

Open access initiatives in European universities: analysis of their implementation and the visibility of publications in the YERUN network

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Abstract

In this paper, the authors analyse the open access (OA) output of the universities in YERUN (the Young European Research Universities Network) and their institutional documentation of their own OA situation. The period from 2009 to 2019 was selected for the bibliometric analysis. The full register of publications for the YERUN universities was downloaded from Clarivate Analytics Web of Science Core Collection, and a set of bibliometric analyses was performed to provide an evidence-based response to the research questions (example: Do YERUN universities follow publication patterns similar to those of their countries of origin? How does OA affect the impact of scientific publications? What types of OA are used at each institution? Is there a relationship between specialization and OA?). The bibliometric analyses looked at four dimensions: activity and context indicators; collaboration indicators; specialization indicators; OA types and impact indicators. The document analysis included variables related to infrastructure, specific support actions, institutional policies and OA information availability. The paper concludes that the institutional measures and actions fostering OA identified on universities' websites bear a correspondence with the bibliometric data. YERUN institutions have higher rates of OA publications than do their host countries, with a clear preference for the green route. OA publications are systematically more cited than non-OA publications, and green OA has more impact than do other types of OA. Also, no relationship was found between specialization and OA publication rate.

Keywords Open access YERUN network Bibliometric analysis Document analysis

1-Introduction

Without doubt, open science implies a cultural change in the way the stakeholders involved in research, education and knowledge exchange, create, store, share and deliver their results (LERU 2018). According to a 2010 Research Information Network definition, open science is a deep-reaching change of the research system, where science is carried out and communicated in a fashion that lets others contribute, collaborate and add to the research effort, and where all kinds Of data, results and protocols are freely available at the various stages Of research. A decade later it is possible to observe that the concept Of "open" has become more complex as open science promises transparent processes and widely available results, but not necessarily free of charge. This is why the

most current definitions of open science include these considerations. Authors like Anglada and Abadal (2018) mention that, this new way of doing science this new paradigm would be based on 3 criteria: science must be open, collaborative and made with and for society. Here the meaning of "open" is twofold: free of charge and available. While the first of the characteristics of openness requires the elimination of economic barriers to access to research results, the second goes further: we want science made by one or some to be reusable by any other.

On the policy front, several organizations have developed strategies in recent years for promoting and consolidating open science, such as the OpenAire project (OpenAire 2017) and the creation of the European Open Science Cloud (EOSC, European Commission 2016) and the Open Science Monitor (European2017).

Under the broad umbrella of open science, one of the most widely-implemented initiatives so far is open access (OA) publications. In 2012 open access was adopted at the European level as a principle for all publicly funded research, and open access has garnered the lion's share of the attention in many other regions' and countries' open science policies as well (De Filippo and D' Onofrio 2019).

At the institutional level, within the university framework, some important networks, such as LERU (League of European Research Universities) and YERUN (Young European Research Universities Network), have moved forward, supporting the promotion of open science culture in universities where the practice of open access also plays a relevant role (LEW 2018; YERUN 2018a, b).

And so, almost 20 years after the Budapest Declaration, the indications are that, far from weakening, interest in open access has increased considerably among all the stakeholders in scientific communication, including researchers, institutions, funding organizations and publishers (Rovira et al. 2019). This growing interest is evidenced by the increase in the number of studies aimed at analysing the availability of open access to scientific publications, both worldwide and at the level Of individual countries, disciplines and types of institutions.

Because universities are one Of the main producers Of knowledge and are responsible for a large proportion of scientific publications (over 70% of the total scientific publication output in some countries (Sanz-Casad0 et al. 2019), a grasp Of the evolution and impact of the implementation of OA in universities is central for understanding the scope of the initiatives that are taking place.

2-Background

A review of studies of open access reveals a range of approaches. On the one hand, there have been extensive discussions about the advantages and limitations of open publishing (Kurtz and Brody 2006; Beall 2012), as well as analyses of its scope and implications (Suber 2003, 2005; Zuccala 2009). The relationship of open access to visibility has also been studied, as has the relationship between these features and an Increase in citations received

(Harnad and Brody 2004; Piwowar et al. 2018; Moed 2007; Gargouri et al. 2010; Suber 2012; Science-Metrix 2018). Over time, the relationship between impact and type of open access has also been studied (Perianes and Olmeda 2019). Some studies focus on the green route (Harnad and Brody 2004; Moed 2007; Gargouri et al. 2010), while others have found the gold route more promising (Jubb et al. 2011; Gumpenberger et al. 2013; TorresSalinas et al. 2018).

Another topic of particular interest to researchers is to identify and quantify the proportion of open access publications. Some authors have analysed the presence of open access

publications in various databases and identified the most "open" disciplines (Laakso et al. 2009; Björk et al. 2010; Gargouri et al. 2012), while others have explored open access publishing in different countries and regions (Archambault 2014; Research Information Network 2010).

In addition to studying the coverage of open access by discipline or country, other authors have analysed the accessibility of publications in specific institutions, such as the universities of Sweden (Fathli et al. 2014), Norway (Elbaek 2014) and the Netherlands (Bosman and Kramer 2018) or research centres of excellence in Catalonia (Rovira et al. 2019).

The impact of some open access policies has also been studied. The European Commission presented a report that evaluated the impact of its policy to support open access in 7 areas of the Seventh Framework Programme (European Commission 2016b). Other studies investigate the availability of publicly funded publications in certain disciplines or countries, such as Canada (Zhang and Watson 2017) or Spain (Borrego 2015; FECYT 2016).

More recent research has focused on the study of dissemination in the academic social network, which has made research results available to a wide audience. Articles such as the one by Laakso et al. (2017) have shown the importance of this means of dissemination. Studies by Pinowar et al. (2018) and Science-Metrix (2018) on the issue of publications' availability are also interesting. Using the oaDOI service, researchers have detected figures of close to 50% access in various types of publications after the embargo period. Similar figures have been found by Borrego (2017) when studying the availability of 13 Spanish universities' scientific output in repositories and on social media.

3-Study contexts and objectives

As mentioned, there are a number of studies that analyse the extent to which open access has been implemented in different institutions, some of which are universities. However, these studies are confined to individual institutions or a single country. By contrast, this study examines the specific case of the universities in the YERUN network, considering that YERUN presents itself as an organisation that is particularly active in open science and open access. The network, created in 2015, is comprised of 17 European universities similar in the sense of being "young" (<50 years old), placed highly in the main international rankings and presenting a clear orientation towards research. From the inception of the network, YERUN has lent a remarkable amount of support to initiatives related to the implementation of open science at member institutions, among which open access is particularly important. These features, together with the volume of its resources (students, teaching and research staff, budget, research results), make YERUN a major actor and certainly a pacesetter in the European and international framework.

Considering the importance that YERUN has given to open science practices, this study has 2 main objectives. First, it will identify and analyse initiatives for the promotion and development of open access at both the university level and the network level. Second, it will analyse practices related with open access to scientific publications, considering their evolution and main characteristics.

The following research questions have been established:

Q1 Are there any explicit initiatives for promoting open access?

Q2 Do YERUN universities follow open publishing trends similar to those of their affiliated countries? What is the percentage of OA documents available at each university?

Q3 Is each institution's specialization related to OA? Are there any differences in open publication from one subject area to another?

Q4 What types of open access are used at each institution?

Q5 How does OA affect the impact of scientific production?

4-Sources and methodology

Sources

Two types of information sources have been used:

Institutional websites (of YERUN and each of the universities in the network)

To compile information on the policies, strategies, proposals and initiatives for the implementation of open science and open access.

International multidisciplinary bibliographic and bibliometric databases

The publications by YERUN universities included in the Clarivate Analytics Web of Science's Core Collection (Science Citation Index, Social Science Citation Index and Arts and Humanities Citation Index) for 2000—2019 were retrieved and analysed. The Science Citation Index covers 9200 journals in 178 scientific disciplines and contains 53 million records. The Social Sciences Citation Index includes 3400 journals in 58 fields (9 million records), and the Arts and Humanities Citation Index has 1800 journals indexed, with more than 4.9 million records attached (Clarivate Analytics 2020).

Case study description

The case study was conducted by analysing open access-related practices at the institutions belonging to the YERUN network. The network's founding goals are to strengthen and develop cooperation in the areas of research, academic education and service to society among a cluster of highly-ranked, young research universities in Europe. YERUN organizes its activities into five lines of strategic action: education collaboration, European policy, graduate employability, research collaboration and open science.

The network is made up of the most prominent universities from I I countries. These higher education institutions have more than 350,000 undergraduate and graduate students, around 30,000 academic staff and an R&D budget of €1,254,484,595 (YERUN 2020).

YERUN includes universities of different sizes. Considering classification of universities by size used in international rankings (QS 2020) we can observe that there are not small universities (fewer than 5000 students). There are one group of medium universities (between 5000 and 12000 students); these are schools like Ulm, Paris Dauphine and Konstanz. A second group contains large institutions (more than 12,000 and less than 30,000 students), which are the majority of YERUN's members. The third

group features just a few extra large universities (more than 30,000 students), like Southern Denmark, the Autonomous University of Madrid, the Autonomous University of Barcelona and Tor Vergata (Table 1).

The analysis of open science and open access-related practices was carried out at the network level and the university level. The study was conducted in 2 phases, document analysis and bibliometric analysis, as described below.

The data are drawn from the universities' own websites. Latest available information, approximate data

Document analysis

The first stage of the study consisted in the retrieval of institutional documentation and a content analysis to identify and classify open access initiatives. This review was not designed for extreme precision, given the fact that some aspects of open access policies and other specific features are dictated by regulations available only in the national languages of the different countries. Hence, the website analysis takes account of only the contents available in each website's English version. This information mainly serves the purpose of providing a framework of rules and regulations for interpreting the analyses in the proper context.

To obtain information from each university, documents such as the following were retrieved from the universities' web pages:

- University statutes
- Library regulations
- Rules and regulations for publication services
- Institutional regulations
- The information was coded and tabulated considering aspects such as:
 - Existence of an institutional repository
 - Identification of a specific open access section in the repository
 - Existence of specific strategies or regulations for the promotion of open access
 - Location of open access information
 - Actions undertaken to promote open access
 - Existing infrastructure (in addition to the repository) for the promotion of open science and open access

Bibliometric analysis

The second stage used a bibliometric approach to analyse the OA publications. The following steps were followed:

Selection of documents from each YERUN university

In the Web of Science using the "Advanced Search" option together with the "Organization Enhanced" field to extract the full record of documents for each institution. All document types for the 2000—2019 period were retrieved. To calculate the total number of YERUN publications, the duplicates produced by collaboration between member institutions were eliminated. This means that the documents comprising the primary research data for this article are unique documents, not the sum of the documents attached to each university.

Document download and construction of a database

With all the bibliographic and bibliometric data for each university's publications. Calculation of bibliometric indicators

The following indicators were found:

Activity and context indicators A set of indicators was calculated, including the volume of OA documents per country and the percentage of OA publication, at the European level and for the whole set of countries indexed in the Web of Science.

To measure the annual evolution and growth in time series (2000—2009; 2010—2019), the cumulative average growth rate (CAGR) was calculated using the following formula:

$$\text{CAGR} = \frac{X_n - X_1}{n - 1} \cdot 100 \quad (1)$$

where X_1 and X_n , respectively, are the values found in the first and last period of the study. The formula is equivalent to the one frequently used in finance to find the compound average growth rate, and it resembles the formulae used in other areas of economics and society to measure average growth in time series (United Nations-ESCAP 2015).

Collaboration indicators The number and annual evolution of documents produced in collaboration by YERUN universities working together were calculated. The percentage of OA documents was also considered. The results were visualized using social network analysis (with Gephi) to analyse the evolution of the links between institutions in 3 years, 2000, 2009 and 2019. The contribution of universities and the subject specialization of publications were also considered.

Specialization indicators The distribution and proportion of publication by Web of Science categories was obtained. With the full output, a correspondence analysis was carried out using the symmetric normalization procedure to obtain a graphic representation of the closeness between universities and fields. To enhance the chart's comprehensibility, only the first 17 WoS categories by total output for all universities are shown; these categories account for 52% of all publications. Entropy (the Shannon—Weiner index) was calculated for the distribution of articles in WoS categories. Entropy has been used extensively as a diversity index in bibliometric studies of interdisciplinary research (Rafols and Meyer 2010). Its formulation considers the number of elements in the distribution (in this case, the number of WoS categories in which the documents were published) and the evenness or otherwise of the distribution of elements in the different categories. Its formulation is as follows:

$$H = - \sum [n_i/N * \ln (n_i/N)] \quad (2)$$

where N is the total number of elements in the distribution (in this case, the number of documents published). Greater values of the indicator indicate greater diversity in the distribution of articles in fields of knowledge and vice-versa.

Open access typology Using oaDOI data, the Web of Science currently labels open access articles as "Gold DOAJ" (articles published in journals listed in the Directory of Open Access Journals); 'Other Gold" (articles with a Creative Commons license but not published in journals listed in the DOAJ); "Bronze" (the licensing for these articles is either unclear or identified by Impactstory's Unpaywall Database as nonCC license articles. These are free-to-read or Public Access articles located on a publisher's site. "Green Accepted" (accepted manuscripts hosted on a repository; content is peer reviewed and final but may not have been through the publisher's copyediting or typesetting) or "Green Published" (final published versions of articles hosted on an institutional or subjectbased repository). Since a publication can have different types of access, all existing types of OA were considered for each document (Clarivate Analytics 2020).

Impact indicators To measure the relationship between impact and visibility, the average citations per document were calculated for OA documents and non-OA documents. The percentage of OA documents in highly cited papers was also considered.

Analysis of the results

Apart from the comparison of the data through charts and tables, a Mann Whitney U test applied to analyse the relationship between different variables, such as impact and type of OA publication.

Relationship between policy and publication records

The quantitative results are related to the document analysis carried out in the first stage and are discussed in the 'Discussion' section below.

5-Results

Document analysis

YERUN has been engaged in promoting open science activities since its creation in 2015. In 2017 the YERUN Working Group on Open Science was established to facilitate the exchange of information on open science policies and practices among YERUN members. Its main aim is to explore the possibility of addressing joint initiatives and best practices on topics such as: policies on open science, infrastructures for open science (new repositories for publications and research data), cultural change endeavours, reward career process, training and technical support.

In 2018 YERUN published the Statement on Open Science, which explains the actions that will be implemented by the network's member institutions. One of the stated priorities is open access, which includes the objective of making all publications (publicly funded research) 100% open access by 2020. Actions are also proposed related to citizen participation in scientific activities, the development of indicators to measure and monitor open science activities and the introduction of OS practices in processes for evaluating academic staff. In addition, the network supports European Commission policies by actively participating in the testing of infrastructure, strategies and indicators (YERUN 2018a).

With the publication of Plan S, YERUN publicly announced its support and point of view on the subject by stating, "YERUN acknowledges the big step taken with the release of Plan S towards truly open science. However, it is limited to OA. Incentives, infrastructures and solutions for a new evaluation system should be developed alongside Plan S to promote Open Research Data and publication of other research outputs along with other Open Science practices" (YERUN 2018b).

At the institutional level, the review of the websites of the universities belonging to the YERUN network painted a rough picture of actions, policies and infrastructure related with open access (Table 2).

All the institutions' websites are available, at least, in English; nevertheless, some regulations that might contain information relevant to the contents of the previous table are either not translated into English or the translation is not considered an official document (that is the case of, In example, some Bremen University regulations) and were not taken into account for the preparation of this table.

The first result of note is that all the universities have an institutional repository. This constitutes an initial pre-condition, in many cases, for actions fostering OA. Twelve of the repositories have a specific section covering OA outputs in various publication formats (5 do not, or no such sections have been identified: DCU, UPD, UAB, USD and TVU).

Only 2 universities (UPD and UTV) out of 17 do not have any specific policies or regulations (displayed or accessible on their institutional websites in English) affecting how OA publications are managed at the institutional level.

Information on OA has a website of its own in six cases, while the library website seems to play a central role in the management of OA publications in five cases. There is one institution (Dublin City University) that has a fully open access university press, a remarkable development. The information on OA for Dublin City University is on the university press's website, but other institutions give their institutional archive web page as the central source of information.

The specific support measures about which information is publicly available include but are not limited to: total or partial funding of article-processing charges (APC) applicable to OA publications (7 cases), curation Of OA contents (1 case), technical support (3 cases), a data management plan (1 case) and a full OA university press (1 case). Some other infrastructure types or support measures have been identified, such as research data curation/ repositories (4 cases) and specific repositories for doctoral theses (2 cases). Fifteen out Of 17 cases were found to explicitly present OA policies, and eight out Of 17 have explicitly communicated open science policies (BU, UC3M, UEF, UKO, [JAB, USD, UUM, UMA) including, for example, data management measures and regulations.

Bibliometric analysis.

The results of the analysis of the publications in the Web of Science are presented below.

Activity and context indicators

In 2000—2019 the YERUN network published 453,573 documents on the Web of Science (32% in OA). The results for each university are shown in Table 3. The sum of documents from all universities is higher than the total number of YERUN publications, because some documents were produced in collaboration with Other universities.

In 2000—2019 YERUN network published 453,573 documents on the Web of Science (32% in OA). The results for each university are shown in Table 3. The sum of the documents from all universities is higher than the number of unique documents from YERUN, because some documents were produced in collaboration between 2 and more YERUN universities (in this case the documents are counted only once).

The universities are in 11 European countries, so each university's percentage of documents in OA was examined in relationship with the figures for that university's country of origin, Europe as a whole and the world to ascertain whether they followed any trends along the lines of geographical context.

The percentage of OA documents over total output is around 23% for the world, while the proportions are higher for all the countries hosting YERUN universities (32.69% on average, from data on Table 3; standard deviation: 5.66). The highest proportions of OA documents were found in the Netherlands, the UK, Denmark and Finland, where OA documents accounted for over 30% of publications (Fig. 1). As shown in Table 4, in absolute values, the number of OA documents in 2010—2019 was triple what it was in the decade before. Also, in the period from 2000 to 2009, OA accounted for no more than 25% of all publications, and the cumulative average growth rate ranged from 9 (in France, the United Kingdom, Denmark and Finland) to in Portugal. In contrast, in the decade from 2010 to 2019, the proportion of OA publications exceeded 30% and the CAGR remained between 9 and 12%. Denmark, Finland and the United Kingdom had a much higher increase in OA production in this period than in the decade before.

On a university-by-university level, the highest percentages of OA documents came from the Spanish YERUN universities, led by Pompeu Fabra University (UPF 49%), followed by Carlos III University of Madrid (UC3M 39%) and the Autonomous University of Madrid (UAM 37%). In most cases YERUN universities report higher proportions of OA documents than their respective countries do. Finland is an exception to this general observation (Fig. 1).

In absolute values the number of OA documents increased remarkably over time. The proportion of OA documents in the decade from 2000 to 2009 ranged from 13% (at the University of Bremen) to 34% (Carlos III University of Madrid and Pompeu Fabra).

By a decade later the figures had risen to over 25%, and at universities such as Essex and Pompeu Fabra, more than 50%. Table 5 shows that, at universities such as Bremen, Eastern Finland, Essex and Konstanz, even the increase of OA publications was higher in the second period.

Collaboration indicators

In order to analyse the relations among institutions in the network, the documents written in collaboration (signed by at least 2 YERUN institutions) were identified. The results show that between 2000 and 2019, 11,362 documents (3% of the network's total publications) were produced in collaboration by YERUN institutions. Of this total, 6448 publications (56%) were in open access. These percentages rose significantly from 18 in 2000 to 62% in 2019 (Fig. 2).

The Autonomous University of Barcelona participated in 42% of the documents produced in collaboration with other YERUN institutions, while the Autonomous University of Madrid signed 35% of such publications. The figures from Pompeu Fabra, Tor Vergata and Antwerp were significant as well; they participated in a quarter of the documents produced in collaboration by YERUN institutions.

Figure 3 shows three networks of collaboration for 2000, 2009 and 2019.

These networks show that links between institutions increased over time from 129 collaborative documents in 2000 to 1456 in 2019. Although collaboration between YERUN institutions was already growing, the formal creation of the network undoubtedly provided an impetus to increase collaborative production. The Autonomous University of Barcelona has a strong presence in the network, with collaborations especially with the other Spanish universities (UPF, UAM). Important links are also found between Tor Vergata University and the University of Antwerp and between Tor Vergata University and the 2 Spanish autonomous universities. Furthermore, Antwerp and Brunel and Tor Vergata have also established links with the NOVA University of Lisbon. In general, collaboration is found among institutions residing in the same country and among universities in regions sharing a certain geographical or cultural proximity (Spain, Portugal, Italy).

By subject, particle and field physics (16%), astronomy (9%) and nuclear physics (5%) are the foremost areas of publication in international collaboration. Relations among institutions in the network are also frequent in fields where there was a significant volume of production, such as neurosciences, genetics and heredity, multidisciplinary science, psychiatry and oncology.

Specialization indicators

In the 2 decades this study covered, YERUN production was concentrated in the neurosciences (5%), biochemistry and molecular biology (5%), oncology (4%), clinical neurology (4%), materials science (3%), applied physics (3%) and psychiatry (3%).

To learn each institution's specialization, each university was related to the number of documents it produced in each WoS category. Figure 4 shows the result of a correspondence analysis in the 17 WoS categories with the highest production. Some institutions, such as Paris Dauphine, Carlos III and Essex, are highly oriented towards publishing on economics. Another large group of universities (Ulm, Antwerp, Maastricht, Southern Denmark) clearly favours the health sciences, and a third group (Tor Vergata, Autonomous University of Madrid, Konstanz) leans towards the experimental sciences. Interestingly, some fields, such as "Multidisciplinary Science", are central to the graph, indicating that they are important fields for all institutions.

To find if there is a relationship between subject diversity and open access, the values of entropy and average percentage of OA were analysed. The range presented by the values of dispersion of articles and percentage of OA publications in each category was observed to be limited. A check was made for a linear relationship between the 2 variables, and the null hypothesis was discarded, since the correlation between the 2 variables was 0.086, which implies a non-existent linear relationship between entropy as an indicator of diversity in production and the percentage of documents in open access (See Table9).

Publication in disciplines with a high availability of open access journals might be thought to be an explanation behind OA percentages. Accordingly, the 17 subject categories with the highest production in YERUN were examined, and the total number of available journals and the percentage of OA for the last year of the JCR (2018) were calculated. The data varied widely, OA values ranging from 4% in physical chemistry to 32% in multidisciplinary science (Table 6).

OA types

Of the 453,573 documents published by YERUN from 2000 to 2019, 147,320 (32%) were in open access, and Green Published accounted for the majority (56%) (Fig. 5).

In general terms, there is a predominance Of Green publications (counting published and accepted together) at all universities. There are, nevertheless, some exceptions, such as the 50.46% of Bronze OA in the case of Dauphine University. Five universities show percentages Of over in Green OA counting both categories (Autonomous University of Madrid, Brunel University, Dublin City University, Carlos III University of Madrid and University of Essex). There seems to be a relationship between the total number of documents and the likelihood of an even distribution of documents among OA types (The correlation between the standard deviation in the distribution of percentages of OA types and the number of documents in OA is -0.39) (fig. 6).

Impact indicators

YERUN publications had received 10,838,431 citations at the time of data collection, yielding an average of 23.89 citations/document. At the institutional level, the results show that the average number of citations received is higher in OA documents, with statistically significant differences (The Mann—Whitney U test was applied; the full table of test results is included in Table 10) in all but 2 cases: Carlos III University of Madrid and Paris Dauphine University (Fig. 7; cases with statistically significant differences are identified with

Looking at impact according to the type of access to documents in general, publications in the green route tend to have a greater impact than publications in the gold route (Table 7).

Open access types and citations per document were subjected to a one-way analysis of variance. All green OA were made aggregate, as were all gold OA. The test showed that OA type had a significant effect on the citations per document ($p < 05$) for all 3 types of OA 11.356, $p = 0.0011$.

The mean volume of citations per document for the gold OA ($i = 19.70$; 5.7) type was significantly different from (and lower than) the mean volume for bronze ($i = 34.23$; 12.8; $p = 0.001$) and green OA ($i = 33.88$; 10.57; $p = 0.001$). Nevertheless, no statistical differences were identified between bronze and green OA citations per document ($p = 0.994$). Tukey HSI) (post-hoc) was used for this purpose. The direction of these results was later confirmed by the Mann—Whitney U tests (Table 11).

Of the total number of YERUN publications, 3855 documents were highly cited (HCP). Among the highly cited papers, 64% were open access. This suggests a close relationship between impact and visibility. The institutions with the highest participation in HCP were Maastricht University and the University of Antwerp. Interestingly, the proportion of OA documents was very high among HCP from all universities (except for Paris Dauphine), especially the Spanish universities (Table 8).

6-Discussion

The scope of open access certainly remains quite a valid topic of study, as demonstrated by the range of research addressing it. Bibliographic databases themselves are also

making a constant effort to provide information on open publications. In 2017 the Web of Science began including information on publications' open access availability using article-level information from Impactstory, and it currently offers a classification of open journals into 5 types.

Although some recent studies show that WoS includes 5% fewer OA journals than Scopus does (Perianes and Olmeda 2019), the detail of classification by type is one of the factors that led us to choose WoS as the source for our study.

The results of this research have enabled us to answer the research questions:

Q1 Are there any explicit initiatives for promoting open access?

At the network level, YERUN has clear policies for the promotion of open science. These policies include the promotion of open access, as explicitly stated on the YERUN website, which devotes a specific section to this subject (YERUN 2020). In fact, one of the pillars of the network's open science policy is collaboration, which is understood by YERUN as collaboration among the members of the network in matters related to open science.

In this study we have analysed scientific collaboration as such and the percentages of OA in collaborative documents. The data show that three Spanish universities engage in a considerable degree of collaboration, although this could be partially explained by their geographical proximity to each other. However, over time, collaboration has also strengthened among the universities in the network in general, and the percentages of open access in collaborative documents have risen. These figures paint a picture of a network of universities with a shared open access policy, evolving in a desirable direction: toward greater collaboration and greater percentages of open access.

At the institutional level, all universities are observed to have institutional repositories. In some cases, as in the case of Spanish universities, the repositories have been in operation since 2006. The vast majority of university repositories have specific OA sections. Documentation on policies for the promotion of open access was located at all universities except two. At all of them OA is mainly promoted through technical support and the financing of open publication fees. The case of Dublin City University, which has a university press for open publications, is unique.

Because the information used in this study was sourced from institutional web pages, we cannot rule out the possibility that other open access initiatives may exist. However, the inaccessibility of such initiatives (on the website and in the English language) makes them difficult to locate and analyse.

Q2 Do YERUN universities follow open publishing trends similar to those of their affiliated countries? What is the percentage of OA documents available at each university?

YERUN universities generally publish higher percentages of open access documents than their host countries do and appear to be leading open access publication in terms of proportion in their countries. This observation is congruent with the evolution of open access outputs at YERUN universities in both periods analysed (2000—2009 and 2010—2019); in all cases the values are greater in the second decade.

Regarding the percentage of documents in open access, the network accounts for 32% of the publications collected on the Web of Science between 2000 and 2019 in open access. At the university level, the Spanish institutions have the highest percentages, led by Pompeu Fabra University with 49%, followed by Carlos III University of Madrid (39%) and the Autonomous University of Madrid (37%); these figures are higher than

Spain's total of around 30%. The high volume of open publication at the UPF also coincides with the findings reported in a study on centres in Catalonia that found that precisely 52% of the institutions' scientific output was openly available in repositories and open access journals alone (Rovira et al. 2019). This shows the importance that Catalan institutions give to promoting open publications and their accessibility.

It has also been noted that the percentages of OA at the individual level of YERUN universities were also higher than those found in other studies analysing the availability of open access at universities in Sweden (Fathli et al. 2014) or Norway (Elbaek 2014), where around 50% of documents were published in open access journals and a slightly lower percentage was deposited in institutional repositories. A more recent study of open access at universities in the Netherlands found a great deal of diversity in the situation, which varies widely between disciplines, languages and institutions (Bosman and Kramer 2018).

Q3 Is each institution's specialization related to OA? Are there any differences in open publication from one subject area to another?

The results show that there are different profiles in terms of universities' subject specialization: Some are more oriented towards publication in the social sciences; others, towards experimental or health sciences. However, publications in the "Multidisciplinary Science" category (which includes journals in different fields, such as Nature, Science and PNAS) are frequent for all universities. This may partly explain the high percentage of open documents, since in the "Multidisciplinary Science" category 32% of the journals are OA. However, in the subject categories where YERUN universities publish the most, there are other fields with very low percentages of open access, such as "Chemistry Physical", with 4%. A similar distribution of OA journals was identified in other recent studies (Perianes and Olmeda 2019).

The hypothesis that diversity in production issues affects the percentage of documents in open access has been ruled out, since no correlation has been detected between the values of institutional multidisciplinary and entropy. However, other studies that analyse the case of Dutch universities have found generalist institutions to have higher percentages of open access. As their authors assert, this likely has to do with these institutions' coverage of the "Life Sciences and Biomedicine" fields (Bosman and Kramer 2018). This feature therefore requires further study, since this relationship between less specialization and a higher percentage of open access may be conditioned by the greater availability of open access journals in areas such as "Multidisciplinary Science".

Q4 What types of open access are used at each institution?

The network's outputs are predominantly green (24%) and gold open access (14%), with a smaller fraction of bronze OA.

The predominance of green publications coincides with the results obtained by other researchers, such as Gargouri et al. who compared the percentage and growth rate of green and gold OA for 14 disciplines of Web of Science indexed journals. Their results, with data through 2010, showed that green OA (21.4%) exceeded gold OA (2.4%) in proportion and growth rate in all disciplines except biomedicine (Gargouri et al. 2012). Our study's findings are also in line with previous studies, such as Archambault et al. (2014). More-recent studies show that, although there is a notable increase in gold publications, both in the Web of Science and in Scopus, green publications are still the most numerous, with high proportions in all disciplines (Perianes and Olmeda 2019). Likewise, other papers, such as TorresSalinas et al. (2018), also show that gold OA has exhibited a decade of remarkable evolution, rising from 4% in 2008 to 12% in 2016, and

they posit the explanation that the overall share of gold OA output may still be increasing due to the emergence Of new players, such as Scientific Reports and Nature Communications. These figures are in line with those obtained for the YERUN universities, and they show that the institutions studied present even higherthan-average values.

Although YERUN's overall production trends heavily towards green publishing, strong differences have nevertheless been identified in the proportions of OA types per institution (a particular case of the Simpson-Yule paradox). This might be explained by a great many factors, such as a particular subject orientation of the institution (e.g., STEM/SSH), or the corresponding availability or unavailability of journals of each OA type in each realm.

However, there are other aspects that may also be influencing the choice of type of access and which we have not considered in this study. One of the main ones is the budget availability for APCs that could influence the choice of publication in Gold OA. As this study does not analyse this issue, we find it interesting to deepen this aspect in further research.

Q5 How does OA affect the impact of scientific production?

The results show open access documents have greater impact than non-open access documents at all YERUN universities. In fact, at nine of the 17 institutions, the average number of citations/document for OA documents is double that of other publications. In our study, of all the OA papers, the green OA papers received the highest average number of citations. While several previous studies have already shown the advantages of open access in terms of citations, our results point to the significant gap that publishing in green open access represents compared to other tracks. Our finding seems to be consistent with some of the results obtained by Zhang and Watson (2017) (with a "Physical Science" dataset) and others, such as Gargouri et al. (2010), who analysed the advantages of green open access publication. Gargouri et al. also mention the importance of open access in high-impact articles. These data are corroborated in our analysis, since more than 50% of the highly cited papers from all the YERUN institutions are open access; that makes HCP documents twice as likely to be OA as non-HCP documents.

Despite these statements, various studies highlight the difficulty of analysing the impact of each type of open access (Torres-Salinas et al. 2018; Perianes and Olmeda 2019). Some researchers agree that a great deal of further investigation is required to understand if accessibility is in itself an added value for obtaining more citations or if, on the contrary, the quality of a text is the factor that promotes its citation. In any case, as argued by Gargouri et al. (2010), even if researchers choose to cite high-impact texts ("high-impact" in terms of the journal in which they are published), the availability of the document in open access will afford an additional advantage.

The research questions have been answered, but it remains for us to mention some limitations of the study. Firstly, the complexity of defining and analysing the concept of "open access" affects the results. Given the diversity of definitions, in this study we chose to include only those documents classified as "open access" by the Web of Science database. Document types (also defined by the database) were considered, in the awareness that a publication may be classified simultaneously into more than one type Of open access.

Furthermore, given our chosen definition of "open access", we did not consider other, increasingly important options for making documents openly available, such as social media (researchers' websites, portals such as Research Gate and Academia.edu etc.).

Other studies, such as Laakso et al. (2017) and Borrego (2017), have shown that more than half of an institution's publications can be made accessible if these routes are considered.

Concerning the review of websites and documents from the universities, some were not included in the analysis given the fact that they were not available in English. Although most of the relevant information has been found in documents in English, it is not possible to affirm that the document analysis is extensive.

Apart from the conceptual issues and the scope of the research, it is important to bear in mind that the institutions were selected using the 'Organization Enhanced' tool, reviewing and validating the different variants of signature. However, those documents that do not have a standardized institutional signature can hardly be analysed.

Conclusion

The bibliometric analysis of the output of YERUN universities leads to a number of specific conclusions.

The first conclusion is that YERUN's stated commitment to OA has a counterpart in the data we analysed.

YERUN institutions have been found to have high percentages of open publications, even higher than the percentages of their countries of origin. A clear pattern emerges in the evolution of OA publication percentages over the two decades we examined: At many universities the percentage of OA publications has been greater in recent years. This evidences the likelihood of a sustained effort by these institutions towards OA publication or, alternatively, the greater availability of OA journals in the period. It is also conceivable that the network's initiatives are facilitating the culture and practice of open access.

These observations are generally congruent with the policies, standards and measures adopted and developed by YERUN universities and made publicly available. Several cases show that not only do member institutions set up specific support measures for OA publication (from APC funding to a full OA university press), but in many cases these actions take place within a comprehensive framework of open science regulations. This advancement towards open science in its facet as open access seems to be the path to follow, given the extraordinary importance of OA data sharing for research purposes, in line with the Horizon 2020 recommendations (European Research Council 2017).

Secondly, universities' preference for the green route of publication has become evident. Although it may be thought that a university's field of specialization or the availability of journals in certain scientific fields favours OA publication in certain disciplines, it has been proved that there is no direct relationship between these variables. It is more feasible, once again, to posit that institutional policies, the existence of repositories and the promotion of open access through different actions have influenced the selection of green publication.

This research also suggests that OA publications are systematically more cited than non-OA publications. The volume of citations per document is significantly different for the three main types of OA (and greater for OA than for non-OA documents). Green OA publications have, on average, more impact than gold OA publications, gold OA documents receive fewer citations than bronze OA documents, and there are no statistically significant differences between bronze and gold OA types. This gives credit to the reasoning behind the lower likelihood of, *ceteris paribus*, a paper published in a gold OA journal being cited with a frequency comparable to that of a paper published in a green OA journal. Since this study includes 17 higher education institutions in different countries, with outputs in a wide variety of research fields, there is no reason to suppose that these results are not at least partially applicable to the output of any other university or institution. Of interest for underscoring the strong relationship between citation

likelihood and OA is the fact that the percentage of OA in highly cited papers is over 50% at 16 of the 17 universities.

Despite the limitations stated above, the results lead to the conclusion that the YERUN network follows the general patterns described in previous literature on OA (greater citation, proportion of OA types) but presents several specific features, including a lack of relationship between subject specialization and OA proportions, a robust evolution in all indicators pertaining to OA (from total output to citations and institutional collaboration) and a diverse landscape of fields, OA types and citation patterns.

Considering the complexities involved in the analysis of open access, we will continue our research with the aim of advancing in the definition of universities' activity profiles by incorporating new variables into the analysis, such as subject specialization, which is an issue that needs to be dealt with in greater depth.

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Appendix (tables and figures)

Table 1. Facts and figures on YERUN universities

University	Code	Country	No. of students (approx.)	Academic staff (approx.)
Autonomous University of Barcelona	UAB	Spain	43,175	3868
Autonomous University of Madrid	UAM	Spain	32,000	2505
Brunel University	UBRUN	United Kingdom	15,000	660
Dublin City University	DCU	Ireland	17,000	624
Maastricht University	UMA	Netherlands	16,000	1841
Pompeu Fabra University	UPF	Spain	14,000	600
Tor Vergata University	UTV	Italy	44,000	1600
Carlos III University of Madrid	UC3M	Spain	18,700	680
Nova University of Lisbon	UNL	Portugal	19,800	1668
Paris Dauphine University	UPD	France	10,000	447
University of Antwerp	UAN	Belgium	20,000	5000
University of Bremen	UBRE	Germany	19,200	2330
University of Eastern Finland	UEF	Finland	15,000	1500
University of Essex	UES	United Kingdom	14,770	850
University of Konstanz	UKO	Germany	11,300	1067
University of Southern Denmark	USD	Denmark	30,000	2200
University of Ulm	UUL	Germany	9800	2470

Table 2. Open Access at YERUN universities. Data collected from institutional websites

University	Institutional repository	Specific OA section	Regulations/strategy for the promotion of OS or OA	Location of information on OS and/or OA	Specific actions on OS or OA	Other infrastructure or specific measures	Institutional OA policy	Institutional OS policy
Autonomous University of Barcelona	Yes	No	Yes	Library	Data management plan	Curation	Yes	Yes
Autonomous University of Madrid	Yes	Yes	Yes	Library	Technical support	No	Yes	No
Brunel University	Yes	Yes	Yes	Repository	Funding	Figshare	Yes	Yes
Dublin City University	Yes	No	Yes	Specific OA university press	Full OA university press	Full university press	Yes	No
Maastricht University	Yes	Yes	Yes	Library and specific website	Technical support and data curation	Data curation	Yes	Yes
Pompeu Fabra University	Yes	Yes	Yes	General website	Information	Thesis repository	Yes	No
Tor Vergata University	Yes	No	No	No	No	No	No	No
Carlos III University of Madrid	Yes	Yes	Yes	Institutional archive	Technical support	Data repository	Yes	Yes
Nova University of Lisbon	Yes	Yes	Yes	Repository	Funding	No	Yes	No
Paris Dauphine University	Yes	No	No	Library	No	No	No	No
University of Antwerp	Yes	Yes	Yes	Specific website	Curation	No	Yes	No
University of Bremen	Yes	Yes	Yes	Specific website	Funding	No	Yes	No
University of Essex	Yes	Yes	Yes	Library	No	No	Yes	No
University of Konstanz	Yes	Yes	Yes	Repository	Funding	Research platform in OA	Yes	Yes
University of Southern Denmark	Yes	No	Yes	Specific website	Funding	No	Yes	Yes
University of Ulm	Yes	Yes	Yes	Specific website	Funding	Data curation	Yes	Yes
University of Eastern Finland	Yes	Yes	Yes	Specific website	Funding and support	Thesis repository	Yes	Yes

Table 3. Total number of documents and publications in OA per university (WoS 2000-2019)

University	No. docs	No. open access docs	% Open access documents
YERUN	453,573	147,320	32.48
DCU	9594	2883	30.05
UAB	61,101	20,259	33.16
UAM	40,467	14,839	36.67
UAN	37,803	10,630	28.12
UBRE	20,544	5300	25.80
UBRUN	15,434	4925	31.91
UC3M	11,997	4648	38.74
UEF	26,921	8239	30.60
UES	11,415	4146	36.32
UKO	14,938	4976	33.31
UMA	58,900	20,488	34.78
UNL	20,373	6229	30.57
UPD	3900	923	23.67
UPF	17,600	8597	48.85
USD	30,338	10,796	35.59
UTV	41,814	13,015	31.13
UUL	41,796	11,191	26.77

Table 4. Evolution of OA publications in WoS core collection per country (2000—2019)

Country/region	Publication period 2000—2009			2010-2019		
	No. OA docs CAGR	% OA/total docs		No. OA docs docs	%/OA total	CAGR
World	2,227,005	13.01	14.41	7,703,912	27.22	9.11
Europe	874,586	15.20	13.22	2,908,329	31.02	9.48
Germany	153,143	15.91	11.78	439,561	32.00	8.90
Belgium	30,129	18.33	12.75	98,750	34.95	8.81
	23,762	20.64	9.59	84,544	37.67	11.40
Spain	75,997	19.68	14.02	258,068	34.70	9.57
Finland	19,367	19.21	9.29	60,841	40.09	12.93
France	115,006	17.43	9.67	284,375	30.42	6.51
Ireland	14,572	18.43	14.23	52,234	32.79	9.28
Italy	87,509	16.81	12.78	265,395	30.66	10.54
Netherlands	72,088	23.50	11.81	218,514	41.98	10.15
Portugal	13,015	19.11	18.12	56,884	32.20	12.71
UK	199,184	19.95	9.00	608,065	40.93	10.28

Table 5. Evolution of OA publications in WoS core collection by university (2000—2019)

Publication period	2000–2009			2010–2019		
	University	No. OA docs	% OA/total docs	CAGR	No. OA docs	%/OA total docs
DCU	726	23.37	21.43	2157	33.25	6.26
UAB	3697	20.09	17.33	16,562	38.79	11.03
UAM	4057	26.21	8.83	10,782	43.15	7.28
UAN	2247	17.70	11.99	8383	33.38	11.9
UBRE	1016	13.29	12.54	4284	33.21	15.27
UBRUN	1068	17.52	15.98	3857	41.30	14.09
UC3M	1231	34.42	13.95	3417	40.58	3.76
UEF	2061	18.53	9.87	6178	39.11	10.78
UES	661	14.67	11.08	3485	50.44	15.29
UKO	1524	24.60	4.64	3452	39.48	8.22
UMA	4391	21.90	15.43	16,097	41.43	10.51
UNL	1053	19.46	16.65	5176	34.60	12.83
UPD	268	20.35	17.14	655	25.36	0.95
UPF	1485	34.61	29.82	7112	53.44	8.01
USD	1763	21.90	14.23	9033	40.53	13.29
UTV	3392	22.01	14.37	9623	36.44	7.22
UUL	2858	16.76	7.86	8333	33.66	5.71

Table 6 Number of open access journals and reviews in the 17 most productive disciplines of YERUN

Web of science categories	No. docs	%total docs	Availability (JCR 2018)		
			als	No. OAjournals	
Neurosciences	21,208	4.64	267	45	16.85
Biochemistry molecular biology	21,038	4.60	298	37	12.42
Oncology	17,812	3.89	230	39	16.96
Clinical neurology	16,609	3.63	199	19	9.55
Materials science	16,519	3.61	293	37	12.63
multidisciplinary	13,812	3.02	148	14	9.46
Physics applied	12,826	2.84	267	31	11.61
Pharmacology pharmacy	12,818	2.80	287	24	8.36
Psychiatry	12,793	2.79	148	6	4.05
Chemistry physical	12,597	2.75	69	22	31.88
Multidisciplinary sciences	12,567	2.75	350	82	23.43
Public environmental occupational health	11,610	2.54	145	20	13.79
Endocrinology metabolism	11,461	2.50	136	15	11.03
Cardiac cardiovascular systems	11,232	2.46	172	26	15.11
Chemistry multidisciplinary	10,881	2.38	173	35	20.23
Genetics heredity	10,886	2.37	251	24	9.56
Environmental sciences	10,716	2.34	193	33	17.1
Cell Biology					

Table 7 Mean for the citations received by open access (OA) and non-open access (non OA) publications by institution (2000—2019)

University	DOAJ gold	Other gold	Bronze	Green published	Green accepted
YERUN	17.88	11.76	10.02	36.91	23.43
DCU	14.15	16.05	27.67	23.63	28.41
UAB	14.03	33.32	11.91	29.33	39.42
UAM	16.04	51.16	39.91	35.50	77.71
UAN	17.92	39.80	41.81	35.50	50.79
UBRE	19.76	17.04	27.34	26.59	37.38
UBRUN	18.62	29.63	26.50	31.16	28.87
UC3M	6.15	37.09	12.87	14.87	19.85
UEF	18.33	37.89	47.04	35.20	68.49
UES	10.69	15.59	41.84	28.38	16.13
UKO	18.89	27.26	39.08	16.81	41.74
UMA	18.86	22.49	40.68	51.93	51.34
UNL	15.56	36.79	32.12	27.59	36.73
UPD	14.17	6.56	16.45	22.54	27.13
UPF	21.15	64.20	54.16	40.24	58.91
USD	16.90	30.70	38.45	30.69	57.53
UTV	17.36	50.42	45.75	40.41	57.54
UUL	15.49	50.54	48.84	37.11	84.67

Table 8 Highly cited papers by university. Percentage of HCP in the YERUN network (Wos 2000-2019)

University	No. HCP docs	% of YERUN HCP	OA	%OA
UAB	186	4.86	165	88.71
UAM	251	6.55	238	94.82
UAN	557	14.54	368	66.07
UBRE	168	4.39	93	55.36
UBRUN	257	6.71	158	61.48
UC3M	45	1.17	26	57.78
UDC	70	1.83	43	61.43
UEF	306	7.99	217	70.92
UES	101	2.64	71	70.30
UKO	122	3.18	75	61.48
UMA	697	18.19	436	62.55
UNL	254	6.63	178	70.08
UPD	31	0.81	7	22.58
UPF	320	8.35	252	78.75
USD	410	10.70	266	64.88
UTV	492	12.84	397	80.69
UUL	501	13.08	324	64.67

Table 9 Entropy associated to the distribution of papers by WoS Subject Category and mean % of OA publications in the 2000—2019 period

University	Entropy (WC)	Mean % of OA (2000-2019)
Autonomous University of Barcelona	27.22	28.28
Tor Vergata University	27.19	28.60
Autonomous University of Madrid	27.07	34.22
Maastricht University	26.84	30.80
University of Antwerp	26.15	24.88
University of Eastern Finland	25.83	28.20
University of Southern Denmark	25.77	29.95
University of Ulm	25.70	24.85
University of Bremen	25.38	22.49
Nova University of Lisbon	25.03	26.04
University of Konstanz	24.06	31.66
Pompeu Fabra University	23.99	41.98
Brunel University	23.78	28.41
University of Essex	23.52	31.18
Dublin City University	22.82	27.06
Carlos III University of Madrid	21.94	37.16
Universite Paris Dauphine	17.05	22.27

Table 10. Mann-Whitney's U test over the % of citation received by OA and non OA documents for all Yerum institutions (2000-2019)

University	Mann—Whitney U Sig.	Asymp. (2-tailed)	Mean range for OA	Mean range for NON OA
Autonomous University of Barcelona	93.0	0.004	25.85	15.15
Autonomous University of Madrid	115.0	0.021	24.75	16.25
Brunel University	109.0	0.014	25.05	15.95
Dublin City University	94.0	0.004	25.80	15.20
Maastricht University	91.0	0.003	25.95	15.05
Pompeu Fabru University	93.0	0.004	25.85	15.15
Tor Vergata University	55.5	0.000	27.73	13.28
Carlos III University of Madrid	143.5	0.191	22.45	17.68
Nova University of Lisbon	114.5	0.021	24.78	16.23
Universite Paris Dauphine	183.0	0.645	21.35	19.65

University of Antwerp	90.0	0.003	26.00	15.00
University of Bremen	105.0	0.010	25.25	15.75
University of Fssex	97.5	0.006	25.63	15.38
University of Konstanz	98.5	0.006	25.58	15.43
University of Southern Denmark	97.0	0.005	25.65	15.35
University of Ulm	59.5	0.000	27.53	13.48
University of Eastern Finland	73.0	0.001	26.85	14.15

Table 11 ANOVA main data

	Sum of SQUARES		Mean square		Sig
Between groups	233.80	2	1167.90	11.35	0.001
Within groups	4936.35	48	10.84		
	7272.15	50			

Figure 1. Distribution of OA publications in WoS core collection by country (Countries with a YERUN university)

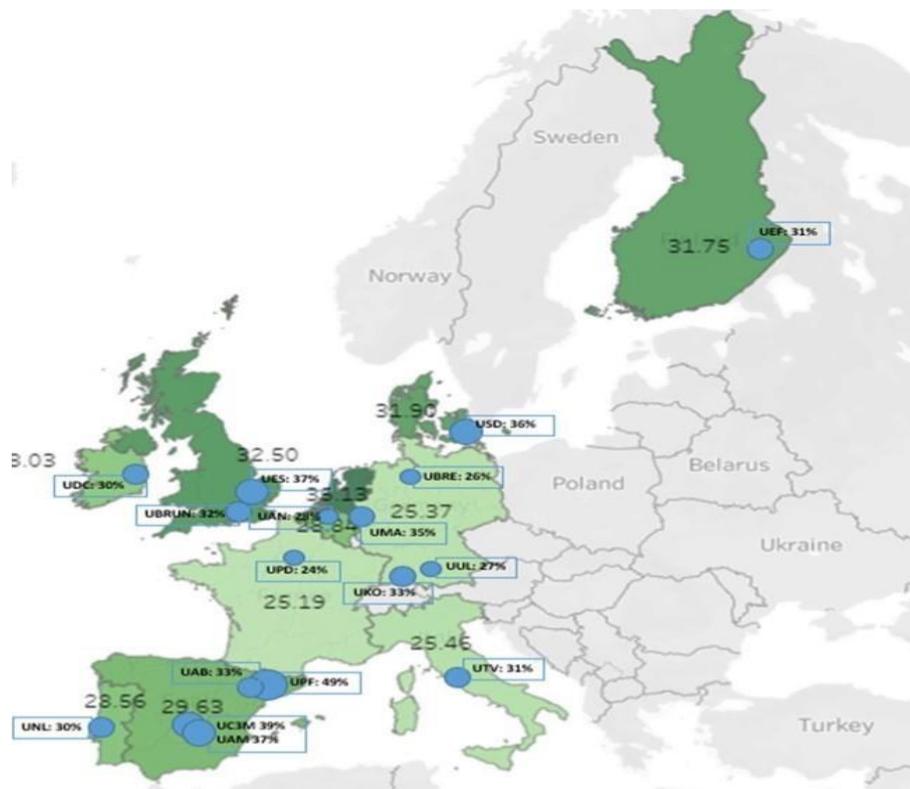


Figure 2. Evolution of the number of publications by YERUN institutions in collaboration. Total documents and percentage of publications in open access

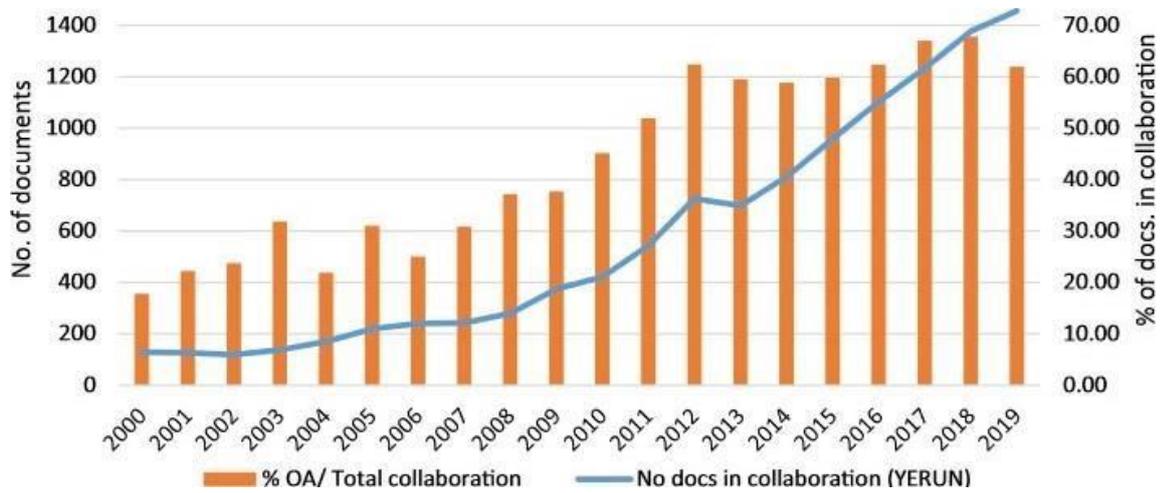


Figure 3. Collaboration among YERUN universities (2000, 2010, 2019)

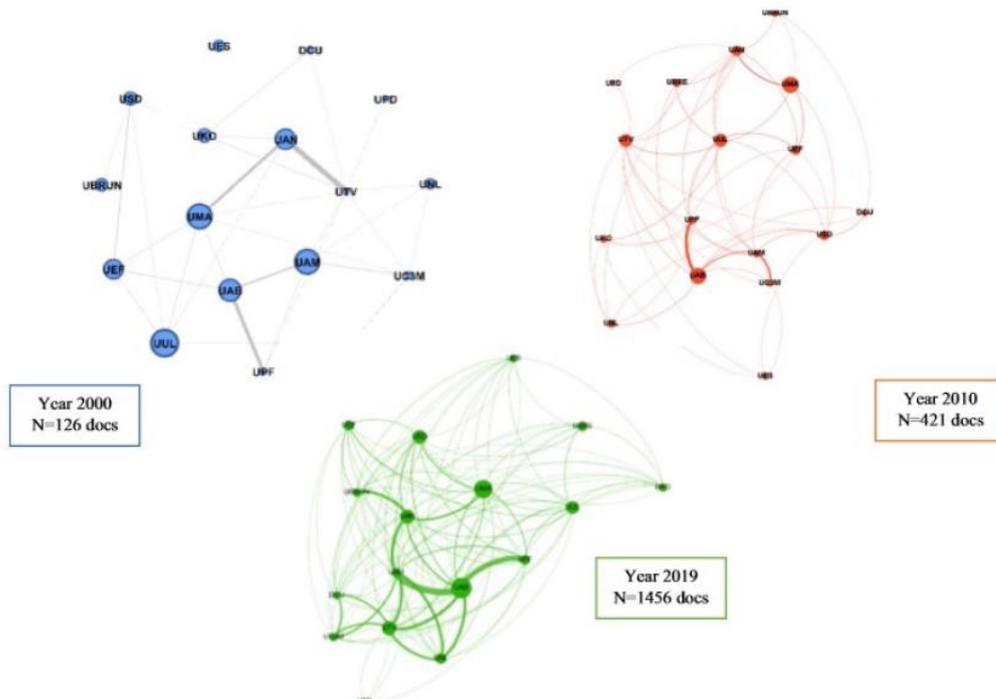


Figure 4. Correspondence analysis with symmetric normalization. Universities and WoS category

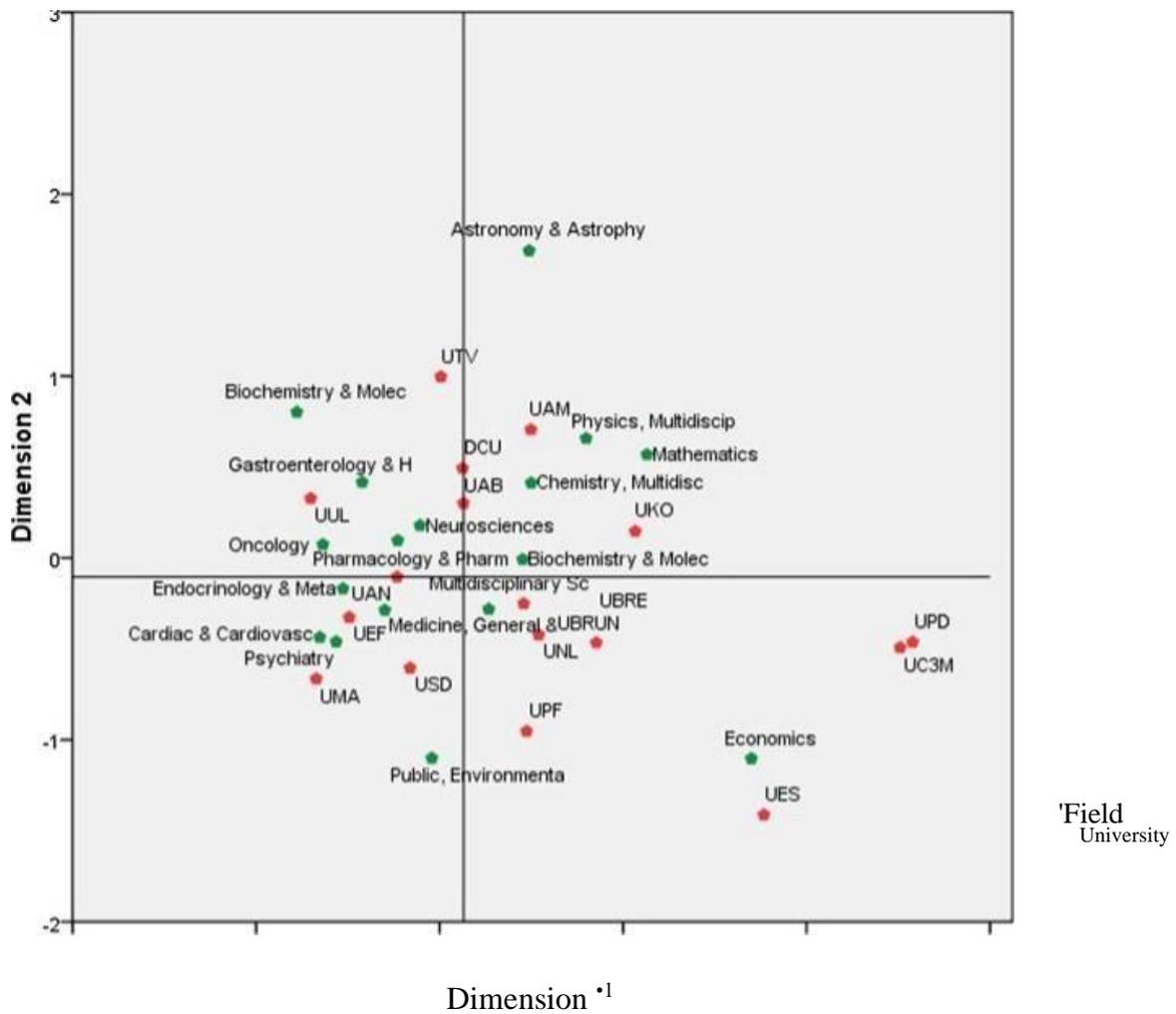


Figure 5. Distribution of YERUN publications by open access type. (Color figure online)

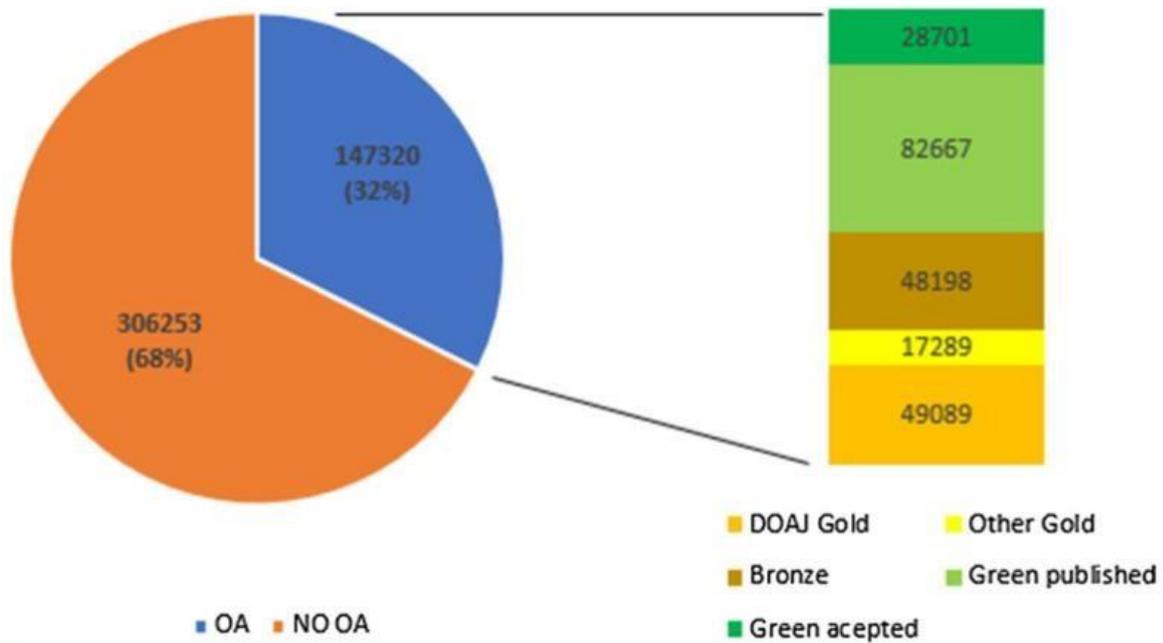


Figure 6. Percentage of open access publications by OA type (2000–2019) for YERUN universities. (Color figure online)

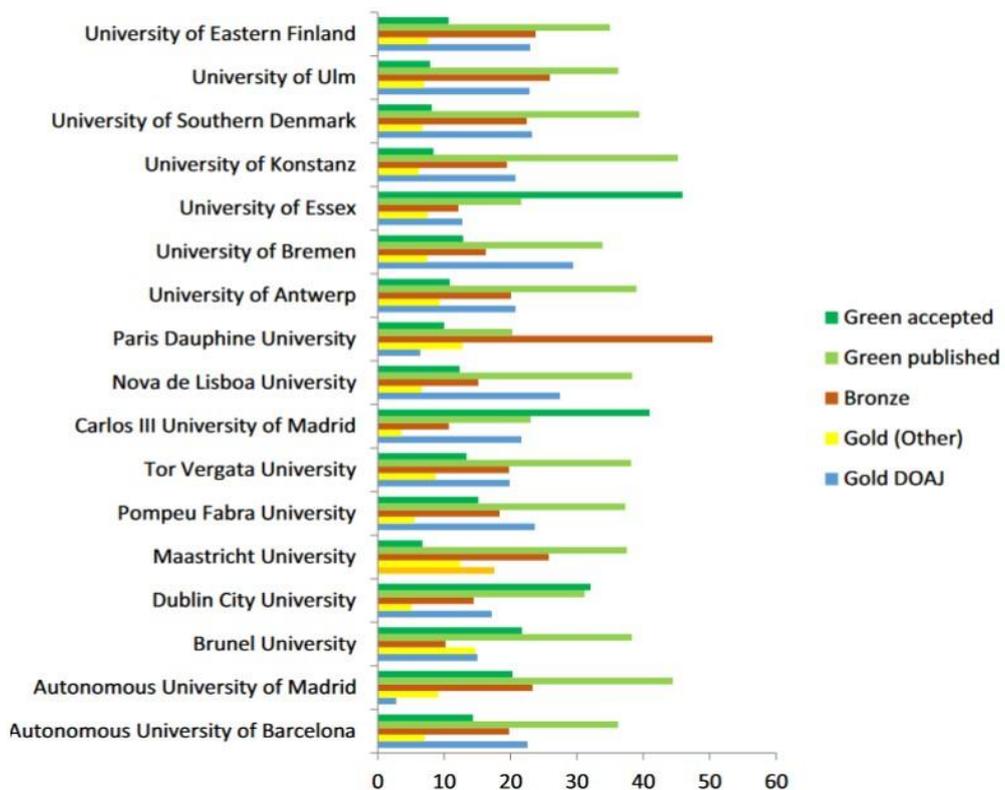


Figure 7. Mean for the citation received by open Access (OA) and non-aopen acces (non OA) publications by institutions (2000-2019)

