An Analysis of Open Access Papers in High-Quality Academic Journals: A Case Study of the Web of Science Core Collection (Postprint)

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Date: 2023-10-08T00:00:00+00:00

Abstract

[Purpose / Significance] This study aims to comprehensively understand the quantity and open access rate of open access (OA) papers, and provide a preliminary evaluation of their quality.

[Method / Process] Using the Web of Science (WoS) Core Collection as the data source, this study statistically analyzes papers published in high-quality academic journals indexed by WoS during the 15-year period from 2002 to 2016 across four dimensions: publication year, research field, country (region), and publishing institution, thereby analyzing and interpreting the changing trends of OA papers. Finally, taking Nature as a case study and using average citations per paper and the proportion of highly cited papers as entry points, a brief analysis of the quality of OA papers is conducted.

[Results / Conclusions] The number of global OA papers has increased year by year, with China being a typical representative. The Chinese Academy of Sciences is the institution with the most papers indexed on the WoS platform, and its OA paper volume ranked first in 2016; however, there remains a certain gap in its OA rate compared with major European and American institutions. The OA practice in the biomedical field demonstrates better effectiveness than in other research fields.

Full Text

Research on OA Papers in High-Quality Academic Journals: A Case Study of Web of Science Core Collection

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Abstract

[**Purpose/Significance**] This study aims to comprehensively understand the quantity and open access (OA) ratio of OA papers while providing a preliminary evaluation of their quality.

[**Method/Process**] Utilizing the Web of Science (WoS) Core Collection as the data source, we investigated papers published in high-quality academic journals indexed by WoS from 2002 to 2016 across four dimensions: publication year, research area, country/territory, and affiliation. We then analyzed and interpreted the changing patterns of OA papers. Finally, taking *Nature* as a case study, we briefly examined OA paper quality through citation metrics and the proportion of highly-cited papers.

[**Result/Conclusion**] The number of OA papers worldwide has increased annually, with China being a particularly notable example. The Chinese Academy of Sciences (CAS) is the institution with the most papers indexed in WoS, and its OA paper count ranked first in 2016, though its OA ratio still lags behind major European and American institutions. The OA practice in biomedicine has proven more effective than in other research fields.

Keywords: open access; OA; OA ratio; Web of Science; high-quality academic journal
Classification Number: G250
Citation Format: Zhu J, Ren X. Research on OA papers in high-quality academic journals: A case study of Web of Science Core Collection[J/OL]. Knowledge Management Forum, 2018, 3(2): 95-105.

The "Budapest Open Access Initiative"(BOAI) released in February 2002 marked the formal global advancement of the open access movement. BOAI proposed two primary OA approaches: self-archiving and open access journals, with the latter being its focus—namely, establishing peer-reviewed OA journals or transforming traditionally published journals into OA journals [1]. Since then, driven jointly by academia, publishing houses, and libraries, the green and gold OA movements have flourished worldwide. Various forms of repositories have been widely established, while pure OA and hybrid OA journals continue to emerge, enabling rapid and broad dissemination of academic research. However, due to the uneven quality of OA journals, compounded by the emergence of "predatory" OA journals and excessive article processing charges (APC), some researchers remain skeptical about the OA publishing model.

Analyzing the quantity and quality of OA literature presents certain challenges due to its vast volume and dispersion across OA publications and repositories. Qiu Fengming et al. [2] analyzed the quantity, citation frequency, country distribution, and subjects of OA papers in information science and library science from 1995-2010 using bibliometric methods. Zang Guoquan et al. [3] constructed quality evaluation indicators for network journal papers. Chen Juan [4], building

upon studies by D. J. Solomon et al. [5] and B. Bo-Christer et al. [6], employed multivariate statistical methods to analyze OA journals indexed in Scopus and Web of Science, comparing differences in evaluation metrics and improvement rates. Liu Chen [7], incorporating Altmetrics concepts and based on multiple scientometric indicators, evaluated the advantages of OA papers from both static perspectives (citations, views, etc.) and dynamic viewpoints.

At the end of 2017, Clarivate began providing OA full-text links for abstracts indexed in the Web of Science platform. Gold OA links are labeled as "Free Full Text from Publisher," pointing to OA full texts, free full texts, or full texts that have become open after a certain embargo period in pure OA and hybrid OA publications (not limited to traditional gold OA literature). Green OA links are divided into dark green "Free Accepted Manuscript in Repository" (accepted version manuscript) and light green "Free Published Article in Repository" (published version), referring respectively to the final peer-reviewed manuscript and the published article freely available from repositories [8]. WoS users can access full texts for free through these links.

To gain a comprehensive understanding of global OA paper quantities and proportions (OA ratio), we retrieved articles (referred to as "papers") published between 2002 and 2016 in high-quality academic journals indexed by WoS in early January 2018. We then utilized WoS' s built-in statistical analysis module to analyze all papers and OA papers across dimensions including publication year, research area, country/territory, and affiliation.

2. Quantity of OA Papers in High-Quality Academic Journals

2.1. Quantity and Annual Growth of OA Papers in High-Quality Academic Journals

Statistics on total papers, OA papers, and the quantities and annual growth rates of gold OA, green-accepted, and green-published papers during 2002-2016 are presented in Table 1 . The data reveal several key patterns:

First, the number of OA papers in WoS showed a year-by-year increasing trend from 2002-2016, with an overall OA ratio of 21.52%. The annual OA ratio rose from 14.00% in 2002 to 26.54% in 2015 (with a slight decline in 2016), representing an increase of nearly 90%.

Second, the annual growth rate of OA papers during 2002-2016 lacked strong regularity, peaking at 17.69% in 2008. After 2014, the annual growth rate began to slow significantly, with the 2016 growth rate reaching only 1.17%, suggesting a possible entry into a bottleneck period.

Third, gold OA papers constitute the primary channel for accessing OA papers on the WoS platform, while the two types of green OA papers serve merely as supplementary channels with very low proportions.

2.2. OA Paper Quantities and Changes Across Research Fields

Examining WoS research fields, we respectively counted the top 20 research fields by total papers, total OA papers, and OA ratio during 2002-2016, and conducted a cross-comparison of their rankings (Tables 2 -4).

Overall, from 2002-2016, three research fields—oncology, cell biology, and cardiovascular system & cardiology—simultaneously ranked in the top 20 for total papers, total OA papers, and OA ratio. The four disciplines with the highest total paper volumes were chemistry, engineering, physics, and materials science, yet their OA ratios were not particularly impressive, ranking around 100th among 151 research fields.

The OA paper volume in biomedicine is substantially larger than in other fields. Except for broad disciplines like mathematics and chemistry and the category "other topics in science and technology," the top ten research fields by OA paper volume all belong to biomedicine. Biochemistry & molecular biology ranked 5th in total papers but 1st in OA paper volume with a significant lead, achieving an OA ratio of 41.52%. Although cell biology did not rank high in total papers, it placed 5th in both OA paper volume and OA ratio. The research field with the highest OA ratio was tropical medicine, with 65.55% of papers being openly accessible.

Ignoring differences in discipline scale, biomedicine dominated 85% of the top 20 research fields by OA ratio, and occupied all top 10 positions. Seven research fields—including tropical medicine, microbiology, virology, developmental biology, cell biology, infectious diseases, and physiology—achieved OA ratios exceeding 50%, demonstrating remarkable OA practice effectiveness. This indicates that the biomedical field strongly supports the OA movement and has developed well, as evidenced by major OA promoters such as the UK publisher BioMed Central (BMC) [9], the U.S. PubMed Central (PMC) [10], and various OA journals founded by PLoS [11].

2.3. Changes in OA Paper Quantities by Major Countries/Territories

We selected the top 10 countries/territories by total papers on the WoS platform during 2002-2016 and analyzed their total paper volumes, OA paper volumes, and annual changes. Due to space limitations, Table 5 presents data for selected years only.

First, the top 10 countries/territories by total papers on WoS during 2002-2016 were essentially also the top 10 by OA paper volume, with the exception of Spain. Spain, which ranked 9th in total papers, placed 12th in OA paper volume, with its 9th position being replaced by Brazil.

Second, as the world' s leading power, the United States consistently ranked 1st globally in total papers, OA papers, and annual rankings during 2002-2016. While paper counts increased year by year, the growth rate has slowed significantly in recent years, with both total papers and OA papers experiencing

negative growth in 2015 and 2016 respectively.

Third, as another global power, China ranked 2nd worldwide in both total papers and OA papers during 2002-2016. Specifically, China ranked 6th in total papers and 14th in OA papers in 2002, but its rankings rose steadily thereafter, reaching 2nd place for both metrics by 2010-2011, where it has remained. Conversely, Japan, which ranked 2nd in both metrics in 2002, has experienced a continuous decline in rankings.

Fourth, England, as an active OA advocate, has consistently maintained an OA paper ranking one position ahead of Germany, which ranks higher in total papers.

Fifth, countries such as India, South Korea, and Brazil have seen substantial growth in OA papers in recent years, with annual statistics showing promising records of entering or approaching the top 10.

2.4. Statistical Analysis of OA Papers from Top 20 Institutions

We selected the top 20 institutions by total papers on the WoS platform during 2002-2016 and counted their total papers, OA papers, and rankings over the 15-year period. Due to space limitations, Table 6 only includes data for selected years.

First, the institution with the most papers on the WoS platform during 2002-2016 was the Chinese Academy of Sciences (CAS). However, CAS had very few OA papers in 2002, with only 398 papers ranking 83rd. Thereafter, CAS' s OA paper volume increased annually, rising to 2nd place in 2014 and capturing the top position in 2016. This achievement is closely related to CAS' s active advocacy and participation in open access and its successful operation of the world' s largest institutional repository. Meanwhile, the Russian Academy of Sciences, which ranked 2nd in total papers during the same period, has not made progress in OA papers, consistently failing to enter the top 50 from 2002-2016. Its ranking showed a pattern of initial decline followed by slow recovery, reaching 113th in 2016.

Second, Harvard University, which ranked 1st in the U.S. and 3rd globally in total papers during 2002-2016, consistently held the 1st position in OA paper volume from 2002-2015, only being surpassed by CAS in 2016.

Third, the University of Tokyo and Kyoto University entered the top 4 and top 18 respectively in total papers, with OA paper volumes ranking 9th and 19th. Overall, the gap was not substantial, but annual data reveal that both universities have experienced noticeable declines, with Kyoto University dropping out of the top 50 as early as 2013. In contrast, Chinese institutions including Shanghai Jiao Tong University, Zhejiang University, Peking University, Fudan University, and Sun Yat-sen University, along with Seoul National University in South Korea and the French National Centre for Scientific Research (CNRS),

have recently entered the dual top 50 for both total papers and OA papers, gradually displacing established European and American universities.

Fourth, the OA paper rankings of renowned British universities have improved steadily, with Oxford University rising from 39th in 2002 to 15th in 2016, representing a typical example from a developing country perspective.

Fifth, the OA paper ranking of the University of São Paulo in Brazil has increased year by year, rising from 39th in 2002 to 15th in 2016, making it a notable representative among developing countries.

Sixth, in 2016, CAS ranked first globally in OA paper volume with an OA ratio of 21.09%. In contrast, Harvard University, Oxford University, and the University of Washington, ranking 2nd-4th, all achieved OA ratios around 50%, with Harvard reaching as high as 55.68%. CAS thus shows a clear gap in OA ratio compared to other leading institutions.

3. Quality of OA Papers in High-Quality Academic Journals

Taking *Nature* as an example, we briefly analyze OA paper quality through citation counts and contributions to journal impact factors (such as average citations per paper and proportion of highly-cited papers) (Table 7).

Nature, as a traditional top-tier journal, enjoys an extremely high reputation in academia. From 2002-2016, WoS indexed 13,059 *Nature* articles, which were cited a total of 3,262,144 times, averaging 249.80 citations per paper. During the same period, there were 3,955 OA papers cited 954,769 times total, averaging 241.41 citations per paper—slightly lower than the overall average.

However, data from the recent decade (2007-2016) show: the total number of papers was 8,277 with 1,697,772 citations, averaging 205.12 citations per paper; OA papers numbered 3,543 with 804,862 citations, averaging 227.17 citations per paper—9.71% higher than the overall average. Additionally, *Nature* published 3,365 highly-cited papers from 2007-2016, of which 1,543 were OA highly-cited papers. The proportion of highly-cited papers among all papers showed an overall upward trend, increasing from 34.27% in 2007 to 43.48% in 2016. The proportion of OA highly-cited papers among OA papers rose from 41.12% in 2007 to 48.35% in 2016, peaking at 51.09% in 2012.

Paper citation counts are influenced by multiple factors and are not the sole indicator of quality. Beyond journal and paper quality, citation counts are also affected by paper visibility and accessibility [12]. The higher average citations per OA paper and the consistently higher proportion of OA highly-cited papers in *Nature* from 2007-2016 suggest that, while we cannot simply conclude that OA papers are of higher quality, their overall higher citation counts have likely contributed to promoting the dissemination and inheritance of scientific research and to the sustained improvement of *Nature*' s impact factor.

Although the OA links in the Web of Science Core Collection are not entirely accurate, analyzing data from the past 15 years yields the following main conclusions:

1. Gold OA papers are the primary channel for accessing OA papers on the WoS platform, while green accepted OA papers and green published OA papers serve merely as supplementary channels.

2. From 2002-2016, OA papers accounted for 21.52% of total papers in WoS, showing a year-by-year increasing trend. However, after 2014, the annual growth rate began to slow significantly, with the 2016 growth rate at only 1.17%, suggesting a possible entry into a bottleneck period.

3. From a research field perspective, biomedicine led in OA paper volume over the 15-year period, with all top 10 fields by OA ratio belonging to biomedical fields. Practice has proven this field to be the main driver of the OA movement.

4. From a country/territory perspective, the top 10 countries/territories by total papers on the WoS platform during 2002-2016 were essentially also the top 10 by OA paper volume, except for Spain. The U.S. consistently ranked 1st in both total papers and OA papers, though both have experienced negative growth in recent years. China's OA paper volume has risen annually, maintaining 2nd place globally in recent years. Japan's rankings in both metrics have continued to decline, while developing countries such as India, Brazil, and others have seen substantial OA paper growth.

5. From an institutional perspective, the Chinese Academy of Sciences has been the institution with the most papers indexed by WoS over the past 15 years. Through active participation in the OA movement, CAS rapidly reversed its initially poor OA paper ranking, surpassing Harvard University for the first time in 2016 to rank 1st globally in OA paper volume. However, its OA ratio still lags behind major European and American institutions. The University of Tokyo and Kyoto University have experienced continuous declines in OA paper rankings, while British university rankings have improved significantly, likely related to OA recognition and implementation.

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Zhu Jiang: Responsible for research design, paper writing, and revision.
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Note: Figure translations are in progress. See original paper for figures.