Quantitative Evaluation of Involvement of Countries of the World in the International Open Access Movement

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Abstract
The article presents the developed method for the quantitative evaluation of involvement of countries of the world in the international open access movement. It consists in the identification of eight country open access indicators initially connected with the open access initiatives and instruments, their weighing, normalization and aggregation in the form of a weighted average value. In a second more strict approximation the number of indicators has been reduced up to six for the account of discarding the data duplicated in ROAR and Open DOAR. Budapest initiative and Berlin declaration were considered as the OA-initiatives, and data from the international registers DOAJ, SHERPA/RoMEO, ROAR MAP and the Webometrics OA-repositories ranking was considered as the instruments. The calculation is done on the basis of the developed method for 133 countries

Keywords: Open access; Involvement of countries in open access; Budapest initiative; Berlin declaration; ROAR; Open DOAR; DOAJ; SHERPA / RoMEO; ROAR Map; Webometrics.

1. Introduction
A fair number of scientific works are devoted to the problem of movement of the open access to scientific knowledge launched at the turn of the century. In the advanced search “Google Scholar” we find 394 responses to the request of the term “Open access to scientific knowledge” in the exact word combination line (8 June, 2017). At the same time there are very few works dedicated to the quantitative analysis of involvement of countries in this movement. Among the above-mentioned responses we managed to single out five articles which considered the distribution of the open access repositories and journals on a country-by-country basis. The work (Wani et al., 2009) gives the distribution of OAR (Open Access Repositories) in the Open DOAR register across the leading countries of the world (Tab. 1).

Table-1. Distribution of the OAR in the Open DOAR across the countries of the world (7-8 October, 2008)

| Country         | OAR   | %    |
|-----------------|-------|------|
| USA             | 317   | 25.36|
| United Kingdom  | 136   | 10.88|
| Germany         | 129   | 10.32|
| Japan           | 69    | 5.52 |
| Australia       | 68    | 5.44 |
| Netherlands     | 45    | 3.60 |
| Canada          | 44    | 3.52 |
| Italy           | 42    | 3.36 |
| 68 other countries | 400  | 32.00|
| Total           | 1250  | 100  |

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More up-to-date data on the OAR distribution in the Open DOAR and ROAR registers are shown in the Table 2

Table 2. Distribution of the OAR in the Open DOAR across the countries of the world (11th March, 2013)

| Country   | OAR  | ROAR |
|-----------|------|------|
| USA       | 395  | 547  |
| Great Britain | 209  | 249  |
| Germany   | 165  | 193  |
| Japan     | 138  | 166  |
| Spain     | 98   | 153  |
| Poland    | 75   | 106  |
| France    | 71   | 82   |
| Italy     | 70   | 88   |
| Canada    | 58   | 85   |
| India     | 54   | 94   |

Having compared these tables, we see what fold the OAR has increased in the Open DOAR for four and a half years. The greatest increase of the OAR has been observed for the USA. Also this article describes the growth dynamics of the number of the OAJ in the DOAJ register for the period from 2002 to 2013. Let’s give the data obtained at the ends of this time interval (Sokolov and Sungatullina, 2015). (Tab.3).

Table 3. Top five countries according to the number of the OAJ in the DOAJ register (17 January, 2013)

| Country   | OAJ-Journals in DOAJ |
|-----------|-----------------------|
|           | 2002  | 2013 |
| USA       | 16    | 1270 |
| Brazil    | 0     | 804  |
| Great Britain | 5    | 575  |
| India     | 0     | 471  |
| Spain     | 0     | 444  |

As we can see from the built tables, the number of the OAJ grows much faster than of the OAR. The work provides the OAR distribution across 11 leading countries distinguishing those of them which function within the frameworks of the Open Archives Initiative Protocol for Metadata Harvesting (PMH OAI), and the work gives the distribution of a wider set of the open access resources and instruments for the Sub-Saharan African countries. The work describes the data of distribution of the OAR and OAJ number across the CIS countries (Roy et al., 2013; Sizyoongo et al., 2014; Zakharyan et al., 2015).

Table 4. Distribution of the OAR and OAJ, 2009

| Country  | OAR | OAJ |
|----------|-----|-----|
| Ukraine  | 13  | 15  |
| Russia   | 29  | 14  |
| Armenia  | 0   | 2   |
| Azerbaijan | 2  | 1   |
| Belarus  | 1   | 0   |
| Georgia  | 1   | 3   |
| Kazakhstan | 1  | 0   |
| Kyrgyzstan | 2 | 0   |
| Moldova  | 1   | 1   |

2. Materials and Methods

We will characterize the involvement of countries in the international open access movement by statistic data from registers of the largest open access initiatives and instruments. We will consider Budapest initiative “Open access” (2002) and Berlin Declaration of the open access to scientific and humanities knowledge (2003) as such initiatives, and the international registers ROAR, Open DOAR, SHERPA/RoMEO, ROAR MAP, DOAJ and Webometrics ranking for the OA-repositories as instruments. In total, we will use 8 quantitative indicators (a number of organisations which have signed Budapest initiative and Berlin declaration shall be taken for the first two). Values of these eight indicators are also recorded in a form of a matrix (table) for fifteen ex-USSR countries and based on it the average values for each index per one country and the total quantitative potential of the open access initiatives and instruments on a country-by-country basis shall be calculated by summation of lines of this matrix. As far as all these indicators are not equal worth, and some of them replicate each other, so we will offer the following procedure for more precise calculation of the quantitative potential of involvement of countries in the open access. Let’s choose one most essential index out of three indicators which relate to the OA-repositories. It should be understood here that organisations usually register their OA-repositories simultaneously in two registers – ROAR and Open DOAR,
provided that the first register is more popular. Besides, the actual number of records in these registers usually exceeds the real number of functioning OA-repositories. Replication of records takes place, for examples, due to the change of an OA-repository name or its re-registration. At the same time, the real number of functioning OA-repositories which data is indexed by search engines is disclosed reliably in the Webometrics ranking. We will take this index as a basis. Let’s break down six selected indicators into three groups in order of importance with assignment weighting coefficients to them (Tab. 5).

Table 5. Quantitative indicators of involvement of countries in the international open access movement: their groups, designations and weighting coefficients

| Group name                          | Indicators included in the group | Designation | Weighting coefficient |
|-------------------------------------|----------------------------------|-------------|-----------------------|
| OA repositories and journals        | number of OA-repositories included in Webometrics | I₁ | 1/4 |
|                                    | number of OA journals included in DOAJ | I₂ | 1/4 |
| OA-policy                           | number of publishing OA policies on self-archiving and copyright in SHERRA/ROMEO | I₃ | 1/6 |
|                                    | number of institutional OA mandates in ROAR MAP | I₄ | 1/6 |
| OA initiatives                      | number of signatories-organization of the Budapest initiative | I₅ | 1/12 |
|                                    | Number of signatories-organization of the Berlin Declaration | I₆ | 1/12 |

When distributing weights for these six indicators, we proceeded from the following considerations. Groups were chosen with the uniform indicators (carriers of the OA-results, OA-policy, OA-initiatives), that is why there were taken equal weighting coefficients among indicators of one group. The significance of the very groups (summary weighting coefficient for a group) was supposed to be increasing with the uniform interval according to the procedure specified in the table 5. Herewith the sum of group weighting coefficients was taken to be equal to one. Thus, the integrated index of involvement of countries in the international open access movement can be calculated using the weighted average value.

$$IOA= \frac{1}{4 \cdot (I_{OA}^1 / I_{OA}^{max1} + I_{OA}^2 / I_{OA}^{max2})} + \frac{1}{6 \cdot (I_{OA}^3 / I_{OA}^{max3} + I_{OA}^4 / I_{OA}^{max4})} + \frac{1}{12 \cdot (I_{OA}^5 / I_{OA}^{max5} + I_{OA}^6 / I_{OA}^{max6})},$$  (1)

Where, \(I_{OA}^{maxi}\) – maximum value of i index over the whole sampling of countries. There is carried out the correlation analysis between \(IOA\) and indicators normalized to the maximum value according to the sampling of countries \(N' = N / N_{max}\). The total number of estimated countries turned out to be 133.

3. Results and Discussion

Initial values of eight indicators of involvement of fifteen ex-USSR countries in the international open access movements, which were collected by us on 24-26 June, 2017 from the OA - initiatives and OA- instruments Websites are shown in the Table 6. This table shows calculated values of \(N, N' = N / N_{max}\) and \(IOA\). Countries in the table are ranked by values of the index \(N'\). There has been obtained a good correlation relationship between \(N'\) and \(IOA\) (Fig. 1).

Figure 1. Linear regression equation between \(N'/IOA\)

\[ γ = 0.8521x + 0.0009 \]
\[ R = 0.9942 \]

76.5% of the total number of the OA-initiatives and OA-instruments is accounted for by 20% of countries (27 countries) (Tab. 6), i.e. we obtained the distribution closed to Pareto distribution.

If we break all countries into 5 groups, according to the five-level uniform classification scale by \(N'\) index, so we can see their very non-uniform distribution. Only USA will fall into a group of countries with very high level of involvement in the OA-movement (0.8 < \(N'\) ≤ 1.0), the United Kingdom will fall into a group of countries with a
high level (0.6 < N’ ≤ 0.8), Brazil will fall into a group of countries with the average level (0.4 < N’ ≤ 0.6), Spain, Germany, Indonesia, Japan, Poland, Italy, India, Egypt, France will fall into a group of countries with a low level (0.2 < N’ ≤ 0.4). The rest of the countries (121 countries) falls into a group with a very low level of involvement in the OA MOVEMENT, which amounts to 91% of their total number (Ike and Lee, 2014; Ussova, 2009).

Table 6. Quantitative indicators of involvement of countries of the world in the international open access movement, 24-26 June, 2017

| Country    | SHERPA/ROAEO | DOI | ROA | DOI | ROAR MAP | Webometrics, OA-Repositories | Berlin Declaration | Budapest Open Access Initiative | N  | N’ | ¹OA |
|------------|---------------|-----|-----|-----|----------|-------------------------------|-------------------|-------------------------------|-----|----|-----|
| Germany    | 96            | 262 | 239 | 195 | 58       | 116                           | 98                | 33                            | 1097| 0.0351|0.3512|
| Indonesia  | 28            | 613 | 111 | 62  | 16       | 69                            | 1                 | 18                            | 918 | 0.2997|0.2434|
| Japan      | 19            | 18  | 228 | 211 | 6        | 276                           | 0                 | 21                            | 779 | 0.2543|0.2119|
| Poland     | 29            | 449 | 120 | 92  | 3        | 32                            | 0                 | 5                             | 730 | 0.2383|0.1508|
| Portugal   | 127           | 77  | 59  | 55  | 22       | 35                            | 7                 | 5                             | 389 | 0.1270|0.1174|
| Russian Federation | 31 | 187 | 61 | 28 | 6 | 23 | 1 | 46 | 383 | 0.1250|0.1186|
| Switzerland | 28 | 237 | 19 | 19 | 10 | 11 | 0 | 27 | 14 | 374 | 0.1221|0.1190|
| Ukraine    | 19            | 81  | 94  | 75  | 15       | 54                            | 3                 | 32                            | 373 | 0.1218|0.1087|
| Australia  | 44            | 83  | 86  | 57  | 33       | 51                            | 0                 | 9                             | 363 | 0.1185|0.1146|
| Iran       | 17            | 290 | 9   | 10  | 0        | 4                             | 0                 | 11                            | 341 | 0.1113|0.0904|
| Romania    | 26            | 286 | 13  | 3   | 1        | 2                             | 1                 | 9                             | 341 | 0.1113|0.0912|
| Netherlands | 23 | 178 | 44 | 35 | 12 | 15 | 1 | 20 | 6 | 333 | 0.1078|0.0983|
| Argentina  | 17            | 145 | 49  | 41  | 5        | 22                            | 0                 | 9                             | 288 | 0.0940|0.0696|
| China      | 10            | 71  | 92  | 34  | 4        | 31                            | 0                 | 39                            | 260 | 0.0891|0.0567|
| Sweden     | 19            | 70  | 57  | 42  | 12       | 40                            | 6                 | 3                             | 247 | 0.0806|0.0662|
| Norway     | 51            | 57  | 59  | 53  | 10       | 9                             | 5                 | 0                             | 244 | 0.0797|0.0518|
| Taiwan     | 1             | 28  | 83  | 60  | 1        | 57                            | 1                 | 0                             | 231 | 0.0754|0.0459|
| Mexico     | 7             | 98  | 41  | 30  | 3        | 13                            | 1                 | 19                            | 212 | 0.0692|0.0559|
| South Africa | 17 | 63  | 49  | 24  | 9        | 21                            | 18                | 3                             | 204 | 0.0666|0.0633|

31 Belgium 18 33 35 25 19 14 17 12 173 0.0565 0.0705
32 Hungary 32 26 40 36 4 19 2 4 163 0.0532 0.0383
33 Peru 6 33 43 42 7 20 0 4 155 0.0306 0.0349
34 Austria 23 37 19 28 8 8 23 4 150 0.0490 0.0540
35 Chile 9 76 22 20 0 15 1 3 146 0.0477 0.0349
36 Greece 16 29 39 35 4 13 6 3 145 0.0473 0.0330
37 Czech Republic 15 75 13 17 4 10 7 2 143 0.0467 0.0424
38 Finland 41 20 22 16 31 11 0 0 141 0.0460 0.0621
39 Malaysia 8 41 57 21 1 28 0 2 138 0.0451 0.0336
40 Serbia 11 91 9 9 2 2 4 0 128 0.0315 0.0183
41 Croatia 10 69 7 21 2 3 1 5 118 0.0385 0.0299
42 Ecuador 5 25 30 26 0 23 0 4 113 0.0369 0.0259
43 Denmark 27 23 17 12 8 8 7 4 106 0.0346 0.0381
44 Korea Republic 8 45 0 33 0 15 0 1 102 0.0333 0.0242
45 Slovenia 7 47 10 11 8 5 2 1 91 0.0297 0.0295
46 Ireland 6 13 24 22 10 14 1 0 90 0.0294 0.0271
47 Belarus 3 5 23 24 3 18 1 2 79 0.0255 0.0237
48 New Zealand 11 15 21 12 7 10 2 7 84 0.0255 0.0252
49 Venezuela 1 18 21 16 4 8 2 7 77 0.0251 0.0225
50 Cuba 9 39 11 10 0 2 1 2 74 0.0242 0.0164
51 Pakistan 12 40 4 3 1 0 1 10 71 0.0232 0.0243
52 Bulgaria 9 33 9 8 1 6 2 3 71 0.0232 0.0204
53 Costa Rica 4 44 9 6 0 6 1 1 71 0.0232 0.0179
54 Lithuania 3 27 11 11 9 4 0 1 66 0.0215 0.0199
55 Kenya 1 2 19 26 5 8 3 1 65 0.0212 0.0154
56 Nigeria 6 8 15 15 1 1 12 58 0.0189 0.0161
57 Thailand 2 21 11 12 0 10 0 1 57 0.0186 0.0132
58 Moldova 2 16 9 7 8 1 1 11 55 0.0180 0.0252
59 Bangladesh 7 16 10 10 0 4 0 6 53 0.0173 0.0138
60 Korea, Democratic People's Republic 1 5 40 0 0 0 0 0 2 50 0.0163 0.0016
61 Algeria 3 12 8 13 4 7 0 3 50 0.0163 0.0158
62 Hong Kong 2 28 4 4 6 1 1 46 0.0150 0.0181
63 Slovakia 5 34 0 0 1 0 0 0 40 0.0131 0.0113
| Country          | 1   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 0.0108 | 0.0103 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------|---------|
| Seychelles       | 131 |     |     |     |     |     |     |     |     |         |         |
| Uzbekistan       | 132 |     |     |     |     |     |     |     |     |         |         |
| Isle of Man      | 133 |     |     |     |     |     |     |     |     |         |         |
| Kosovo           | 134 |     |     |     |     |     |     |     |     |         |         |
| Luxembourg       | 135 |     |     |     |     |     |     |     |     |         |         |
| Malawi           | 136 |     |     |     |     |     |     |     |     |         |         |
| Summa            | 137 |     |     |     |     |     |     |     |     |         |         |
| Summa/133        | 138 |     |     |     |     |     |     |     |     |         |         |

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4. Conclusion

Thus, this article presents the developed method of the quantitative evaluation of involvement of countries in the international open access movement which principle consists in the identification of indicators of involvement of countries in the open access, their weighing, normalization and aggregation on the weighted average value basis. Two global initiatives – Budapest initiative and Berlin declaration were considered as the OA-initiative, and particularly, databases according to their subscribers. The international registers according to the OA-repositories (ROAR, Open DOAR), OA-journals (DOAJ), OA-policies (SHERPA/RoMEO, ROAR MAP) and ranking of the OA-repositories in Webometrics were considered initially as the OA-instruments. During more strict selection of indicators we excluded from consideration the data of ROAR and Open DOAR registers due to their errors and duplication. Finally, six quantitative indicators were broken down into three groups (OA-carriers, OA-policies, OA-initiatives) with different weighting coefficients. Weighing and normalization of these indicators provided the opportunity to obtain the weighted average integrated index of involvement of countries in the open access which varies from 0 to 1. There has been obtained a high correlation relationship between values of this index and the total number of the OA-initiatives and OA-instruments. It is shown that 76.5% of the total number of these initiatives and instruments is accounted for by the first 20% of countries. Use of the uniform five-level classification scale according to N index shows that 91% of countries (121 countries) falls into the group with very low level of involvement of countries in the OA-movement (Shishkina et al., 2015).

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