



Research on Open Access Journals Based on Article Processing Charges

Meiping Wang

Department of Information Consultation, Library of Henan Agricultural University, Zhengzhou, China

Email: wangmp2014@henau.edu.cn

How to cite this paper: Wang, M.P. (2024) Research on Open Access Journals Based on Article Processing Charges. *Open Access Library Journal*, 11: e11916.
<https://doi.org/10.4236/oalib.1111916>

Received: July 7, 2024

Accepted: August 26, 2024

Published: August 29, 2024

Copyright © 2024 by author(s) and Open Access Library Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Authors pay article processing charges for open access journals, while readers can access articles. With the development of open access, the expenditures of article processing charges are increasing. It becomes a burden for scientists, especially in developing countries. Since it is a market competition, most publishers must charge article processing charges. However, the price of article processing charges should be reasonable. This study chooses 494 journals to analyze article processing charges, mainly in agricultural and biological sciences (miscellaneous), and closely related disciplines. The results show that since 2012, the total expenditure of article processing charges for open access journals in agriculture and biology has been increasing. The total expenditure of article processing charges in engineering is the highest. In the paper, an analysis is conducted on the concentration trend of article processing charges (APCs) for open access journals, including the mean, median, mode, skewness, kurtosis, and other relevant measures. Factors influencing the average APC of open access journals are also examined. Finally, a three-stage least squares (3SLS) approach is employed to study a model for determining reasonable pricing. The findings provide confidence in the future of APC pricing in quantitative research.

Subject Areas

Business Analysis, Information Science

Keywords

Open Access, Article Processing Charges, Price Mechanism

1. Introduction

In the 1990s, digital technology and network development make profound changes

in the publishing industry, especially the emergence of Open Access (OA), which leads to Open Access Publishing (OAP). Academic open access journals enable anyone to obtain articles free of charge, which challenges the market monopoly of subscription-based journals. In the traditional publishing mode, the income of periodical publishing institutions mainly comes from the subscription fees of readers. The early publication of open access journals mainly depended on the labor of volunteers and a small part of subsidies. In 2000, two new professional publishers, Public Library of Science (PLOS) and BioMed Central (BMC), operated journals on the basis of article processing charge (APC). Later, many traditional leading publishing companies began to launch OA journals funded by APC. Therefore, the revenue of OA journals mainly comes from the author's payment. That is, the author is charged with a particular article processing fee. By October 2022, the Directory of Open Access Journals (DOAJ) has had 18,385 open access journals, including 12,698 journals that do not charge any APC fees and accounting for 69% (<https://doaj.org/>). The OA model sponsored by APC has changed the relation among authors, publishers, and readers. For the study of article processing charges, there are few studies at home and abroad. In the Springer database, there are only 14 articles for title retrieval.

About APC research, professor Björk and professor Solomon [1] studied the relation between the quality of scientific journals and OA journal publishing fees. They found that, compared with the distribution of journals at different levels, the average number of articles in the low and moderately high APC price range would be higher. The distribution of SNIP (Source Normalized Impact per Paper) in the articles was inconsistent with that in the journals. The correlation between APC and SNIP based on journals showed that their correlation was very low, while the correlation between APC and SNIP based on articles showed that their correlation was very high. According to research on 23 institutions in the UK from 2007 to 2014, they found that hybrid journals were more expensive than fully open access journals. Most APCs were paid to traditional commercial publishers, which had a large amount of subscription income. Therefore, first of all, in addition to subscription fees, APC accounted for a large proportion of publishing fees. APC from the university budget had increased significantly since 2012, which was mainly due to changes in British policies and fund sponsorship, and it accelerated the adoption of gold OA publishing funded by APC. Secondly, the total cost of publication (TCP) data model showed that, in addition to management fees, APC accounted for 10%, and subscription fees accounted for 90%. For academic institutions, APC accounted for the main part of TCP [2]. The total cost of publication (TCP) data model suggested that APCs account for 10% of the total cost, while subscription fees accounted for 90%. For academic institutions, APCs constituted the primary part of the TCP. Additionally, the use of an Institutional Central Fund to pay APCs for open access, studied through the lens of Innovation Diffusion Theory, indicated that the adoption of this fund had diffused within organizations. The payment of APCs had increased from less than 1% of the institution to over 12%.

The Fund's usage was higher in Health and Life Sciences disciplines compared to other disciplines, suggesting that the Gold OA market was still in its early stages of development [3].

Cheng and Ren [4] investigated the charging standards of APCs for OA journals such as Elsevier, Springer, Taylor & Francis, Willey Blackwell and NPG, as well as BMC, Plos, Hindawi, and other international OA journal publishers. They analyzed APC charging strategies with MDPI as an example. The majority of open access articles were published in the minority of journals that charged according to the model selection of likelihood-ratio test, and higher APCs were associated with the increase in article volumes. Market competition and author choice could not suppress APC hyperinflation. All the data is from four major commercial publishers, which included BMC, Frontiers, MDPI, and Hindawi [5].

Professor Asai had made a relatively in-depth study on APC. In 2019, Professor Asai conducted pivotal research on Article Processing Charges (APC), selecting BMC Press as a focal point for her study. In her paper, she employed a sample selection model to scrutinize the determinants behind APCs. The findings revealed that, after adjusting for various factors, BMC Press imposed higher fees on journals that were frequently cited, while opting to charge lower fees for newly launched journals [6]. This work laid the groundwork for further exploration into the economics of academic publishing. Building on her previous research, in 2020, professor Asai expanded her investigation to assess the impact of publishing houses' processing fees for open access journal articles on market dynamics. She meticulously analyzed 535 journals, utilizing a three-stage least squares (3SLS) method to evaluate the interrelationships among three critical variables: APC, Source Normalized Impact per Publication (SNIP), and the publication volume. This comprehensive study led to the identification of key factors influencing APC determination. Contrary to what might be expected, the study found that the Herfindahl-Hirschman Index (HHI) related to the number of articles published had no significant effect on APCs. Interestingly, it was observed that large subscription-based publishers did not levy higher APCs. Instead, these entities strategically acquired open access publishers that had demonstrated significant achievements, indicating that major subscription journal publishers have the potential to shape the open access market through mergers and acquisitions of renowned open access platforms, though such market influence was not currently evident [7]. The research further highlighted a direct correlation between citation metrics and APC setting: journals with higher citation scores tended to increase their APCs, whereas those with lower scores decreased them. Notably, the revenue gain from increasing APCs far outweighed the loss incurred from reducing them, leading to an escalated economic burden on authors. These findings underscored the complex interplay between citation performance, market strategies of publishing houses, and the financial implications for academic authors [8].

The gold open access (OA) publishing model has garnered significant atten-

tion in scholarly research, particularly regarding the mechanisms through which equilibrium article processing charges (APCs) were determined. A notable investigation by Yuan et al. [9] applied a three-stage Hotelling duopoly model to dissect the dynamic and competitive attributes influenced by journals' APCs. This study illuminated that gold OA journals boasting superior academic prestige and reduced publication delays possess the leverage to impose higher APCs.

Additionally, from 2015-2020, it was observed that APC expenses had surged across six nations, each with distinct OA policies—namely the United States, China, the United Kingdom, France, the Netherlands, and Norway. According to the analysis, in 2020, the combined total from these six countries was 1.6 times greater than that in 2015. This uptrend underscored the burgeoning financial implications for scholars aiming to publish within the gold OA framework. Complementing these findings, research by Zhang et al. [10] delved into publishers' predilection for the APC-based OA business model. This preference was indicative of a broader industry trend, suggesting that APCs were pivotal in shaping the competitive landscape and market dynamics of gold OA publishing. The cumulative evidence from these studies pointed to a significant role of APCs in the gold OA market, influencing not only competition among publishers but also accessibility for researchers seeking to disseminate their work through gold OA channels. The escalating APC expenses, as highlighted, presented potential hurdles for academics aspiring to publish in gold OA journals, thereby raising critical considerations for the future of scholarly communication and open access dissemination.

On the basis of above research, it is clear that further understanding of the reasonable APC price for open access journals is necessary. Different publishers have different approaches to charging APC fees, such as fixed fees for all journals, different fees for different types of articles (e.g., research papers, review articles, short comments), charging based on the number of pages, offering discounts, or providing waivers for authors who cannot afford to pay. In this paper, the subject category of the SCImago website is used to classify, which include agricultural and biological sciences (miscellaneous), biochemistry, genetics and molecular biology (miscellaneous), engineering (miscellaneous), environmental science (miscellaneous), social sciences (miscellaneous), and economics, econometrics, and finance (miscellaneous). The analysis focuses on these categories to gain insights into open access publishing in these fields.

One limitation of the paper is the lack of data on the actual APC prices of each article. Instead, only the basic price data of the journal is considered. It is worth noting that there can be significant differences between currency conversion rates and the actual prices. For example, in 2019, the APC price for the journal **Molecular Systems Biology** was 3960 GBP. According to currency conversion rates between USD and GBP, this amounts to approximately \$4477. However, the actual journal price is \$5000, indicating a difference due to various factors.

It's important to point out that the current research represents the first systematic study of APCs in agriculture, biology, and related fields. It encompasses

an analysis of total APC expenditures for open access articles in agriculture and biology over the past decade, factors influencing total APC expenditures, and more. Additionally, an innovative OA model for subjects in agriculture and biology is proposed. By examining APC dynamics within agriculture, biology, and allied disciplines, our study aims to provide scholars with essential insights for making informed decisions regarding journal selection for publishing OA articles. This effort aims to foster enriched academic discourse. Furthermore, this investigation into OA journal article APCs across specific disciplines serves two main objectives. Firstly, it aims to educate researchers about the financial implications of publishing in OA journals, potentially guiding them towards more economically sustainable options without compromising on quality or reach. Secondly, by initiating a discussion on what constitutes reasonable APCs, the study seeks to promote wider acceptance of OA publication charges within the academic community. The underlying premise is that through informed discussion and analysis, the OA publishing model can be optimized to achieve a balance between financial sustainability for publishers and affordability for authors, thereby enhancing accessibility to OA publishing for a broader range of scholars. In conclusion, while the research provides valuable insights into the classification and analysis of open access journals in specific subject categories, more comprehensive data on actual APC prices per article would enhance the accuracy of the findings.

2. Method

This article leverages data sourced from the Directory of Open Access Journals (<https://doaj.org/>) and the SCImago website (<https://www.scimagojr.com/>) to conduct a preliminary analysis of open access journals across various disciplines. The data collection period is from May 1, 2022 to November 30, 2022. The methodology begins with identifying open access journals on the SCImago website, categorized according to discipline classifications that, while simplified for this study, align with the objective standards set by Scopus and ensure that all analyzed journals are indexed by the Web of Science (WoS). To enhance the reliability of the open access journals under review, the author verifies and retrieves the International Standard Serial Number (ISSN), whether in print or online format, for each journal listed in the DOAJ. This verification process ensures the inclusion of only those journals recognized by DOAJ, thereby excluding any journal not featured on the DOAJ platform from our statistical analysis. Publisher information, article processing charges (APCs), and the count of open access articles per journal are all meticulously gathered directly from the DOAJ website. The analysis explicitly excludes journals that report zero APCs and have no open access articles published, as these parameters are critical for the statistical evaluation conducted in this study. Furthermore, the SCImago Journal & Country Rank (SJR) and citation data, essential metrics for assessing journal impact and influence, are extracted from the Scopus database and SCImago. Any journal lacking an SJR value is omitted from calculations to maintain the integ-

rity and accuracy of the analysis. The collected data undergoes rigorous processing and analysis using software tools such as EXCEL or EViews, facilitating a comprehensive examination of the current landscape of open access publishing. This methodical approach aims to shed light on the credibility, accessibility, and scholarly impact of open access journals, contributing valuable insights to the ongoing discourse on open access publishing practices and policies.

In this study, while the Article Processing Charges (APC) set by publishers are denominated in various currencies, the analysis is confined to seven major currencies. This decision is made to streamline the assessment process and ensure consistency in comparing APCs across different journals and publishers. To achieve a uniform basis for comparison, the author employs the exchange rates as of November 3, 2022, converting all APCs not originally in these seven currencies into United States dollar (USD) equivalents. This conversion to USD allows for a more straightforward and coherent analysis, eliminating the complexities and potential inaccuracies that might arise from dealing with a multitude of currency values. It facilitates a more accessible understanding of the financial aspects of publishing in open access journals, providing a common ground for evaluating the economic implications for authors worldwide. Employing a single day's exchange rate for all conversions ensures that the analysis is not unduly affected by the fluctuations in currency values that can occur over time. This methodological choice underscores an effort to maintain objectivity and reliability in the study's findings, offering a snapshot of the APC landscape that is as accurate and representative as possible given the constraints of the data. Such an approach underscores the global nature of academic publishing and the necessity of considering the diverse economic contexts from which researchers operate. By standardizing APCs into USD, the study aims to present a clear, comprehensive picture of the costs associated with publishing in open access journals, thereby contributing valuable insights into the financial dynamics of open access publishing.

3. Results

Research efforts at agricultural universities and institutions, which are primarily dedicated to the study of agriculture and biology, have focused extensively on these core areas. Moreover, attention has been directed towards other disciplines that are closely interconnected with agricultural studies. This multidisciplinary approach not only deepens the understanding of core agricultural and biological concepts but also explores the intersection of these fields with other areas of study. Such an inclusive research framework allows for a comprehensive exploration of agriculture in its broadest sense, encompassing aspects like environmental science, agrotechnology, and sustainable practices. This deliberate selection is driven by the intent to furnish researchers within these domains with comprehensive insights into the landscape of Article Processing Charges (APC) associated with open access (OA) journals. **Figure 1** shows the total APC expenditure of open access articles in agriculture and biology over the past ten

years. **Figure 2** is a histogram comparison of the total APC expenditure of open access articles among agricultural and biological sciences and other disciplines.

3.1. Analysis of the Total APC Expenditure of Open Access Journals in Agriculture and Biology

The trend depicted in **Figure 1** offers a compelling narrative on the evolution of Article Processing Charges (APC) expenditure within the realms of agriculture and biology over the past decade. This upward trajectory in APC spending, particularly for open access journals, reflects broader trends in academic publishing and underscores the growing emphasis on open access as a preferred mode of dissemination for scholarly work. From 2012 to 2015, the increase in total APC expenditure was modest, suggesting a period of gradual acceptance and adaptation to the open access model by researchers in agriculture and biology. This could be attributed to the initial phase of transition towards open access publishing, where both researchers and publishers were navigating the implications of this shift. The slight uptick in expenditure from 2015 to 2017 indicates a steady, albeit cautious, growth in the adoption of open access publishing within these disciplines. During this phase, the benefits of open access, such as increased visibility, accessibility, and potential for higher citation rates, might have begun to outweigh concerns over APCs, leading to a more pronounced commitment to open access journals. In 2018, APC expenditure reached the peak with a growth rate of 48.46%. Post-2018, the data reveals a continuous increase in APC expenditures, notably surging in 2021 with a growth rate of 57.56%. This remarkable growth can be interpreted as a sign of the maturation of open access publishing in agriculture and biology. By this point, the academic community's recognition of the value provided by open access—coupled with the proliferation of reputable open access journals in these fields—likely contributed to the

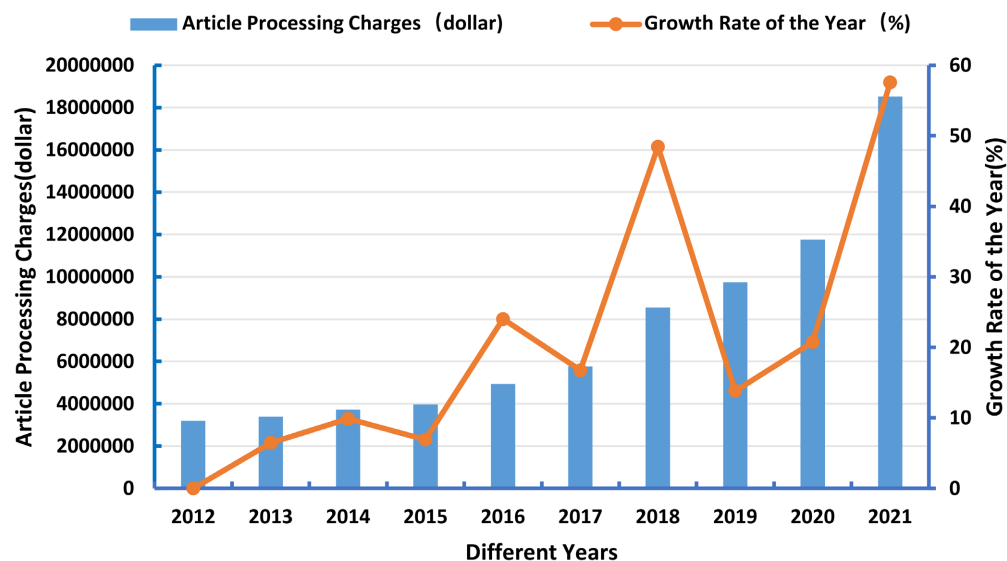


Figure 1. Total APC expenditure distribution for open access Journals of Agricultural and Biological disciplines in recent 10 years.

willingness of researchers and funding bodies to invest more substantially in APCs. The quantitative leap from a total APC expenditure of \$3,182,816 in 2012 to \$18,524,307 in 2021 is striking, marking an almost sixfold increase (5.8 times to be precise). This escalation not only highlights the expanding footprint of open access publishing in agriculture and biology but also raises important considerations about the sustainability of APC models, the availability of funding for open access publications, and the economic pressures faced by researchers in these fields. In essence, the data from **Figure 1** captures a pivotal shift in the landscape of scholarly communication for agriculture and biology, reflecting broader trends towards open access while also prompting critical reflection on how best to support equitable, sustainable access to research outputs in these vital scientific domains.

3.2. Analysis of the Total APC Expenditure of Open Access Journals in Agricultural and Biological Sciences and Other Disciplines

Figure 2 provides a comparative analysis of total Article Processing Charges (APC) expenditure across various disciplines in 2021, highlighting the significant disparities in open access publishing costs among different fields of study. This comparison reveals the substantial financial investment required to publish in certain areas, particularly within the natural sciences, and underscores the economic challenges and considerations that researchers face when choosing to publish their work in open access journals. Engineering emerges as the discipline with the highest total APC expenditure in the natural sciences, amounting to \$92,554,102. The figure not only reflects the high volume of research output within the engineering field but also suggests a robust engagement with open access publishing modalities. Following closely is Biochemistry, Genetics, and Molecular Biology, with an expenditure of \$87,725,021, indicating a similar commitment to making research findings widely accessible through open access channels. The analysis further reveals that Environmental Science incurs higher APC costs than Agricultural and Biological Sciences, pointing to varying levels

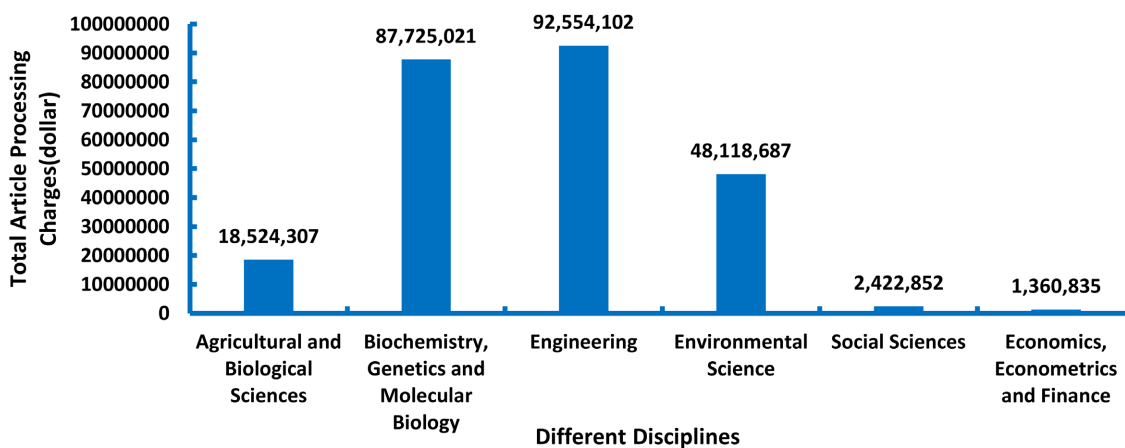


Figure 2. Total APC expenditure of open access journals in different disciplines in 2021.

of adoption and investment in open access publishing across related disciplines. Notably, the total APC for Engineering is nearly five times that of Agricultural and Biological Sciences disciplines, while Biochemistry, Genetics, and Molecular Biology's total APC is 4.7 times as much. These disparities underscore the significant financial implications of disciplinary choices for open access publishing.

In contrast, the social sciences and humanities exhibit relatively lower total APC expenditures, with Social Science at \$2,422,852 and Economics, Econometrics, and Finance at the lowest, with \$1,360,835. The stark difference between these figures and those of the natural sciences—where Engineering's total APC is 68 times that of Economics, Econometrics, and Finance, and 13.6 times that of Agricultural and Biological Sciences—highlights the divergent economic landscapes of open access publishing across academic domains. This variance in APC expenditure not only reflects disciplinary differences in research output and publication practices but also points to broader issues of accessibility and affordability within the academic publishing ecosystem. The significantly lower total APC expenditure in humanities and social sciences compared to natural sciences raises questions about the equity of access to open access publishing opportunities and the potential barriers that high APCs may pose to researchers in fields with less funding availability. Overall, **Figure 2** illustrates the complex interplay between discipline, publishing costs, and the pursuit of open access, emphasizing the need for sustainable models that can support equitable access to publishing opportunities across all fields of research.

3.3. Reasons Affecting Total APC Expenditure and Average APC of Open Access Journals

In the analysis of the crucial factors influencing the total APC expenditure by DOAJ, SCImago and Scopus, it is found that the number of open access articles and APC prices of open access journals are the crucial factors affecting the total APC expenditure. The following figure is the study of the number of open access articles.

3.3.1. The Study of the Number of Open Access Articles

The number of articles affects the total APC expenditure of open access journals. **Figure 3** shows that Engineering has the most significant number of open access articles, which is 47,408. The number of open access articles in the Environmental Science discipline is the second, and the number of open access articles in Agricultural and Biological Sciences is the third, which is 11,667. Economics, Econometrics and Finance have the least number of open access articles, only 1591.

The size of the journal impact factors, and the different publishers and other factors also affect the APCs of open access journals. Because the total APC expenditure of the open access journals in agriculture and biology in **Figure 1** is the highest in 2021, its APC is selected for analysis.

3.3.2. Analysis of APC Concentration Trend of Open Access Journal

To clearly understand APC fees of open access journals, **Table 1** lists the APC

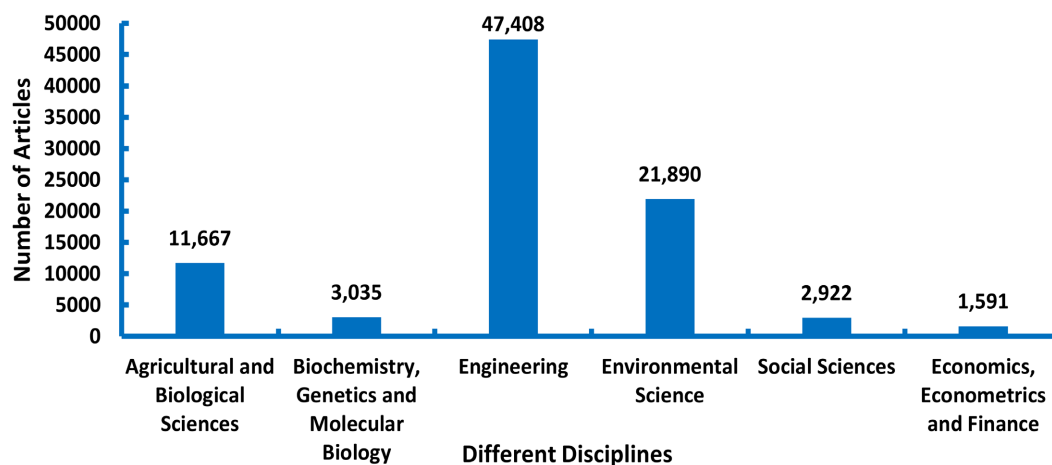


Figure 3. Number of open access articles in agricultural and biological sciences and other disciplines in 2021.

Table 1. APCs of open access journals in Agricultural and Biological Sciences and other disciplines in 2021 (dollar).

	Agricultural and Biological Sciences	Biochemistry, Genetics and Molecular Biology	Engineering	Environmental Science	Social Sciences	Economics, Econometrics and Finance
Mean	1348.88	2009.56	1169.54	1485.92	827.44	937.87
Median	1000	1775	900	1536.5	590	983
Mode	500	5200	2200	2400	1119	1401
Stand Error of Mean	168.61	181.50	154.53	130.43	141.84	203.35
Stand Deviation	1180.30	1394.10	965.04	804.00	601.78	787.58
Variance	1,393,097.69	1,943,521.53	931,300.83	646,423.21	362,143.67	620,282.70
Skewness	1.46	0.78	1.71	0.27	2.31	1.77
Kurtosis	2.70	0.17	5.06	-0.25	7.08	4.99
Range	5265	5150	4881	3437	2636	3255
Minimum	35	150	119	63	200	150
Maximum	5300	5300	5000	3500	2836	3105
Number of journals	49	59	39	38	18	15

statistical analysis results of agriculture, biology and other disciplines in detail. For each statistical result, an in-depth analysis is carried out. The analysis results are as follows.

In **Table 1**, the arithmetic mean value of APC in biochemical, genetic and molecular is the highest, which is \$2009.56. The second is environmental science. The average APC of open access journals is 1485.92 dollars. The average APC in the Open Access journal of Agriculture and Biological Sciences is \$1348.88. The average APC in the Open Access Journal of Social Sciences is the

lowest, which is \$827.44. However, the arithmetic mean is easily affected by extreme values, so it needs to be further analyzed with median and mode.

The median value serves as a robust indicator of the central tendency, effectively minimizing the distortion caused by exceptionally high or low APCs. In this context, Biochemistry, Genetics, and Molecular Science stand out with the highest median APC at \$1775. This figure suggests that half of the open access journals in this discipline charge more than \$1775 for APCs, highlighting the considerable financial commitment required to publish in these areas. Environmental Science follows with a median APC of \$1536.5, indicating a similarly high but slightly less expensive cost structure compared to Biochemistry, Genetics, and Molecular Science. Agriculture and Biological Sciences have a median APC of \$1000, placing them third in terms of expense. This relatively lower median suggests a more moderate financial barrier to open access publishing within these fields. Social Sciences, on the other hand, exhibit the lowest median APC at \$590, reflecting the generally lower cost of publishing in these disciplines. This discrepancy underscores the disciplinary differences in open access publishing economics, potentially influencing researchers' decisions based on available funding and the perceived value of open access visibility.

The mode, representing the most frequently occurring APC within a dataset, offers another dimension to understanding open access publishing costs. In this analysis, Biochemistry, Genetics, and Molecular Science again top the list with a mode APC of \$5200, indicating a significant concentration of journals within this discipline charging this rate. This high mode APC points to a premium placed on publishing in top-tier journals within the field. Environmental Science and Engineering follow with mode APCs of \$2400 and \$2200, respectively, suggesting a notable presence of journals within these disciplines that align around these APC figures. Agricultural and Biological Sciences and Social Sciences exhibit lower mode APCs, with Social Sciences having the lowest, which aligns with the observations made from the median APC analysis.

The standard deviation measures the amount of variation or dispersion in a dataset, with a smaller standard deviation indicating less variation and a larger standard deviation suggesting more significant variability. In this context, Social Sciences exhibit the smallest standard deviation, indicating that the data set is relatively concentrated around the median or mean APC value. This finding suggests that the cost of open access publishing within Social Science fields is relatively uniform, with fewer outliers or exceptional APC values. Agricultural and Biological Sciences have the largest standard deviation, indicating greater variability in APC costs within this field. The broad range of APC values suggests that researchers in Agricultural and Biological Sciences may face greater uncertainty around the cost of open access publishing, with higher outliers potentially limiting accessibility for those with limited funding.

The analysis of the range in APC fees across disciplines provides insights into the spread or dispersion of costs within each field. The APC of Agricultural and

Biological Sciences has the most extensive range, and the data is relatively scattered. The range of Social Science is the smallest, and the data is relatively centralized. In **Table 1**, in natural sciences, the maximum APC fee for open access journals is relatively high, exceeding \$3500. This indicates that researchers in this field may encounter higher costs when publishing their work in open access journals. On the other hand, social sciences and humanities have lower maximum APC fees compared to other disciplines, suggesting that the cost of open access publishing within these fields tends to be more affordable. Agricultural and Biological Sciences have the lowest minimum APC fee at \$35, indicating that there are open access journal options available at a relatively low cost within this field. Similarly, Environmental Science exhibits a low minimum APC fee of \$63, highlighting accessible publishing options for researchers in this discipline. Except for Engineering, where the APC fee is \$119, all other disciplines have APC fees above \$150. This suggests that most researchers, regardless of their field, can pay above \$150 for open access publishing.

Skewness and kurtosis are used to analyze the overall distribution of APC in journal articles. Skewness measures the asymmetry of a distribution around its average value. A positive skewness value indicates that the distribution has a longer tail on the right side, while a negative skewness value suggests a longer tail on the left side. In **Table 1**, all disciplines exhibit positive skewness values, indicating that the distribution of APC fees is right-skewed, with more articles having lower APC fees. The order of skewness values, from highest to lowest, is Social Science, Economics, Econometrics and Finance, Engineering, Agriculture and Biological Sciences, Biochemistry, Genetics, and Molecular Science, and Environmental Science. Therefore, humanities and social sciences have a relatively larger number of articles with lower APC fees, resulting in a right-skewed distribution within these disciplines. Kurtosis measures the shape of a distribution, with positive values indicating a relatively sharp distribution and negative values representing a relatively flat distribution. Among the natural science disciplines in **Table 1**, Biochemistry, Genetics, and Molecular Science exhibit a kurtosis value of 0.17, indicating a normal distribution. Environmental Science has a kurtosis value of -0.25 , suggesting a relatively flat distribution. Agricultural and Biological Sciences show the highest kurtosis value of 2.70, indicating a sharp distribution. Engineering has the largest kurtosis among the natural science disciplines, implying a sharp distribution as well. Social Science has the highest positive kurtosis value, indicating the sharpest distribution among all disciplines in **Table 1**.

The number of open access journals within a discipline can impact the total APC expenditure. In **Table 1**, we can see that Biochemistry, Genetics, and Molecular Science have the highest number of open access journals, with 59 journals in total. This indicates that researchers in this field may have more options for open access publishing, potentially leading to increased competition among journals and lower APC fees. Agriculture and Biological Science also have a rela-

tively high number of open access journals, with 49 journals in total. This suggests that researchers in this field may also have a range of options to choose from when deciding where to publish their work. In contrast, humanities and social sciences have a relatively smaller number of open access journals, with only 18 journals in Social Sciences and 15 journals in Economics, Econometrics, and Finance. This may limit the options available to researchers in these fields and could potentially result in higher APC fees due to lower competition among journals.

In summary, **Table 1** and **Figure 3** show that Engineering disciplines have the most significant number of open access articles. However, the average APC of open access journals is lower than that of Agricultural and Biological Sciences. Moreover, the skewness to the right also indicates that most APCs are distributed in the lower price part (compared with agricultural and biological sciences). At the same time, the total APC expenditure in 2021 is higher. Therefore, the total number of open access articles is essential to the total APC expenditure. The number of open access articles in Biochemistry, Genetics and Molecular Science is less than in Agricultural and Biological Sciences. However, the average APC of open access journals is higher than that in Agricultural and Biological Sciences. Compared with Agricultural and Biological Sciences, the skewness in Biochemistry, Genetics and Molecular Sciences is smaller and the total APC expenditure in 2021 is higher. Therefore, the APC level of the article also affects the total APC expenditure. The statistical analysis results in **Table 1** and the column data in **Figure 3** will not be analyzed individually. The following is an analysis of the impact on average APC costs.

3.3.3. The Influence of Open Access Journal SJR on Average APC of Open Access

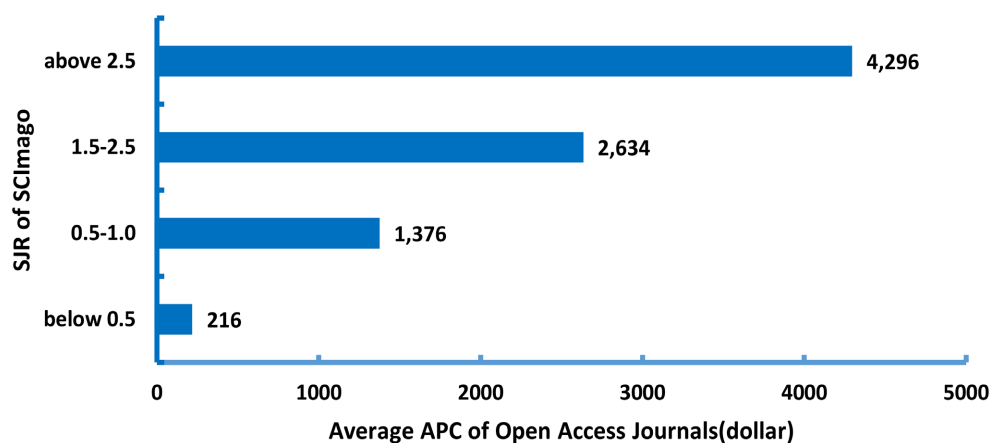


Figure 4. SJR and average APC of open access journals in agricultural and biological sciences in 2021.

The SCImago Journal Rank (SCImago Journal & Country Rank) is an evaluative metric derived from the Scopus database, developed by the Spanish SCIma-

go research group. It employs a computation method akin to Google's PageRank algorithm, once viewed as a contender to Thomson Reuters' Impact Factor (IF). According to **Figure 4**, there is a noticeable trend where the Average Article Processing Charge (APC) escalates in tandem with the SCImago Journal Rank (SJR) of open access journals within the fields of agriculture and biology. Specifically, when the SJR is under 0.5, the average APC for open access journals stands at merely \$216. However, as the SJR surpasses 2.5, the average APC soars to \$4296, marking an almost twentyfold increase compared to journals with an SJR of 0.5.

3.3.4. The Influence of Different Publishers on the Average APC of Open Access Journals

Figure 5 presents an analysis of the average Article Processing Charges (APC) for open access journals in the fields of agriculture and biological sciences in 2021. It reveals that the highest average APCs are attributed to the major Big Database Vendors, with an average cost of \$2297. These prominent vendors include Wiley, Elsevier, Taylor & Francis, and Springer. Following them, Independent Publishing Companies also exhibit a relatively high average APC, amounting to \$1109. The next tier comprises University Presses, among which Cambridge University Press, Oxford University Press, and Aristotle University of Thessaloniki Press stand out, while APCs at other university presses are notably lower. Institutes represent the category with the lowest average APC. Notably, the average APC charged by Big Database Vendors is almost four times higher than that of the Institutes.

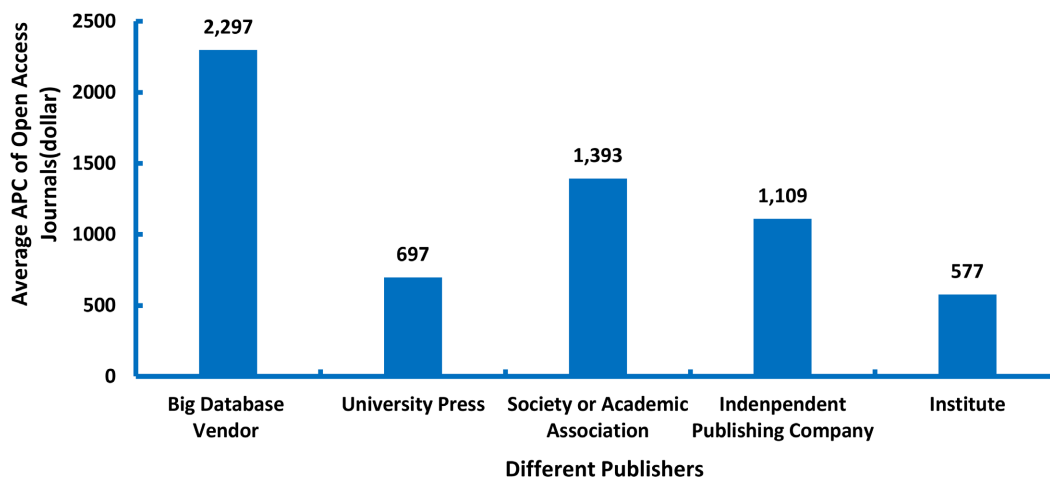


Figure 5. The influence of different publishers on the average APC of open access journals in 2021.

3.4. Establish a Reasonable APC Mechanism of Open Access Journals

The landscape of academic publishing has witnessed a significant rise in gold open access journals, which allow researchers and readers to access articles without charge. This model, adopted by some of the most prestigious journals, necessitates that scientists pay an Article Processing Charge (APC) to publish

their work. According to information from the Directory of Open Access Journals (DOAJ), publishers offer waivers to scientists hailing from low-income countries to mitigate financial barriers. Despite these efforts, the high cost of APCs remains a formidable obstacle for researchers in developing countries, highlighting the pressing need for a more equitable business model in the publishing industry. For nations still in development, it is crucial for policymakers to devise and implement strategies that ensure the affordability of APCs, thereby fostering a more inclusive scientific community. Encouraging researchers to contribute to journals of high prestige and reputation is important for advancing their careers and enhancing the visibility of their work. Nevertheless, given the commercial nature of academic publishing, researchers must also be acutely aware of the financial implications of APCs. In response to the call for a fair pricing strategy for APCs, the author proposes a straightforward and effective model based on the three-stage least squares method [7]. This model aims to balance the financial sustainability of publishers with the accessibility needs of the global research community, particularly those in less affluent regions. By establishing a reasonable APC pricing structure, we can move closer to a more equitable and accessible system of scholarly communication.

4. Model

Through correlation analysis from agricultural and biological sciences, it was found it was closely related between APC and SNIP, and between APC and SJR. These findings suggest that journals with higher impact metrics, as measured by SNIP and SJR, tend to charge higher APCs. This is likely reflective of the perceived value and demand for publishing in journals that are recognized for their influence and reach within the scientific community. Conversely, the correlation between APC and the number of articles published is notably weak, as indicated by a correlation coefficient of only 0.068. This suggests that the quantity of articles a journal publishes does not significantly influence the APC, which could imply that factors such as journal prestige, impact, and quality of peer review are more pivotal in determining the cost to publish. The following equations are about APC model of agricultural and biological sciences.

$$\ln \text{APC}21 = \alpha_0 + \alpha_1 \ln \text{Article}21 + \alpha_2 \text{SJR}21 + \alpha_3 \text{Year} + \alpha_4 \text{BDV} + \alpha_5 \text{University} + \alpha_6 \text{SOAA} + \alpha_7 \text{IPC} + \alpha_8 \text{Institute} \quad (1)$$

$$\text{SJR}21 = \beta_0 + \beta_1 \text{SJR}20 + \beta_2 \text{SJR}19 + \beta_3 \text{Year} + \beta_4 \text{BDV} + \beta_5 \text{University} + \beta_6 \text{SOAA} + \beta_7 \text{IPC} + \beta_8 \text{Institute} \quad (2)$$

$$\ln \text{Article}21 = \gamma_0 + \gamma_1 \ln \text{Citation}21 + \gamma_2 \text{Year} + \gamma_3 \text{BDV} + \gamma_4 \text{University} + \gamma_5 \text{SOAA} + \gamma_6 \text{IPC} + \gamma_7 \text{Institute} \quad (3)$$

In Equation (1), dependent variable APC21 is of the journal from 2021, and unit conversion is dollar. The independent variable Article21 is defined as the number of articles in a journal in 2021. Instead of SNIP, this study uses SJR as an index. There are two reasons. First, SJR has a closer relation with APC, com-

pared with SNIP. According to Scopus data, The APC is high or low according to the size of SJR. It means the higher the SJR value, the higher the APC. Of course, different publishers have an important effect on APC. Second, scientists prefer to choose high SJR to publish their papers. Most time, they don't consider SNIP. Institutes or universities often think SJR is more important than SNIP. That is, the impact factor of an article is more important than its citation. SJR21 means the SJR value is of 2021. Year is defined as the number of years from the start of open access journal (2020 = 1), and it has a positive effect on APC. University, SOAA, SOAA, IPC and Institute belong to different publishers. BDV is the abbreviated form of a big database vendor. SOAA is the abbreviated form of society or academic association. IPC is the abbreviated form of the independent publishing company. It will be set to 1 if the journal is BDV. Otherwise, it will be set to 0. The same is for other publishers.

In Equation (2), journals that have high SJR attract scientists' interest, leading to many more papers being submitted. Since the academic community regards SJR as important, this study uses SJRs as the independent variable. SJR20 means SJR value in 2020. Similarly, SJR19 refers to the SJR value in 2019. Generally, the earlier the open access journals are opened, the higher the impact factor of journals. So, Year has a close relationship with SJR. In addition, different publishers have an important influence on the SJR.

Equation (3) estimates the number of articles in 2021, which closely relates to citation. The correlation coefficient between the number of articles and citations is 0.789. While the correlation coefficient between the number of articles and year is -0.248. Of course, different publishers have an influence on the number of articles. **InCitation21** means the number of citations in 2021.

Table 2 shows the results of estimating the three equations by 3SLS. From Equation (1), the coefficient of Article 21 is negative. And the coefficient of Year is also negative. It tells us the earlier the start of open access journals, the lower of APC. All the coefficients of publishers have positive relations with APCs. SOAA's coefficient is the biggest, and the value is 11.438. From Equation (2), the coefficient of BDV is negative, and the coefficients of other publishers are positive. From Equation (3), except for the coefficients of the University and Institute, the other coefficients of publishers are negative. R-squared of Equation (2) is the best among the three formulas.

5. Discussion

Scientists publish their research findings, which significantly impact their careers. Therefore, publishing plays a crucial role for scientists, as it allows them to showcase their work to the government and secure continued support for their research. This is especially true when they publish in renowned journals, as it enhances their chances of promotion. Conversely, failure to publish high-level articles may result in a loss of public funding from the national budget and potential missed opportunities for new grants.

Table 2. Estimation results of three-stage least squares (3SLS).

Adjusted R-squared	lnAPC21 (1)	SJR21 (2)	lnarticle21 (3)
Constant	8.886	-0.157	-1.019
lnArticle21	-0.112		
SJR21	0.654		
SJR20		0.263	
SJR19		0.598	
Year	-0.647	0.009	0.017
BDV	5.088	-0.574	-1.054
University	9.269	0.026	0.063
SOAA	11.438	0.074	-1.300
IPC	4.847	0.055	-0.092
Institute	6.919	0.033	0.699
lnCitation21			0.904
R-squared	-3.717	0.970	0.825
Adjusted R-squared	-5.604	0.958	0.767
Durbin-Watson statistics	1.913	2.579	2.121
S.E. of regression	2.813	0.275	0.667

However, a major challenge associated with publishing is the issue of Article Processing Charges (APC), as many authors struggle to afford these expenses on their own. The financial burden imposed by APCs can be substantial, creating barriers for authors at all levels. While APCs generate revenue for publishers, they also pose a growing problem for authors, as highlighted by Vrana [11]. This demonstrates that access to scientific knowledge is often limited to well-funded individuals and institutions, undermining the goal of Open Access initiatives. Publishers, however, strive to find a balance in adjusting APCs to retain authors and support the academic community. In the following sections, the article will delve into the specific challenges associated with APCs, examining their implications accordingly.

The Open Access (OA) model, supported by the APC Fund, primarily targets life and basic science research. Full OA journals typically have an average APC of under \$2000, while hybrid OA articles have an average APC of approximately \$3000, making them more expensive than full OA journals. Regional journals with very low APCs are often not preferred by researchers [12]. Data from the paper suggests that biochemistry, genetics, and molecular biology disciplines have higher average APCs than other fields due to their classification as basic sciences. Further research is needed to explore the differences between the APCs of full OA journals and hybrid OA articles. Multilevel modeling has shown that higher APCs are associated with increased article volumes for the four largest APC-funded commercial OA

publishers from 2012 to 2018 [5]. This indicates that APC prices are not limited by market competition or author choice. Future studies should examine the relationship between APC prices and the number of articles published.

OA publishers employ various business models, such as relying on grants to fund APCs or institutions purchasing institutional memberships with OA publishers, which can result in discounted APCs for authors. However, many students and junior faculty do not have access to these options, creating a problem. Newer business models such as the “Author Membership” model by PeerJ, which offers lower fees than traditional APCs, and consortial membership within a discipline, may be worth considering [13]. Nevertheless, these approaches may not offer the best solutions to address the issue of high APC costs.

The journals of developing countries charged the lowest APC and the journals with high impact factors from major international publishers charged the highest APC. This can be attributed to various factors, such as the availability of funding and resources in different regions [14]. This is because professional associations can rely on member fees to support their publishing activities, while universities may subsidize university presses. On the other hand, commercial publishers typically do not receive subsidies and therefore have higher APCs [15]. Based on the data analyzed in this paper, it seems that the findings are consistent with the view that journals from developing countries and those published by societies or universities generally have lower APCs, while commercial publishers have higher APCs. It is important to consider these factors when making decisions about where to publish research and how to allocate limited resources for open access publishing.

Contrary to other scholars’ results, high APCs do not necessarily increase the impact of publications. There are two reasons. First, large publishers with high impact are relatively inexpensive. Second, publishers with the highest APCs could be better in terms of impact. From the results, APC is not necessarily determined by the impact [16]. Moreover, the use of metrics such as SNIP or citation rates may also have limitations in capturing the true impact of research. The reality also tells us that SCI or SSCI may only index articles with a few references. At last, this paper proposes an APC price model with reference to Asai’s research [7]. It is important to note that different regions and institutions may have different criteria for evaluating the quality of research output. In China, for example, libraries and scientific research institutions may not place as much emphasis on impact factors or citation rates. Instead, they may rely on other metrics such as the division of JCR from Thomson Reuters or the Chinese Academy of Sciences. The proposed APC price model may provide a useful framework for analyzing and predicting APC costs, but it is important to keep in mind that APCs alone may not fully capture the quality or impact of research. Other factors such as peer review processes, editorial policies, and community engagement can also play a role in determining the value of a publication.

For libraries, on one hand, some libraries and institutions may provide finan-

cial support to local authors to cover APCs. However, this approach can be costly and may only be able to support a limited number of articles. Alternatively, crowdfunding models have emerged as a way to distribute the cost of open access among multiple libraries, reducing the burden on individual institutions [17]. On the other hand, some concerns relying on APC-funded open access can contradict the traditional values of librarianship. Paying APCs for scholars using library budgets can divert resources from other essential library services and collections. Some argue that this practice may undermine the overall mission of academic libraries. There is a paradox in using library subscription budgets to fund APC-based open access. If authors are responsible for the economic decisions of where to publish, it could create a market-based approach to open access. This could potentially lead to price competition among publishers. The involvement of libraries in APC management has both advantages and disadvantages that require further investigation and study [18].

6. Conclusion

Open access has undoubtedly brought many benefits to the research community, including increased visibility, wider dissemination of knowledge, and potential for greater societal impact. It is crucial not to dismiss open access solely based on the cost of APCs. In this paper, the APCs of open access journals are extensively discussed, and the results still need to be more conclusive. Therefore, at the next stage, a quantitative study of APCs is necessary. Since there are still scholars who continue to investigate the APC prices of open access journals, the confidence in the future of open access remains robust.

Acknowledgments

This paper gets help from Dr. Xia Zongliang. He revises the paper and gives many reasonable suggestions, especially the arrangement of pictures in the article. Thank him very much.

Conflicts of Interest

The author declares no conflicts of interest.

References

- [1] Björk, B.C. and Solomon, D. (2015) Article Processing Charges in OA Journals: Relationship between Price and Quality. *Scientometrics*, **103**, 373-385. <https://doi.org/10.1007/s11192-015-1556-z>
- [2] Pinfield, S., Salter, J. and Bath, P.A. (2015) The “Total Cost of Publication” in a Hybrid Open-Access Environment: Institutional Approaches to Funding Journal Article-Processing Charges in Combination with Subscriptions. *Journal of the Association for Information Science and Technology*, **67**, 1751-1766. <https://doi.org/10.1002/asi.23446>
- [3] Pinfield, S. and Middleton, C. (2016) Researchers’ Adoption of an Institutional Central Fund for Open-Access Article-Processing Charges. *SAGE Open*, **6**, 1-18.

- <https://doi.org/10.1177/2158244015625447>
- [4] Cheng, W.H. and Ren, S.L. (2017) Investigation on Article Processing Charges for OA Papers in Foreign Countries. *Acta Editologica*, **29**, 192-195.
- [5] Khoo, S.Y. (2019) Article Processing Charge Hyperinflation and Price Insensitivity: An Open Access Sequel to the Serials Crisis. *LIBER Quarterly*, **29**, 1-18.
<https://doi.org/10.18352/lq.10280>
- [6] Asai, S. (2019) Changes in Revenue Structure of a Leading Open Access Journal Publisher: The Case of BMC. *Scientometrics*, **121**, 53-63.
<https://doi.org/10.1007/s11192-019-03200-1>
- [7] Asai, S. (2020) Market Power of Publishers in Setting Article Processing Charges for Open Access Journals. *Scientometrics*, **123**, 1037-1049.
<https://doi.org/10.1007/s11192-020-03402-y>
- [8] Asai, S. (2019) Determinants of Revisions to Article Processing Charges for BMC Journals. *Publishing Research Quarterly*, **36**, 63-73.
<https://doi.org/10.1007/s12109-019-09677-1>
- [9] Yuan, X., Wang, Q., Jiang, M., Liu, Y. and Yang, X. (2020) Investigating the Article Processing Charge of Journals in the Gold Open Access Market: A Game Theory Approach. *Proceedings of the Association for Information Science and Technology*, **57**, e217. <https://doi.org/10.1002/pra2.217>
- [10] Zhang, L., Wei, Y., Huang, Y. and Sivertsen, G. (2022) Should Open Access Lead to Closed Research? The Trends towards Paying to Perform Research. *Scientometrics*, **127**, 7653-7679. <https://doi.org/10.1007/s11192-022-04407-5>
- [11] Vrana, R. (2016) Is Open Access Still Open: The Case of Article Processing Charge. *Central European Conference on Information & Intelligent Systems*, Varaždin, 21-23 September 2016, 177-184.
- [12] Solomon, D.J. and Björk, B. (2012) A Study of Open Access Journals Using Article Processing Charges. *Journal of the American Society for Information Science and Technology*, **63**, 1485-1495. <https://doi.org/10.1002/asi.22673>
- [13] Fruin, C. and Rascoe, F. (2014) Funding Open Access Journal Publishing: Article Processing Charges. *College & Research Libraries News*, **75**, 240-243.
<https://doi.org/10.5860/crln.75.5.9120>
- [14] Solomon, D. and Björk, B. (2016) Article Processing Charges for Open Access Publication—The Situation for Research Intensive Universities in the USA and Canada. *PeerJ*, **4**, e2264. <https://doi.org/10.7717/peerj.2264>
- [15] Asai, S. (2018) Determinants of Library Subscription Prices of Economic Journals. *International Journal of Economics, Finance and Management Sciences*, **6**, 1-5.
<https://doi.org/10.11648/j.ijefm.20180601.11>
- [16] Maddi, A. and Sapinho, D. (2022) Article Processing Charges, Altmetrics and Citation Impact: Is There an Economic Rationale? *Scientometrics*, **127**, 7351-7368.
<https://doi.org/10.1007/s11192-022-04284-y>
- [17] Reinsfelder, T.L. and Pike, C.A. (2018) Using Library Funds to Support Open Access Publishing through Crowdfunding: Going Beyond Article Processing Charges. *Collection Management*, **43**, 138-149.
<https://doi.org/10.1080/01462679.2017.1415826>
- [18] Scott, A.M. (2018) Article Processing Charges Threaten Academic Libraries: A Librarian's Opinion. *Journal of Scholarly Publishing*, **49**, 260-266.
<https://doi.org/10.3138/jsp.49.2.260>