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Article processing charge (APC) for publishing open access articles: the Brazilian scenario

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Abstract
The article processing charge (APC) provides economic sustainability for scientific journals that publish in open access (OA). In this work, documents published in OA between 2012 and 2016 by authors with Brazilian affiliation are identified, the profile of these publications is analyzed and the cost of APC is estimated. In order to do so, data from 930 journals and 63,847 documents were collected from the Web of Science Core Collection. It was found that 59% of these documents were published in journals that charge APC. The total expenditures for the 5-year period were estimated at approximately USD 36 million, the weighted average cost per document at USD 957.75 and the average cost per journal at USD 1492.27. The profile of these publications shows that journals indexed by SciELO represent 67% of the 63,847 documents. The use of mega-journals increased over the period, which implies an increase in expenditure in publications, since the average APC per journal was USD 2059.77. It was observed that the OA Brazilian scientific production is characterized by an endogenic profile and has a preference for the Gold road with APC. These results suggest that policies for funding charges are required to stimulate a more international attitude.

Keywords Article processing charge · Open access · Public funding · Scientific journal

Mathematics Subject Classification 00A99

JEL Classification Z00

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Introduction

The open access (OA) to scientific information movement was launched in 2002. Since then, this campaign has influenced governments, research institutes and funding agencies around the world to establish mandatory or recommendatory policies which would require scientists who have received public funding to develop their research to publish their scientific results in OA. According to Solomon et al. (2013), scholarly publishing is in the early stages of a slow transition from the traditional subscription model to other economic models of funding publication, in which all the documents would be available on the Internet. Countries, mainly from Europe and North America, are looking for new ways to fund their publications while implementing OA policies.

The publication in open access journals (OAJ) is well established (Laakso et al. 2011), however, it has its costs. Different journals models coexist: fully OAJ with or without Article Processing Charge (APC) and hybrid journals (based on subscription with the option to make the papers free to read through payment of fees). The idea behind the hybrid system is to maintain the subscription system while attracting publications of authors from countries which require OA. This existence of hybrid journals is limited to a "percolation" threshold of a number of OA articles per issue, beyond which it will not be worthwhile for the libraries to pay for the subscriptions. The APC is practiced by the minority of fully OAJ (Morrison et al. 2015; Crawford 2017), and a single fixed charge is the most common option (Björk and Solomon 2012).

The economic sustainability of journals varies according to the publisher, and the same journal can adopt different forms of financing, for example: subscription, advertisement, APC, external subsidies. In the case of OAJ with APC, commercial publishers with ten or more journals have the highest average APC (USD 1345), scientific societies generally have a much lower pricing (USD 461), while the lowest averages are among the university departments (USD 246) (Solomon and Björk 2012b). In another study, the same authors analyzed journals indexed in Scopus and found that the average APC for the full OAJ published by non-subscription publisher, full OAJ and the hybrid published by subscription publisher were, respectively, USD 1418, USD 2097 and USD 2727 (Björk and Solomon 2014).

While the original idea behind OA was to make the findings of science available to everybody, the market response was to transfer the costs to the authors. Consequently, in the business model that the large editorial groups are constructing under the OA model, science can be accessed by everyone, but the results of the research cannot be published by everyone. The natural question is how much countries today are able to pay for publicizing the results of the work produced in these countries.

The focus of this study is to analyze the cost of OA articles today in the Brazilian production. For this purpose, the production in APC-based OAJ is computed. In the world, this type of publication has been growing rapidly since the emergence, in the 2000s, of publishers like BioMed Central, Public Library of Science and Hindawi. For example, in 2011 the number of journals charging APC was 1825 (Solomon and Björk 2012b), and currently they are 2744 (Directory of Open Access Journals 2017). Scopus database also shows that the number of APC funded papers surpassed the number of papers from OAJ funded by other means in 2010 (Solomon et al. 2013). Crawford (2017), based on 8992 OAJ from the Directory of Open Access Journals (DOAJ), reports that, in 2016, OAJ with APC (32% of the total number of OAJ) were responsible for 57% (or 298,397) of the papers published in OAJ, while OAJ which do not charge APC (68%) published 43% (or

224,808) of the total number of papers in OAJ; more than doubling the volume of publications if compared to 2011 (133,651). These numbers show that this business model is becoming a viable financing option for journals. As a consequence, the demand for funding and funding policies for the publication of papers should increase in the coming years.

Brazil occupies a leading role in the quantity of OA publications. As reported by Archambault et al. (2014), it has the highest proportion of articles published in OA (76%). However, regarding planning funds for OA publications, only five of the 29 Brazilian granting agencies assist in the payment of publication charges (Pavan and Barbosa 2017). The country does not have an OA policy for its researchers.

Regardless of proper funding policies, the prominence of Brazil in adopting OA is evident. Its roots rely on the implementation and expansion of the Scientific Electronic Library Online (SciELO). Created in 1998 to overcome the weak presence of journals from developing countries in international indexes, SciELO fulfills two roles: publishes and indexes OAJ (Packer and Meneghini 2014). According to the authors, most Latin American journals indexed by the Web of Science and Scopus databases are OA and are mostly published by SciELO. SciELO's relevance also comes from establishing a series of requirements for journals to be accepted, which raised the standards of already existing Brazilian journals and gave rise to the creation of others.

In April 2017, the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) endorsed the OA2020 Initiative (CAPES 2017a), which aims to implement the OA model in scientific journals on a large scale. This action expresses an interest on the part of CAPES to deepen and expand the adoption of the OA model. Then it becomes natural to raise the question of how to be prepared for funding OA in Brazil.

In order to answer this question in this paper, some characteristics of the documents published in OA by authors with Brazilian affiliation in the period 2012–2016 were analyzed, in particular the APC prices distribution, the nationality and the nature of the journals. Also, an estimate of how much authors would spend if they had to bear the entire APC is presented. The results can help granting agencies and academic institutions in the development of policies for funding APC and of strategic planning. Currently, many of these institutions subsidize the publication of journals or bear the cost of subscriptions (e.g. the Portal de Periódicos da CAPES) and, now, have the additional cost of funding APC. The remaining of the paper goes as follows: in chapter 2 the method is presented, chapter 3 has results and discussion and chapter 4 concludes the paper.

Method

The data on Brazilian scientific production were collected on April 25, 2017. It refers to documents published in the years from 2012 to 2016, indexed by the Science Citation Index Expanded, the Social Sciences Citation Index and the Arts & Humanities Citation Index of the Web of Science Core Collection (WoS). Of the 242,347 documents retrieved, 67,818 are classified as open access. After that, the two most common types of documents (article and review) were identified, totaling 63,851. After the creation of the database, the following steps were performed:

1. each journal's APC was collected from the Directory of Open Access Journals (DOAJ) and, when that information was not available, their websites were consulted (May 2017). If more than one currency was indicated on the journal website (for example, US dollar and Euro), US dollar was chosen. Submission fees were not considered. The

twelve currencies found were: ARS, AUD, BRL, CHF, CNY, CZK, GBP, EUR, JPY, MXN, USD, ZAR (we used ISO code in this study). In this step, we:

- verified the presence of three non-OAJ which were excluded from the database: "Low temperature physics" and "Physics of the solid state" with one paper each, and "Pramana" with two papers. Therefore, the final database contained 63,847 documents;
- identified five journals with titles in English and Portuguese. This ambiguity was solved by consulting the International Standard Serial Number (ISSN) and the journals' websites, so the titles were considered together;

2. the search system of SciELO was used to check whether each journal is indexed by that database;
3. mega-journals were identified in the database based on the list proposed by Spezi et al. (2017);
4. the Web of Science Category Terms (WC) assigned to each record by WoS were adapted to fit the nine areas of knowledge (Agricultural sciences, Applied social sciences, Biological sciences, Engineering, Exact and earth sciences, Health sciences, Human sciences, Linguistics, literature and arts, Others) used by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) as a way of grouping the journals. Also, a tenth area was added to the former nine: the Category Term *Multidisciplinary sciences.* Since many journals cover more than one area of knowledge, these journals were included in all of the CNPq areas of knowledge covered by them. As a result, the total amount of vehicles and documents is larger than the database;
5. the country of the entity that edited the OAJ, which should not be confused with the publisher's country, was identified by the Source Publication Documents of the three indexes of WoS mentioned earlier.

BibExcel and Microsoft Excel software were used for the processing and analysis of data. To estimate APC, eleven different currencies were converted to USD on June 3, 2017. In addition, only journals classified as "OAJ with APC" were considered, and those classified as "OAJ with APC variable" were excluded (which totaled 11 journals and 43 documents). For the latter category, the APC varies according to the number of pages or according to the type of document (letter, review, article, among others).

It should be emphasized that this study covers only part of the Brazilian scientific production published in OA in the period studied, that is, only the production indexed in a specific database. Another limitation is that the APC used for the 2012–2016 period were those valid at the moment of data collection and not the ones valid at the time in which each document was submitted. A third limitation is that papers published in hybrid journals in the OA modality were not included due to the fact that WoS identifies the status of the journal as a whole, but not of the individual articles.

Another WoS search was conducted on May 2, 2017 to find the number of documents published by Brazil from 2007 to 2016 according to the form of access. This search was made in order to assess the growth of OA documents in a longer time frame (10 years).

Results and discussion

The participation of open access documents in the Brazilian scientific production

According to WoS data, along the decade from 2007 to 2016, a total of 425,809 (both OA and non-OA) documents were published by authors with Brazilian affiliation. Out of these, 28,911 were published in 2007 and 52,086 were published in 2016 (Fig. 1). The left scale in Fig. 1 illustrates the publications versus the years and compares the OA (number inside the dark gray area) and non-OA documents (number inside the light gray area). The percentage of OA documents is shown in the right scale (black line).

Figure 1 shows that while the absolute number of documents published in OA has remained roughly stable since 2011, the percentage of OA documents declined from 31% in 2011 to 26% in 2016. In order to understand the cause of this percentage decrease, a detailed study of how the amount of Brazilian grants changed over time would be necessary. Other factors would be how OAJ evolve in Journals Citation Reports (JCR) in time, since JCR are used by CNPq to evaluate researchers; and whether the value of OAJ changed how they are classified by CAPES (Brazilian agency that evaluates post-graduate programs). This would represent a new study, not under the scope of this paper.

When compared with other twelve countries, among them the United States, China and Germany, Brazil has the highest proportion of papers published in OAJ, about one third (Madham et al. 2017). This leadership is attributed to SciELO, which started promoting OA in Brazil even before the formalization of the OA movement. So, SciELO represented a healthy environment for OA to grow in Brazil. This explains why in 2007, 5 years after the proposition of the OA movement, 23% of the Brazilian production was already in OAJ

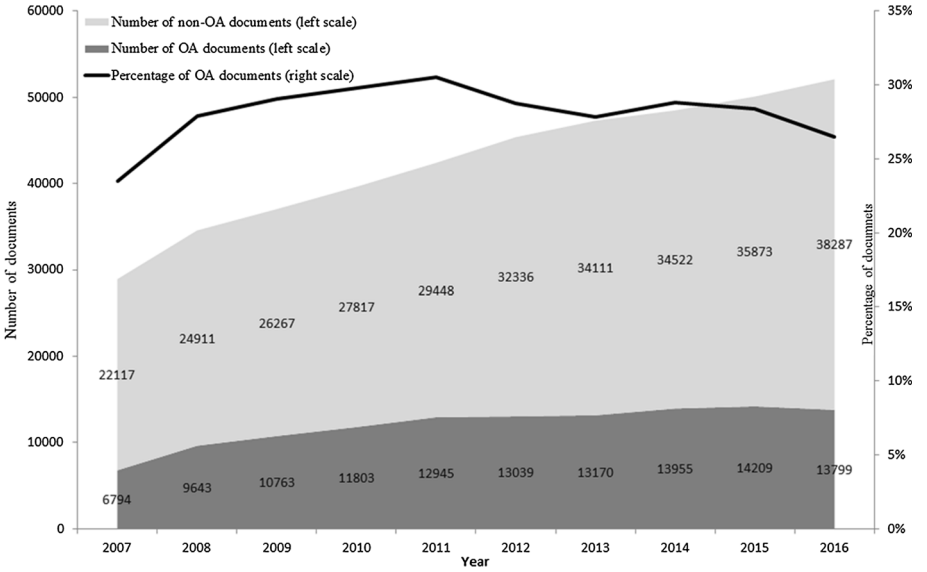

Fig. 1 (Left scale) Total number of documents published by Brazil (non-OA documents in the light gray area and OA documents in the dark gray area); (Right scale) Percentage of OA documents, 2007–2016. *Source*: Research data

(Fig. 1). On the one hand, possible reasons for the growth of OA in Latin America is that scientific journals in these countries are supported by public money, with no submission fees and no major business interests, and the understanding that knowledge produced in universities is a public good led to a massive use of OA in Latin America (Alperin and Fischman 2015). On the other hand, since developing countries tend to publish in less prestigious journals, the large amount of papers published in OAJ already in 2007 suggests that this reflects low standards in the selection of journals. Although the consolidation of this publication model in Brazil was able to reach many scientists and fields of science, Leta et al. (2017) reveal that the elite of the Brazilian researchers (granted researcher 1A CNPq) tends to publish in more prestigious journals, which in many cases are non-OA.

The profile of the open access Brazilian scientific production

The majority of the 930 OAJ used to publish the 63,847 documents found from 2012 to 2016 are foreign, spread across 52 countries. The five countries with the highest numbers of vehicles are: England (240), United States (127), Brazil (115), Switzerland (60) and Germany (43), which together represent 63% of the journals. Thus, the Brazilian scientific production in OA can be found in 815 foreign-headquartered journals and 115 national journals (edited by an entity with a Brazilian address, which should not be confused with the publisher's country).

Even though the majority of the journals are foreign, 69% of the documents were published in Brazilian journals. Within the non-Brazilian journals, 12% of the documents were published in journals from the United States, 8% in journals from England, 4% from Switzerland and 1% from Germany, while other countries represented less than 1% each. Brazilian journals were responsible for most of the research published in OA. This endogenic behavior of publishing the majority of the Brazilian scientific production in local journals, which have only national impact, is not surprising, and it has been observed in previous studies. Leta (2012) examined the total, including OA and non-OA documents, Brazilian scientific production published in three different years (1991, 2001 and 2010) and found that, out of the 29 journals most used for publication, 19 were Brazilian. According to Collazo-Reyes (2014), 88.8% of the articles published in Brazilian journals are authored by Brazilian researchers, making the country the most endogenous in Latin America and the Caribbean. This same feature is also found in other emerging countries, like China and Russia, with endogeny levels that approximate 80% (Strehl et al. 2016). Our results confirm that this behavior is also observed for OA articles. This implies that these articles have a limited impact, since Brazilian journals are unable to attract a broad audience and a broad community of contributors. Moreover, SciELO helped some Brazilian journals reach an editorial level and, consequently, led them to international indexation. Due to this indexation, Brazilian agencies and universities accept them for promotion and grants and, since this evaluation measures number of papers, the agencies indirectly stimulated the endogeny.

Out of the 63,847 documents employed in our analysis, 60,861 (equivalent to 95%) are classified as articles, and 2986 (equivalent to 5%) are classified as reviews. The language in which 74% of the documents were written is English, 25% are in Portuguese and, for the remaining documents, the languages used are French, Galician, German, Italian, Polish, Spanish and Welsh. The predominance of English is not a surprise since many Brazilian journals, in order to reach a broader community, employ English as their language of publication. The presence of documents in Portuguese is due to the fact that journals from

developing or emerging countries as a rule publish most of their research in English or in the national language (Packer and Meneghini 2014). There was also an increase in the number of published Brazilian journals indexed by Scopus and WoS, but they are still published in Portuguese (Leta 2012). For example, WoS was indexing 14 Brazilian titles in 1997 (Packer and Meneghini 2014) and is currently indexing 135 (Clarivate Analytics 2017).

The distribution of the Brazilian scientific production in different research areas is illustrated in Table 1. Since many journals cover more than one area of knowledge, these journals were included in all of the CNPq areas of knowledge covered by them. As a result, the total amount of vehicles and documents is larger than the database. The data show that Biological sciences, Health sciences and Agricultural sciences concentrate most of the Brazilian production. Previous studies show that publication in Biology, Agriculture and Earth and Space are predominant in Brazil, with a relative increase in Clinical Medicine more recently (2007–2011) (Glanzel et al. 2006; Leta et al. 2013). Our study observed similar results in OA publications.

Out of the 930 journals, 621 have APC (including 610 OAJ with APC and 11 OAJ with APC variable). Table 2 shows the number of published documents each year. The total number of journals has grown over the period, from 497 in 2012 to 682 in 2016; and the number of journals with APC (from 327 in 2012 to 470 in 2016) has increased at a faster rate than the journals without APC.

OAJ with APC and APC variable represent 59% of the published documents, and the documents published in OAJ without APC add up to 41%. Therefore, authors from Brazil are not only publishing more in OA, but the rate of this increase is larger for publications in journals with APC. The average growth of papers in these journals is of 2% for the period 2012–2016, while OAJ without APC have a decrease of − 1%. Among Indian researchers, in contrast, it seems to be the opposite: most papers are published in non-APC journals (21,685 out of the 37,078 papers analyzed) (Madham et al. 2017).

Table 1 Distribution of open access journals (OAJ) and documents by areas of knowledge, 2012–2016. *Source*: Research data

Areas of knowledge	No. of journals	No. of documents	% of documents
Agricultural sciences	94	16,513	22.3
Applied social sciences	24	690	0.9
Biological sciences	363	19,807	26.8
Engineering	95	3454	4.7
Exact and earth sciences	211	5963	8.1
Health sciences	299	19,461	26.3
Human sciences	70	1790	2.4
Linguistics, literature and arts	6	92	0.1
Multidisciplinary sciences[a]	14	6005	8.1
Other	4	129	0.2
Total	1180	73,904[b]	100

[a]Web of Science Category Term

[b]This number is larger than the 63,647 documents analyzed because some of them belong to two areas of knowledge

Table 2 Distribution of open access journals (OAJ) with or without article processing charge (APC) and documents by year of publication. *Source*: Research data

Year	OAJ with APC			OAJ with APC variable		OAJ without APC		No. total of documents	No. total of journals
	No. of documents	% of documents	No. of journals	No. of documents	No. of journals	No. of documents	No. of journals		
2012	6873	56.5	327	8	7	5283	163	12,164	497
2013	7099	57	377	10	5	5340	180	12,449	562
2014	7872	59.7	445	9	5	5304	200	13,185	650
2015	8105	60.4	446	10	7	5295	210	13,410	663
2016	7493	59.2	470	6	5	5140	207	12,639	682
Total	37,442			43		26,362		63,847	

Table 3 Open access journals (OAJ) with more than 500 documents published in 2012–2016 *Source*: Research data

Journals	No. of documents	APC (USD)
PLoS One	3994	1495
Semina - Ciências Agrarias	1803	93
Ciência Rural	1772	217
Ciência & Saúde Coletiva	1601	–
Arquivo Brasileiro de Medicina Veterinária e Zootecnia	1192	800
Química Nova	1086	–
Pesquisa Veterinária Brasileira	1059	480
Cadernos de Saúde Pública	1009	–
Journal of the Brazilian Chemical Society	954	449.50
Revista Brasileira de Engenharia Agrícola e Ambiental	891	–
Pesquisa Agropecuária Brasileira	890	–
Revista da Escola de Enfermagem da USP	813	360
Revista Brasileira de Ciência do Solo	755	1200
Anais da Academia Brasileira de Ciências	721	–
Anais Brasileiros de Dermatologia	702	–
Brazilian Journal of Biology	687	80
Arquivos de Neuro-Psiquiatria	680	–
Materials Research - Ibero-American Journal of Materials	677	–
Revista da Sociedade Brasileira de Medicina Tropical	670	–
Revista Brasileira de Fruticultura	626	434
Revista Brasileira de Zootecnia	621	317.44
Clinics	620	930
Arquivos Brasileiros de Cardiologia	608	–
Acta Cirúrgica Brasileira	590	248
Revista Latino-Americana de Enfermagem	570	–
Revista Árvore	566	–
Memórias do Instituto Oswaldo Cruz	557	–
Revista de Saúde Pública	542	558
Revista Ciência Agronômica	520	111.60
Engenharia Agrícola	515	34.10
Acta Paulista de Enfermagem	509	496
Scientific Reports	507	1431.90
Other journals	34,540	–

The sign – indicates that no numerical value is applied

Table 3 shows the journals according to the amount of papers published (more than 500). These 32 OAJ are 3% of the total number of journals, but published 46% of the total of documents in the 2012–2016 period. Only two of them are not Brazilian (PLoS One and Scientific Research). Also, 18 titles are OAJ with APC ranging from USD 34 to USD 1500.

The analysis of the journals in which the OA Brazilian production is published indicates that the majority of the papers appear in national journals, some of them in Portuguese.

Since most authors in these journals are also from Brazil, the comprehensiveness of these publications is questionable. According to Glanzel et al. (2006), Brazilian scientists still prefer publishing in national or regional journals, which implies low visibility and impact. When looking at the APC publications, the endogenic behavior of the OA Brazilian scientific production becomes more damaging, since it results in more costs. This naturally raises the question of the efficiency of funding this type of science.

The cost of the open access Brazilian scientific production

The APC-based model is relatively new and in a highly volatile phase (Morrison et al. 2015), but it is here to stay (Björk and Solomon 2012). The estimated expenditures with paper submission by authors with Brazilian affiliation analyzed here include only the fully OAJ with APC. The numbers would be higher if the publications from hybrid journals were added, even more so considering that these journals tend to have more expensive APC (Björk and Solomon 2014; Jahn and Tullney 2016). The costs presented below do not include these journals.

In the period of 2007 to 2016, about 30% of the total number of publications is OA (see Fig. 1). Out of this amount, 59% (see Table 2, from 2012 to 2016) are in journals with APC, therefore around 17% of the scientific production in Brazil is published in journals with APC. Even though the growth of OAJ in the world is a reality (Laakso et al. 2011) and that a full OA system is a very plausible scenario, in Brazil there is no clear policy about the distribution of funds for APC (Pavan and Barbosa 2017). Before defining a government policy for APC, it would be important to identify how much Brazilian articles published with APC are already costing.

The average APC for the 610 journals found is USD 1492.27, while the weighted average for the 5-year period is USD 957.75. The rates vary from USD 20 to USD 5000. Some of these costs are illustrated in the Table 3, in which only the journals that published more than 500 documents are shown. The total cost of the 37,442 published documents was estimated at almost USD 36 million (Table 4). The average cost increased by approximately USD 100 in the early years, and remained stable at around USD 1000 in recent years.

Other researchers also estimated the spending on APC worldwide. Walters and Linvill (2011) reported an average APC of USD 1109 per article and USD 923 per journal while studying 663 OAJ from six disciplines (Biology, Computer Science, Economics, History, Medicine, and Psychology). In 2010, Solomon and Björk (2012b) verified 1090 OAJ

Table 4 Annual cost and average cost of open access journals (OAJ) with article processing charge (APC)
Source: Research data

Year	No. of documents	Annual cost (USD)	Average cost of APC (USD)
2012	6873	5,380,397.08	782.83
2013	7099	6,412,912.37	903.35
2014	7872	7,932,360.19	1007.67
2015	8105	8,346,076.49	1029.74
2016	7493	7,788,168.74	1039.39
Total	37,442	35,859,914.88	957.75

funded by APC from DOAJ and found average APC of USD 904 and USD 906 for articles and for journals, respectively. After this study, a larger number of journals, also included in DOAJ, were looked into by Morrison et al. (2015) and the average APC for 1432 journals was USD 964, an increase of 6% in 4 years when compared to the results of Solomon and Björk. More recently, Crawford (2017) estimated the average APC per article for all journals in DOAJ as USD 803 and the APC range from USD 4 to USD 5200. Higher averages were found in journals indexed by Scopus: USD 1418 in OAJ published by non-subscription publishers, and USD 2097 in full OAJ published by subscription publishers (Björk and Solomon 2014). These authors also found that APC prices increased by 5% a year.

The average cost of APC for OAJ used by Indian authors is USD 1173 per paper and total expenditure is around USD 16.75 million for the period 2010–2014 (Madham et al. 2017). The Research Councils UK (2016), which has already spent approximately GBP 60 million in three block grants, reported a 14% average increase of APC (from GBP 1580 in 2013/14 to GBP 1811 in 2015/16). German universities and research institutions spent EUR 9627.537 from 2005 to 2015 to publish 7417 OA papers, with an average APC of EUR 1298 (Jahn and Tullney 2016). These numbers become larger for universities in the USA and Canada, where the average cost in 2014 was around USD 2000 for full OAJ and about USD 3000 for hybrid journals (Solomon and Björk 2016). This can be explained by the fact that these countries are already fully involved with the OA policy and have more funds for science than developing countries. It is interesting to notice that Brazil has the average cost of APC quite similar to the average in the world and to the average of some regions, even though no specific policy for funding exists.

If any policy for APC is to be implemented in Brazil, the country needs to know in which areas it spends more with APC. We found that most of the OAJ with APC (334 of 610 journals) are concentrated in the USD 1000 to USD 2000 range. The lowest fees are found in Agricultural sciences, while Biological and Health sciences have the biggest number of OAJ and the highest rates. The area of Linguistics, literature and arts was the only one found without journals with APC. As explained earlier, the 11 OAJ with APC variable were not included in the estimates related to APC. Those OAJ have fees that vary according to the length of text (USD 90–USD 180) or type of document (USD 50–USD 1480).

These results agree with the findings of Solomon and Björk (2012b), which report widespread charging among Scientific, Technical and Medical journals (with the highest charges in Biomedicine), some growth in the Social Sciences and a comparatively rare charging in the Arts and Humanities. Crawford (2017) corroborates, indicating that in 2016 more than half of OAJ in Biology and Medicine charged fees (1406 out of 2562 journals).

Table 5 shows the distribution and total cost of documents published in OAJ with APC by area of knowledge. The three areas with most papers published are Agricultural sciences, Health sciences and Biological sciences. Agricultural sciences represents 10.3% of the total cost, while the other two areas represent around 29% each. And Multidisciplinary sciences, an area in which publication is done mainly by mega-journals, represents 17%.

The analysis of the five countries in this study with the largest number of OAJ with APC shows that Brazil's charges are the lowest (Table 6). This is not surprising, as the majority of Brazilian journals are considered regionals. The other countries have a higher number of journals that charge fees from USD 1000.01 to USD 2000. These countries are in the top five positions due to the fact that they host important OA publishers. For example, England's BioMed Central, United States' Hindawi and Public Library of Science, and Brazil's SciELO.

Table 5 Percentage of documents published in open access journals (OAJ) with article processing charge (APC), and percentage of the total cost of APC by areas of knowledge, 2012–2016. *Source*: Research data

Areas of knowledge	% of documents published in OAJ with APC	% of total cost of APC[b]
Agricultural sciences	29.1	10.3
Applied social sciences	0.0	0.0
Biological sciences	23.9	29.1
Engineering	2.3	3.5
Exact and earth sciences	7.9	8.9
Health sciences	24	29.3
Human sciences	1.3	1.7
Multidisciplinary sciences[a]	11.5	17
Other	0.0	0.0
Total	100	100

[a]Web of Science Category Term

[b]The values were rounded to the nearest tenth

Relative numbers may not add to 100 due to rounding

Table 6 Top five countries in number of open access journals (OAJ) with article processing charge (APC) *Source*: Research data

Journal country	Categorized APC (USD)										No. total of journals	
	≤ 500		500.01–1000		1000.01–2000		2000.01–3000		≥ 3000.01			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
England	4	1.7	5	2.2	165	71.7	46	20.0	10	4.3	230	100
United States	4	3.6	10	8.9	73	65.2	19	17.0	6	5.4	112	100
Switzerland	1	1.7	6	10.3	31	53.4	20	34.5	–	0.0	58	100
Brazil	29	74.4	6	15.4	4	10.3	–	0.0	–	0.0	39	100
Germany	2	6.3	3	9.4	22	68.8	4	12.5	1	3.1	32	100
Other countries	58	41.7	31	22.3	39	28.1	7	5.0	4	2.9	139	100
Total											610	100

The sign – indicates that no numerical value is applied

In sum, OAJ based on charges tend to work best in fields in which the research is well funded, and non-fee OAJ work best in fields and countries where comparatively little research is supported by funds (Suber 2012). These particularities should be considered by policymakers when designing a method to provide funds for publication charges. A second aspect to be considered is the type of the journal, full OA or hybrid, to avoid double payment (APC and subscription). A third point is the origin of the journal. In the case of Brazilian journals, many of them are already supported by public funds. So, the addition of fees would mean paying twice to make the same work OA.

Open access Brazilian scientific production in SciELO and in mega-journals

The OA Brazilian scientific production was analyzed using two complementary aspects: the publication in SciELO, which requires a certain quality standard of the journals to integrate the portal; and the publication in mega-journals, which are responsible for a large percentage of the publications in science. While SciELO is an important ingredient for the high percentage of Brazilian production in OA, mega-journals are a business model that quickly responds to the worldwide increase in publication and in OA policy.

SciELO is a platform developed in Brazil which publishes and indexes OAJ. In order to have their journals linked to it, editors need to follow a number of quality control measures. Over the years the number of journals listed there have grown and SciELO is today one of the main journal platforms in the world. It indexes approximately 1250 journals from all areas of knowledge, and has Journal Collections from 15 countries (currently the Paraguay collection is in development). In 2017, SciELO announced a new preprint platform which will provide a service similar to the arXiv, expanding its activities to accelerate scientific communication (Packer et al. 2017).

In this study we found 169 journals, from nine countries, published in SciELO (Table 7). All these titles continue to be indexed, except for the journal of the Venezuelan collection, which was interrupted in November 2012. The countries that do not have journals in our database are: Bolivia, Cuba, Paraguay, Peru and Portugal. Out of the total of 63,847 documents analyzed, the expressive percentage of 67% is indexed by SciELO (and only 2% do not refer to Brazilian Collection). And out of the Brazilian OAJ in Table 3, only one is not indexed by SciELO.

CAPES is the government agency responsible for securing the quality of post-graduation programs in Brazil. One of the mechanisms for this is to evaluate the programs according to the quantity and quality of the publications generated by the researchers. To secure the quality, journals are classified through Qualis, a system created to evaluate the Brazilian scientific production. Mueller (2011) points out that SciELO, together with Qualis, has established international quality criteria for journals to be included in this

Table 7 Distribution of journals by journal collections of SciELO. *Source*: Research data

Journal collections	No. of journals	No. of OAJ with APC	Categorized APC (USD)			No. of documents
			≤ 500	500,01–1000	1000,01–2000	
Brazil	106	37	28	6	3	41,284
Colombia	15	1	1	–	–	257
Mexico	14	4	4	–	–	95
Chile	10	4	1	1	2	293
South Africa	8	4	2	2	–	16
Spain	8	3	1	2	–	395
Argentina	6	2	2	–	–	43
Costa Rica	1	–	–	–	–	114
Venezuela	1[a]	–	–	–	–	1
Total	169	55				42,498

The sign – indicates that no numerical value is applied

[a]Indexing interrupted in Nov./2012

system. The desire of having their journals indexed by SciELO and with the visibility granted by that requires more effort from Brazilian editors, but leads to a more qualified Brazilian journal production. The combination of these factors: being indexed by SciELO and consequently being well evaluated by Qualis as well as the endogeny of the Brazilian scientific production, explains the high frequency of use of journals indexed by the database.

The realization that most of the Brazilian research is published in national journals and gains visibility through SciELO raises a question as to what is the cost of publishing. Fifty-five (32%) of the 169 journals indexed by SciELO adhered to the APC-based model, most with rates up to USD 500, and are responsible for 22% (USD 8,058,479.70) of the total USD 35,859,914.88 expenses in APC.

It is important to notice that when a document is indexed by SciELO, redundant payments may occur as SciELO itself is supported by public funding. In the case of Brazil, an analysis of 193 journals indexed in 2008 by SciELO identified 41 journals which charged the authors for publication and 19 of them were APC (Mueller 2011). Although our study does not analyze the totality of indexed Brazilian journals, we found that, currently, more journals have adopted APC as source of revenue (37, in comparison to the 19 found in 2008).

Mega-journals have been described as having the following main characteristics (not necessarily all present simultaneously): broad disciplinary scope; fast and large scale of publication; a peer review policy that works toward the "scientific soundness" of the research; usually based on the APC business model; and make use of altmetrics (Solomon 2014; Spezi et al. 2017). Mega-journals are a fact in scientific communication and have been gaining more and more space, although they are subject of debates for representing at the same time a paradigm for the future of scientific communication and the decline in publication patterns (Spezi et al. 2017). According to Björk and Solomon (2014), the mega-journal segment is the one with the fastest growth in the APC funding OAJ market.

Because the peer review of mega-journals is different from traditional journals, leaving some evaluation criteria for readers in the post-publication phase, they are viewed by some as a "cash cow". The study of mega-journals is also relevant given that, as a rule, they charge higher rates than other OAJ, with implications on the costs of article publication.

This study identified 42 mega-journals among the 930 journals used for the publication of the documents retrieved from 2012 to 2016. These 42 mega-journals published 9% (or 6064) of the 63,847 documents and represent 27% (USD 9,765,609.10) of the USD 35,859,914.88 spent with APC. Only one of the mega-journals does not have APC, and the average APC of the group is USD 2059.77, high when compared to the average of the 610 OAJ with APC (USD 1492.27). The rates for the mega-journals range from USD 800 to USD 5000, and most of their titles are dedicated to a specialized area, while six are multidisciplinary. It was also found that the rates are higher than those charged in 2011, when the range of values for mega-journals was between USD 1000 and USD 1500 (Solomon and Björk 2012b).

The two mega-journals with most articles published out of the documents retrieved are PLoS One (3994 documents and USD 1495 charge) and Scientific reports (507 documents and USD 1431.90 charge). The pioneer PLoS One, which is often regarded as a benchmark for other mega-journal publishers, has nearly eight times as many published papers as the journal in second place in this analysis. The other OA mega-journals published less than 200 articles each.

Figure 2 shows the relative growth in the number of mega-journals, non-mega-journals, documents published in mega-journals and in non-mega journals, and the documents/

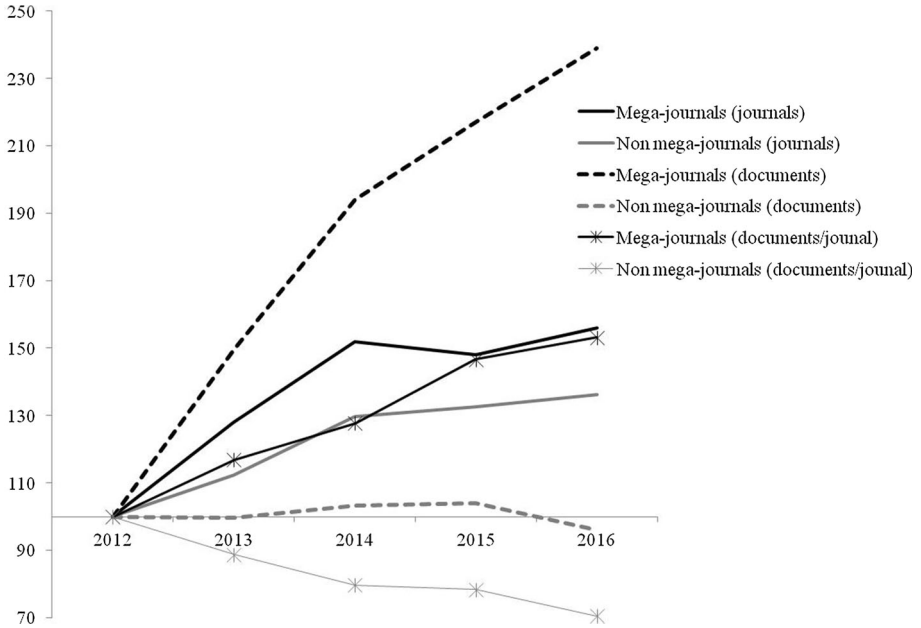

Fig. 2 Relative evolution of the number of journals, documents and averages of documents published by journal (2012 = 100), 2012–2016. *Source*: Research data

vehicle ratio between 2012 and 2016, considering the values in 2012 as base 100. The values are computed as follows: (number of documents in the year/number of documents in 2012) * 100. The gray dashed line, which is the ratio of documents published in non-mega-journals, stagnated throughout the period despite the growing number of non-mega-journals, shown in Fig. 2 as a solid gray line, This increase in the number of journals and stagnation of the number of documents translates into a decrease in the average number of documents published in that type of vehicle, illustrated in Fig. 2 as a gray solid line with stars. In the case of the number of mega-journals, the growth is more pronounced than that of the non-mega-journals (approximately 50% in 4 years), shown as a black dashed line. In addition, the average number of documents in each mega-journal, shown in Fig. 2 as a solid black line with stars, increased by about 50% in the period, a result of a nearly 150% increase in the number of documents published by this type of journal in the 4 years period, as the solid black line in Fig. 2 demonstrates.

A survey with authors who published in four mega-journals found that most would submit a paper to the same mega-journal or to a similar publication again. According to them, the two most important factors in that decision are the quality of the journals and the short waiting time between acceptance and publication (Solomon 2014). It is not possible to predict whether these characteristics of mega-journals will persist in the next few years, but they will certainly continue to be an option for scientific publication. Even though Brazil does not have a specific national funding grant for publication charges, the possibility of fast publishing is quite interesting for the evaluation processes employed by CAPES and CNPq. Therefore it is not surprising that Brazilian researchers are opting to publish in these journals. However, the cost of these publications and the reputation that

comes with accepting work that is incremental seem to be undesirable characteristics for a research community that should be looking for impact.

Funding policies

The growth of the OA publication system is a reality thanks to the United States and European policy of having articles and scientific data open to the general public. The system at some point may become predominant and non-OAJ may be far less common or even disappear in the future. Countries like Brazil need to be prepared for that scenario (Pavan and Barbosa 2017).

Brazil's tendency to publish in national journals with less international impact is observed both in OA and non-OAJ. This endogenic behavior, when results are published in journals with APC, implies additional cost for the funding system. It is important to point out that many of these journals with APC already receive Brazilian grants for existing. Therefore, the research, the journal and the paper publication costs are covered by the funding agencies and/or universities/research institutes. This fact does not stimulate journals to compete for better articles to publish nor does it stimulate them to aspire for larger fees to charge since their financial support is already covered by public funds. Similarly, scientists settle for publishing in journals that do not require high scientific standards for their papers.

Brazil integrates the scientific publication system and needs to adapt itself to the transition from subscription journals to OAJ. Currently, the country funds both the Portal de Periódicos da CAPES and the publication of journals. In 2016, CAPES invested BRL 357.5 million for the Portal maintenance (CAPES 2017b). CNPq also has a program that funds scientific journals; in 2015, the amount spent was of BRL 5,199,000 (203 funded journals) and in 2017 BRL 961,000 (57 journals) (CNPq 2017). In addition, some state agencies support this type of publishing (Pavan and Barbosa 2017). SciELO is also supported by CNPq, by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Latin American and Caribbean Center on Health Sciences Information (BIREME)/Pan American Health Organization (PAHO)/World Health Organization (WHO) and Fundação de Apoio à Universidade de São Paulo.

Even though the Brazilian participation in OA, through both papers and journals, is increasing, most of Brazilian agencies have no policy regarding publication charges and it is not yet possible to know which strategies the country will adopt to finance the publication of national scientific research and to maintain the Portal de Periódicos da CAPES.

According to a survey with scientists, the most recurrent reason not to publish OA articles is the lack of funding (39%) to pay charges, and the two types of institutions with the greatest difficulty in obtaining funding were hospitals or medical schools and universities or colleges (Dallmeier-Tiessen 2011). Another finding is that 31% of the respondents used part of research funding not specifically intended for paying fees to be able to publish in OA; 28% used research funding that includes money to pay fees; in 24% of the cases the institution paid the fees; in 12% of the cases it was the authors who paid; and in 5% the fees were paid by other source. Solomon and Björk (2012a) found in another survey that research grants and institutional funds are the most used sources to pay for the highest APC, while personal funds are more used to pay cheaper APC and also more commonly used by authors from lower income countries. Therefore, if no funding policy is implemented, the participation of Brazilian scientists in large impact publications will

decrease, since the cost of publication rates influences the choice of journal to which authors will submit their articles.

Conclusion

In the last 15 years the scholarly publishing market has been transformed by the OA movement. This impacts authors, editors, reviewers, readers and policymakers around the world. Each country has its peculiarities in relation to the support of OA, so the pace of implementation of this model varies significantly among them. The movement started as a political issue, but has grown as a state policy, particularly in countries of the North hemisphere. The economic sector and journals responded with the creation of the APC business model, which charges the authors (or the institutions or countries they're affiliated with) in order to make the results of their scientific studies free to the readers. In Brazil, many of the national journals, since they are covered by public funds, adapted to the OA initiative.

In this paper, we measured the growth of the number of OA and non-OA documents over the period of a decade trying to understand the mechanism behind the high participation of Brazil in OA publications. We also showed that the average percentage of documents published in journals with APC increased in the period 2012–2016. This growth is not obvious since scientific grants in Brazil are quite limited. The costs involved with APC, for the 5-year period, represented an average value of around USD 960, which, though lower than the average cost for publishing in most of the journals with APC, still requires provision of funds. In a previous study we showed that the main Brazilian agencies do not have a specific policy for covering publication charges. We suggest that this large growth has its origin in two complementary aspects. First, the creation of SciELO before the beginning of the OA movement generated an environment appropriate for the increase of OA in Brazil. This platform, partially supported by Brazilian agencies, establishes publication standards for OAJ indexation, which allowed for better evaluations by CAPES and CNPq. The second aspect relates to authors' desire for visibility and, hence, to their preference for publishing in OA journals, which results in a large number of this type of document in SciELO and in the non-particularly selective mega-journals.

Unfortunately, these two aspects led to an endogenic profile of the OA Brazilian scientific production, and a preference for the Gold road with APC. These aspects might not be reverted if Brazilian agencies do not provide funding for publication charges which stimulate a more international attitude. And, as fees tend to increase over time and budget constraints are frequent in the day-to-day of researchers, it is desirable that the ways for financing scientific publications be redefined soon in Brazil. It is necessary to remember that Brazilian funding agencies support scientific research, but also evaluate the scientific production of their researchers. When developing a new OA policy, it would be important for Brazilian agencies to learn with the problems that will arise with its implementation, problems which were already identified by other agencies (Welcome Trust Blog 2015).

Finally, our analysis also provides the percentage of the publications in each research area, which allows for proper planning for the creation of specific grants for pre-publication charges.

References

Alperin, J. P., & Fischman, G. E. (2015). Scientific journals made in Latin America. In J. P. Alperin & G. E. Fischman (Eds.), *Made in Latin American: open access, scholarly journals, and regional innovations* (pp. 103–112). Ciudad Autónoma de Buenos Aires: CLACSO. http://biblioteca.clacso.edu.ar/clacso/se/20150921045253/MadeInLatinAmerica.pdf. Accessed 18 April 2017.

Archambault, E., et al. (2014). *Proportion of open access papers published in peer-reviewed journals at the European and world levels—1996–2013*. [S.l]: European Commission. http://science-metrix.com/en/publications/reports/proportion-of-open-access-papers-published-in-peer-reviewed-journals-at-the. Accessed 14 October 2017.

Björk, B.-C., & Solomon, D. (2012). Pricing principles used by scholarly open access publishers. *Learned Publishing*. https://doi.org/10.1087/20120207.

Björk, B.-C. & Solomon, D. (2014). *Development an effective market for open access article processing charge*. London: Welcome Trust. https://wellcome.ac.uk/sites/default/files/developing-effective-market-for-open-access-article-processing-charges-mar14.pdf. Accessed 28 Septrmber 2017.

CAPES. (2017a). *Notícias. Conselho Consultivo do PAAP se reúne na CAPES para debater temas importantes*. http://www.periodicos.capes.gov.br/?option=com_pnews&component=NewsShow&view=pnewsnewsshow&cid=533&mn=0. Accessed 20 August 2017.

CAPES. (2017b). *Relatório de gestão do exercício de 2016. Brasília, 2017*. http://www.capes.gov.br/images/stories/download/acessoainformacao/Relatorio_de_Gestao_CAPES_2016.pdf. Accessed 20 August 2017.

Clarivate Analytics. (2017). *Source publication list for Web of Science*. http://ip-science.thomsonreuters.com/mjl/. Accessed 24 June 2017.

CNPq. (2017). *Painel de investimentos. Brasília, 2017*. http://www.cnpq.br/painel-de-investimentos. Accessed 22 August 2017.

Collazo-Reyes, F. (2014). Growth of the number of indexed journals of Latin America and the Caribbean: The effect on the impact of each country. *Scientometrics*. https://doi.org/10.1007/s11192-013-1036-2.

Crawford, W. (2017). *GOAJ2: Golden open access journals 2011–2016*. Livermore: Cites & Insights Books. https://waltcrawford.name/goaj2.pdf. Accessed 03 October 2017.

Dallmeier-Tiessen, S., et al. (2011). *The SOAP symposium—III Open access publishing today: What scientists do and why. SOAP symposium, January 13th, 2011, Berlin*. http://edoc.mpg.de/524968. Accessed 22 June 2017.

Directory of Open Access Journals. (2017). *Directory of open access journals*. https://doaj.org/search. Accessed 10 May 2017.

Glanzel, W., Leta, J., & Thijs, B. (2006). Science in Brazil. Part 1: A macro-level comparative study. *Scientometrics*. https://doi.org/10.1007/s11192-006-0055-7.

Jahn, N., & Tullney, M. (2016). A study of institutional spending on open access publication fees in Germany. *PeerJ*. https://doi.org/10.7717/peerj.2323.

Laakso, M., et al. (2011). The development of open access journal publishing from 1993 to 2009. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0020961.

Leta, J. (2012). Brazilian growth in the mainstream science: The role of human resources and national journals. *Journal of Scientometric Research*. https://doi.org/10.5530/jscires.2012.1.9.

Leta, J., Costa, E. H. S., & Mena-Chalco, J. P. (2017). Artigos em periódicos de acesso aberto: um estudo com pesquisadores bolsistas de produtividade do CNPq. *RECIIS-Revista Eletrônica de Comunicação, Informação e Inovação em Saúde, 11*(supl), 6.

Leta, J., Thijs, B., & Glanzel, W. (2013). A macro-level study of science in Brazil: Seven years later. *Encontros Bibli*. https://doi.org/10.5007/1518-2924.2013v18n36p51.

Madham, M., et al. (2017). Should Indian researchers pay to get their work published? *Current Science India, 112*(4), 703–713.

Morrison, H., et al. (2015). Open access article processing charges: DOAJ survey 2014. *Publications*. https://doi.org/10.3390/publications3010001.

Mueller, S. P. M. (2011). Produção e financiamento de periódicos científicos de acesso aberto: um estudo na base SciELO. In: D. A. Plobación et al. (Org.), *Revistas Científicas: dos processos tradicionais às perspectivas alternativas de comunicação* (pp. 201–230). Cotia: Ateliê Editorial.

Packer, A. L., & Meneghini, R. (2014). O SciELO aos 15 anos: raison d'être, avanços e desafios para o futuro. In A. L. Packer et al. (Org.), *SciELO – 15 anos de Acesso Aberto: um estudo analítico sobre acesso aberto e comunicação científica* (pp. 15-28). Paris: UNESCO. https://doi.org/10.7476/9789237012376.

Packer, A. L., Santos, S., & Meneghini, R. (2017). SciELO Preprints a caminho. *SciELO em Perspectiva*. http://blog.scielo.org/blog/2017/02/22/scielo-preprints-a-caminho/. Accessed 30 October 2017.

Pavan, C., & Barbosa, M. C. B. (2017). Financiamento público no Brasil para a publicação de artigos em acesso aberto: alguns apontamentos. *Em Questão*. https://doi.org/10.19132/1808-5245232.120-145.

Research Councils UK. (2016). *RCUK open access block grant analysis 2013/14, 2014/2015 and 2015/2016*. http://www.rcuk.ac.uk/documents/oadocs/rcukapcreturnsanalysis2014-16-pdf/. Accessed 10 August 2017.

Solomon, D. J. (2014). A survey of authors publishing in four megajournals. *PeerJ*. https://doi.org/10.7717/peerj.365.

Solomon, D. J., & Björk, B.-C. (2012a). Publication fees in open access publishing: sources of funding and factors influencing choice of journal. *Journal of the American Society for Information Science and Technology*. https://doi.org/10.1002/asi.21660.

Solomon, D. J., & Björk, B.-C. (2012b). A study of open access journals using article processing charges. *Journal of the American Society for Information Science and Technology*. https://doi.org/10.1002/asi.22673.

Solomon, D. J., & Björk, B.-C. (2016). Article processing charges for open access publication—The situation for research intensive universities in the USA and Canada. *PeerJ*. https://doi.org/10.7717/peerj.2264.

Solomon, D. J., Laakso, M., & Björk, B.-C. (2013). A longitudinal comparison of citation rates and growth among open access journals. *Journal of Informetrics*. https://doi.org/10.1016/j.joi.2013.03.008.

Spezi, V., et al. (2017). Open-access mega-journals: The future of scholarly communication or academic dumping ground? A review. *Journal of Documentation*. https://doi.org/10.1108/JD-06-2016-0082.

Strehl, L., et al. (2016). Brazilian science between national and foreign journals: Methodology for analyzing the production and impact in emerging scientific communities. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0155148.

Suber, P. (2012). *Open access*. Cambridge: MIT.

Walters, H., & Linvill, A. (2011). Characteristics of open access journals in six subject areas. *College & Research Libraries*. https://doi.org/10.5860/crl-132.

Welcome Trust Blog. (2015). *The reckoning: An analysis of Welcome Trust open access spend 2013–14*. https://blog.wellcome.ac.uk/2015/03/03/the-reckoning-an-analysis-of-wellcome-trust-open-access-spend-2013-14/. Accessed 6 June 2018.