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International movement of open access to scientific knowledge: A quantitative analysis of country involvement☆

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ABSTRACT

The study aims are to conduct a systematic quantitative analysis of Open Access (OA) Instruments and Initiatives, justify and develop the methodology for calculating the index of countries' involvement in the Open Access movement. The authors identified all the significant OA-Instruments and OA-Initiatives, which were counted on the basis of the records in their OA-registers. Consolidation of records in these registers, according to literature data from the moment of their launch, made it possible to identify important patterns and features of the evolution of the OA-movement. The proposed methodology when applied to all countries of the world as of 2017 and 2019 allowed the authors to rank and classify them according to a degree of their involvement in the OA-movement. The article affirms that the proposed methodology in the context of regular comparative analysis of the benchmarking tables with setting the target integral indicators for the lagging countries is very convenient for the development of Global or Regional OA-Strategies. So the authors define the concept of the International or Regional OA-movement Scoreboard, underlying the development of these strategies.

Introduction

The Open Access movement received global recognition as one of the goals of creating a scientific environment in 2002, with the adoption of the Budapest Open Access Initiative (February 14, 2002). Then followed Bethesda Statement on Open Access Publishing (April 11, 2003) and very important Berlin Declaration on Open Access to Knowledge in the Science and Humanities (October, 22, 2003), supported at the intergovernmental level and by the European Commission. By 2008, there had already been six initiatives, statements and declarations of open access to scientific and humanitarian knowledge (Moskovkin, 2008a).

The first three OA-Initiatives showed great interest in analyzing the features and principles of the OA-movement. Our experiments in Google Scholar showed that until 2012 the term "Open Access" was used exclusively in technical and medical senses (for example, open access endoscopy), then in 2002 it was already combined with the term Open Access in the sense of Open Access to Scientific Knowledge. And since 2003, the lion's share of publications has been already published within the OA-movement. The number of articles with "Open Access" in their titles grew as follows: in 2003–369 articles, in 2008–1140, in 2013–2340, in 2018–2640, and in 2019–2700 articles (the requests were made to Google Scholar on October 15, 2020).

There are many similar definitions of Open Access, which are formulated in the OA-Initiatives. "Generally 'Open Access' refers to the free availability of peer-reviewed literature on the public internet, permitting any user to read, download, copy, distribute, print, search, or link to the full texts of the articles. There is a growing trend in the R&D organizations to set up digital archives (institutional repositories) of the information and knowledge generated by their scientists and engineers" (Roy, Biswas, & Mukhopadhyay, 2012a, p. 91).

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Table 1
Dynamics of the number of OA-repositories in OpenDOAR in selected countries.

Countries	May 2006[a]	December 2006[b]	7–8 October 2008[c]	11 March 2013[d]	24–26 June 2017[e]	Growth, %
United States	102	256	317	395	498	388.2
United Kingdom	56	93	136	209	252	350.0
Germany	39	111	129	165	195	400.0
Japan	4	16	69	138	211	5175.0
Canada	18	29	44	58	81	350.0
Italy	15	24	42	70	110	633.3

[a] Oliver and Swain (2006).
[b] Pinfield et al. (2014).
[c] Wani, Gul, and Rah (2009).
[d] Das (2014).
[e] Moskovkin, Polukhin, Sadovski, Sizyoongo, and Shevchenko (2018).

The first OA-Initiatives defined the essence of the OA-movement as Gold OA Road (the launch of OA -journals) and Green OA-Road (the creation of Institutional OA-repositories). In the first case, it was assumed that OA-journals were indexed in Directory of Open Access Journals (DOAJ, launched in May 2003), in the second – that articles published in subscription journals under different conditions could be placed in Institutional OA–repositories, for which there were created their own registers – Registry of Open Access Repositories (ROAR, launched in 2003 at the University of Southampton) and Directory of Open Access Repositories (OpenDOAR, launched in 2005 at the University of Nottingham). So OA-journals and OA-repositories, along with their registers, were identified as the main OA tools, which will be an important consideration for our research.

At the same time, the following registers for OA-policies were created:

1. SHERPA/RoMEO is a service run by SHERPA in 2002 to show the copyright and access self-archiving publisher policies of scientific journals. SHERPA stands for Securing a Hybrid Environment for Research Preservation and Access, and RoMEO stands for Rights MEta data for Open archiving. This register, as well as OpenDOAR, was created on the basis of the University of Nottingham. Okpala (2017) notes that the number of such publisher policies increased from 0 in 2003 to 2339 in November 2016. The SHERPA/Juliet register was launched in 2008 to track and store research funder's OA-policies within the SHERPA project;
2. Register of Open Access Repository Mandates and Policies (ROAR-MAP), as well as ROAR, was created by Eprints at the University of Southampton in 2003. M. Costa, Amaro, and Assis (2012) notes that the number of OA-policies (mandates) in this register increased from 0 in 2003 to about 230 by the beginning of 2012, with a clear predominance of Institutional Mandates (in addition to them, Funder, Multi-Institutional and Sub-Institutional Mandates are registered). Salager-Meyer (2012) refines this as of September 2012. It notes that "according to ROARMAP, out of a total of 429 OA-Repository mandates worldwide, 190 (44%) are multi- or sub-institutional mandates, 93 (22%) are thesis mandates, and 53 (12%) are funder mandates. The remaining 22% correspond to either unspecified or proposed mandates" (Salager-Meyer, 2012, p. 63). Most of them are located in Europe and North America.

Generally, "Open access has traditionally been categorized into types like Green OA (self-archiving of pre- and post-prints), Gold OA (fully accessible articles in OA journals), and Hybrid OA (individual articles are made OA in what otherwise are subscription-only journals). Some journals also make articles open access after a specific embargo period" (Chatterjee, Biswas, & Mishra, 2013, p. 128). An embargo period is indicated in publishers' policies on copyright and self-archiving. The features of Hybrid OA were discussed in detail in Moskovkin (2008b).

In the last 10–15 years, a number of studies have appeared on the quantitative assessment of countries' involvement into the international Open Access movement, primarily examining the distribution of the number of OA-repositories, OA-journals, Institutional OA-policies and OA-papers among the selected countries.

Therefore, our aim was to make a comprehensive quantitative analysis of countries' involvement in the OA-movement based on the main registers of OA-repositories, OA-journals, OA-policies and OA-Initiatives. For this purpose, we developed a quantitative methodology for ranking countries according to a degree of their involvement in the OA-movement.

Further, we will give an overview of publications on the involvement of individual countries, continents and the whole world in the OA-movement, trying to consolidate scattered data where possible. The above-mentioned registers provide only cumulative data; therefore, the consolidation of scattered data gives us an understanding of the dynamics of the process of replenishing these registers.

Tables 1 and 2 show the data by various researchers on the number of OA-repositories in OpenDOAR and OA-journals in DOAJ in the selected countries, demonstrating the dynamics of these indicators over quite a long period, with a calculated percentage increase.

In Table 1, we can see a quite large increase in the number of OA-repositories from May to December 2006. This appears to have been a key year when the rapid growth of OA-repositories began as, according to Arlitsch and Grant (2018), the number of OA-repositories was low and growth was slow until around 2005. They also noted that in 2017 the number of OA-repositories in OpenDOAR reached 3448 and in ROAR – 4585. Over the entire period under study, the largest increase in the number of OA-repositories occurred in Japan and Italy (Table 1).

A decline in the number of American and Indian OA-journals from 2013 to 2017 was due to a significant overhaul of OA-journals in DOAJ at this period (Table 2). Indeed, on May 9, 2016, many sub-standard and predatory OA-journals were removed from DOAJ, though as early as in December 2012, it had been announced that new and more stringent criteria would be introduced for registration of OA-journals in DOAJ (Frantsvåg, 2019).

Our experience in monitoring OA-processes shows that on the back of Open Access in the USA and especially in India, a large number of predatory OA-journals appeared. The effect of removing them from DOAJ is shown in Table 2. We did not include the most recent data (as of May 4, 2019) for the countries from Sharma (2020) in this Table, as it has the incorrect numbers of OA-journals in Brazil (83) and Spain (55). Hugar (2019) supplies the credible data for them as of 9 September 2018. At the same time, the data missing from this Table, concerning India – 261 OA-journals (Sharma, 2020) and Indonesia – 1359 OA-journals (Hugar, 2019), evidence that Indonesia took over India right after the DOAJ revision in 2016 resulting in the exclusion of about a half of Indian journals from the directory, and was ranked second in the world after the United Kingdom, with a huge number of journals. It is now essential for Indonesia not to follow India's path.

Miguel, Tannuri de Oliveira, and Cabrini Gracio (2016) distribute Scopus publications by subjects in Open Access according to countries. They searched for the articles in the Scopus database, as of 2 September

Table 2
Dynamics of the number of OA-journals in DOAJ in selected countries.

Countries	2002[a]	2003[a]	May 2012[b]	10 December 2012[c]	17 January 2013[a]	24–26 June 2017[d]	9 September 2018[e]	Growth (from 2003), %
United States	16	213	1231	1270	1270	544	664	211.7
Brazil	0	8	753	801	804	987	1275	15,837.5
United Kingdom	5	111	546	545	575	886	1406	1166.7
India	0	14	425	463	471	233	–	–
Spain	0	5	417	442	444	539	656	13,020.0

[a] Das (2014).
[b] Gumpenberger, Ovalle-Perandones, and Gorraiz (2013).
[c] Pandita (2013).
[d] Moskovkin et al. (2018).
[e] Hugar (2019).

Table 3
Countries as per number and percentage of OAI-PMH repositories, 2012.[a]

Countries	No. of repositories	No. of OAI-PMH compliant repositories	Percentage (%) of OAI-PMH compliant repositories	Data for comparison[b]	
				OpenDOAR	ROAR
United States	407	265	65	395	547
UK	220	169	77	209	249
Germany	132	94	71	165	193
Spain	114	89	78	98	153
Brazil	105	81	77		
Japan	104	79	76	138	166
India	77	60	78	54	94
Canada	67	61	91	58	85
Italy	67	55	82	70	88
France	67	52	78	71	82
Taiwan	63	55	88		

[a] Roy, Biswas, and Mukhopadhyay (2013) [December 2011].
[b] Das (2014) [11/03/13].

2015, aimed at studying Open Access. Their research shows that the first 6 countries (United State, United Kingdom, Spain, Germany, Canada, and India) out of 22 account for 56.6% of Scopus publications. As seen from that research, most of the leading countries in producing Scopus publications on Open Access topics are also leaders in the number of OA-repositories and OA-journals (Tables 1, 2).

In addition to the data in Table 1, Table 3 provides the data on the number of repositories and OAI-PMH Compliant Repositories from Roy et al. (2013). These data consolidate OA-repositories from OpenDOAR and ROAR. For each OA-repository in the Detail Record of these registers, there are labels "OA-PMH URL" (for OpenDOAR) and "OAI-PMH Interface" (for ROAR).

As Table 3 shows, the largest share of more advanced OAI-PMH (Open Archiving Initiative Protocol for Metadata Harvesting) Compliant Repositories can be found in Canada, Taiwan and Italy. As the data for comparison, Table 3 shows the figures from Das (2014) by the number of OA-repositories listed in OpenDOAR and ROAR as of March 11, 2013.

We managed to collect the data from four different sources on the continental distribution of OA-repositories, OA-journals and OA-policies in OA-registers. Three sources gave data for 2012 and one for 2017 (Table 4).

The analysis of these data shows that the largest increase in the number of OA-repositories in OpenDOAR over four and a half years occurred in Africa (2.77 times), which is more than the world increase over this period of time (1.57 times). However, their absolute value is still very low in comparison with all the major continents. The ratio between OA-repositories in ROAR and OA-policies in ROARMAP in 2012 was the worst in Asia (484/27 = 17.93) (the world average was 2406/429 = 5.61). The number of OA-repositories in ROAR exceeded their number in OpenDOAR in 2012 by 9.4%, while the largest excess was in Oceania and South America. Table 4 shows that there are more OA-repositories in Europe than in other territories.

Ocholla and Ocholla (2016) highlight the importance of research on the involvement of African countries in the OA-movement. They studied the development of Open Access initiatives in Africa, presenting the OpenDOAR structure by member countries and continents and proving the benefits of Open Access to scientific publications for the development of society, especially for higher education and science. "Out of 2993 repositories reported by DOAR worldwide in 2016, Africa repositories accounted for less than 4.4%. For example, Europe accounted for 44.2%, Asia 20%, North America 19.1%, and South America 8.9%" (Ocholla & Ocholla, 2016, p. 189).

Roy, Biswas, and Mukhopadhyay (2016) determined the distribution of agricultural OA-repositories in OpenDOAR by continents and countries. According to the study performed in 2015, "the database

Table 4
Worldwide ROAR, ROARMAP and DOAJ.[a]

Continents	ROAR[a,b]	ROARMAP[a]	OpenDOAR[c]	OpenDOAR[d]	DOAJ[e]
Africa	58	10	56	155	477
Asia	484	27	386	701	1477
Europe	1041	235	1040	1558	3165
North America	522	103	468 + 14[f]	614 + 38[g]	1749
Oceania	82	34	59	70	243
South America	219	16	166	308	1407
International	–	4	11	2	–
Total	2406	429	2200	3446	8518

[a] Salager-Meyer (2012) [03/09/12].
[b] In Salager-Meyer (2012), they mistakenly use DOAR instead of ROAR, as referred to URL: http://roarmap.eprints.org/.
[c] Roy, Biswas, and Mukhopadhyay (2012b) [05/09/12].
[d] Bashir, Mir, and Sofi (2019) [May, 2017].
[e] Pandita (2013) [10/12/12].
[f] Caribbean countries.
[g] Caribbean countries (19) and Central America (19).

OpenDOAR (Directory of Open Access Repositories) has recorded 2728 repositories, out of which 122 (4%) repositories are from Agriculture, Food and Veterinary" (Roy et al., 2016, p. 2). Europe contributes 45 repositories (36.9%), which is the largest part of the continental OpenDOAR database. That study made it possible to conclude that it was necessary to rank OA-repositories by a number of indicators that reflect their influence, location, and a current status at the state, national and global levels.

In addition to the country and continental distribution of OA-repositories, we present their global estimates. Pinfield et al. (2014), when studying one of the rapidly developing OpenDOAR open data warehouses, found the following: from 2005 to 2012, the number of OA repositories increased from 128 to 2253. Roy et al. (2012b) indicate approximately the same number (Table 4). For the same seven-year time interval, Salager-Meyer (2012) studied the dynamics of replenishing the DOAJ and ROAR registries. The number of journals registered in the Directory of Open Access Journals (DOAJ) increased rapidly "from 1400 titles in early 2005 to 5138 as of June 2010, 7500 titles as of March 2012 and 8098 in September 2012" (Salager-Meyer, 2012, p. 62). Pandita (2013) examined the annual dynamics of DOAJ replenishing over a longer time interval (2002−2012), showing a surge in the number of OA-journals in 2003 (2002 – 34, 2003 – 552, 2012 – 8518 OA-journals). All this data were provided at the end of the year. A similar situation was observed with the Registry of Open Access Repositories (ROAR): in "2007, there were 830 repositories worldwide; in 2009 that number jumped to 1300 (about 250 new ones per year), and in September 2012, their number reached 2406" (Salager-Meyer, 2012, p. 62). Arlitsch and Grant (2018) give the more recent related data taken from the sites of OA-registries, according to their replenishing rate: ROAR, November 24, 2017 – 4585 OA-repositories; OpenDOAR, November 23, 2017 – 3448 OA-repositories.

The analysis of all data above on the replenishing of ROAR and OpenDOAR shows the excess of records in the former compared to the latter. We find an explanation for this in the literature: according to Arlitsch and Grant (2018), that "ROAR's number are potentially inflated as a results of its automated harvesting model, which" tends to pick up a significant number of invalid sites, including implementations that have few records or those with metadata-only entries" (Pinfield et al., 2014)" (Arlitsch & Grant, 2018, p. 267). Our regular monitoring of Russian OA-repositories also shows that many repositories in ROAR have several duplicate records with incomplete data. Unlike ROAR, OpenDOAR controls submission of materials. We agree that "OpenDOAR has been identified as a key resource for the Open Access community and identified as the leader in repository directories in a study by Johns Hopkins University" (Okpala, 2017, p. 12). Besides, OpenDOAR has been also selected as the main register for OA-repositories in Plan S (launched on September 4, 2018 and aiming at abandoning the subscription business model with the transition to the OA business model).

In addition to research that study the country, continental and global distribution of OA-instruments, we would like to mention a number of regional studies on the involvement of developing countries in the Open Access movement.

A great number of papers have been published on the study of the OA-movement in Asian countries. Singh and Chikate (2014) analyze the growth in the number of OA-journals in LIS (Library and Information Science) with a focus on Asian countries and claim that OA removes the existing limitations on access to scientific information and knowledge, providing readers with the opportunity to use relevant literature in their own research and authors with good visibility of their papers, substantial readership and good standing in the scientific community. The global prospects for the OpenDOAR-based development of Open Access in Asia were also investigated in Wani et al. (2009).

An extensive report on the development of country involvement in the international Open Access movement was presented by COAR (Confederation of Open Access Repositories), which studied 16 respondents in the Asian region (Bangladesh, China, Hong Kong, India, Indonesia, Japan, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, South Korea, Taiwan, and Thailand) (Asian Open Access: Regional Survey, 2017). The responses regarding the presence of OA-policies, OA-communities and centralized support for OA from that report showed that 42 countries responded positively and 22 countries responded negatively.

Kenneway (2011) carried out a similar but broader survey. He studied the attitudes of authors to Open Access. The analysis of 2568 responses from 10 countries (Mexico, Brasil, Spain, Iran, Italy, Turkey, China, United State, Japan, and India) showed that most of the authors were positive about OA: over 80% of the respondents thought that OA was very important in such countries as Mexico, Brazil, Spain, and Iran.

The analysis in Fukuzawa (2017) "included publications from 77 countries from 2010 to 2012. This analysis included 19,530 journals and 3,215,742 papers without duplication from DOAJ. The results showed that papers published in OA and international journals were cited in more countries than non-OA and domestic journals, and a higher percentage of these were being cited by foreign countries" (Fukuzawa, 2017, p. 1007). Some of the data obtained by Fukuzawa (2017) and the total number of OA-papers counted for the purpose of present paper exceeding 25% of the total number of publications are shown in Table 5.

The obtained results (Table 5) show that the countries with the low-income countries are more eager to implement Open Access in full. Iyandemye and Thomas (2019) received the same result based on the biomedical research database (PubMed, data for the entire 2015): "While the vast majority of open access repositories and funding organization with open access policies are based in high countries, the geographical patterns of open access publications are not well characterized. Surprisingly, we found a strong negative correlation between country per capita income and the percentage of open access publications" (Iyandemye & Thomas, 2019). They indicate that the OA-publication rates were particularly high in Sub-Saharan Africa. This is a very important result, which was also obtained according to studing OA-publications of scientists from 77 countries (Fukuzawa, 2017), and it requires a further discussion.

Iyandemye and Thomas (2019) believe that there is a joint influence of such factors as: 1. Academics in low income countries struggle to again access to full canon of research publications and this motivates them to make their articles freely available to other researchers; 2. Widespread practice of research collaboration with foreign scientists from developed countries in biomedical research; 3. Large OA-publication fee waivers are offered to authors from low-income countries. We may agree with these arguments of researchers from Rwanda, except for one. Namely, in the new conditions of Open Access, no one is now struggling to get access to full canon of research articles, as Google Scholar and Sci-Hub together are working together to solve this problem now. Concerning Sci-Hub, the very article headings by Bohannon (2016) and Himmelstein et al. (2018) speak volumes about it. In our opinion, the most important thing here is that researchers in low-income countries, whose publications are poorly cited and often ignored by western researchers are strongly motivated to publish their articles on various Open Access platforms and in OA-journals.

The present review shows that a lot of scattered quantitative data on the involvement of countries in the Open Access movement have been accumulated so far, which makes it imperative to arrange these data in a more systematic way and propose a methodology for calculating the integral indicator of countries' involvement in OA-movement.

Methods

Moskovkin et al. (2018) conducted a study of the involvement of countries in the international Open Access movement, identifying 8 key quantitative indicators for the year of 2017 and developed a methodology for calculating the index of countries' involvement in this movement.

Table 5
Number of Papers and Ratio of International non-OA, Domestic non-OA, International OA, Domestic OA in Each Journal categories for 11 countries with total number of OA-Papers ≥ 25% (average values for 2010–2012).[a]

Countries	Total no. of papers	International non-OA, %	Domestic non-OA, %	International OA, %	Domestic OA, %	Total no. of OA-Papers[b]
Jamaica	283	60.0	1.1	12.0	26.9	38.9
Bosnia and Herzegovina	426	51.1	13.5	27.2	8.2	35.4
Iraq	689	63.5	3.9	29.5	3.0	32.5
Croatia	3420	63.3	6.0	13.0	17.7	30.7
Malaysia	10,824	62.3	7.7	25.5	4.5	30.0
Libyan Arab Jamahiriya	230	63.2	8.6	25.5	2.8	28.3
Morocco	1758	70.1	1.9	26.2	1.8	28.0
Nigeria	4498	59.5	12.8	26.5	1.2	27.7
Ethiopia	882	65.8	7.1	26.5	0.7	27.2
Kenya	1537	71.5	2.5	25.9	0.1	26.0
Brazil	31,104	73.5	1.4	10.6	14.5	25.1

[a] Fukuzawa (2017).
[b] Calculated by the authors of the present paper.

- The largest Open Access initiatives: Berlin Declaration, Budapest Open Access Initiative and OA2020 Initiative,
- the main Open Access instruments are the following international registers: ROAR, OpenDOAR, DOAJ, SHERPA/RoMEO, SHERPA/Juliet, ROARMAP and Webometrics for OA-repositories.

Webometrics ranking for OA-Repositories was discontinued some years ago (in 2018), and has been recently resumed, though it looks incomplete, and a new format is not quite convenient for the country analysis; therefore in our study, the corresponding country-specific quantitative indicator was replaced by the OpenDOAR country-specific quantitative indicator, which was recommended as the main OA-repositories register in Plan S. In 2018, OA2020 Initiative (the initiative to replace the journal subscription business model in the European Union countries after 2020, accelerating the transition to open access for publications) was launched, but it has not yet gained many signatories, so in our new study we decided to use the index of countries' involvement in OA-movement of Budapest Open Access Initiative for calculations. We did not include any entries from SHERPA/Juliet register in calculation of this index either, since ROARMAP records all the major Open Access policies for research funding organizations.

Table 6 shows the structure of indicators for this index for two our studies.

Table 6
Quantitative indicators of countries' involvement in the international Open Access movement: their groups, indicators in groups, symbols and weights.

Group	Indications in groups			Weight
	2017	2019	Symbols	
OA-Repositories and OA-Journals	Number of OA-Repositories listed in Webometrics	Number of OA-Repositories listed in Open DOAR	I_1	1/4
	Number of OA-Journals, listed in DOAJ	Number of OA-Journals, listed in DOAJ	I_2	1/4
OA-Policies	Number of publishing OA-Policies on self-archiving and copyright in SHERRA/ROMEO	Number of publishing OA-Policies on self-archiving and copyright in SHERRA/ROMEO	I_3	1/6
	Number of institutional OA-mandates in ROAR MAP	Number of institutional OA-mandates in ROAR MAP	I_4	1/6
OA-Initiatives	Number of institutional signatories to the Budapest Initiative	Number of institutional signatories to the Budapest Initiative	I_5	1/12
	Number of institutional signatories to the Berlin Declaration	Number of institutional signatories to the Berlin Declaration	I_6	1/12

When distributing weights among six indicators, we took into account the following considerations. We chose groups with homogeneous indicators (OA-Repositories & OA-Journals, OA-Policies, OA-Initiative), so the indicators of one group had the same weights. The significance of the groups themselves (the total weight for each group) was assumed to increase with the same step (1/6) from more weighty groups to less weighty ones: group 1 with a weight equal to 1/2, each of its indicators has a weight of 1/4; group 2 with a weight equal to 1/3, each of its indicators has a weight of 1/6; group 3 with a weight of 1/6, each of its indicators has a weight of 1/12 as Table 6 shows. The sum of a group's weights was equal to one ($1/2 + 1/3 + 1/6 = 1$).

In Introduction we noted that OA-Repositories and OA-Journals are the most important tools for the OA-movement. In this regard, we must add that they have a direct effect on increasing the publication activity and research citations. Indeed, the creation of OA-Journals increase publication activity in a country, as well as improves the visibility of publications, and, consequently, their citations. At the same time, OA-Repositories improve the visibility and citations of publications. OA-Policies, through their mandates, promote and, in some cases, oblige to post publications in Open Access, that is, to place them in OA-Repositories and publish in OA-Journals. We gave a little less weight to such policies. OA-Initiatives are advisory and image-based, so we gave them the minimum weight.

When we distributed the groups of indicators in order of their decreasing importance, we concluded that the easiest way was to give them decreasing weights with the same step. Otherwise, the solution to this problem by paired or sequential comparison methods would be complicated as it would require the involvement of a large number of experts, whose opinions are always subjective. Usually, when it is required to construct an integral indicator from specific indicators, for which it is difficult to estimate significance of their weights, the same weights are applied.

To make the values of dissimilar indicators comparable and varied in the range from 0 to 1, we used the normalization procedure, which consisted in dividing the values of these indicators by the maximum number in the sample. All this allowed us to write the integral indicator (or index) of countries' involvement in the international Open Access movement in the following form (Moskovkin et al., 2018):

$$I_{OA} = \frac{1}{4} \times \left(\frac{I_1}{I_{1max}} + \frac{I_2}{I_{2max}} \right) + \frac{1}{6} \times \left(\frac{I_3}{I_{3max}} + \frac{I_4}{I_{4max}} \right) + \frac{1}{12} \times \left(\frac{I_5}{I_{5max}} + \frac{I_6}{I_{6max}} \right) \quad (1)$$

where $I_{i\ \max}$ – maximum value for i indicator across the whole sample of countries.

The value of integral indicator in formula (1) varies in the range from 0 to 1, so as the values of the indicators themselves.

The updated data on the quantitative indicators of the involvement of countries in the Open Access movement were collected from 5 to 9

June 2019 (*See* Appendix). In this Appendix, we calculated total records (N) for nine OA-registries in addition to the calculation of integral indicator *Ioa*, using formula (1) based on the records in six OA-registries. We added ROAR, SHERPA/Juliet, OA2020 Initiative to the basic six registers OpenDOAR, DOAJ, SHERPA/RoMEO, ROARMAP, Berlin Declaration, and Budapest OA-Initiative. After their normalization, the resulting indicator N′ was correlated with the integral indicator I_{OA}. In this case, we used linear regression analysis in Excel.

Results

In Appendix, the countries are ranked in I_{OA} (2019) and it shows that the number of the countries participating in the international Open Access movement increased from 133 in 2017 (Moskovkin et al., 2018) to about 170 in 2019.

The two-year dynamics of the indicators of the involvement of the first 25 countries in OA- movement as of June 2019 is shown in Table 7. The Table also includes the growth rate of the indicators under study for this period. In Table 7, the countries are ranked according to Total *N* (2019) (See Appendix). Among them, thirteen countries are developed ones. Among the developing countries, the top ten include Indonesia, Brazil, and Turkey. In general, we can say that developed and all other countries (developing countries and countries with transition economies) have parity in the degree of involvement in the OA-movement.

The Table 7 shows the steady growth trend for the indicators of the largest OA-initiatives and registries, which existed both in 2017 and in 2019.

In 2019, 20% of the participating countries (34 countries) accounted for 85.5% of the total number of OA-initiatives and OA-instruments, which slightly exceeds 80% of the Pareto law, which states that 80% of effects come from 20% of the cause.

The leaders in the OA movement are the United States and the United Kingdom, accounting for over 20% of OA-Repositories registered in each of the registers, and for about 17% of OA-Journals registered in DOAJ. The top-20 of the countries in terms of their participation in Open Access registries remains stable.

The data in the Appendix shows that 47 countries (28.3%) have no OA-journals registered in DOAJ, and 30 countries (18.1%) have no OA-repositories listed in both ROAR and Open DOAR registers. The first two countries in the ranked group, United States and United Kingdom account for 20.6% of all OA-initiatives and OA-instruments (or 20.6% of all the records in OA-registers).

Based on Table 7, the first Top-5 groups were obtained according to their involvement in the Open Access movement in 2019 (Table 8).

In this Table, we can see such developing countries as Indonesia, Brasil, India, and Turkey, which have done a great job of integrating into the international OA-movement. Indonesia has achieved outstanding success among these countries in creating OA-journals, which, as we stated in Introduction, helped it force India in 2017 out of the top five by this indicator. Thanks to the value of just this indicator, Indonesia was able to take the third place in the integral indicators *N* and I_{OA} (See Appendix). We assume that this is due to a large number of universities in this country, which accounted to 2694 as of July 2020, according to Webometrics.

According to the data in Table 8, the frequencies of the countries entering the first Top-5's according to the above indicators were obtained (Table 9). The USA, Great Britain, Germany, and Spain showed the best results here. The first three countries from this list by the values of the integral indicator I_{OA} (2019) were simultaneously included in four groups of OA-registers.

The top five countries with maximum growth indicators (or records in OA-registries) determined in Table 7 are shown in Table 10.

Unlike Table 8, it doesn't include any countries entering more than 50% of the groups. Indonesia, Switzerland, France, and Russia entered 3 groups out of 7, and 2 groups out of 7 included Netherlands, Turkey, Ukraine, Iran, Colombia, Romania, and Poland. These calculations show that the developing countries and countries with transition economies have great potential for involvement in the OA-movement.

Based on Formula (1), we calculated the index for reflecting the degree of countries' involvement in the OA-movement (I_{OA}) in 2019. Also for a comparable analysis, we calculated the same index for 2017, taking into account the number of OA-repositories listed in Open DOAR rather than the number of OA-repositories ranked in Webometrics (Moskovkin et al., 2018). The results of this calculation are shown in the Appendix, in which there is also information for each country concerning a total of all the nine indicators (*N*), normalized to the maximum value for the entire sample of the countries, which is in this case equal to the United States' indicator ($N' = N/N_{max}$). In the Appendix, the countries are ranked by their I_{OA} integral indicator in 2019.

The linear regression equations between N' and I_{OA} for the data of 2017 and 2019 are presented in Figs. 1 and 2.

When grouping the indicators of countries' involvement in the OA-movement according to normalized values N' and I_{OA}, with both integral indicators ranging from 0 to 1, we divided the countries into 5 groups with the same step of 0.2 by a degree of their involvement in the OA-movement (Table 11).

As we can see from this Table, most of the countries in the world have a very low degree of involvement in the OA-movement, which requires great efforts from the world scientific community and international inter-governmental organizations for the development of the Open Access movement. Unfortunately, we have not seen any powerful UNESCO initiatives in this regard yet.

Conclusion

In our study, the goal was to conduct a systematic quantitative analysis of Open Access instruments and initiatives and develop a methodology for calculating the involvement of countries in the Open Access movement. In this regard, we identified all the significant OA-instruments and OA-initiatives, which were counted on the basis of records in their OA-registers. Since these OA-registers do not count records on an annual basis, but provide only cumulative data, we studied their retrospective records basing on literature data. The consolidation of these data presented in the summary tables and their analysis led to the following conclusions.

The main OA-registers for OA-instruments were created immediately after the launch of the Budapest OA Initiative (2013), Bethesda Statement on Open Access Publishing (2002) and Berlin Declaration on Open Access to Knowledge in the Science and Humanities (2002) in Southampton University (ROAR, ROARMAP), Nottingham University (OpenDOAR, SHERPA/RoMEO), and Lund University (DOAJ) in 2002–2005.

For the period from May 2006 to June 2017, we revealed the dynamics of the leading countries by the number of OA-repositories in OpenDOAR, and their largest growth was observed in Japan and Italy. In addition, we identified a surge in the number of OA-repositories between May and December 2006.

We revealed a systematic excess of records in ROAR in comparison with those in OpenDOAR, which is due to automatic data collection in the former, which in turn leads to a large number of erroneous and duplicate records with incomplete data. We assumed that this circumstance was the main reason for selecting OpenDOAR as the main register in the OA2020 Initiative, that is, in Plan S.

For the period from the end of 2012 to September 2018, we revealed the dynamics of the leading countries by the number of OA-journals in DOAJ, and their largest increase was observed in Brazil and Spain. It was shown that immediately after the DOAJ revision in 2016 with the exclusion of about a half of Indian journals from it, India's place in the top five countries by the number of OA-journals was taken by Indonesia. We account this phenomenon for a huge number of universities in this country (2694 in total, according to Webometrics, as of July 2020).

The analysis of the distributions of OA-repositories in OpenDOAR over 4.5 years (September 2012–May 2017) by continents showed that

Table 7
Dynamics of the indicators of the involvement of country-participants in IOA movement.

№	Country	SHERPA/RoMEO			DOAJ			ROAR			Open DOAR			ROARMAP			Berlin declaration			Budapest Open Access initiative			Webometrics, OA-repositories, 2017	SHERPA Juliet, 2019	OA2020 initiative, 2019
		2017	2019	Growth %	2017	2019	Growth %	2017	2019	Growth %	2017	2019	Growth %	2017	2019	Growth %	2017	2019	Growth %	2017	2019	Growth %			
1.	United States	558	576	3.23	544	708	30.15	808	844	4.46	498	575	15.46	137	143	4.38	37	37	0	90	131	45.56	391	16	16
2.	United Kingdom	280	314	12.14	886	1554	75.40	258	257	−0.39	252	284	12.70	120	120	0	1	1	0	44	44	0	141	64	2
3.	Indonesia	28	29	3.57	613	1508	146.00	111	133	19.82	62	99	59.68	16	20	25.00	1	1	0	18	20	11.11	69	0	0
4.	Brazil	67	69	2.99	987	1390	40.83	158	170	7.59	92	110	19.57	20	25	25.00	1	1	0	9	10	11.11	52	0	1
5.	Spain	93	96	3.23	539	722	33.95	178	185	3.93	125	146	16.80	38	39	2.63	52	61	17.31	38	39	2.63	67	4	4
6.	Germany	96	101	5.21	262	271	3.44	239	250	4.60	195	237	21.54	58	75	29.31	98	116	18.37	33	39	18.18	116	4	28
7.	Poland	29	31	6.90	449	596	32.74	120	121	0.83	92	107	16.30	3	7	133.33	0	1	100	5	7	40.00	32	0	1
8.	Italy	47	51	8.51	282	374	32.62	93	95	2.15	110	139	26.36	23	28	21.74	83	84	1.20	20	22	10.00	53	3	4
9.	India	118	124	5.08	233	277	18.88	118	121	2.54	76	86	13.16	16	17	6.25	3	3	0	98	107	9.18	39	1	2
10.	Turkey	28	28	0	203	379	86.70	62	67	8.06	75	91	21.33	45	54	20.00	0	0	0	55	83	50.91	31	0	1
11.	France	45	50	11.11	191	218	14.14	96	98	2.08	119	141	18.49	23	23	0	23	24	4.35	13	21	61.54	115	5	0
12.	Iran	17	18	5.88	290	503	73.45	9	15	66.67	10	17	70.00	0	0	0	0	0	0	11	10	−9.09	4	0	0
13.	Colombia	31	32	3.23	255	350	37.25	65	82	26.15	44	69	56.82	5	6	20.00	1	1	0	16	18	12.50	43	0	0
14.	Japan	19	19	0	18	31	72.22	228	231	1.32	211	235	11.37	6	15	150.00	0	0	0	21	21	0	276	1	2
15.	Russian Federation	31	43	38.71	187	342	82.89	61	65	6.56	28	35	25.00	6	8	33.33	1	2	100.00	46	52	13.04	23	0	3
16.	Ukraine	19	19	0	81	231	185.19	94	103	9.57	75	93	24.00	15	20	33.33	3	3	0	32	35	9.38	54	0	0
17.	Canada	75	77	2.67	122	154	26.23	96	96	0	81	87	7.41	27	28	3.70	13	13	0	26	25	−3.85	48	14	0
18.	Switzerland	28	31	10.71	257	303	17.90	19	19	0	18	24	33.33	10	18	80.00	27	30	11.11	4	6	50.00	11	4	4
19.	Portugal	129	172	33.33	77	98	27.27	59	61	3.39	55	58	5.45	22	27	22.73	7	7	0	5	4	−20.00	35	1	2
20.	Netherlands	23	26	13.04	178	220	23.60	44	46	4.55	35	65	85.71	12	12	0	20	20	0	6	8	33.33	15	1	7
21.	Romania	26	27	3.85	286	337	17.83	13	15	15.38	3	5	66.67	1	1	0	1	1	0	9	10	11.11	2	0	0
22.	Argentina	17	17	0	145	232	60.00	49	57	16.33	41	54	31.71	5	7	40.00	0	0	0	9	9	0	22	0	0
23.	Australia	44	46	4.55	83	102	22.89	86	83	−3.49	57	86	50.88	33	33	0.00	0	0	0	9	8	−11.11	51	2	1
24.	China	10	10	0	71	133	87.32	92	92	0	39	42	7.69	4	4	0	2	2	0	11	12	9.09	31	2	19
25.	Norway	51	51	0	57	100	75.44	59	59	0	53	55	3.77	10	11	10.00	5	5	0	0	0	0	9	1	9

*2017 – data collected from 24 to 26 June 2017.
**2019 – data collected from 5 to 9 June 2019.

Table 8
First five-country groups with most numbers of records in OA registries.

N⁰	Country	Indicator	N⁰	Country	Indicator	N⁰	Country	Indicator
SHERPA/RoMEO			DOAJ			ROAR		
1.	United States	576	1.	United Kingdom	1554	1.	United States	844
2.	United Kingdom	314	2.	Indonesia	1508	2.	United Kingdom	257
3.	Portugal	172	3.	Brazil	1390	3.	Germany	250
4.	India	124	4.	Spain	722	4.	Japan	231
5.	Germany	101	5.	United States	708	5.	Spain	185
Open DOAR			ROARMAP			Berlin Declaration		
1.	United States	575	1.	United States	143	1.	Germany	116
2.	United Kingdom	284	2.	United Kingdom	120	2.	Italy	84
3.	Germany	237	3.	Germany	75	3.	Spain	61
4.	Japan	235	4.	Turkey	54	4.	United States	37
5.	Spain	146	5.	Spain	39	5.	Switzerland	30
Budapest Open Access Initiative			SHERPA Juliet			OA2020 Initiative		
1.	United States	131	1.	United Kingdom	64	1.	Germany	28
2.	India	107	2.	United States	16	2.	China	19
3.	Turkey	83	3.	Canada	14	3.	United States	16
4.	Russian Federation	52	4.	Ireland France Belgium	6	4.	Norway	9
5.	United Kingdom	44	5.	Sweden	by 5	5.	Netherlands	7

Table 9
Frequency of countries entering nine groups from OA registries.

Country	Number of country's entries into top-5
United States	9 out of 9
United Kingdom	7 out of 9
Germany	6 out of 9
Spain	5 out of 9
India, Japan, Turkey	2 out of 9
Portugal, Indonesia, China, Russian Federation, Canada, France, Norway, Netherlands, Brazil, Italy, Switzerland, Sweden, Belgium	1 out of 9

their largest increase occurred in Africa, with a relatively small number of them at the end of the period under review.

Based on our processing of the data from a comprehensive Japanese study (Fukuzawa, 2017), we concluded that scientists from low-income countries are more motivated to publish their articles in Open Access journals or platforms than scientists from high-income countries. The research results of the scientists from Rwanda (Iyandemye & Thomas, 2019) also confirm our conclusion.

Our research on the development and approbation of methodology for calculating the index of countries' involvement in the OA-movement led to the following conclusions:

1. We substantiated in detail the methodology for calculating the integral indicator of countries' involvement in the OA-movement with the identification of six basic OA-registers.

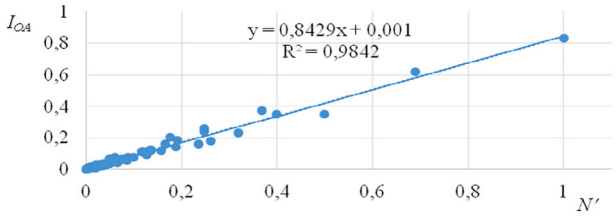

Fig. 1. Linear regression equation between N' and I_{OA} in 2017.

Table 10
First five-country groups with maximum increase in the numbers of record in OA-registers.

N⁰	Country	Growth %	N⁰	Country	Growth %	N⁰	Country	Growth %
SHERPA/RoMEO			DOAJ			ROAR		
1.	Russian Federation	38.71	1.	Ukraine	185.19	1.	Iran	66.67
2.	Portugal	33.33	2.	Indonesia	146.00	2.	Colombia	26.15
3.	Netherlands	13.04	3.	China	87.32	3.	Indonesia	19.82
4.	United Kingdom	12.14	4.	Turkey	86.70	4.	Argentina	16.33
5.	France	11.11	5.	Russian Federation	82.89	5	Romania	15.38
Open DOAR			ROARMAP			BerlinDeclaration		
1.	Netherlands	85.71	1.	Japan	150.00	1.	Russian Federation	100.00
2.	Iran	70.00	2.	Poland	133.33	2.	Germany	18.37
3.	Romania	66.67	3.	Switzerland	80.00	3.	Spain	17.31
4.	Indonesia	59.68	4.	Argentina	40.00	4.	Switzerland	11.11
5	Colombia	56.82	5.	Russian Federation Ukraine	33.33	5.	France	4.35
BudapestOpenAccessInitiative								
1.	France	61.54						
2.	Turkey	50.91						
3.	Switzerland	50.00						
4.	United States	45.56						
5.	Poland	40.00						

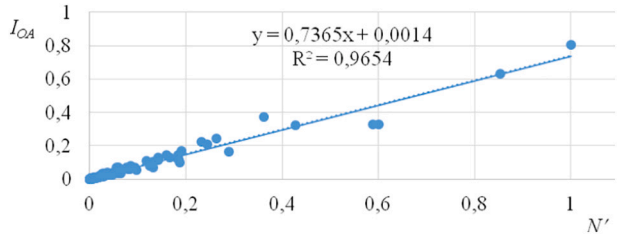

Fig. 2. Linear regression equation between N' and I_{OA} in 2019.

Table 11
Grouping of Country-participants in OA-Movement in 2019 by Variation Intervals of Integral Indicators N' and I_{OA}.

Degree of involvement in the OA-movement	Variation interval	N'	I_{OA}
Very strong	0.8–1	United States, United Kingdom	United States
Strong	0.6–0.8	–	United Kingdom
Middle	0.4–0.6	Indonesia, Brazil, Spain	–
Low	0.2–0.4	Germany, Poland, Italy, India, Turkey	Germany, Indonesia, Brazil, Spain, Italy, Turkey, India
Very low	0–0.2	Participants 11–168	Participants 10–168

2. We applied this methodology to all the countries of the world that have at least one non-zero record in at least one OA-register. The calculations performed for the June 2019 level in comparison with our previous calculations two years ago showed an increase in the number of countries involved in the OA-movement during this period from 133 to 170.
3. We identified the top five countries by the number of records in these registers and their increments for all OA-registers. They include developed countries (USA, UK, Germany, etc.), developing countries (Indonesia, Brasil, India, Turkey, etc.), and countries with transition economies (Russia, Ukraine, Poland, etc.).
4. The selection of the first 25 countries in the world by the total number of records in OA-registers showed that developed countries, on the one hand, and developing countries and countries with transition economies, on the other hand, are approximately on par in terms of their involvement degree in the OA-movement.
5. We obtained a linear regression relationship between the normalized number of total records for all OA-registers (N') and the integral indicator of countries' involvement in the OA-movement (I_{OA}), which can be used in simplified express calculations of the countries' ranking in various regional groupings by degree of their involvement in the OA-movement.
6. We proposed a 5-level proportionate classification scale for two integral indicators (N' and I_{OA}), varying in the range from 0 to 1, which made it possible to classify all the countries in the world according to the degree of their involvement in the OA-movement. The United States and the United Kingdom take the lead here, accounting for more than 20% of all the OA-instruments and OA-initiatives.
7. The methodology for assessing the level of countries' involvement in the Open Access movement can be used in the future when developing a global strategy for the development of the international Open Access movement. Such strategies should be based on an annual construction of tables similar to those in Appendix. Their comparative analysis within the framework of the benchmarking procedure with the selection of target (leading) countries makes it possible to develop strategies for achieving these countries' targets by lagging countries.

The benchmarking tables show clearly how much you need to increase the number of records in certain OA-registers in order to achieve the targets of the leading countries. The same calculations can be carried out by the integral indicator of countries' involvement in the OA-movement. Such strategies can be built at regional levels as well. Strategies similar to that of the European Innovation Policy have been developed since the early 21st century within the framework of the European Innovation Scoreboard. By analogy with this scoreboard, the benchmarking tables we offer can be called the International OA-movement Scoreboard.

Author statement

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Appendix A. Involvement of countries into the Open Access movement.

№	Country	OA-repositories & OA-Journals			OA-Policy			OA-Initiative			Total (N), 2019	N'	I_{OA} 2019	I_{OA}, 2017
		ROAR	OpenDOAR	DOAJ	SHERPA/ RoMEO	ROARMAP	SHERPA Juliet	Berlin Declaration	Budapest Open Access initiative	OA2020 initiative				
	N max	844	575	1554	576	143	64	116	131	28				
1.	United States	844	575	708	576	143	16	37	131	16	3046	1	0.8071	0.8291
2.	United Kingdom	257	284	1554	314	120	64	1	44	2	2640	0.8667	0.6329	0.5825
3.	Germany	250	237	271	101	75	4	116	39	28	1121	0.3680	0.3714	0.3512
4.	Indonesia	133	99	1508	29	20	0	1	20	0	1810	0.5942	0.3308	0.2434
5.	Brazil	170	110	1390	69	25	0	1	10	1	1776	0.5831	0.3276	0.3361
6.	Spain	185	146	722	96	39	4	61	39	4	1296	0.4255	0.3215	0.3299
7.	Italy	95	139	374	51	28	3	84	22	4	800	0.2626	0.2423	0.2349
8.	Turkey	67	91	379	28	54	0	0	83	1	703	0.2308	0.2244	0.1811
9.	India	121	86	277	124	17	1	3	107	2	738	0.2423	0.2079	0.2245
10.	France	98	141	218	50	23	5	24	21	0	580	0.1904	0.1682	0.1939
11.	Poland	121	107	596	31	7	0	1	7	1	871	0.2859	0.1647	0.1508

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(*continued*)

№	Country	OA-repositories & OA-Journals			OA-Policy			OA-Initiative			Total (N), 2019	N'	I_{OA} 2019	I_{OA}, 2017
		ROAR	OpenDOAR	DOAJ	SHERPA/ RoMEO	ROARMAP	SHERPA Juliet	Berlin Declaration	Budapest Open Access initiative	OA2020 initiative				
12.	Japan	231	235	31	19	15	1	0	21	2	555	0.1822	0.1435	0.2119
13.	Canada	96	87	154	77	28	14	13	25	0	494	0.1622	0.1428	0.1500
14.	Ukraine	103	93	231	19	20	0	3	35	0	504	0.1655	0.1308	0.1087
15.	Portugal	61	58	98	172	27	1	7	4	2	430	0.1412	0.1298	0.1174
16.	Russian Federation	65	35	342	43	8	0	2	52	3	550	0.1806	0.1265	0.1186
17.	Colombia	82	69	350	32	6	0	1	18	0	558	0.1832	0.1147	0.1219
18.	Switzerland	19	24	303	31	18	4	30	6	4	439	0.1441	0.1145	0.1190
19.	Australia	83	86	102	46	33	2	0	8	1	361	0.1185	0.1107	0.1146
20.	Netherlands	46	65	220	26	12	1	20	8	7	405	0.1330	0.1046	0.0983
21.	Iran	15	17	503	18	0	0	0	10	0	563	0.1848	0.0999	0.0904
22.	Argentina	57	54	232	17	7	0	0	9	0	376	0.1234	0.0796	0.0696
23.	Croatia	7	117	115	10	2	0	1	6	0	258	0.0847	0.0791	0.0299
24.	Romania	15	5	337	27	1	0	1	10	0	396	0.1300	0.0724	0.0912
25.	Belgium	36	34	41	18	21	5	17	13	0	185	0.0607	0.0715	0.0705
26.	Norway	59	55	100	51	11	1	5	0	9	291	0.0955	0.0712	0.0518
27.	Finland	23	21	30	63	33	1	0	0	1	172	0.0565	0.0706	0.0621
28.	Austria	21	35	53	24	14	1	26	4	3	181	0.0594	0.0682	0.0540
29.	South Africa	47	41	92	18	11	1	21	3	4	238	0.0781	0.0677	0.0633
30.	Serbia	14	21	176	11	11	1	7	0	0	241	0.0791	0.0585	0.0334
31.	Mexico	46	41	130	8	3	0	1	20	0	249	0.0817	0.0580	0.0559
32.	China	92	42	133	10	4	2	2	12	19	316	0.1037	0.0563	0.0567
33.	Sweden	75	47	39	19	12	5	6	2	5	210	0.0689	0.0518	0.0662
34.	Peru	52	64	59	6	8	0	0	5	0	194	0.0637	0.0516	0.0349
35.	Hungary	43	41	38	39	4	2	2	6	1	176	0.0578	0.0451	0.0383
36.	Czech Republic	13	18	111	15	5	0	8	2	3	175	0.0575	0.0429	0.0424
37.	Greece	38	38	41	16	5	0	6	4	2	150	0.0492	0.0404	0.0330
38.	Denmark	17	12	30	27	9	3	7	7	2	114	0.0374	0.0378	0.0381
39.	Korea, Republic of	46	39	101	8	1	0	0	1	4	200	0.0657	0.0373	0.0242
40.	Chile	23	25	119	9	0	0	1	4	2	183	0.0601	0.0359	0.0349
41.	Kenya	22	37	5	1	13	0	4	1	2	85	0.0279	0.0358	0.0154
42.	Taiwan	83	61	34	1	1	0	1	0	0	181	0.0594	0.0342	0.0459
43.	Lithuania	11	14	74	3	11	0	0	1	0	114	0.0374	0.0323	0.0221
44.	Ireland	25	26	20	8	12	6	1	0	0	98	0.0322	0.0315	0.0271
45.	Moldova	11	10	31	2	9	0	1	11	0	75	0.0246	0.0281	0.0252
46.	Ecuador	30	33	56	5	0	0	0	4	0	128	0.0420	0.0273	0.0259
47.	Slovenia	9	11	52	7	8	0	2	1	0	90	0.0295	0.0266	0.0295
48.	Pakistan	5	4	57	14	1	0	1	15	0	97	0.0318	0.0264	0.0243
49.	Malaysia	39	22	69	7	2	0	0	1	0	140	0.0460	0.0257	0.0336
50.	Nigeria	13	27	13	7	1	0	1	12	4	78	0.0256	0.0254	0.0161
51.	Belarus	29	31	9	3	4	0	1	5	0	82	0.0269	0.0244	0.0199
52.	Cuba	11	12	87	9	0	0	1	2	0	122	0.0401	0.0238	0.0164
53.	New Zealand	21	16	21	12	7	1	0	2	0	80	0.0263	0.0232	0.0237
54.	Venezuela	24	16	33	1	4	0	2	6	0	86	0.0282	0.0225	0.0225
55.	Bulgaria	9	9	59	9	1	0	2	4	1	94	0.0309	0.0212	0.0204
56.	Algeria	9	15	22	5	3	0	0	2	0	56	0.0184	0.0163	0.0158
57.	Slovakia	1	2	59	6	1	0	0	3	0	72	0.0236	0.0152	0.0113
58.	Costa Rica	9	6	61	4	0	0	1	1	0	82	0.0269	0.0149	0.0179
59.	Bangladesh	10	14	20	7	0	0	0	4	0	55	0.0181	0.0139	0.0138
60.	Hong Kong	10	5	28	2	4	0	1	1	0	51	0.0167	0.0133	0.0181
61.	Egypt	11	8	34	2	0	0	2	3	0	60	0.0197	0.0129	0.1583
62.	Macedonia	3	5	9	8	0	0	1	8	0	34	0.0112	0.0117	0.0130
63.	Thailand	12	13	29	2	0	0	0	1	0	57	0.0187	0.0115	0.0132
64.	Sri Lanka	2	15	14	2	0	0	3	0	0	36	0.0118	0.0115	0.0090
65.	Iceland	2	3	6	1	5	0	4	0	1	22	0.0072	0.0113	0.0117
66.	Estonia	4	7	22	1	3	0	1	0	1	39	0.0128	0.0111	0.0103
67.	Iraq	2	1	40	3	0	0	1	2	0	49	0.0161	0.0097	0.0081
68.	Singapore	7	5	16	3	3	0	0	0	0	34	0.0112	0.0091	0.0065
69.	Bosnia and Herzegovina	3	2	21	6	0	0	1	3	0	36	0.0118	0.0086	0.0098
70.	Saudi Arabia	9	10	18	0	1	0	0	0	1	39	0.0128	0.0084	0.0071
71.	Ghana	6	5	6	2	1	0	3	2	0	25	0.0082	0.0083	0.0084
72.	Azerbaijan	4	2	8	0	2	0	2	3	0	21	0.0069	0.0078	0.0071
73.	Tanzania	9	13	0	0	1	0	1	0	0	24	0.0079	0.0075	0.0040
74.	Zimbabwe	0	11	1	0	2	0	0	0	0	14	0.0046	0.0073	0
75.	Uruguay	3	4	25	2	0	0	0	1	0	35	0.0115	0.0070	0.0044
76.	Sudan	13	14	1	0	0	0	0	1	0	29	0.0095	0.0069	0.0060
77.	Kazakhstan	7	11	4	1	1	0	0	0	0	24	0.0079	0.0069	0.0062
78.	Georgia	2	3	3	1	0	0	0	7	0	16	0.0053	0.0065	0.0077
79.	Philippines	12	7	9	2	0	0	0	2	0	32	0.0105	0.0063	0.0059

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№	Country	OA-repositories & OA-Journals			OA-Policy			OA-Initiative			Total (N), 2019	N'	I_{OA} 2019	I_{OA}, 2017
		ROAR	OpenDOAR	DOAJ	SHERPA/ RoMEO	ROARMAP	SHERPA Juliet	Berlin Declaration	Budapest Open Access initiative	OA2020 initiative				
80.	Latvia	4	4	11	1	2	0	0	0	0	22	0.0072	0.0061	0.0044
81.	Zimbabwe	11	0	1	0	0	0	7	1	0	20	0.0066	0.0058	0.0106
82.	Uganda	4	9	1	0	0	0	2	0	1	17	0.0056	0.0055	0.0026
83.	United Arab Emirates	0	1	17	3	0	0	0	2	0	23	0.0076	0.0053	0.0021
84.	Cyprus	7	5	4	1	0	0	3	0	0	20	0.0066	0.0053	0.0056
85.	Nicaragua	3	6	6	1	1	0	0	0	0	17	0.0056	0.0050	0.0026
86.	Morocco	4	2	14	1	0	0	1	1	0	23	0.0076	0.0048	0.0052
87.	Nepal	3	1	16	3	0	0	1	0	0	24	0.0079	0.0046	0.0050
88.	Bolivia	3	2	5	1	1	0	0	2	0	14	0.0046	0.0044	0.0049
89.	El Salvador	13	7	3	0	0	0	0	0	0	23	0.0076	0.0035	0
90.	Palestine	0	5	1	0	1	0	0	0	0	7	0.0023	0.0035	0
91.	Ethiopia	3	3	4	0	0	0	2	0	0	12	0.0039	0.0034	0.0034
92.	Luxembourg	2	4	3	0	1	1	0	0	0	11	0.0036	0.0034	0.0006
93.	Armenia	2	2	2	1	0	0	0	3	0	10	0.0033	0.0034	0.0031
94.	Yugoslavia	0	0	0	0	0	0	0	5	0	5	0.0016	0.0032	0
95.	Senegal	2	2	0	1	0	0	0	3	0	8	0.0026	0.0031	0.0028
96.	Israel	1	0	2	2	0	0	2	1	0	8	0.0026	0.0030	0.0036
97.	Tunisia	2	2	5	2	0	0	0	1	0	12	0.0039	0.0029	0.0017
98.	Paraguay	0	1	15	0	0	0	0	0	0	16	0.0053	0.0028	0
99.	Cameroon	1	1	1	0	0	0	3	0	1	7	0.0023	0.0028	0.0028
100.	Albania	1	1	5	3	0	0	0	1	0	11	0.0036	0.0027	0.0031
101.	Dominican Republic	4	4	2	0	0	0	0	1	0	11	0.0036	0.0027	0
102.	Montenegro	0	0	8	2	0	0	1	0	0	11	0.0036	0.0026	0.0016
103.	Namibia	2	2	0	0	0	0	0	2	0	6	0.0020	0.0021	0.0023
104.	Jordan	0	0	5	2	0	0	0	1	0	8	0.0026	0.0020	0.0038
105.	Jamaica	4	4	1	0	0	0	0	0	0	9	0.0030	0.0019	0
106.	Malta	1	1	2	0	1	0	0	0	0	5	0.0016	0.0019	0
107.	Viet Nam	0	1	1	0	1	0	0	0	0	3	0.0010	0.0018	0
108.	Puerto Rico	1	1	4	2	0	0	0	0	0	8	0.0026	0.0017	0.0015
109.	Botswana	3	2	0	0	0	0	0	1	0	6	0.0020	0.0015	0.0015
110.	Lebanon	1	3	1	0	0	0	0	0	0	5	0.0016	0.0015	0.0011
111.	Lesotho	2	2	0	0	0	0	0	1	0	5	0.0016	0.0015	0.0009
112.	Panama	2	2	0	0	0	0	0	1	0	5	0.0016	0.0015	0
113.	Kyrgyzstan	4	2	3	0	0	0	0	0	0	9	0.0030	0.0014	0.0029
114.	Qatar	1	1	4	1	0	0	0	0	1	8	0.0026	0.0014	0.0025
115.	Libya	1	2	3	0	0	0	0	0	0	6	0.0020	0.0014	0.0008
116.	Honduras	1	3	0	0	0	0	0	0	0	4	0.0013	0.0013	0
117.	Vietnam	0	0	0	0	0	0	0	2	0	2	0.0007	0.0013	0.0030
118.	Somalia	0	0	0	0	0	0	0	2	0	2	0.0007	0.0013	0.0009
119.	Guatemala	0	1	3	1	0	0	0	0	0	5	0.0016	0.0012	0.0011
120.	Burundi	0	0	0	0	1	0	0	0	0	1	0.0003	0.0012	0
121.	Oman	0	0	7	0	0	0	0	0	0	7	0.0023	0.0011	0.0005
122.	Yemen	0	0	6	0	0	0	0	0	0	6	0.0020	0.0010	0.0005
123.	Mozambique	2	2	0	0	0	0	0	0	0	4	0.0013	0.0009	0
124.	Fiji	2	2	0	0	0	0	0	0	0	4	0.0013	0.0009	0
125.	Cabo Verde	0	2	0	0	0	0	0	0	0	2	0.0007	0.0009	0
126.	Myanmar	0	2	0	0	0	0	0	0	0	2	0.0007	0.0009	0
127.	Mali	0	0	1	0	0	0	0	1	0	2	0.0007	0.0008	0.0009
128.	Guinea	0	0	0	0	0	0	1	0	0	1	0.0003	0.0007	0.0009
129.	Gambia	0	0	0	0	0	0	1	0	0	1	0.0003	0.0007	0.0009
130.	Rwanda	1	1	1	0	0	0	0	0	0	3	0.0010	0.0006	0.0000
131.	Angola	0	0	2	1	0	0	0	0	0	3	0.0010	0.0006	0.0003
132.	Malawi	1	1	1	0	0	0	0	0	0	3	0.0010	0.0006	0.0000
133.	Martinique Franch	2	0	0	0	0	0	0	1	0	3	0.0010	0.0006	0
134.	Afghanistan	1	0	0	0	0	0	0	1	0	2	0.0007	0.0006	0.0009
135.	Kuwait	0	1	1	0	0	0	0	0	0	2	0.0007	0.0006	0
136.	Burkina Faso	0	0	0	0	0	0	0	1	0	1	0.0003	0.0006	0.0015
137.	Madagascar	0	0	0	0	0	0	0	1	0	1	0.0003	0.0006	0.0011
138.	Liberia	0	0	0	0	0	0	0	1	0	1	0.0003	0.0006	0.0009
139.	Uzbekistan	0	0	0	0	0	0	0	1	0	1	0.0003	0.0006	0.0009
140.	Cote D'Ivoire (Ivory Coast)	0	0	0	0	0	0	0	1	0	1	0.0003	0.0006	0
141.	Suriname	0	0	0	0	0	0	0	1	0	1	0.0003	0.0006	0
142.	Mauritius	0	0	1	1	0	0	0	0	0	2	0.0007	0.0005	0.0006
143.	Turkmenistan	0	0	1	1	0	0	0	0	0	2	0.0007	0.0005	0.0000
144.	Guadeloupe	2	1	0	0	0	0	0	0	0	3	0.0010	0.0004	0
145.	New Caledonia	1	1	0	0	0	0	0	0	0	2	0.0007	0.0004	0
146.	Zambia	0	1	0	0	0	0	0	0	0	1	0.0003	0.0004	0

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N⁰	Country	OA-repositories & OA-Journals			OA-Policy			OA-Initiative			Total (N), 2019	N'	I_{OA} 2019	I_{OA}, 2017
		ROAR	OpenDOAR	DOAJ	SHERPA/ RoMEO	ROARMAP	SHERPA Juliet	Berlin Declaration	Budapest Open Access initiative	OA2020 initiative				
147.	Trinidad and Tobago	0	1	0	0	0	0	0	0	0	1	0.0003	0.0004	0
148.	Lao People's Democratic Republic	0	1	0	0	0	0	0	0	0	1	0.0003	0.0004	0
149.	Northern Mariana Islands	0	1	0	0	0	0	0	0	0	1	0.0003	0.0004	0
150.	Korea, Democratic People's Republic	1	0	0	1	0	0	0	0	0	2	0.0007	0.0003	0.0016
151.	Syria	1	0	0	1	0	0	0	0	0	2	0.0007	0.0003	0.0003
152.	Reunion	0	0	0	1	0	0	0	0	0	1	0.0003	0.0003	0.0003
153.	Bahrain	0	0	0	1	0	0	0	0	0	1	0.0003	0.0003	0.0003
154.	Seychelles	0	0	0	1	0	0	0	0	0	1	0.0003	0.0003	0.0003
155.	Isle of Man	0	0	0	1	0	0	0	0	0	1	0.0003	0.0003	0.0003
156.	Kosovo	0	0	0	1	0	0	0	0	0	1	0.0003	0.0003	0.0003
157.	Palestinian Territories	3	0	0	0	0	0	0	0	0	3	0.0010	0.0000	0.0015
158.	Dominica	2	0	0	0	0	0	0	0	0	2	0.0007	0.0000	0
159.	French Guyana	2	0	0	0	0	0	0	0	0	2	0.0007	0.0000	0
160.	Europe	0	0	0	0	0	0	0	0	2	2	0.0007	0.0000	0
161.	Polynesia French	1	0	0	0	0	0	0	0	0	1	0.0003	0.0000	0
162.	French Southern Territories	1	0	0	0	0	0	0	0	0	1	0.0003	0.0000	0
163.	Samoa	1	0	0	0	0	0	0	0	0	1	0.0003	0.0000	0
164.	USA Minor Outlying Islands	1	0	0	0	0	0	0	0	0	1	0.0003	0.0000	0
165.	Benin	0	0	0	0	0	0	0	0	1	1	0.0003	0.0000	0
166.	Vatican City	0	0	0	0	0	0	0	0	1	1	0.0003	0.0000	0
167.	Cape Verde	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0010
168.	Côte D'Ivoire	0	0	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0009
	Total	4501	4150	13,558	2535	990	150	579	976	151	27,590			

References

Arlitsch, K., & Grant, C. (2018). Why so many repositories? Examining the limitations and possibilities of the institutional repositories landscape. *Journal of Library Administration, 58*(3), 264–281. https://doi.org/10.1080/01930826.2018.1436778

Asian Open Access: Regional Survey. COAR. (2017). Resource document. *https://www.coar-repositories.org/files/Asia-OA-survey-results-June-15-2017.pdf*. (Accessed 17 February 2020).

Bashir, A., Mir, A. A., & Sofi, Z. A. (2019). Global landscape of open access repositories. *Library Philosophy and Practice, 2445*. Available at: https://digitalcommons.unl.edu/libphilprac/2445.

Bohannon, J. (2016). Who's downloading pirated papers? Everyone. *Science, 352*(6285), 508–512 (doi:10.126/science.352.6285.508).

Chatterjee, P., Biswas, T., & Mishra, V. (2013). Open access: The changing face of scientific publishing. *Journal of Family Medicine and Primary Care, 2*(2), 128–130. https://doi.org/10.4103/2249-4863.117400

Costa, M., Amaro, B., & Assis, T. (2012). Serviços de difusão de políticas para o acesso aberto: Sherpa/Juliet, Melibea e ROARMAP. *Encontros Bibli: revista eletrônica de biblioteconomia e ciência da informação, 17*(2), 36–54.

Das, A. K. (2014). Open access to scientific knowledge: Policy perspectives and national initiatives. In *, Vol. Volume 3. India-science and technology* (pp. 292–299). Delhi: Cambridge University Press India.

Frantsvåg, J. E. (2019). The DOAJ spring cleaning 2016 and what was removed — Tragic loss or good riddance? *Publications, 7*(3), 45. https://doi.org/10.3390/publications7030045

Fukuzawa, N. (2017). Characteristics of papers published in journals: An analysis of open access journals, country of publication, and languages used. *Scientometrics, 112*(2), 1007–1023. https://doi.org/10.1007/s11192-017-2414-y

Gumpenberger, C., Ovalle-Perandones, M. A., & Gorraiz, J. (2013). On the impact of gold open access journals. *Scientometrics. Scientometrics, 96*(1), 221–238. https://doi.org/10.1007/s11192-012-0902-7

Himmelstein, D. S., Romero, A. R., Levernier, J. G., Mundo, T. A., McLaughlin, S. R., Tzovaras, B. G., & Creene, C. S. (2018). Sci-hub provides access to nearly all scholarly literature. *eLife, 2018*(7), e32822. https://doi.org/10.7554/eLife.32822.001

Hugar, J. G. (2019). Impact of open access in DOAJ: An analysis. *International Journal of Advanced Library and Information Science, 7*(1), 448–455. https://doi.org/10.23953/cloud.ijalis.399

Iyandemye, J., & Thomas, M. P. (2019). Low income countries have the highest percentages of open access publication: A systematic computational analysis of biomedical literature. *PLoS One, 14*(7), e0220229. https://doi.org/10.1371/journal.pone.0220229

Kenneway, M. (2011). Author attitudes towards open access publishing. TBI communications on behalf of Intech open access Publisher. Resource document. http://www.intechweb.org/public_files/Intech_OA_Apr11.pdf. (Accessed 17 February 2020).

Miguel, S., Tannuri de Oliveira, E. F., & Cabrini Gracio, M. C. (2016). Scientific production on open access: A worldwide Bibliometric analysis in the academic and scientific context. *Publications, 4*(1), 1. https://doi.org/10.3390/publications4010001

Moskovkin, V. M. (2008a). Institutional policies for open access to the results of scientific research. *Scientific and Technical Information Processing, 35*(6), 269–273. https://doi.org/10.3103/S0147688208060075

Moskovkin, V. M. (2008b). Open access hybrid journals. *Scientific and Technical Information Processing, 35*(6), 260–262. https://doi.org/10.3103/S0147688208060051

Moskovkin, V. M., Polukhin, O. N., Sadovski, M. V., Sizyoongo, M., & Shevchenko, O. V. (2018). Quantitative evaluation of involvement of counties in the international open access movement. *The Journal of Social Sciences Research, 4*, 69–76. https://doi.org/10.32861/jssr.spi1.69.76

Ocholla, D. N., & Ocholla, L. (2016). Does open access prevent plagiarism in higher education. *African Journal of Library, Archives and Information Science, 26*(2), 189–202.

Okpala, H. N. (2017). Access tools and services to open access: DOAR, ROAR, SHERPA RoMEO, SPARC AND DOAJ. *Informatics Studies, 4*(3), 5–20.

Oliver, K. B., & Swain, R. (2006). Directories of institutional repositories: Research results & recommendations. In *Paper presented at the 72nd IFLA general conference and council, 20–24 august 2006, Seoul* (pp. 20–24). August https://archive.ifla.org/IV/ifla72/papers/151-Oliver_Swain-en.pdf.

Pandita, R. (2013). Growing trend towards open access publishing at global level: An analysis of directory of open access journals (doaj). *International Research: Journal of Library & Information Science, 3*(3), 562–577.

Pinfield, S., Salter, J., Bath, P. A., Hubbard, B., Millington, P., Anders, J. H., & Hussain, A. (2014). Open access repositories worldwide, 2005–2012: Past growth, current characteristics, and future possibilities. *Journal of the Association for Information Science and Technology, 65*(12), 2404–2421. https://doi.org/10.1002/asi.23131

Roy, B. K., Biswas, S. C., & Mukhopadhyay, P. (2012a). Open access to scholarly information in India: Trends and developments. *International Research: Journal of Library and Information Science, 2*(1), 89–101.

Roy, B. K., Biswas, S. C., & Mukhopadhyay, P. (2012b). *Study of open access repositories: A global perspective. Information-innovation-technology: Creating seamless linkages, 29th Convention & Conference of Society of Information Science (November 26–28, 2012, Silchar)*. Silchar: National Institute of Technology.

Roy, B. K., Biswas, S. C., & Mukhopadhyay, P. (2013). Global visibility of Indian open access institutional digital repositories. *International Research: Journal of Library and Information Science, 3*(1), 182–194.

Roy, B. K., Biswas, S. C., & Mukhopadhyay, P. (February 2016). Status of open access institutional digital repositories in agricultural sciences: A case study of Asia. In *Library Philosophy and Practice, Paper 1329*.

Salager-Meyer, F. (2012). The open access movement or "edemocracy": Its birth, rise, problems and solutions. *Ibérica Revista de la Asociación Europea de Lenguas para Fines Específicos, 24*, 55–73.

Sharma, N. (2020). The journey of DOAJ from 2002 to 2019: The developing supplier of scholarly literature. *Library Philosophy and Practice (e-journal), 4159*. Available at: https://digitalcommons.unl.edu/libphilprac/4159/.

Singh, N., & Chikate, A. (2014). Open access LIS periodicals and digital archives. *The Electronic Library, 32*(5), 710–725.

Wani, Z. A., Gul, S., & Rah, J. A. (2009). Open access repositories: A global perspective with an emphasis on Asia. *Chinese Librarianship: an International Electronic Journal, 29*, 1–13.