

The World's Approach toward Publishing in Springer and Elsevier's APC-Funded Open Access Journals

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Purpose: The present study explored tendencies of the world's countries—at individual and scientific development levels—toward publishing in APC-funded open access journals.

Design/Methodology/Approach: Using a bibliometric method, it studied OA and NOA articles issued in Springer and Elsevier's APC journals during 2007–2011. The data were gathered using a wide number of sources including Sherpa/Romeo, Springer Author-mapper, Science Direct, Google, and journals' websites.

Findings: The Netherlands, Norway, and Poland ranked highest in terms of their OA shares. This can be attributed to the financial resources allocated to publication in general, and publishing in OA journals in particular, by the countries. All developed countries and a large number of scientifically lagging and developing nations were found to publish OA articles in the APC journals. The OA papers have been exponentially growing across all the countries' scientific groups annually. Although the advanced nations published the lion's share of the OA-APC papers and exhibited the highest growth, the underdeveloped groups have been displaying high OA growth rates.

Practical Implications: Given the reliance of the APC model on authors' affluence and motivation, its affordability and sustainability have been challenged. This communication helps understand how countries at different scientific development and thus wealth levels contribute to the model.

Originality/Value: This is the first study conducted at macro level clarifying countries' contribution to the APC model—at individual and scientific-development levels—as the ultimate result of the interaction between authors' willingness, the model affordability, and publishers and funding agencies' support.

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Introduction

The Open Access reform movement emerged to pave the way to optimize public access to information and eliminate commercial publishers' monopoly over the flow of information.¹ Following the resistance of commercial publishers as one of the most powerful interest groups in the scientific publication sphere certain boycotts were imposed by the proponents of the movement,² including librarians who have been advocating for open access as a remedy for inequality in access to scientific information.

Long before the outbreak of the protests, the commercial publishers had offered Author-Pays model in response to their demands. In this model, the author would pay article processing charges (APC) set by the publisher, facilitating public access to her paper.³ Springer and Elsevier are among the most prestigious commercial publishers, who have embraced this model since 2004 and 2006, respectively.⁴ In Gold OA journals, authors are required to pay the APC, while in the hybrid ones they choose to pay for the open accessibility of their papers. According to the statistics published by Sherpa-Romeo database and based on Björk's findings,⁵ these two houses are now publishing the lion share of hybrid journals (1,360 and 1,160 titles respectively, accounting for 31.04 and 26.5 percent of total journals studied by Björk).⁶

As the publishers' tendency to implement this model increases, there will be a growth in those of the authors and researchers. This is reflected in the growth of publication rates in hybrid open access journals,⁷ particularly for publishing high-quality works.⁸ However, the number of OA papers published in the journals remains small compared to their total number of papers,⁹ and adoption rates vary strongly across different disciplines.¹⁰

Since the APC model does not confront journals with funding difficulties and financial complexities, it might enjoy more stability and a higher chance of survival.¹¹ However, the model involves a heavy financial burden on the author who is likely to run into major difficulties while paying for publication in any journal.¹² For instance, she has to pay \$3,000 and \$500–\$5,000 for each paper to be published in Elsevier and Springer journals, respectively.

Authors' willingness to support OA is among the most critical factors of its success. Furthermore, financial problems pose a formidable obstacle to open access and are among the major concerns of authors.¹³ Consequently, the model's success depends on the authors' will, motivation, and financial support.¹⁴ Besides, the model is seen to increase the science gaps between haves and have-nots, by discriminating against authors from developing countries, underfunded disciplines, independent and unfunded researchers, and young and unknown scientists.¹⁵ Thus, one may wonder if a widespread and balanced approach toward this model is formed throughout the world, particularly by scientists from less developed countries or those working in low-income fields. Furthermore, authors may lack any incentive to adopt this model due to their inadequate knowledge on the advantages of the model or lack of motivation. Therefore, they avoid taking an extra step in the publication process. This gives rise to the question whether the prevalence of the APC model would result in making information more widely accessible to scholars-as-readers, while narrowing the publishing opportunities available to scholars-as-authors? This article attempts to answer the question.

Scientists' approach to the model has not comprehensively been studied on a global scale. Conducting such a comprehensive study of the world's scientific communities' approach toward publishing papers in hybrid OA journals is, therefore, prerequisite to evaluate the model's success or failure in attracting authors. Thus, the present study attempts to investigate the status of OA and non-OA papers published in Elsevier and Springer's APC-funded journals (APCJ) as two leading publishers of hybrid OA

journals¹⁶ to explore the world's approach to paying for open accessibility of their research outputs. To do so, it applied a bibliometric method to study a purposeful sample consisting of the papers published in Springer and Elsevier's APC-funded OA journals between 2007 and 2011.

The model's affordability varies for researchers from different countries with different economic and scientific development levels. We therefore endeavored to study the OA status at macro aggregation levels including countries and nation scientific-development groups. To gain insight into the countries' affluence, we used an index developed by RAND Group¹⁷ to characterize nations' S&T investment and capacity. The RAND classification groups countries into four categories including: "22 Scientifically advanced countries" (with a scientific capacity well above the international mean); "24 Scientifically proficient countries" (with a positive standing in scientific capacity when compared to the rest of the world); "23 Scientifically developing countries" (with some features of scientific capacity, and a positive trend in spending but a scientific capacity below the international mean); and finally "81 Scientifically lagging nations" (with little data indicating scientific capacity).

Purpose

Performing a macro-level analysis, the present study attempts to investigate the status of OA and non-OA papers published in Elsevier and Springer's APC-funded journals (APCJ) as two leading publishers of hybrid OA journals¹⁸ to explore OA contributions of universities, countries—individually or in scientific development groups—and their growth models.

Methodology

The study was conducted using a bibliometric method based on a publication analysis approach. The purposeful sample consisted of the papers published in the OA journals of Elsevier and Springer from 2007 to 2011, identified by,¹⁹ analyzed at first, last, and corresponding author levels separately.

As described earlier in the paper, the two publishers are the highest ones in terms of the number of hybrid journals published. They are also among the pioneers in proposing and adopting the model since 2004 and 2006, respectively. The time span of the study begins, therefore, with 2007 to ensure at least one year of familiarity of authors with the model. However, the verification of the journals having adopted the APC model showed that many of them failed to attract any OA papers since 2007. Consequently, to avoid any inconsistency in the sample, we eliminated from the study those journals that had not applied this model throughout the mentioned time period or had failed to realize at least one OA-APC paper in 2007.

APCJ Identification: Through searching in Sherpa/Romeo, Springer Author-mapper and Science Direct in late 2012 and early 2013, 576 OA-APC journals published by Springer and 47 ones published by Elsevier from 2007 to 2011 were selected. In this way, the final purposeful sample included 623 APC journals copublished by Springer and Elsevier. It should be mentioned that the journal collection mostly consisted of those proposing the hybrid model; just 6 Gold APCJ were found in the collection, accounting for less than 1 percent of the total journals and less than 10 percent of the OA papers identified.

The emphasis on the hybrid model is due to the fact that, unlike the Gold model, it does not oblige authors to pay for publishing their papers. This may affect authors' willingness to pay for open accessibility of their papers, especially given the high price of the model and its unaffordability for low-income individuals, organizations, and disciplines.

OA Papers Identification: After searching Springer and Scopus databases, all the papers published in the APCJ between 2007 and 2011 were identified and downloaded. In the next stage, OA papers were separated from non-OA ones using “open access” label. To check the correctness of the identification, the researchers tried to test the open accessibility of all the papers by downloading their full-text versions via an off-campus IP. The websites of all the identified OA journals were also consulted to ensure the announcement of the “author-pays” model. To avoid other OA models including self-archived Green papers and delayed OA, the URL of the OA papers were also checked.²⁰

Identifying Countries and Organizational Affiliations: The contributing countries and universities were identified through the author address fields. Given the multiauthorship phenomenon and the fact that the APC does not seem to be prorated among the authors, the researchers should have found the author responsible for paying the APC. As far as our review of the literature and verification of the documents issued by the publishers showed, there were no notifications clarifying the author in charge of payment. Some documents had just mentioned that the corresponding author has to arrange for paying, but not necessarily at the expense of her own.²¹ Phil Davis,²² citing from Klimley’s speech, expressed that it is not obvious which of the contributors of multiauthored papers pays for the APC. As a result, the researchers limited the study to the first and last authors, assuming that: 1) in many disciplines, the main author or senior researcher is named first or last in author byline or as corresponding author, and s/he has the main responsibility of the contribution;²³ 2) the institutions to which the main authors are affiliated accept responsibility for payment of the APC. Although the corresponding author is most likely to appear first and then last in the author bylines,²⁴ we also repeated the analyses at corresponding-author level to overcome the complexity of determining authors responsible for paying APC based on the method applied.²⁵ As the results were approximately similar for the analyses carried out on the three author groups, the researchers report just the results obtained for the first authors. The results of the analyses on the last and corresponding authors are summarized in the appendices.

Numerous educational and research institutions with various inconsistently recorded names contribute to the journals. It was therefore extremely difficult (if not impossible) to standardize their names. Consequently, the study was limited to universities excluding other kinds of educational and research institutions. To facilitate the identification of the contributing universities, the researchers first sifted and picked out the records where the stem of the word university (that is, “univ”), commonly used in English and romance languages, occurred in their “organizational affiliation.” Then they manually verified the remaining list to find and identify the universities lacking the term in their names as accurately as possible.

The results showed that, out of the 18,654 OA papers, 12,777 (68.5%) had been published by universities. About the same percentage was observed for the non-OA group, where, of the 378,106 non-OA papers, 255,271 (67.52%) were found to be authored by universities. It thus becomes apparent that a large percentage of the OA papers can be studied in terms of the status of their contributing organizations.

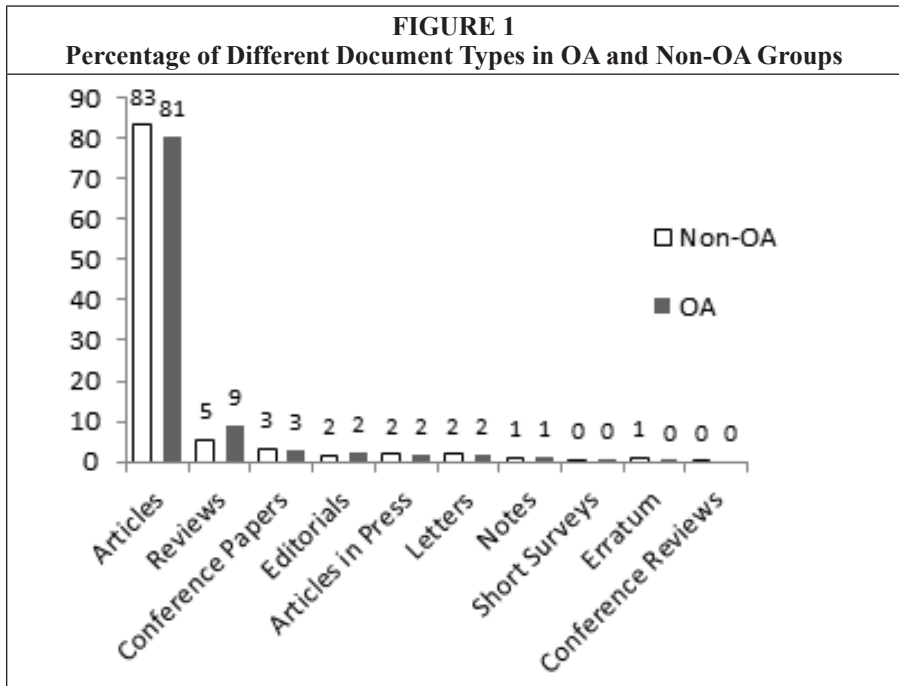
Findings

Descriptive Findings

According to the results obtained from examining the articles, the two publishers had published a total of 18,654 APC-OA papers, which is about 4.7 percent of the total number of their published papers in the APCJ (396,760). Of these, 17,672 titles belonged to Springer (94.73% of the total number of the OA papers), and 982 titles (5.27% of the total number of the OA papers) belonged to Elsevier. Thus, it seems that, compared

to Elsevier, Springer has absorbed a larger uptake of the OA papers. To control for the impact of the two databases' difference in their coverage, the percentage of the OA papers was calculated based on the total number of their journals indexed. The results showed that 5.77 percent of the total number of the papers was published by Springer, and 1.1 percent of the total number of papers was published by Elsevier. It indicates the former's superiority in publishing OA papers.

The analysis of the "document type" field shows that the papers had been presented in ten different document types, including conference papers, articles, articles in press, conference reviews, editorials, errata, letters, short surveys, reviews, and notes. As figure 1 shows, research papers are the most common document type in both OA and non-OA groups. The number of the non-OA research papers is a bit larger compared to that of the OA papers. The percentages of the other types of documents have been found to be identical in both groups and accounted for smaller share compared to those of research papers.



Universities' Contribution to the APCJ

An examination of the contributing universities showed that 1,429 universities (24.36% of all the universities contributing to the APCJ) have authored at least one OA paper, while 4,437 (75.64%) of the universities had no OA contribution. On average, each of the contributing universities had accounted for 2.18 percent of the OA and 43.62 percent of the non-OA papers.

The OA Contributing Universities

The results presented in table 1 show the universities with the highest number of OA contributions. The universities' OA uptakes would be a function of their total pro-

ductivity. As a result, the table ranks them based on their numbers of the OA papers normalized by their total share in the journals, to get a more realistic image.

As seen, if one takes into consideration the percentage of OA papers normalized by the total number of papers published by each university in the same journals, Delft University of Technology of the Netherlands (71.34%) will rank first in terms of its share of OA papers (see table 1), followed by Wageningen University (59.28%) and University of Amsterdam (56.94%). Vu University Medical Center, University of Groningen, University of Utrecht, University of Goettingen, Radboud University Nijmegen, Maastricht University, and Leiden University occupied the next positions in this ranking. The Universities of California, with the highest contribution in terms of its absolute number of OA publications (1,310), ranked the lowest among the contributing universities (with OA papers accounting for 24.09% of its total publications in the journals; see table 1).

Countries' Contribution to the APCJ

Of 189 countries and territories contributing to the APCJ—EU, World Bank, and United Nations (with 10 contributions) being excepted—110 countries (58.20%) had authored at least one OA paper, while the remaining 79 countries (41.80%) had no OA contribution. The Netherlands (with 5,321 titles) and the United States (with 89,078 titles) ranked first in terms of the number of OA and non-OA publications, respectively. The average contribution per country was 27.102 for the OA and 2,061.09 for the non-OA papers. Furthermore, the median value of the countries' contribution in publishing OA papers showed a value of 1, indicating that half of the contributing countries had published only one OA paper. However, according to the median value associated with non-OA papers, 50 percent of the contributing countries had contributed 43 non-OA papers.

TABLE 1
The Highest Ranking Universities in Terms of the Number of Published OA Paper

Rank	University	Country	No. of OA Papers	Normalized OA Share
1	Delft University of Technology	NL	239	71.34
2	Wageningen University	NL	278	59.28
3	University of Amsterdam	NL	394	56.94
4	Vu University Medical Center	NL	372	56.36
5	University of Groningen	NL	250	54.82
6	University of Utrecht	NL	301	51.81
7	University of Goettingen	DE	366	48.87
8	Radboud University Nijmegen	NL	382	47.04
9	Maastricht University	NL	265	46.90
10	Leiden University	NL	389	46.70
11	California Universities*	USA	1,310	24.09

*with UC, Santa Cruz= 30; UC, Santa Barbara= 29.94; UC, Davis= 28.33; UC, Riverside= 28.17; UC, San Francisco= 27.99; UC, Los Angeles= 25.16; UC, Berkeley= 24.33; UC, Irvine= 23.88; UC, San Diego= 22.06; UC, Merced=21.43 having the highest percent of OA share (normalized) among the California universities

TABLE 2
Countries' Contributions to the APCJ across Scientific Blocks

Wagner's Scientific Development Level for Countries		Total in the APCJ			OA Model in the APCJ			Mean OA Share (%)	OA Mean Rank
		Countries		No. of Total Papers	Countries		No. of Papers		
		N	%		N	%			
Scientifically	Advanced	22	11.58	285,945	22	19.82	15,786	5.5	97.95
	Proficient	24	12.63	80,380	24	21.62	2,167	2.65	78.42
	Developing	23	12.11	18,047	16	14.41	347	2.58	64.80
	Lagging	76	40.00	6,147	41	36.94	193	3.58	66.55
	NA	45	23.68	6,241	8	7.21	161	2.44	—
Total Sum		190	100	396,760	111	100	18,654	3.29	—

Table 2 indicates the status of the contributing countries in terms of their scientific development level. Based on RAND classification, the countries have been divided into four groups of scientifically advanced, proficient, developing, and lagging.²⁶ As seen in table 2, all countries in the advanced and proficient groups have been revealed to contribute to the OA-APC papers. More than half of the developing nations are found among the OA-APC contributors (69.56% of the total 23 members). The lagging countries group is the least frequent in terms of the percentage of its members contributing to the OA-APC model (39 accounting for 48.15% of the 81 countries in the group), though the most frequent regarding the absolute number of the OA-APC contributing countries. The low number of the contributors could not be attributed to a probable inactivity of the rest, because 35 lagging nations (accounting for 43.21% of the 81 countries in the group) were found to have a total of 432 non-OA contributions in the journals.

The share of the OA-APC papers was also taken into consideration for each developmental group. As seen in table 2, the highest mean share of the OA-APC papers belongs to the lagging class, followed by the advanced class (5.65 and 5.52, respectively). The developing group ranked the next by getting 3.72 percent of its total papers in the APCJ published as OA. The proficient group seems to have the least OA share in the APCJ.

To statistically compare the OA share of the countries in the RAND classification, Kruskal-Wallis test was conducted across the countries in different groups, given the non-normality of the data distribution. According to the result yielded, the countries OA uptakes in the RAND scientific groups seem to significantly differ (Chi Square = 11.11, Sig. = 0.011, df = 3). As seen in table 2, the developed class is found to have the highest share of the OA papers normalized by their total papers in the APCJ. The proficient group occupies the next rank. The developing and lagging groups, seemingly having equal shares, rank the lowest compared to the two other groups.

Table 3 shows the status of those countries with the highest OA-APC contribution. Here again, given the dependence of OA contribution on the total scientific productivity, the countries are ranked in terms of both the absolute frequency of their OA papers and their normalized OA shares (that is, the country's percentage of OA papers in its total number of scientific publications in the APCJ)®.

As seen in table 3, the Netherlands has had the highest contribution rate, by publishing 5,321 OA papers, followed by the United States, Germany, the United Kingdom, China, Japan, Poland, Italy, Spain, France, and Norway, respectively.

TABLE 3
The Highest Ranking Countries in Terms of Their OA Uptakes

Rank	Ranking in Terms of Absolute OA Uptake				Rank	Ranking in Terms of the Normalized OA Share			
	Nation	Total Number of Papers	Number of OA Papers	Percent in Total OA		Nation	Total Number of Papers	Number of OA Papers	OA Share
1	Netherlands	11,009	5,321	48.33	1	Honduras	2	1	50
2	United States	92,914	3,836	4.13	2	Netherlands	11,009	5,321	48.33
3	Germany	29,123	1,850	6.35	3	Guam	5	1	20
4	UK	23,202	1,403	6.05	4	Swaziland	6	1	16.67
5	China	29,414	753	2.56	5	Nicaragua	7	1	14.29
6	Japan	23,558	519	2.2	6	Poland	3,542	501	14.14
7	Poland	3,542	501	14.14	7	Armenia	83	11	13.25
8	Italy	15,967	383	2.4	8	Kenya	158	19	12.03
9	France	14,644	302	2.06	9	Norway	2,546	275	10.8
10	Norway	2,546	275	10.8	10	Cyprus	131	14	10.69

Results obtained from estimating the OA share for each country show that Honduras (50%) ranks first in terms of the percentage of its OA papers to its total number of scientific publications in the studied journals, followed by the Netherlands, Guam, Swaziland, Nicaragua, Poland, Armenia, Kenya, Norway, and Cyprus, respectively.

However, as shown in table 3, the high ranks of countries such as Honduras, Guam, Swaziland, and Nicaragua is due to the small number of their total scientific publications. For example, the total number of scientific publications by Honduran authors in the APCJ is only 2 papers, one of which was published as OA.

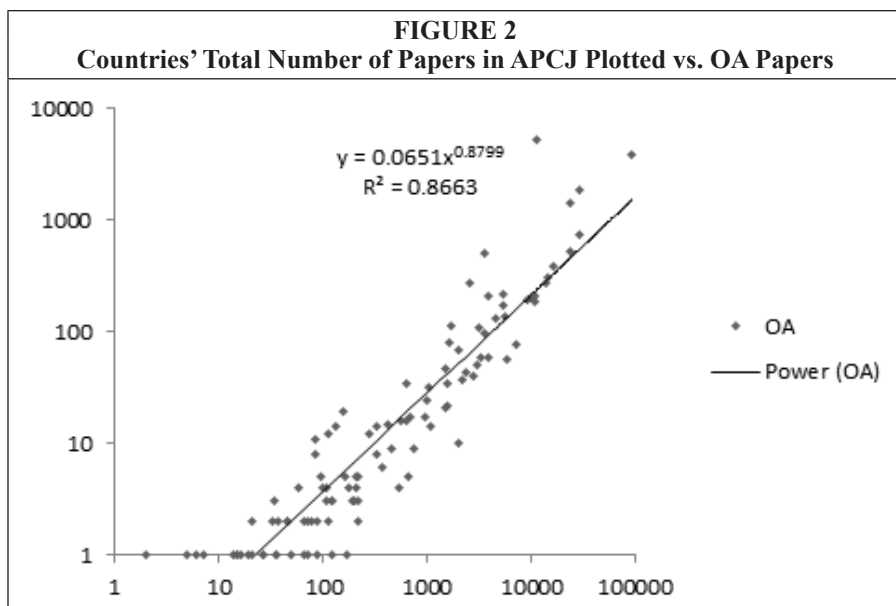
The Correlation between OA and Total Number of Papers across Countries

To investigate the relationship between the number of OA publications and total scientific outputs in the APCJ across the 107 OA contributing countries, Pearson’s correlation test was used. The findings showed a significant and direct correlation between the number of OA papers and the total number of papers across countries ($r = 0.68, P < 0.0001, N = 107$).

Regression analysis used to describe the model of the relationship confirmed a power correlation to best fit the distribution of the two variables (see figure 2). Based on the adjusted R square yielded ($R^2 = 0.87$), the power model can predict 87 percent of the variations in countries’ OA contributions in terms of their total number of papers in the APCJ. According to the exponent of the equation ($n = 0.88$), if the scientific output of a country is twice as large as that of another country, the magnitude of its OA papers will be expected to be $2^{0.88} = 1.84$ times larger. In other words, the OA shares increase as the scientific outputs increase across countries, though at a smaller rate.

The OA Annual Growth Model in Different Country Scientific Levels

The growth of scientific papers adheres to a size-independent model. Scale-independent measures derived from the scaling properties of a complex system are naturally normal-



ized, making them comparable across entities of vastly different sizes.²⁷ Since the size of the papers—whether OA or in general—vary strongly among the RAND country classes, the exponential and power regression models, which are scale-independent, seem to be the best way to compare the annual growth rate of the papers within and between OA and non-OA models. To explore the annual growth model of the OA papers in the APCJ, the researchers first carried out regression analyses. The results showed that the OA papers have been annually increasing on an exponential basis in each of the RAND groups. The results are summarized in table 4 and figure 3.

As seen, all of the RAND nation groups have been exhibiting a significant annual growth in their OA papers. According to the unstandardized coefficients (B values) yielded, the advanced group has witnessed an annual growth of about 18 percent in its OA-APC papers, while each of the three other scientific groups have exhibited about 40 percent increase in their OA uptakes.

To understand the result, it is necessary to look at the annual growth model of the groups' total papers in the APCJ, illustrated in table 4. As shown, unlike other RAND

TABLE 4
The Annual Growth of OA and Total Papers in APCJ in Scientific Blocks

Scientific Block	OA					TOTAL				
	ANOVA			Coefficients		ANOVA			Coefficients	
	R2	F	Sig.	B	Std. Error	R2	F	Sig.	B	Std. Error
Advanced	0.94	50.16	0.006	0.18	0.03	0.68	6.47	0.084	—	—
Proficient	0.98	131.16	0.001	0.43	0.04	0.72	7.70	0.001	0.11	0.008
Developing	0.88	23.08	0.02	0.41	0.09	0.98	128.48	0.001	0.12	0.011
Lagging	0.86	19.21	0.02	0.42	0.10	0.92	32.70	0.011	0.34	0.060
NA	0.36	1.67	0.29	—	—	0.98	186.05	0.069	—	—

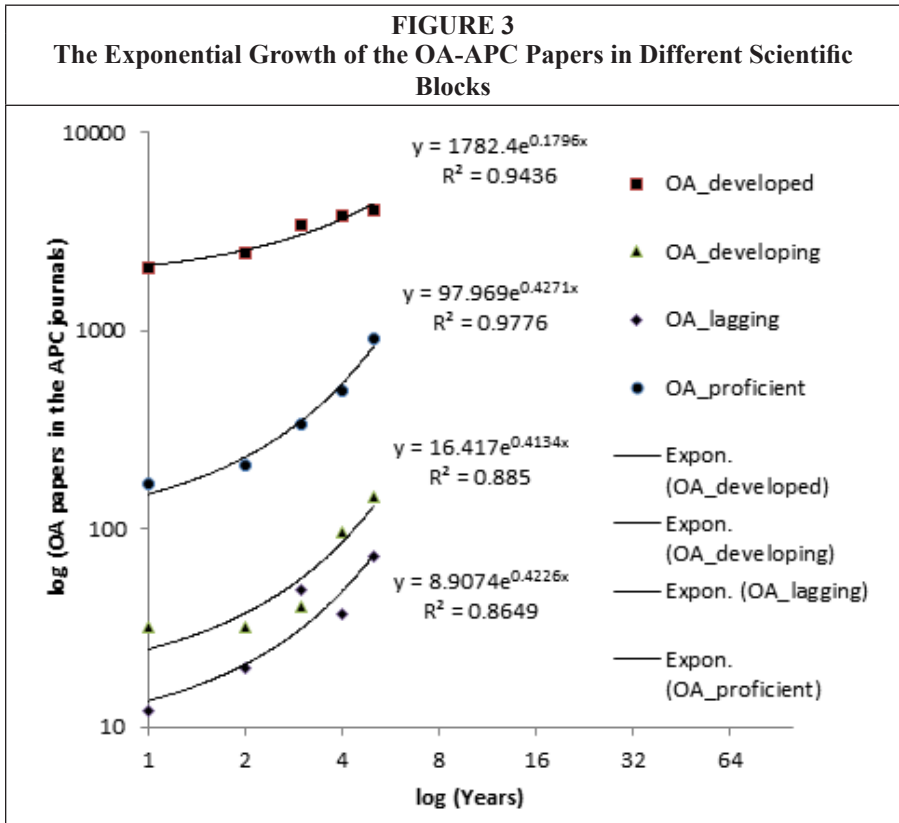
groups, the scientifically advanced group shows no significant annual growth in its total papers published in the journals ($F = 6.47$, $\text{Sig.} = 0.08$ for first authors analysis and $F = 1.26$, $\text{Sig.} = 0.34$ for corresponding authors analysis). It would not be far from expectation, as the group seems to have exploited almost all its scientific potentials, and hence matured in its scientific productivity. The increase in its annual scholarly outputs is not, therefore, statistically significant.

However, based on the unstandardized coefficients, the three other groups' OA contributions are found to have been annually growing, with the lagging group enjoying the highest rate, compared to the scientifically developing and proficient nations ($B = 0.34$ vs. $B = 0.12$, $B = 0.11$ respectively; see table 4).

As mentioned, the total number of the advanced group's papers in the APCJ is revealed to be stable, with no significant growth throughout the years. Consequently, the result of the regression for OA papers shows that the group has been increasing its OA share each year by a factor of 18 percent. However, the same could not be concluded for the underdeveloped groups. That is, the OA annual growth rate (40% a year for each group) cannot be interpreted as a sign of their pure inclination to the OA-APC model. Since their total outputs in the APCJ are found to be annually growing, the increase observed in their OA uptake may be affected by their total growth rate. Consequently, it is necessary to control for the effect of the science systems' overall growths.

Predicting OA Annual Growth Based on the Total Number of Papers in the APCJ

To control for the effect of the groups' total scientific productivity, the researchers tried

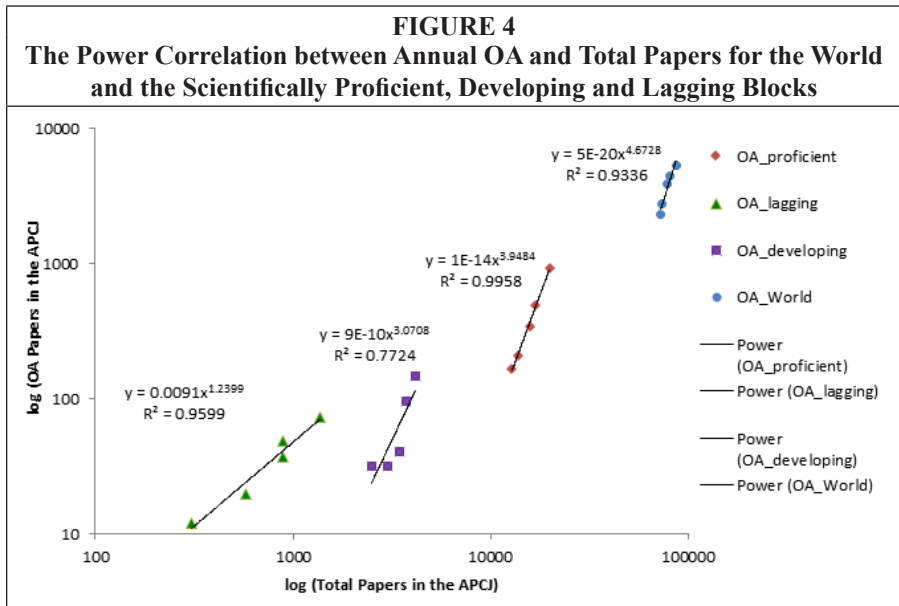


to explore the annual changes in their OA uptake by plotting the total number of the papers they published annually in the APCJ versus their OA papers in the same journals.

When two variables are correlated with a third one by an exponential regression model, they are to be correlated with each other by a power law model. As a result, the correlation between the groups' annual OA and total papers in the APCJ were analyzed using a power law model. The advanced nations were excluded due to their total insignificant growth trend.

The results are illustrated in table 5 and figure 4. As seen, the power correlation between annual OA and total papers in the APCJ are significant across the three groups and the world.

NO	Blocks	ANOVA					Coefficients	
		N	r	R ²	F	Sig.	B	Std. Error
1	Proficient	5	0.998	0.996	706.14	0.00	3.95	0.15
2	Developing	5	0.879	0.772	10.18	0.05	3.07	0.96
3	Lagging	5	0.980	0.960	71.73	0.00	1.24	0.15
4	World	5	0.966	0.934	42.17	0.01	4.67	0.72



As seen, the world has been observing an annual growth rate in the OA-APC papers relative to the total papers published in the APCJ. If the total number of papers published in the journals doubles in a given year, the share of OA-APC would increase by a factor of 24.67 = 25.46 compared to that of the previous year. Among the three scientifically underdeveloped groups, the proficient nations exhibit the highest annual

changes in their OA papers relative to their total papers published in the APCJ ($B = 3.95$). That is, if they double their total number of papers in the APCJ in a given year, they would be expected to produce $2^{3.95} = 15.44$ times as many OA papers as those of the previous year. The annual changes of OA to total papers are smaller in the developing class—that is, ($2^{3.07} = 8.4$)—and reach its least value for the lagging nations ($2^{1.24} = 2.36$) (see table 5 and figure 4). To ensure that the models are comparable between the groups, the r values were transformed to Z values, and then the observed Z values were calculated based on the equation:²⁸

The results are as follows:

$$\begin{aligned} Z_{\text{observed}} \text{ for } z_{\text{proficient}} \text{ and } z_{\text{developing}} &= 1.62; \\ Z_{\text{observed}} \text{ for } z_{\text{proficient}} \text{ and } z_{\text{lagging}} &= 0.70; \\ Z_{\text{observed}} \text{ for } z_{\text{proficient}} \text{ and } z_{\text{the world}} &= 0.98; \\ Z_{\text{observed}} \text{ for } z_{\text{developing}} \text{ and } z_{\text{lagging}} &= -0.92; \\ Z_{\text{observed}} \text{ for } z_{\text{developing}} \text{ and } z_{\text{the world}} &= -0.64; \\ Z_{\text{observed}} \text{ for } z_{\text{lagging}} \text{ and } z_{\text{the world}} &= 0.28. \end{aligned}$$

The observed values of z , all ranging between -1.96 and $+1.96$, confirm insignificant differences between the strengths of the correlations yielded for the groups.

Here, one would observe a clearer picture for the OA contribution of the scientifically advanced group, when last authors' contributions are taken into the consideration (see appendix B, table 10). As mentioned before, the OA as well as the total share of the country scientific group in the APCJ were found to be exponentially growing across the years. The researchers could, therefore, plot their total papers vs. their OA papers to highlight the annual OA changes. As seen, the highest OA changes relative to the total papers published in APCJ belongs to the developed nation group. The exponent yielded for the class ($n = 7.61$) is roughly twice as large as those obtained for the proficient ($n = 3.85$), the developing ($n = 4.61$), and the lagging ($n = 3.63$) ones.

Discussion

Generally speaking, the results of the present study showed that the percentage of OA papers published in the APCJ is smaller than that of non-OA papers, so that the highest OA share did not exceed a minor portion of the total contributions in the journals (3.29%, see table 2). This is in line with Björk,²⁹ who had demonstrated that the ratio of OA papers published in hybrid OA journals has not been significant compared to that of non-OA papers. A quick examination of the types of documents showed that the percentage of different types of documents was almost equal in both OA and non-OA papers. The proportion of "research article" document type in the OA group was close to its percentage in the non-OA group. Research articles have scientific value and prestige, and most scientific output is presented in this form. Review papers, editorials, notes, and short reviews are also research-based in nature. This observation confirmed the fact that researchers pay to publish their original research outcomes in OA format. The finding demonstrates the scientific value of the OA-APC papers, thereby responding to the concerns regarding the quality and scientific reliability of such paid papers.³⁰ It also provides further evidence about the motivation of authors to pay for their articles.

Universities' Contribution in APCJ

According to our findings, of the 5,866 contributing universities, 1,429 universities (24.36%) had contributed to at least one OA-APC paper. On average, each university had contributed to 2.18 OA and 43.52 non-OA papers. The University of California, the University of Amsterdam, Leiden University, Radboud University, Nijmegen University, the Vu University's Medical Center, the University of Goettingen, the University of Utrecht,

Wageningen University, Maastricht University, the University of Groningen, and Delft University of Technology ranked highest in terms of the frequency of OA-APC papers.

Since the large volume of scientific output by such universities was likely to affect the frequency of their OA papers, the quantity of OA papers were normalized based on the total number of papers published in the same journals by the universities. The results showed that ten universities with the smallest scientific output and a total number of papers ranging between 1 and 2 papers had published all their papers in OA format (see table 1), thus placing themselves among the universities with the largest contribution. Since the advantage of such universities in publishing OA papers is explained by the small size of their scientific output, they were omitted from the ranking so that the results were not affected by their overall performance. According to the findings, among the OA-APC contributing universities, Delft University of Technology, Wageningen University, the University of Amsterdam, the Vu University's Medical Center, the University of Groningen, the University of Utrecht, the University of Goettingen, Radboud University, Nijmegen University, Maastricht University, Leiden University, and the University of California were the highest-ranking universities in terms of the normalized OA share (see table 1).

As seen, of these universities, nine were located in the Netherlands. Delft University of Technology, Wageningen University, the University of Amsterdam, and the University of Utrecht were supported by the Netherlands Organization for Scientific Research (NOW) in their efforts to publish OA papers, allocating funding resources to OA contributions. Furthermore, NOW has also signed agreements with Springer and BMC for publishing these universities' research outputs in OA format.³¹ As a result, the APC discounts or waivers for institutional subscriptions³² can partially account for the greater tendency toward publishing in the OA mode among the developed universities, including those in the Netherlands.

Countries' Contribution to APCJ

The results of the present study showed that, of the 181 contributing countries, 107 countries (59.11%) had contributed to the publication of OA papers. The development status of these 107 countries was examined using RAND classification of countries based on their scientific development. As shown by the results, all scientifically advanced and proficient countries had authored at least one OA-APC model. They were followed by the scientifically advanced group, of which 91.66 percent of the nations have contributed to the model. The percentage of scientifically lagging countries contributing to OA (48.75%) was also significant. Despite the fact that the percentage of OA-APC contributions of the lagging countries seemed to be smaller than that of other groups, their contribution level was still significant (see table 2). This fact indicates the wide geographical distribution of OA papers and global attention to their significance.

Later on, the frequency of OA papers was calculated separately for each country. According to the results, the Netherlands, the United States, the United Kingdom, China, Japan, Poland, Italy, France, and Norway ranked highest in terms of the frequency of OA papers. According to David King,³³ the United States has the largest number of scientific output, followed by the United Kingdom, Germany, and the Netherlands, respectively. Previous studies³⁴ have identified the United States, the United Kingdom, the Netherlands, and Germany as making the largest contribution to OA papers.

This finding may be accounted for by the large number of their scientific output. Therefore, the percentage of OA papers to the total number of papers was calculated separately for each country. According to the results, Honduras, the Netherlands, Guam, Swaziland, Nicaragua, Poland, Armenia, Kenya, Norway, and Cyprus ranked highest in terms of the percentage of OA papers to the total number of papers. However, given

the very small quantity of scientific output for countries such as Honduras, Guam, Swaziland, Nicaragua, Armenia, and Kenya, publishing one or two OA papers greatly improved their ranking in terms of the percentage of OA papers to the total number of papers (see table 3). However, the Netherlands, Poland, and Norway ranked highest in terms of both the percentage and the frequency of OA papers.

This finding supports Woutersen-Windhouwer's results³⁵ concerning the large percent of scientific output in the Netherlands published in OA format. However, the percentage calculated by him (25%) was significantly different from that obtained in the present study (48.33%). This difference is probably due to the difference between the statistical populations used in the two papers. The present study focused exclusively on the publications in two scientific databases, namely Springer and Elsevier, and on the first authors of these publications, while Woutersen-Windhouwer³⁶ extended the scope of his study to include the whole scientific output of the Netherlands. Furthermore, Poland has been among the leading countries in the open access movement. The Budapest conference, as one of the movement's most celebrated events, demonstrates this fact.³⁷

The highest number of the OA-APC papers came from the advanced nations, and the share of the underdeveloped groups tended to be comparatively lower. However, they all have been revealed to increasingly pay for publishing in the APCJ. The underdeveloped nations were exhibiting higher growth in terms of their papers annually published as OA in the APCJ compared to the advanced ones (see table 4 and figure 3). As the country scientific group differed in their total scientific productivity, the annual growth of the OA papers should have been interpreted in light of the total papers published by the nations in the APCJ. As the results obtained for the last-author analyses showed, the advanced group exhibited the highest annual OA changes relative to its total papers in the APCJ (see appendix B, table 10). Among the underdeveloped groups, the proficient class exhibited the highest annual OA share in its total papers published in the APCJ. It was followed by the developing and lagging groups, respectively, for the first-author analyses (see table 5, figure 4). However, the picture is slightly different for the last-author and corresponding-author analyses. The groups were revealed to have approximately the same annual OA changes, when last authors are analyzed (see appendix B, table 10) and the scientifically developing group shows the highest annual OA changes when the corresponding authors are taken into consideration (see appendix A, table 7). Accordingly, one may notice that paying for open accessibility does not depend on the scientific level of the countries, which seems to be directly dependent on the wealth of the nations. However, the quantity and the annual increase seem to be scientific-level-dependent characteristics.

The low level of OA publishing of the underdeveloped countries was not far from expectation, given the scarcity of research and publication funding and lack of wealthy sponsors, as opposed to those of the developed world, which have ready funds from grants or sponsors.³⁸ As Papin-Ramcharan and Dawe³⁹ stated, page charges certainly deter the less well-funded researcher from publishing in APC journals. Besides, APC is believed to have created a scholarly gap between those scholars who get the financial support and those who are either deprived of the financial support or get a very small amount that cannot meet their needs. Consequently, the not-yet-resolved issue of inequity for less-endowed authors, especially those from the third world, may imperil long-term sustainability of scientific publishing based on free and instant access on the cost of authors.⁴⁰ However, the OA share of the developed nations does not pass a minimum of their total publications in the APCJ. As a result, it seems that the critical mass required for the establishment of a model has not yet been reached in any of the RAND country groups.

Conclusion

The OA-APC model has been proposed by publishers with the aim of facing the financial challenges and risks in adopting the OA model. In this model, after a paper is accepted for publication, the author may choose to make the paper available to the public by selecting the OA option and paying the specified costs. Therefore, some researchers have expressed doubts concerning the success of such a model, particularly given its reliance on authors' financial status, motivation, and awareness. The results of the present study showed that many universities and countries across the world have contributed to the OA model. The increasing tendency toward the OA model attested to its sustainability. The OA-APC papers were often published in the form of research papers and reviews. The findings generally demonstrated the worldwide adoption of the APC-OA model. Unlike occasional concerns about its efficiency, this model has turned out to be increasingly attracting much attention in academic communities throughout the world.

Many nations (110, accounting for 58.20% of the total number of countries contributing to the journals) at different scientific development levels were found to have been increasingly contributing to the OA-APC papers. However, the model was revealed to be mainly indebted to the advanced ones not only in its quantity but also in its annual enlargement.

The difference observed among the scientifically developed and underdeveloped classes concerning their initial OA bulk as well as their growth trend implies that, although the latter are increasingly contributing to OA, their share would relatively decrease in time compared to their advantaged peers from developed countries. Especially significant is the fact that they have to publish their papers in low-tiered journals where they can afford the publication fees.⁴¹ Hence, the question is whether the APC model is here to bridge the gap between the first and the third worlds or to increase it and thereby further marginalize the role of the latter's already lost science.⁴²

Furthermore, given the high prices of the APC model, waivers and discounts have been granted to less-endowed authors, in particular those from the less-developed nations.⁴³ Consequently, the growing body of the OA papers published by the underdeveloped groups gives rise to another question: whether the very small number of the OA papers is due to the waivers and discounts. According to Jeffrey Beall,⁴⁴ most nonpredatory OA publishers grant fee waivers to scholars from lower-income countries (as long as they don't submit too many articles), but these waivers are generally not applied to many middle-income countries. On the word of Björk and Solomon,⁴⁵ although the percentage of waivers or discounts granted to authors cannot be strictly estimated, it is expected to be granted for only a small percentage of the articles published in OA journals that charge fees. Besides in the sample studied by Burchardt,⁴⁶ half of the publishers do not waive the APC at all. Only four publishers provide automatic support for researchers in poor countries. Due to the lack of transparency about the number of waiver applications, and the likelihood of changes in publisher policy without the public's awareness, the proportion of refusals is assumed to be high in areas with many poor scholars. Consequently, the number of waivers and discounts actually advocated to less privileged authors is low—even lower for the developing countries.

Accordingly, the waivers and discounts being low, limited, and rare, the cause of the OA growth among the nondeveloped nations should be, therefore, looked for in other factors. In addition to the strategies devised to augment the affordability of the APC model to low-income authors, this may have roots in other factors, including the motivation to support the OA movement, membership and subscription programs, the research funds and grants internationally devoted to authors from the third world, and their collaboration with wealthy researchers and organizations. Further studies are

required to determine the real impact of these factors, their interaction, and the extent to which they play role in OA inclination. However, Solomon and Björk found that a considerably higher number of peripheral authors (that is, those from less-developed and hence deprived nations, compared to their peers from the advanced regions) paid the APCs out of pocket, and just 3 percent benefited from the waivers.⁴⁷ Consequently, it seems that, among the above-mentioned sources, personal funds of the third-world researchers play an important role.

To increase their scientific productivity, universities—even in the low-income nations—devised policies to pay the APCs from their libraries' subscription budgets or universitywide funds or research grants. Another important point is that, in addition to the APC, other costs—whether tangible or intangible—are imposed to finalize the payment processes (such as extra efforts to get permissions to pay APC, as well as administrative and transaction costs).⁴⁸ As a result, it seems that an increasing part of academic libraries' budgets or research grants, all around the world, is being spent for publishing the research outputs, a large sum of money that could have been allocated to other important research purposes such as upgrading research instruments and lab equipment, library collections, or scientific expeditions. Therefore, the countries' growing OA contributions, facing economic shortcomings, would give rise to the problem of scalability and hence obscuring the future prospects of their OA contribution.

Besides the fact that the results imply that the danger of a “double dipping” phenomenon could spread worldwide, libraries in nondeveloped countries being doubly at risk due to their meager budgets, poor collections, and lack of organizational workflows to control for and manage the payments. Consequently, the model would likely to end up undermining the research and library infrastructures, especially in the periphery, if a remedy is not found to avoid its pitfalls.

Overall, the worldwide spread of the model highlights the need for a balanced, customized APC model fitting the conditions and requirements of researchers and libraries all over the world. The revised model might not preferably rely on discounts or waivers, given their unstable and thus unreliable nature in economic downturns.⁴⁹ It is, therefore, required to seek for all-inclusive, enduring, and dependable alternatives, which not only empower researchers to equitably contribute to the OA movement but also avoid imperiling research and library budgets. In addition to engagement in OA funding, education, outreach,⁵⁰ and advocacy,⁵¹ libraries can play an outstanding role in proposing new financial models or revising the existing ones. Some solutions already proposed are mainly concentrated on libraries' roles, experiences and expertise, such as consortial solutions⁵² with library leadership,⁵³ library publishing coalitions,⁵⁴ contractual agreements, and offsetting arrangements (unifying OA subscription and APC contracts).⁵⁵

Appendix A. Corresponding Author-level Analyses of OA Papers

FIGURE 5
Countries' Total Number of Papers in APCJ Plotted vs. Their OA Papers (for Corresponding Authors) (N = 106)

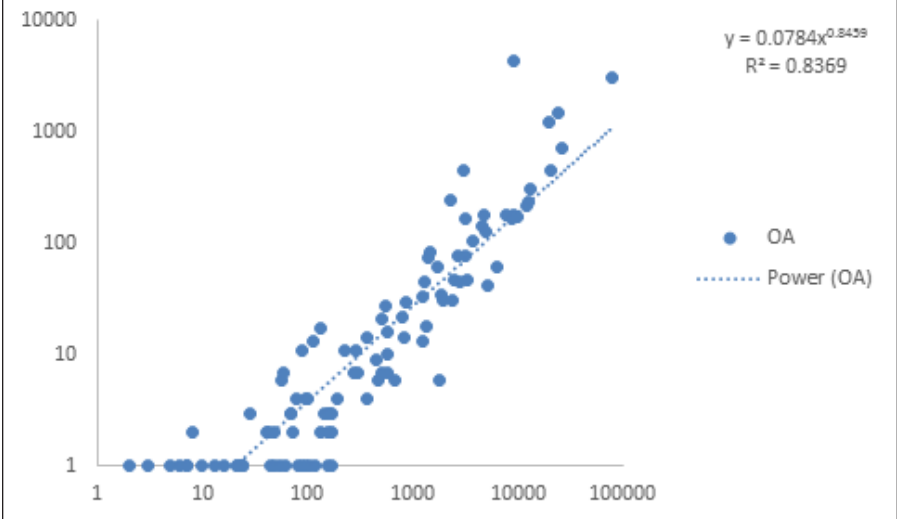
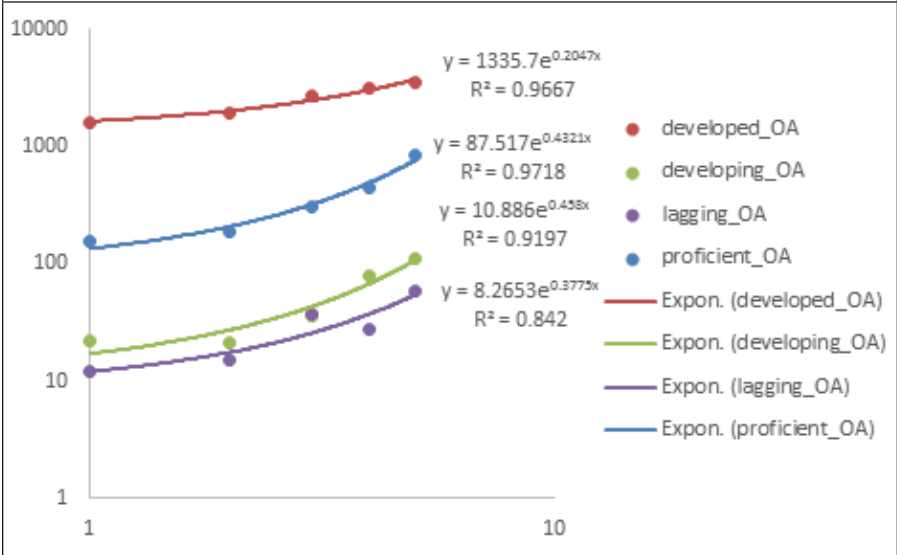
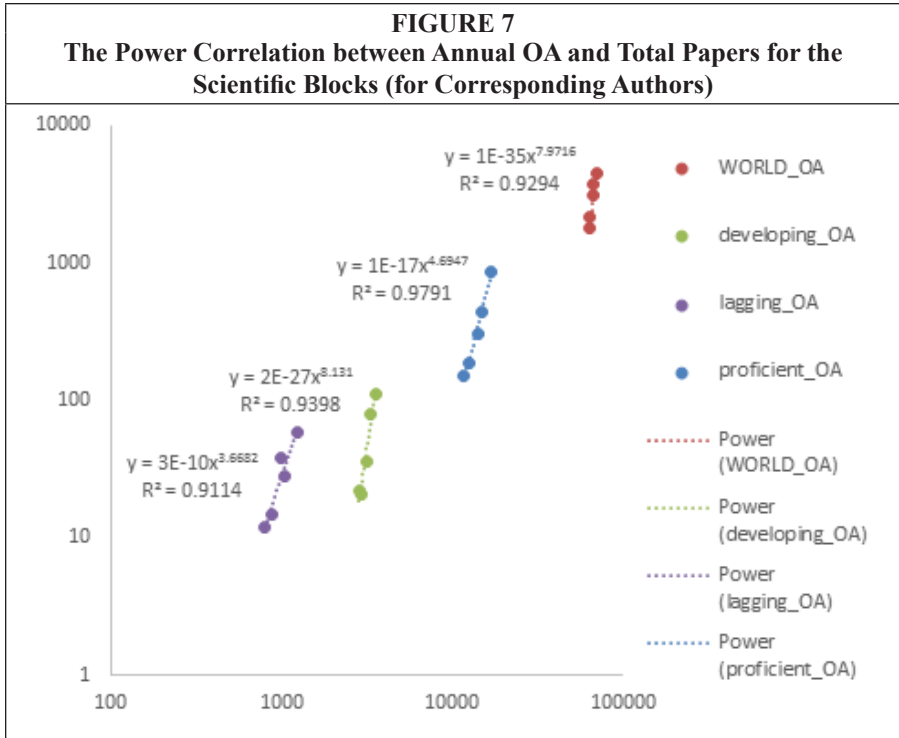


FIGURE 6
The Exponential Growth Of The OA-APC Papers for Different Scientific Blocks (for Corresponding Authors)





Appendix B. Last-Author-level Analyses of OA Papers

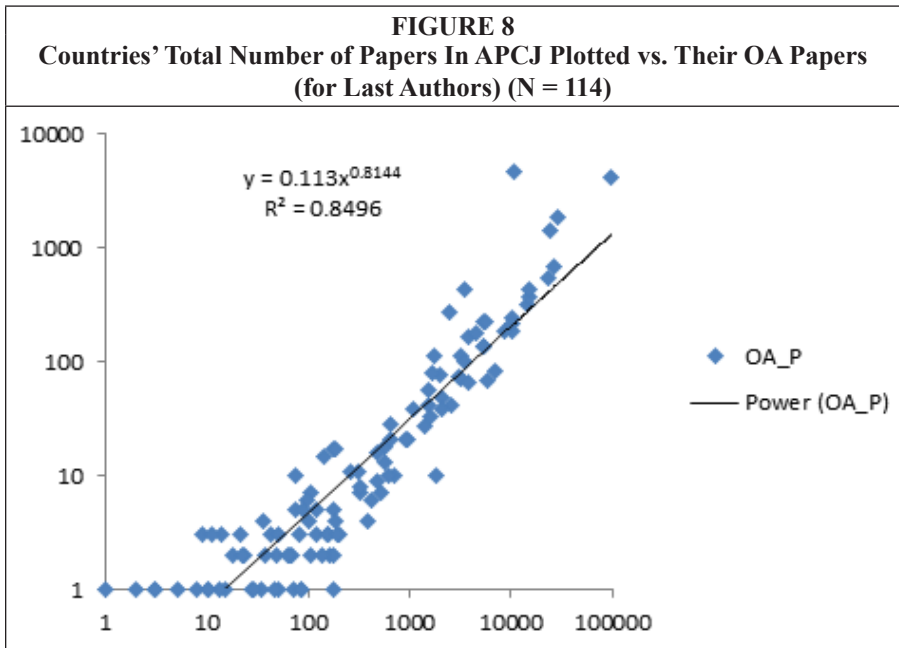


FIGURE 9
The Exponential Growth of the OA-APC Papers for Different Scientific Blocks (for Last Authors)

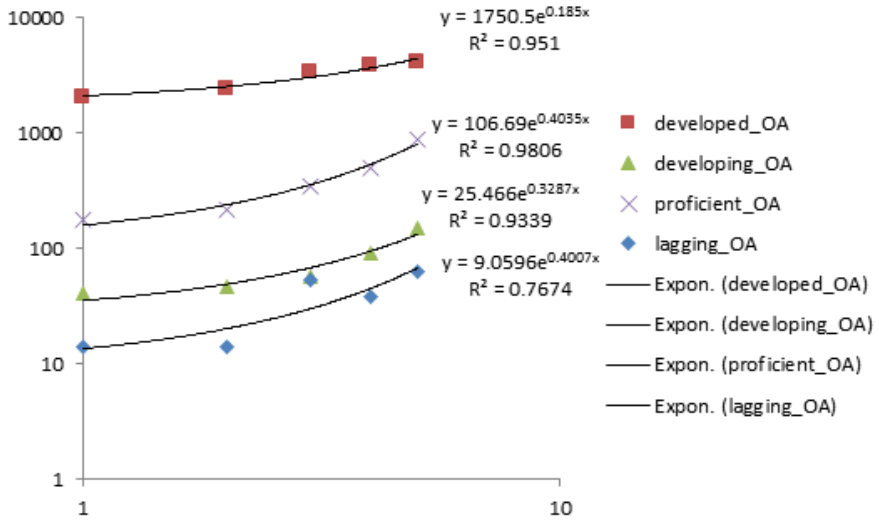
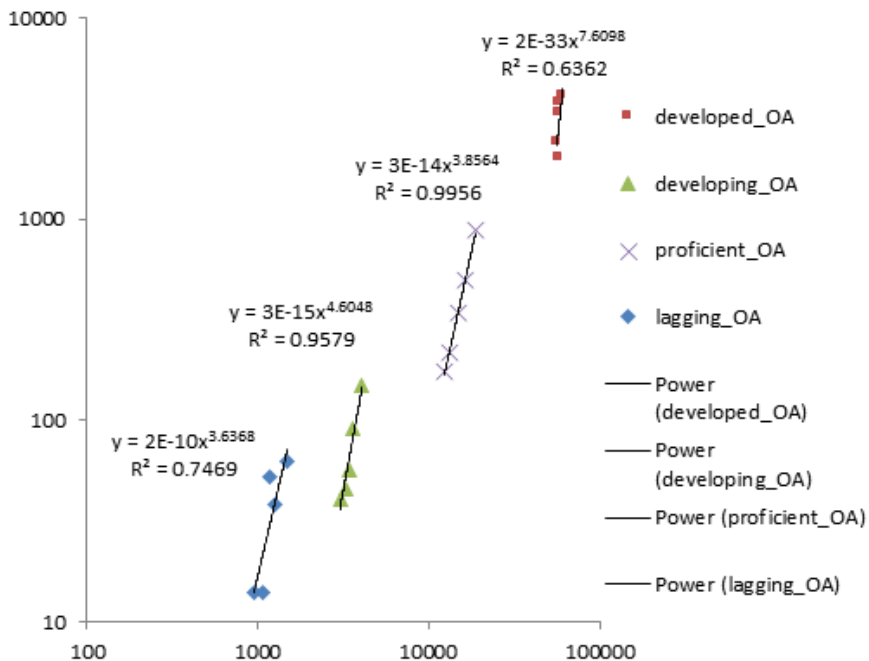


FIGURE 10
The Power Correlation between Annual OA and Total Papers for the Scientific Blocks (for Last Authors)



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