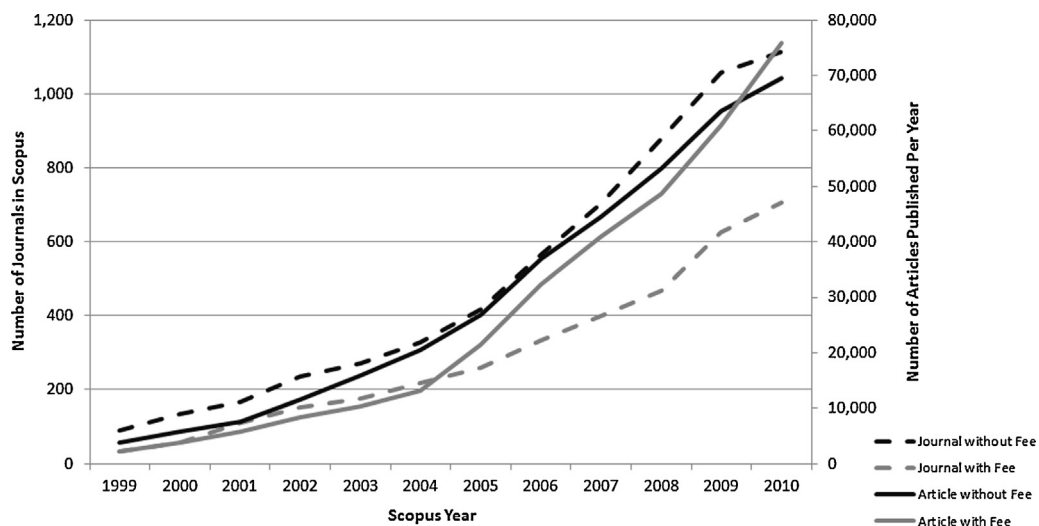
Subscription – journals that charge subscription fees.

born OA are evenly split between the large publishing countries and the rest of the world. Subscription journals that began making their digital versions freely available are largely located outside the major publishing countries.

Table 2 presents the number of OA journals funded without charging APCs, those charging APCs, and subscription journals for each year between 1999 and 2010 within the health sciences and in other disciplines. We chose to focus on this breakdown given that professional OA publishing funded by APCs has been most readily adopted in the health sciences.

Although growing far more rapidly than subscription journals, OA journals and articles currently account for only a small percentage of the total content indexed in the Scopus database. To put this growth in perspective, in 2010 OA journals funded by APCs and other means accounted for 4.1% and 6.4% of the journals and 4.2% and 3.9% of the articles respectively in the Scopus database.

Fig. 2 presents the growth in OA journals and articles, funded by APCs and funded by other means between 1999 and 2010. The left axis of the graph scales the number of journals while the right axis scales the number of articles. This allows the reader to simultaneously compare the rate of growth of journals and articles. As can be seen by the figure there has been



**Fig. 2.** Growth in fee and non-fee based open access journals and articles in Scopus. Left axis presents number of journals; right axis presents number of articles.

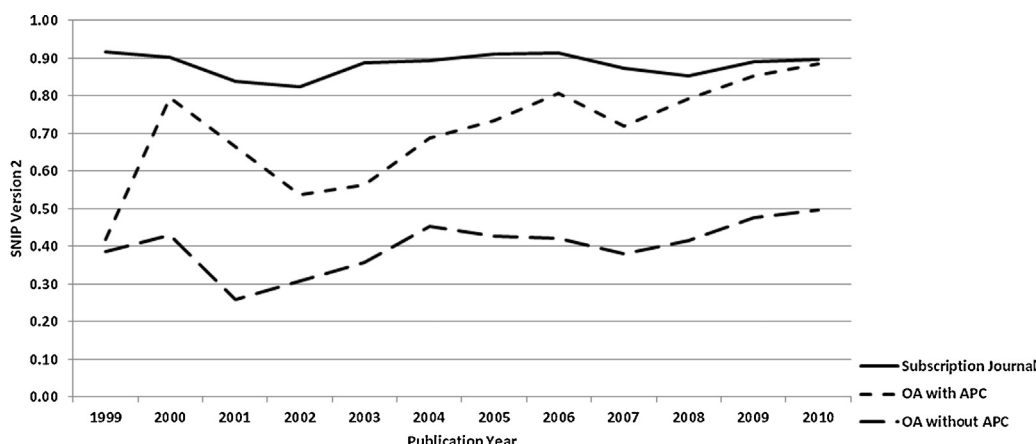


Fig. 3. Weighted Source-Normalized Impact per Paper Version 2 (SNIP2) citation rates for health science journals.

a steady increase in both OA journals and articles in Scopus over this period. The rate of increase for APC funded journals has been slower than that of OA journals funded by other means however starting about 2004 the number of APC funded articles has increased rapidly and eventually surpassing the articles from journals funded by other means about 2009. The rapid increase in journals and articles funded by means other than APCs likely reflects the rapid increase during the period between 1999 and 2005 in subscription journals making their digital versions freely available. The fact the increase continues post 2005 suggests that a significant number of new OA journals funded by means other than APCs have been created over the last 6 or 7 years.

Figs. 3 and 4 present two-year SNIP2 averages for subscription journals, OA journals with and without publication fees for journals in the health sciences (Fig. 3) and other journals (Fig. 4) between 1999 and 2010.

The SNIP2 weighted averages in the health sciences for journals funded by APCs increased to roughly that of subscription journals by approximately 2010. SNIP2 weighted averages for OA journals funded by other means remained approximately 0.4–0.5 points below subscription journals during the time period.

The SNIP2 averages OA journals funded by APCs in non-health science disciplines began rising sharply in 2001 reaching the level of subscription journals in 2004 but appears to be declining slightly in the later years. As with the health science journals, OA journals in other fields that are not funded by APCs tend to have lower weighted SNIP2 averages than APC funded journals and those funded by other means.

Fig. 5 presents the two-year citation averages for subscription journals, born OA and journals that converted to OA some point in their history. As with the previous figures, citation averages are tracked between 1999 and 2010. Journals that converted to OA are only included in the years after they converted to OA. SNIP2 values for converted journals remained below subscription journals remained relatively steady and somewhat below subscription journals. The SNIP2 values of born OA journals rose sharply between 2003 and 2005 to just under subscription journals.



Fig. 4. Weighted Source-Normalized Impact per Paper Version 2 (SNIP2) citation rates for non-health science journals.



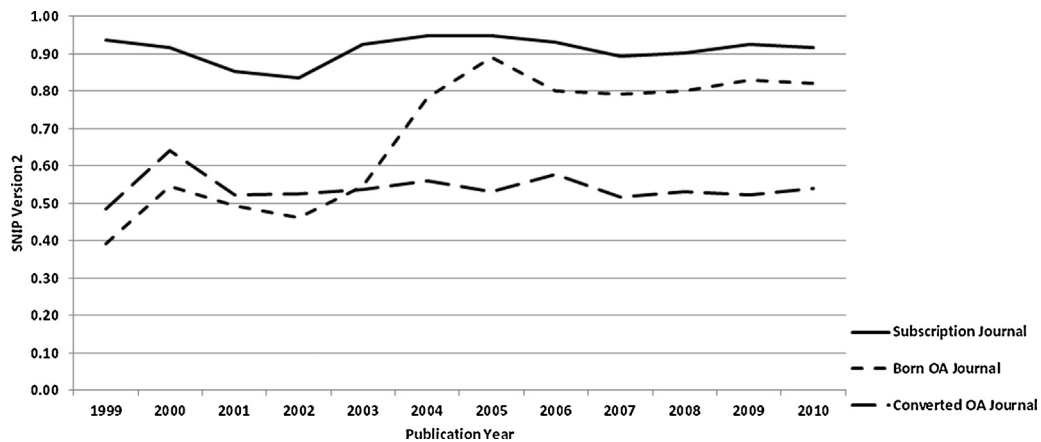


Fig. 5. Weighted Source-Normalized Impact per Paper Version 2 (SNIP2) citation averages for subscription, born and converted OA journals.

#### 4. Discussion

Scholarly publishing is in the early stage of what appears to be a slow transition from a subscriptions to other economic models of funding publication that allow the published material to be freely accessed. This paper adds to the growing body of literature documenting this transition. Some writers have expressed concern as to whether high quality scholarly publishing can be maintained with open access funding models. Of particular concern is that funding publication through APCs is resulting in low quality and/or ethically compromised publishing (Beall, 2012).

As in previous studies that sampled a broader population of OA journals (Laakso & Björk, 2012), our research using the Scopus database suggests the number of OA journals and the articles they published grew steadily during the first decade of the 21st century and at a much higher rate than subscription journals. As shown in Fig. 1 there was a surge of journals converting their digital versions from a subscription model to OA peaking around 2005 and then tailing off over the rest of the decade. A significant number of these appear to be journals owned and operated by scholarly societies (Sutton & Suber, 2007). There are also a large and overlapping number of journals that are disseminated via national and international web platforms such as Scileo, Redalyc and J-STAGE. While we did not specifically collect this information, it appeared when reviewing journal websites that many of these journals were published by universities or departments within universities. This suggests that when provided with the support of a web based journal management system, university faculty are able to create and maintain peer-reviewed scholarly journals of sufficient quality to meet the criteria necessary to be included in the Scopus citation database.

As can be seen in Table 1, the bulk of converted OA journals are located outside the four major publishing countries. The distribution of APC funded OA journals is quite different, evenly split between the four major publishing countries and the rest of the world while nearly three quarters of the subscription journals are located in the large publishing countries. While we did not specifically track this, our manual review of the OA journals to determine the date of conversion suggested a high percentage of the journals that converted to OA are also in languages other than English.

The number of OA journals that do not charge APCs, shown in Fig. 2, rose steadily between 1999 and 2010 with the growth rate actually increasing after 2005 as the number of subscription journals converting to OA began tapering off. This seems to indicate there has been a healthy growth over the last 6 or 7 years in newly launched OA journals that do not charge APCs. The number of APC funded OA journals in the Scopus database is also growing but at a somewhat slower pace however the articles they publish began increasing rapidly after about 2004 and appear poised to surpass the number of OA articles published by journals funded by other means. This reflects the success of the major professional OA publishers such as Public Library of Science, BioMed Central and Hindawi.

As found in our previous research using the JCR data (Björk & Solomon, 2012), OA journals funded by APCs in the Scopus database are currently cited at a similar rate as subscription journals. The longitudinal data available from this study indicates citation rates for APC funded OA journals increased significantly between 1999 and 2010. The increase in citation rates for both the health sciences and other disciplines were somewhat erratic, particularly in the earlier years included in the study. We expect this is in part due to sampling error given the small number of APC funded journals particularly outside of the health sciences.

OA journals funded by means other than APCs are cited about half as often as APC funded OA and subscription journals within the health sciences. The pattern is similar in other fields but the discrepancy is somewhat less. In both sets of disciplines, The SNIP2 values for APC funded journals increased over the time period studied while they did not for the journals funded by other means. We do not believe this represents a gap in quality but rather reflects the limitations of citation rate as a measure of quality and is in fact due to differences in language and the location of the journals.

We found a similar pattern breaking down citation averages by converted versus born OA journals with born OA journals showing a rapid rise in citation averages beginning around 2000 and reaching level slightly under subscription journals around 2005 and holding steady at that rate. We expect this largely reflects the development of professional OA publishing funded by APCs beginning with the launch of BioMed Central and PLoS and their relatively rapid integration into main stream biomedical research and acceptance by the research community.

## 5. Conclusions

Over the last decade there has been a rapid proliferation of OA publishers using the APC model. Clearly some of these publishers lack the expertise and/or interest in publishing high quality scholarly journals. This study demonstrates that much the growth in OA publishing, particularly at the level of articles, is in reputable journals that follow good publishing practices and legitimate peer-review meeting the requirements of inclusion in the Scopus citation database. Along with journals funded by APCs there are a large number of formally subscription journals that have made at least their digital versions freely available as well as newly launched OA journals that are funded by means other than APCs.

Clearly objective standards and systems for documenting quality are needed for publishers using the APC model in order to protect authors and funders as well as maintain confidence in professional OA publishing. At the same time high quality OA publishing is growing at a rapid rate and in the case of OA publishing funded by APCs, there is evidence based on citation rates that these journals on par with subscription journals.

## Appendix I. Assumptions for determining “born” versus “converted” and date of conversion

When there is information on the website that allows determination of the conversion date or that the journal is born OA that date is used. Otherwise:

- When a start date cannot be determined any other way, the entry date in the DOAJ is used and the journal is assumed converted. When a journal was launched after 2000 and all volumes are available OA, it is assumed to have been born OA.
- Journals with Ulrichweb start dates or article archives before 1993 are assumed to be converted.
- When start dates are in the in the mid-1990s and all back issues are available the journal is assumed to be born OA particularly when the websites looks to be mid-1990 vintage.
- When journals are converted OA from before 1993 and digital articles are available OA after mid-1990s it is assumed the journal became OA with the first available OA available volume.
- When articles are available OA before mid-1990s, it is assumed it is assumed back issues were made OA at the point of conversion and if no other information is available, the DOAJ entry date is used.
- SciELO journals are assumed converted OA and the date of entry into SciELO or if not available, the first SciELO volume is used for the date the journal became OA.
- Redalyc journals are assumed to be converted OA and the earliest volume available on the website is assumed to be the conversion date or 2002 if there are articles available before 2002.

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