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Open Access Dynamics in Latin America: Insights from the Chilean case

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Abstract

Free access to research articles has been a key objective of an important part of scientific community around the world. In the past 20 years this debate has been fueled by researchers and agencies from Europe, and the discussion therein has propagated to the rest of the world, which includes declarations, initiatives and public policies. Latin-America resolved this problem very early, even before open access concept was coined, with the creation of SciELO network. However, the European discussion and the main proposal emerged there, to follow the gold route, has arrived to Latin-American countries bypassing the SciELO initiative. Chile is a good proxy to study the behavior of Latin-America research system during this discussion. We have analyzed the research literature leaded by Chilean authors, from 2011 to 2023. We have found that there is a fast-growing number of articles in the gold open access model in English language, which apparently has grown at expenses of SciELO articles. The main driver of this growth has been articles in Natural Sciences journals, and in two specifically for-profit editorials: MDPI and Frontiers. Citation metrics indicate that gold articles have mediocre visibility, below other models of open access. The total cost in APC spent by Chilean research has been calculated in 9 millions USD just for 2023, which gives an idea of the cost of adhere to European model in a country that already have a solution to open access, SciELO, which is mainly based diamond open access journals, free of cost to authors and to readers. We hope these results serve to public policy discussion at local, regional and even worldwide level, given that an important number of European researchers have seen SciELO as an example of alternative to the expensive gold model impulsed by Plan S.

Resumen

El libre acceso a los artículos de investigación ha sido un objetivo clave para una parte importante de la comunidad científica mundial. En los últimos 20 años, este debate ha sido impulsado por investigadores y agencias de Europa, y la discusión se ha propagado al resto del mundo, incluyendo declaraciones, iniciativas y políticas públicas. Latinoamérica resolvió este problema tempranamente, incluso antes de que se acuñara el concepto de acceso abierto, con

la creación de la red SciELO. Sin embargo, la discusión europea y la principal propuesta surgida allí, de seguir la ruta dorada, ha llegado a los países latinoamericanos pasando por alto la iniciativa SciELO. Chile es un buen ejemplo para estudiar el comportamiento del sistema de investigación latinoamericano durante esta discusión. Hemos analizado la literatura de investigación liderada por autores chilenos, entre 2011 y 2023. Hemos encontrado que existe un rápido crecimiento en el número de artículos en el modelo de acceso abierto dorado, que aparentemente ha crecido a expensas de los artículos SciELO. El principal impulsor de este crecimiento han sido los artículos en revistas de ciencias naturales y, particularmente, en dos editoriales con fines de lucro: MDPI y Frontiers. Las métricas de citación indican que los artículos de acceso abierto analizados tienen una visibilidad mediocre, inferior a la de otros modelos de acceso abierto. El costo total en APC invertido por la investigación chilena se ha calculado en 9 millones de dólares solo para 2023, lo que da una idea del costo de adherirse al modelo europeo en un país que ya cuenta con una solución de acceso abierto, SciELO, que se basa principalmente en revistas de acceso abierto de alto nivel, gratuitas para autores y lectores. Esperamos que estos resultados sirvan como insumo para el debate sobre políticas públicas a nivel local, regional e incluso mundial, dado que un número importante de investigadores europeos han visto a SciELO como un ejemplo de alternativa al costoso modelo de acceso abierto dorado impulsado por el Plan S.

Keywords: open access, Chile, SciELO, APC, citations

Introduction

In the last 20 years, there have been an intense debate about the accessibility of scientific publications. This debate has been fueled by the criticism to the pay-walled barrier created by subscription-based journals. This barrier is relatively higher in poor and developing countries, where the budget for research is limited and most of it is done using public resources (Alperin et al., 2014).

The answer to this situation has been the promotion of open access (OA) as a way to transform knowledge into a public asset. Several research organizations (including national councils), mainly from the north hemisphere, have signed successive declarations to promote open access, and in 2018 the European Union have impulsed the so-called Plan S, which forces the publication in this format of author rights (Kosmopoulos, 2022). The Plan S has received numerous critics from research community, among other reasons, due to transfer (and amplification) of cost from readers to researchers (Holmwood, 2018; Brainard, 2019).

Interestingly, Latin-America has preceded Europe in this discussion, and the answer were launched in 1997 with the birth of SciELO, a multinational repository of scientific publications based on collections of OA journals (Aguado-López et al., 2015). Several other local initiatives respond to the same objectives of SciELO (Redalyc, AmeliCA, LaReferencia), with a focus on cooperation and participation of the research community, instead of focusing on for-profit publisher market, as Plan S do (Becerril-García, 2019). Indeed, the eventual adhesion of Latin-

American countries to this plan has been seen as a risk for the long OA tradition of the region (Debat & Babini, 2019).

SciELO platform has been fundamental for the development of scientific knowledge in Spanish-speaking countries. Besides to give free access to knowledge, it gives visibility for local publications, it promotes south-south collaboration, it fosters undergraduate education (through the availability of part of the core bibliographies for the training courses) (Packer & Babini, 2020).

Chile, a Latin-American country with a developing economy, has not been immune to this debate. While Chilean scientific community is relatively small (less than 2 researchers per 1,000 work force), it is quite productive in terms of scientific publications, being only below Brazil and Argentina on the continent (Van Noorden, 2014). The scientific articles leaded by Chilean researchers are the most cited in the continent, and the country has a community with high levels of collaboration with researchers in the global north (Koch et al., 2020; Narayan et al., 2023). Besides, Chile was one of the first countries to participate in SciELO (1998). These facts turn Chile as a good place to analyze the impact of OA promotion and the nature of it.

To date, different forms of OA have been defined, which can be applied to journals or publications, with four universally accepted models: green, bronze, gold, hybrid and diamond. Green OA is when the authors of an article publish a version of it (before or after peer review) in a database external to the journal itself (preprints or postprints). This must be allowed by the journal, which are usually subscription-based. Bronze OA are those articles made accessible to the general public, but in a variety of proprietary rights, which depends on the journal, normally after a time embargo. Gold OA journals are those that are immediately available for reading by anyone, charging the authors a fee called "article processing charge" (APC) once the article is accepted for publication. Hybrid OA or hybrid gold OA are those journals which are subscription-based, but allow the authors of each article to put their individual publication with immediate open access, upon payment of an APC. Then, each issue of a hybrid OA journal can have a mix of closed access (CA) and OA articles. Finally, diamond OA is those where articles are immediately available for anyone, upon acceptance, without any type of charge or fee.

Global tendency analysis point out that the OA publications have been dominated in the world by bronze OA, followed by the green OA. However, from 2012 on, there has been an explosive rising in gold OA, probably impulsed by Finch plan developed in UK in that year (Pinowar et al., 2018). For South-American countries, there is a general rise in the proportion of OA publications (Narayan et al., 2023), but to this date, there are very few studies which account for the different types of OA in the region (Beigel et al., 2024). Nevertheless, the advance of the gold OA in has been somewhat documented (Vessuri et al., 2014; Pavan & Barbosa, 2018; Figueiredo et al., 2014).

A key motivation for researchers to publish in OA, is the higher visibility reached by these types of publications. It has been shown that OA publications receive more cites compared with their CA counterparts (Eysenbach, 2006; Tennant et al., 2016; Langham-Putrow et al., 2021).

However, some authors have made a call to analyze these results cautiously (McCabe & Snyder, 2014; Ottaviani, 2016), because the higher citation level of OA papers could not be exclusively caused by the OA *per se*, instead by their immediate availability (early access hypothesis) or because authors select their best works to be published in OA (selection bias hypothesis) (Kurtz et al., 2005).

A relevant aspect in bibliometric analysis of OA, particularly for gold and hybrid OA, is the APC fee. For several authors, the APC fee creates a new economical barrier which could be even worse than the former, specially for poor and developing countries (Demeter & Istratii, 2020; Zhang et al., 2022, Fonturbel & Vizentin-Bugoni, 2020). Even in developed countries, there are worrisome because the benefit of OA could not compensate for the high and growing amount of money spent in APC annually (Pinfield et al., 2016; Khoo, 2019; Ross-Hellauer et al., 2021). About the relationship between money paid via APC and the visibility of publications, there is no consensus. Some studies see a poor correlation (Bjork & Solomon, 2015), but in other there is no correlation at all (Yuen et al., 2018). In fact, it was shown that in some big editorials, researcher from poor or developing countries publish more in expensive and less-selective journals (“mega-journals”), while authors from developed countries publish in top journals from the same editorials, creating a cross-subsidy (Ellers et al., 2017).

APC fee payments in poor and developing countries are a key public policy matter, given the relatively small public budget for research, while the benefits for publishing in OA are not really clear. This way, APC fees could make deeper the regional differences, especially those related to language (MoChridhe, 2019) and some disciplines (Demeter & Istratii, 2020). Indeed, the analysis of language is relevant given Chile is a Spanish-speaking country (Jenkins, 2013; Finardi et al., 2022).

In the following study we analyze the evolution of OA articles led by authors with Chilean affiliation, that is, publications where the first and/or last author have at least one institutional affiliation with address on Chilean territory. We choose the last author, assuming he/she is the corresponding author. We see that the preferred type of OA is SciELO, however there is a rapid growing of non-SciELO gold OA articles, which in turn present moderate indicators both in citations and in journal indicators. Total money spent in APC fees is also of worry, which is consistent with the criticism made to Plan S and the eventual adhesion of Latin-American countries.

Methodology

All publications in Scopus and SciELO were extracted, where at least one author had an institutional affiliation with an address in Chile. The data was obtained on June 25, 2023 in CSV format and its subsequent analysis was done using python tools. All conference articles, books and books chapters were removed. The articles were filtered, leaving only those where the first and/or last author of the publication had at least one affiliation in Chile. This dataset is considered to be articles with “leadership by Chilean authors” and consists of 196,449 documents. Scopus and SciELO databases allow obtaining the following data for each article:

title, authors, institutional affiliations of each author, number of citations at the time of downloading the data, language of the article, journal, company/institution that publishes the journal, among other data not used in this work. The OA status of each article was also provided by Scopus, but this data was checked manually because several inconsistencies were observed. For this revision, all articles published on journals registered in SciELO or in the Directory of Open Access Journals (DOAJ) database were considered to be diamond OA, if they do not charge any fee, or gold OA if they do.

The APC cost data associated with OA journals were obtained from DOAJ, data that were obtained on November 16, 2023. For the historical analysis of APC costs of some journals, the WayBack Machine tool of the Internet Archive (https://web.archive.org/) was used. The APC of hybrid journals or other gold journals not registered on DOAJ were searched manually. In the cases of journals which have APC which depends on page number, we consider a standard number of 10 pages per article. In journals which use other measures to calculate the final APC, the middle value was selected. Other costs charged by journals, different from APCs, were not considered (submission fee, revision fee, editorial revision fee, additional cost per color pages, etc).

The data on the knowledge area of each journal, the Scimago Journal Rank (SJR; Guerrero-Bote & Moya-Anegón, 2012) and other indicators of each journal, were obtained from Scimago (https://www.scimagojr.com/). Scimago knowledge area was manually converted to Organization for Economic Co-operation and Development (OECD) knowledge area. In case of several areas were reported, only the first was considering, except for some mega-journals (PeerJ, PlosOne, whose were manually assigned to Multidisciplinary).

Random Forest (RF) regression was done using as target the normalized citation count (number of cites divided by the average number of cites on the corresponding year) using all articles downloaded from Scopus and the following features for each article: age of the article (2024 minus year of publication), total number of authors (nAuth), total number of different addresses reported (nInst), SJR of the journal on the year of publication (SJR), average SJR of the journal from 2011 to 2023 (when data were available) (SJRm), quartile of the journal in their discipline on the year of publication (from 1 to 4, and 0 for journals not indexed this way) (Q), average Q from 2011 to 2023 (when data were available) (Qm), if the article is OA (boolean feature), if the article has at least one author from countries in the G7 group (USA, UK, Germany, Japan, France, Canada, Italy; boolean feature). Dataset was divided in English and Spanish written articles, training different models for both groups. In each case, 10,000 trees were generated at the deepest level possible, using one third of the sample for training.

Correlation, models, statistics and figures were prepared using python3 and corresponding libraries (numpy, pandas, scipy, statmodels, matplotlib).

Results

Evolution of Open Access in Chilean-lead articles

All articles with leadership by Chilean authors from 2011 to 2023 were obtained from the Scopus and SciELO databases. We gathered a total of 196,449 documents, where 104,119 were obtained from Scopus and 23,517 from SciELO (68,813 SciELO documents were indexed on Scopus). By analyzing these data, it is possible to observe the sustained increase in OA publications during the period, with the consequent stagnation of CA publications (Figure 1). SciELO articles have been declining over the years to be under 40% of the total in 2023. In terms of language, the balance between English and Spanish articles has remained relatively constant (between 35% and 41% of articles are in Spanish) in our dataset. Other languages are marginal.

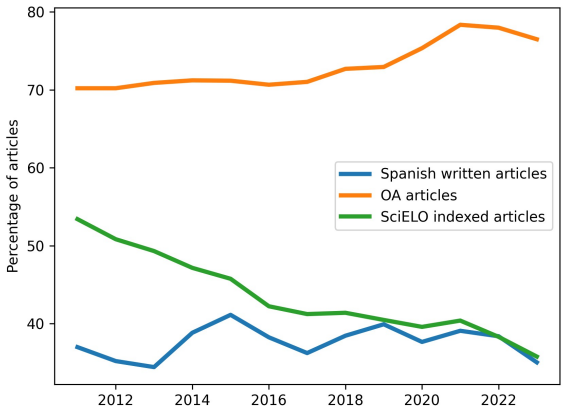

Figure 1. Behavior of articles leaded by Chilean authors as percentage of total dataset. SciELO articles include those also indexed in Scopus. OA articles include all models.

In only-Scopus indexed articles, historically, CA have dominated the distribution, but a very fast-growing gold OA can be seen from 2018 (Figure 2A). Hybrid and diamond OA models are also growing in English written articles. In SciELO indexed articles (which includes a portion also indexed in Scopus) diamond OA articles had dominated the distribution, going from ~70% of the total to ~80% in 2023 (Figure 2B). The other types of OA remain below 10%, and they only are observed in only-Scopus indexed articles. However, from 2016 there has been a sustained decline in both green and bronze OA publications (Figures 2A).

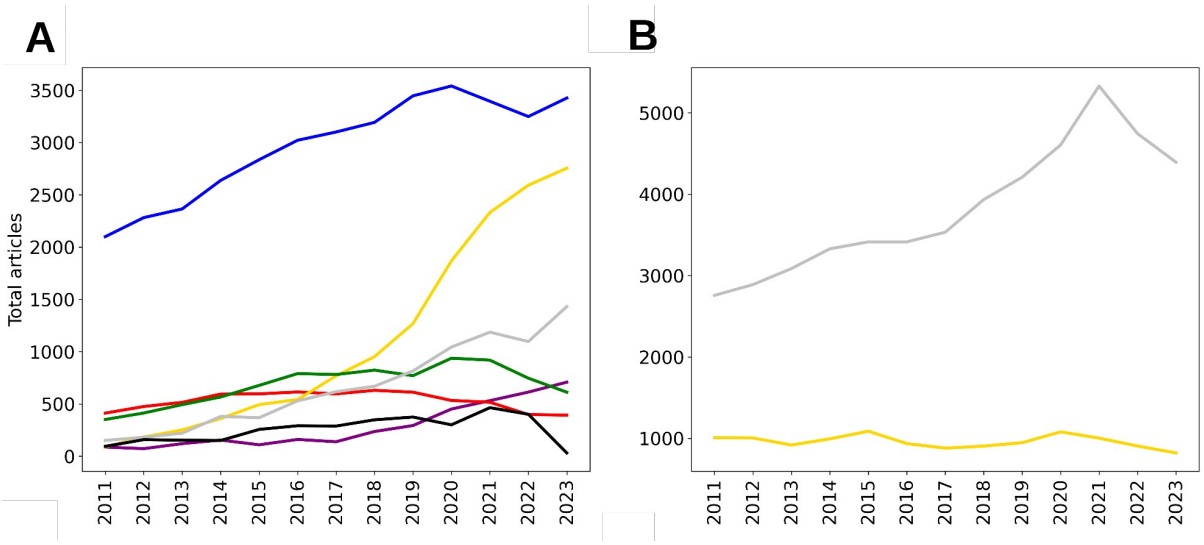

Figure 2. Evolution of CA (in blue) and OA articles, in their different variants: gold (yellow); bronze (red); green (green); diamond (gray), hybrid gold (purple), unknown (black). A. Number of articles indexed only in Scopus. B. Cumulative percentage of articles indexed only in Scopus.

To have a detailed picture of the data, we study the OA behavior in the data classified by the knowledge area (using OECD categories) and language (Figure 3, Figure S1). When analyzing both, the main knowledge area and the language of the publication, it can be seen that OA publications have increased in all cases, but with some differences (Figure 3).

Articles in English have been historically dominated by CA articles, reached by gold OA in 2023. Instead, articles in Spanish are largely dominated by diamond OA articles, with a modest and decreasing number of gold OA articles (Figure 2, second column). The latter can be explained because most Spanish articles are indexed in SciELO and not in Scopus, where gold OA growing is observed.

In most of the knowledge areas, CA articles have been declining over the years, in favor of gold or diamond OA journals (Figure 3). Relative importance of gold OA articles raises in all categories of English articles, but for Social Sciences and Arts and Humanities. Diamond OA are the majoritarian in Spanish articles, but in Engineering & Technology, this category is declining in favor of gold OA. In the most important subcategory, Natural Sciences in English (20% of all dataset), all categories are decreasing, except hybrid gold OA and gold OA, which becomes the most populous in 2023. Medical & Health Sciences, Social Sciences and Arts & Humanities articles, show a relatively stable distribution of OA models in the years analyzed, in both languages.

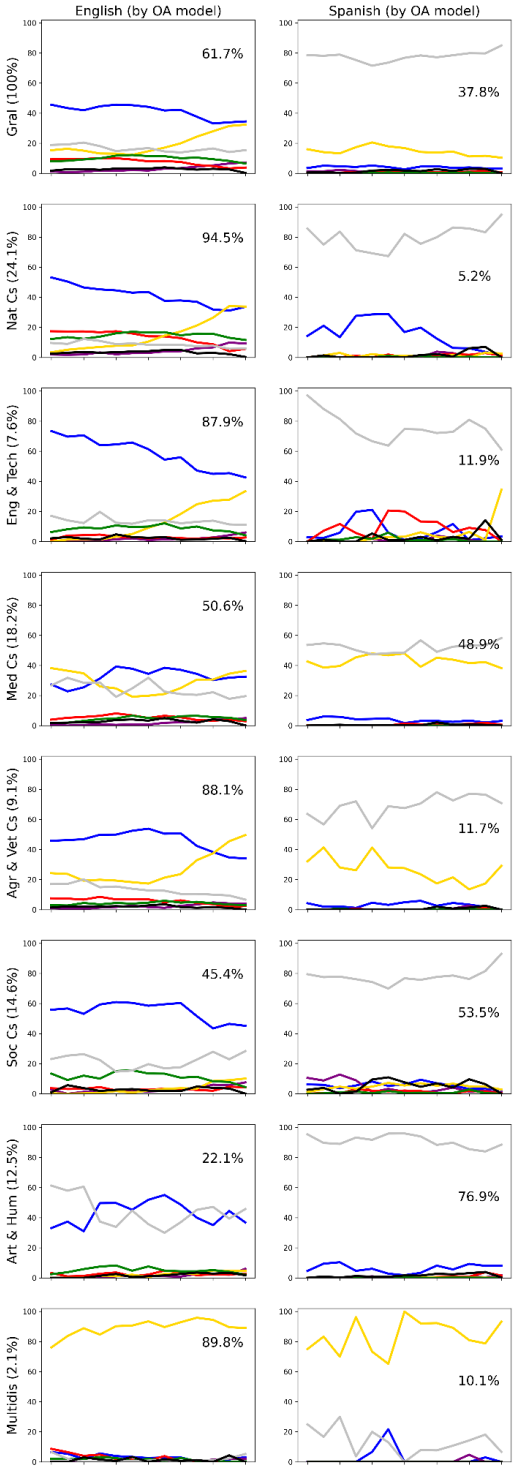

Figure 3. Behavior of the different OA models, in each language and area of knowledge. First column: Articles in English. Second column: Articles in Spanish. Each row indicates the OECD area, being the first row an analysis of all articles. In parentheses, it is shown the percentage of articles of each area (including all languages). The percentage inside each plot indicates the proportion of that language in the corresponding category (in the same row). Color code are the same from Figure 2.

Editorial Analysis

We next analyze what type of publishers are involved in the articles leaded by Chilean authors. Two main groups are identified: non-profit organizations/institutions, where we find universities, scientific societies, governmental organizations, among others; and for-profit publishers, where the four major multinational publishers are individualized: Springer-Nature, Elsevier, Wiley and Taylor & Francis (T&F); plus two relatively new and rapidly growing only-gold OA publishers: Multidisciplinary Digital Publishing Institute (MDPI) and Frontiers Media (Figure 4).

The sum of articles published in journals of non-profit organizations, is more than that of for-profit journals in the analyzed period. However, from 2019 onwards, we see an explosive increase in the number of publications in journals of the so-called emerging publishers (MDPI and Frontiers), concomitant with a stagnation in the growth of traditional for-profit publishers. This behavior is clearly visible in articles written in English language (Figure 4A).

Publications in journals of Universities (Chilean and non-Chilean) are the most common in Spanish written articles, where Taylor & Francis is the only big for-profit company to have articles in this language (Figure 4B). It is worth to mention, the decline in articles published in journals of Chilean organizations (most are Scientific and Professional Societies), in both languages (Figure 4, solid green line).

To explore the increasing in OA articles observed, we made the publisher analysis on OA articles in English language (Figure 4C). Here, it can be seen more clearly, the fast increase of articles published in MDPI, compared with other publishing houses. In fact, the MDPI company is that with the higher steep, surpassing in 2021, all traditional publisher companies (in OA articles). It is not informative to analyze Spanish OA articles, because there are not CA articles in this language.

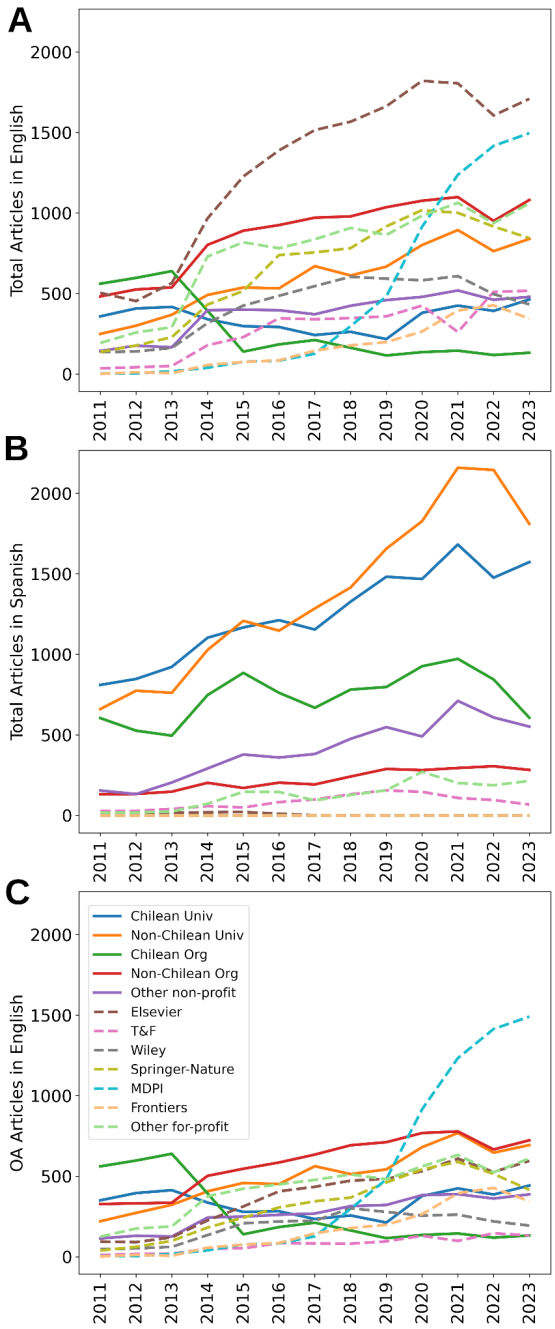

Figure 4. Behavior of publications based on the publisher house. A. Total articles in English language. B Total articles in Spanish language. C. Total articles in English language. Legend shown in C is valid for all three plots.

When the data of English written OA articles are analyzed by OECD knowledge area (Figure S2), we see that the impressive growth of MDPI is based on three areas: Natural Sciences, Engineering & Technology and Agricultural & Veterinary Sciences. In the other areas, also there is a sustained raise in MDPI articles, but it is lower and mixed with other publisher categories. In Medical & Health Sciences, the more popular category before 2015 was by far Chilean Scientific and Professional Societies (abv, Chilean Org, mainly journals from local Medical Societies),

which shows a sharp decline over the years. Publications in journals from Chilean Universities are declining in Engineering & Technology and Agricultural & Veterinary Sciences.

Visibility of publications

One way to measure the impact of publications or journals is the number of citations they receive. There are different metrics that are calculated from citations, but in this study we analyzed the citations that each article has received at the time the data was downloaded. Since this is a value that increases over time, we normalized the data by the annual average. Sadly, citation data from Scopus and SciELO are calculated in different ways, then they are not comparables. Hence, we only use data of Scopus for citation to articles, because it includes two thirds of the articles indexed in SciELO.

To measure the impact of journals where the articles are published, we used the Scimago Journal Rank (SJR) indicator, averaged for each year weighted by the number of articles published in each category. This indicator includes all articles published in that journal, regardless of the author's origin, in a time window of three years. It has been shown that SJR is a better indicator than others like Journal Impact Factor (Yuen et al., 2018).

We see that there is an important difference in the behavior of English and Spanish articles/journals. In English (Figure 5, first column), we see that publications in green and bronze OA models are those with the highest number of normalized citations, and high but declining values for SJR. OA publications in hybrid journals have a noisy, but increasing behavior. Around 2012, normalized citations of hybrid gold OA articles started to growth to become the most cited category in 2017. In terms of SJR, hybrid journals started under green and bronze articles in 2011, to reach them in 2018, and it keeps in a similar level that those OA categories. CA in subscription journals have a relatively constant values for normalized citations and SJR, just under bronze, green and hybrid gold OA. Gold OA articles have citations and SJR similar to CA articles. Finally, diamond OA journals have very low visibility, seen in normalized citations and SJR of the journals, but this situation changes in Spanish articles, where SciELO articles are majoritarian.

In Spanish articles (Figure 5, second column), we see that diamond articles have normalized citations near to 1, which is expected given that they dominate this category. Other models of OA are noisy, given that they are very scarce in Spanish articles. It is worth to mention gold OA articles, which are between 20 and 30% of Spanish articles. Both indicators (normalized citations and SJR) are higher than diamond OA, but they tend to approach each other in the last three years.

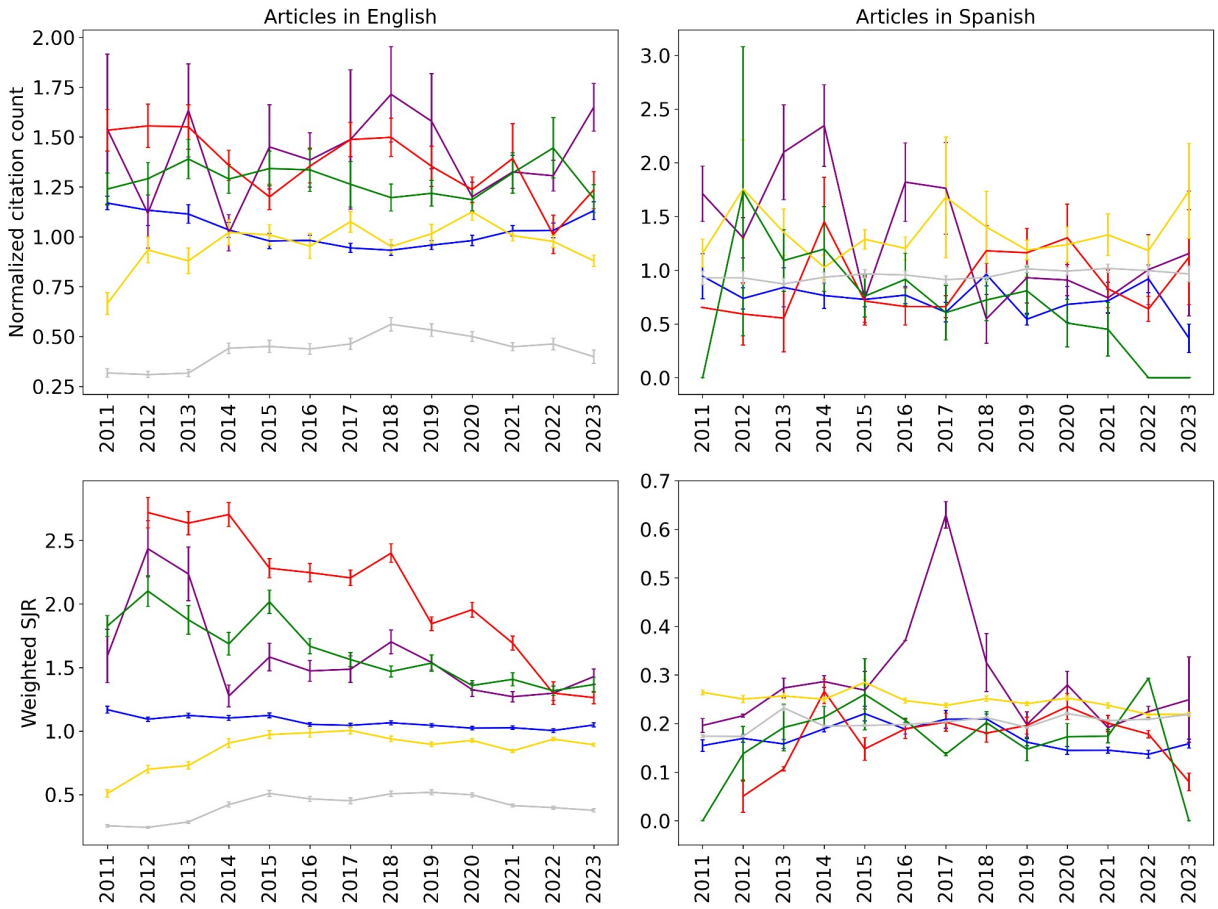

Figure 5. Impact of publications according to the CA/OA model. First column: English articles. Second column: Spanish articles. First row: Citation count per article normalized by the annual average; Second row: Average Scimago Journal Rank (SJR) of the journal in which each article is published, weighted by the number of articles in each journal. Color code are the same from Figure 1.

When analyzing these same indicators, but now broken down by publisher houses, we see that the trends are noisy (Figure 6). In English articles, the best performers in normalized citations are articles published in Elsevier and non-Chilean organizations journals (Figure 6, upper-left plot). Under they, we find the two emergent companies, MDPI and Frontiers. Frontiers have very high citations in articles published before 2017, but the trend tends to decay very fast. MDPI articles are in the middle of the distribution, under the aforementioned companies, but ahead of the other big publishing houses.

In terms of SJR of journals in English language (Figure 6, lower-left plot), non-Chilean organizations and Frontiers are by far the best performance journals, although they show a fast decline over the years. After those, we find the other for-profit companies like Elsevier, Wiley, Springer-Nature and non-Chilean university journals. The SJR indicators of these categories are declining over time, but more slowly than the first two. Then we have the journals of MDPI, Taylor & Francis and other non-profit organizations, which show low SJR indicators (between

0.5 and 1.0), but slowly growing over time. Finally, we find journals of Chilean Universities and organizations which are the worst performers, at the level of normalized citations and SJR.

For Spanish written articles, we see that all categories are similar in terms of normalized citations, with the exception of Taylor & Francis and non-Chilean organizations papers (Figure 6, upper-right plot). The first starts to detach from the rest around 2016, to keep high until 2023. Articles published on non-Chilean organizations journals, start to raise very fast in 2019, to be almost 5 times more cited than average in 2023.

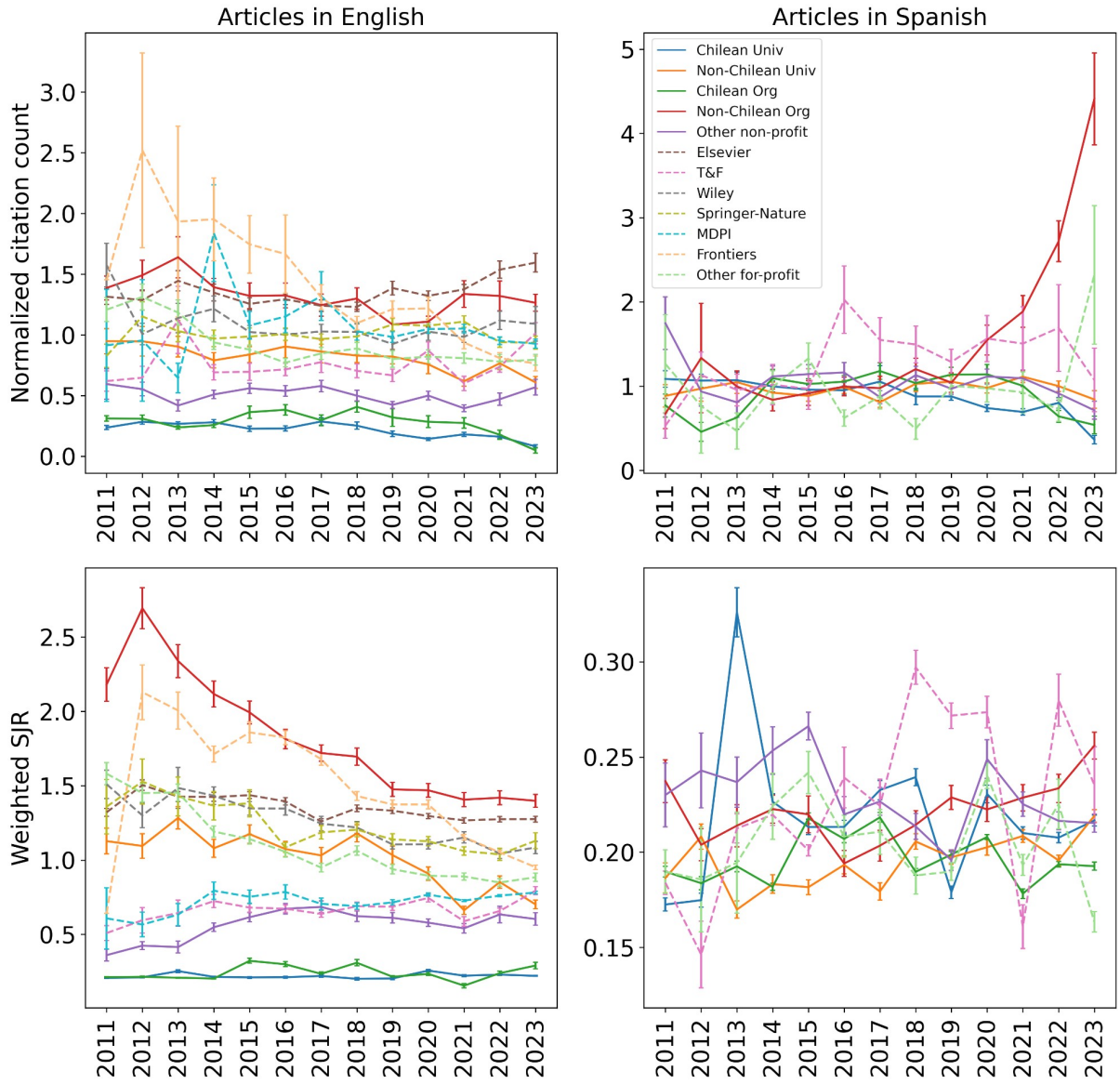

Figure 6. Impact of publications according to the publishing house. First column: English articles. Second column: Spanish articles. First row: Citation count per article normalized by the annual average; Second row: Average Scimago Journal Rank (SJR) of the journal in which each article is published, weighted by the number of articles in each journal. Categories with less than 100 articles in the sample (all the years summed) are not shown.

When SJR of journals in Spanish are observed, we see that all categories are in the range 0.15 - 0.30 (Figure 5, lower-right plot). Here Taylor & Francis, better SJR, starting from 2018 and non-Chilean organizations journals have a raising behavior. Notably, Chilean University and organizations journals have better SJR than other categories like Non-Chilean Universities and other for-profit editorials.

To get a picture of the main drivers of the citation of Chilean-led articles, we adjust Random Forest (RF) models for English and Spanish written articles, separately. These models allow to see: (1) if it is possible to predict citations based on available features; (2) what features are the most relevant to that prediction. We train the models to predict normalized citations as target feature. The first observation is that we obtain an RF models which have poor adjustment, because the error is very high (Figure 7). This means that the features used to train the model are not enough to predict adequately the citation number. In spite of the poor adjustment of the general model, it is possible to get the features sorted by their importance to the model (Figure 6). Interestingly, we see that the order of relevance of the features change between English and Spanish written articles. In English, SJR of the corresponding journal is the main factor influencing citations, followed by the total number of institutions (nInst) and the number of authors (nAuth). After those, it is the average Q position of the journal (Qm). Unexpectedly, other features are less relevant to predict citations, like APC fee, if the paper is OA ("is-OA", boolean feature), and the presence of an author of developed countries ("has-G7", boolean feature). In Spanish, the features relative to journals are less relevant, being SJR in third place and average Q in 6th place. The total number of institutions and the number of authors of each paper are the most relevant features to predict citations. Again, APC fee, if the paper is OA, and the presence of an author of developed countries, are not relevant for the prediction. It´s worth to mention, that the feature importance obtained from RF model indicates an order of the features, but cannot be analyzed to qualify these differences.

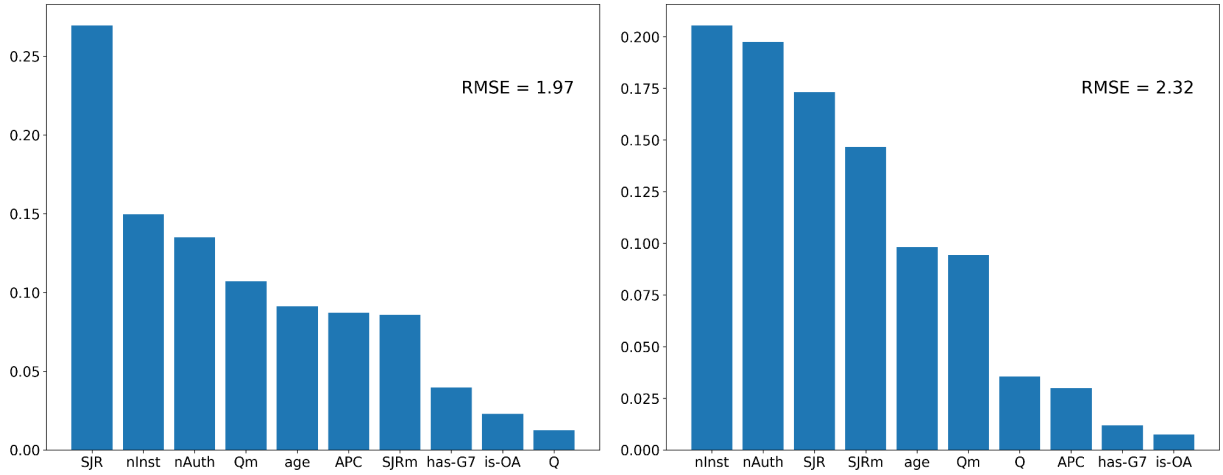

Figure 7. Relevance of the features used to train the RF model. A. Using only English language articles. B. Using only Spanish language articles. Accuracy of the models are shown as RMSE on the same plots. For the meaning of each feature, see the text.

APC costs

To analyze the costs associated with APC of the different OA publications, we used the information available in DOAJ (for gold OA journals), together with manually collected information (for hybrid journals and gold journals not indexed in DOAJ). In Table 1 we see that average APC 2023 for hybrid and gold journals in English language was more than US$3,000 and US$2,000, respectively; while hybrid and gold OA in Spanish was US$121 and US$430, respectively. Table 1 also shows the average APC 2023 for the different types of publishers. Most journals from universities and Chilean institutions have very low APCs, while for-profit editorials this cost ranges from US$1,300 (other for-profit editorials) to US$3,286 (Wiley). Journals from non-Chilean organizations are the only non-profit publisher with high average APC costs (US$ 1,782). All the APCs 2023 for journals in Spanish are below US$500.

Category	**Average APC 2023 (US$)**	
	Articles in English	**Articles in Spanish**
Hybrid Gold OA	3,029	121
Gold OA	2.191	430
Chilean Universities	102	33
Non-Chilean Universities	426	11
Chilean Organizations	414	81
Non-Chilean Organizations	1,782	259
Other non-profit	334	13
Elsevier	2,379	-
Taylor & Francis	1,924	182
Wiley	3,286	-
Springer-Nature	2,480	-
MDPI	2,362	-
Frontiers	2,751	-
Other for-profit	1,309	139

Table 1. Average APC 2023 weighted over the number of articles in each category in the dataset.

Next, we analyze the impact of APC costs on the visibility and quality of Chilean research. Figure 8 shows the distribution of APC total costs for the year 2023. Publications in gold OA journals represent nearly three quarters of all year cost, while APC paid in hybrid gold journals represents one quarter. It is surprising that OA articles in hybrid journals represent one quarter of total 2023 APC cost, while they are less than 10% of the total articles published by Chilean authors. The reason which explains this is the high average APC of hybrid journals (Table 1).

As for the classification by knowledge area, publications in Natural Sciences represent the largest proportion of total APC paid in 2022, while publications in the areas of Social Sciences and Arts and Humanities are the ones that spend the least on APC (Figure 8B).

Finally, if we look at the distribution of total APC costs by type of journal publisher, we see that the two emerging publishers, MDPI and Frontiers, takes almost 50% of the total payments in this concept, followed by non-Chilean organizations (13.6%), Elsevier publisher (11.3%) and Springer-Nature (7.2%) (Figure 8C).

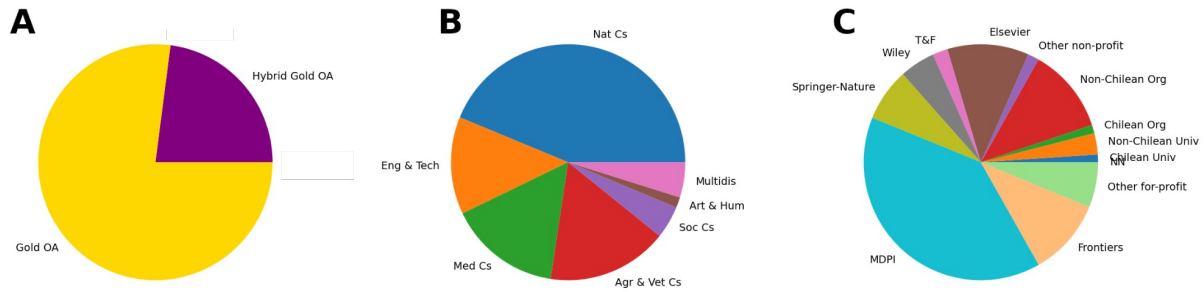

Figure 8. Proportion of the cost of the total APC paid in publications by authors with Chilean leadership, during 2023, according to different types of classification. A. According to OA model; B: According to the OECD knowledge area; C: According to publisher house.

To better understand the observation of high APC costs paid to only two publishers, we analyzed the historical cost of APCs for the journals of MDPI and Frontiers companies, from 2011 to date (Figure 9). Additionally, we added the cost of PLOS journals for reference, as these journals follow a similar strategy of only gold OA journals, high APC fees and a growing number of journals.

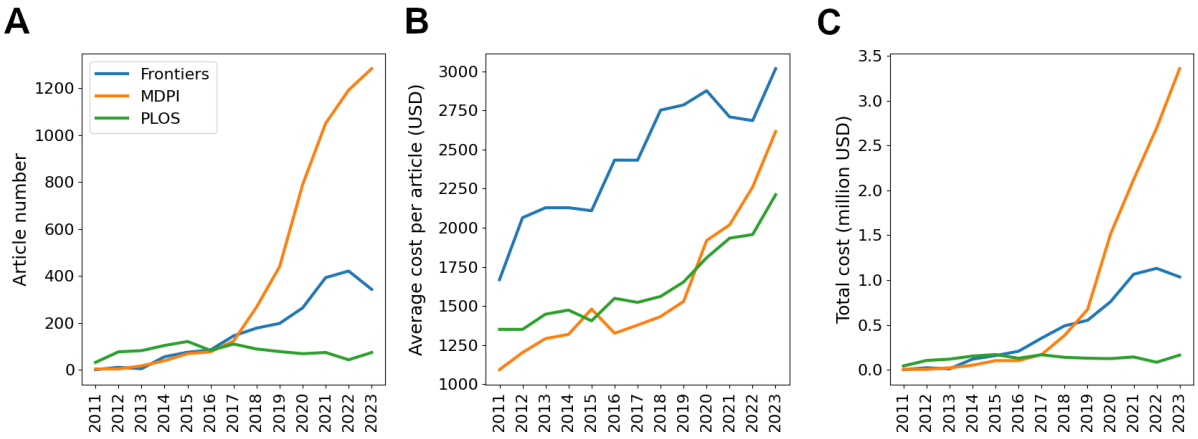

Figure 9. Evolution of publications in journals of PLOS, MDPI and Frontiers publishers and their cost. A. Evolution of the number of articles. B. Evolution of the average APC cost per article. C. Evolution of the total cost per year spent in APCs in the identified publishers.

We see that the high cost paid in APC to MDPI and Frontiers is due to two factors. On one hand, there is a sustained increase in the number of publications in these publishers, particularly for MDPI, where exponential growth is observed. On the other hand, there is a sustained increase in APC costs per publication for both publishers, with each article in Frontiers being, on average, 1,000 USD more expensive than an article in MDPI, at least until 2021, when the average cost per MDPI article increases rapidly to stay very close to the costs of Frontiers (3,000 and 2,600 USD respectively). The cost of APC in PLOS journals follows a similar path than MDPI journals, indicating that this behavior could be a common strategy in this type of companies. When considering the total costs for APC paid by publications with leadership by Chilean authors, we see that by 2023, almost 4 million dollars were paid to MDPI and 1 million dollars to Frontiers (Figure 9).

Discussion

For many years, knowledge in scientific and specialized journals has been under a paywalled barrier, due to access via subscription. This barrier to knowledge works both for the scientific community and for the community in general. OA came about precisely as a way to break down this barrier and allow equal access to knowledge. This promise was much more relevant for scientific communities in poor and developing countries, which saw their access to knowledge frustrated by their lower capacity for access via subscription (Bravo-Marchant & Cabezas-Bullemore, 2020; Vessuri et al., 2014). A direct consequence of the rapid increase in OA publications around the world was the increase in the visibility of this type of publications, verified in the number of citations received, among other indicators.

Nevertheless, to analyze Latin-American knowledge productivity, a key actor must be taken into account: SciELO network. SciELO was truly the OA before OA, giving free access to knowledge to specialized and general communities. The data we gather for Chilean-led articles indicate

that there is a predominance of SciELO articles, but this predominance has been challenged by non-SciELO gold OA articles.

Gold OA near-exponential growth has been at expenses of English non-OA articles, but also concomitant with a sustained decrease in SciELO indexed articles, in English and in Spanish. This is interesting because both non-SciELO gold and SciELO articles are OA, but in most of the cases, non-SciELO gold journals charge a very high APC fee (Table 1), while most of SciELO are free (diamond OA).

Social Sciences and Arts & Humanities appears to be the only to not shown a increasing in gold OA, nor in English nor in Spanish. A reason to explain that these categories are not affected by the growing of gold OA, could be that most of the research in these areas are local, and then, they are not so globalized as the rest (Koch & Vanderstraeten, 2018). Researchers from globalized knowledge areas must compete with research from all around the world, and then, English non-SciELO gold OA journals could offer an advantage in that competition, at least at a theoretical level (Morillo et al., 2020).

The language dimension is interesting because, in spite of the decline in SciELO numbers, the relation between English and Spanish articles have been relatively stable (Figure 1). In another study, using data from WoS, researchers found that Chilean articles are increasingly in English, even in Chilean journals (Koch & Vanderstraeten, 2018). This difference can be explained by the differences in the dataset, while in Koch & Vanderstraeten (2018) they include articles from WoS with Chilean co-authors in any position, in this study, articles with Chilean co-authors in first or last position, including data extracted from SciELO, which is mainly in Spanish language.

We choose first and last authors as key to build our dataset, because authors in these positions are more probable to be the ones to choose the journal where the article would be published, as well as, the source of money to pay the APC in case where APC do exist.

It has been argued that the OA improves the visibility of publications, and also their impact, something that has been widely demonstrated. However, in our dataset we see that gold OA articles have a modest performance, in terms of article citation and the SJR of the journal (Figure 5). This is consistent with other studies (Figueiredo et al., 2014; Pinowar et al., 2018).

The worst performing publications in English language are local ones, that is, journals from Chilean universities or Chilean scientific and professional societies. This is not surprising, since these journals usually have a local focus and, therefore, will necessarily receive fewer citations. However, articles submitted to Chilean publishers and the journals themselves in Spanish language, have indicators similar to other publishing houses categories, suggesting that their poor performance in English could be due to the smaller English-speaking audience for journals from non-English native countries (Jenkins, 2013: Alperin et al., 2014). A smaller global audience for Spanish articles could be the reason to explain the range of SJR for Spanish journals (0.15-0.30), which is very low compared with that of journals in English language (1.0-2.5) (Figure 6). Of course, how the language of the articles and the origin of the journals impact

the visibility of the research, is a matter which is intermixed with the discussion about North-South relationships around science and research, but this is a matter that exceeds the purpose of this work. The only result related to this discussion is that the presence of authors from developed countries in an article, are not relevant to predict the citation of that article (Figure 7), which is consistent with some works on research productivity in the region (Ordoñez et al., 2020).

To understand the citation behavior in a better way, we train RF models to see what features are more important to predict normalized citations (Figure 7). The first result from this study is that the model do not fit well, this is, it is not possible to accurately predict citation in this dataset, at least with the data available. Anyway, we observe that the most relevant feature, at least for English written articles, is the SJR of the journal at the year when the article was published. At first, this result seems obvious because SJR are based on past citations, but it considers citations of the overall universe of that journal. There was a possibility that the citation performance of a journal would not be transferred to a specific subset of articles, as are the articles analyzed in this study. Our RF model indicates that this is not the case for English written articles, but the poor fitting of the model, keeps some doubts about the matter. This could be the case of Spanish written articles, where both metrics for journals, SJR and Q, are not the most relevant features to predict citations. It is important to note that ~80% of Spanish written articles are published in journals that also publish articles in English.

Other features identified as relevant for the model, in both cases, were the number of authors and the number of institutions (counted as different addresses), which are features that were identified previously as important for citations (Vieira & Gomes, 2020). Other similar features have also been identified as relevant for citation, like number of pages and number of references (Xie et al., 2018; Vieira & Gomes, 2020), sadly we do not have these data, then we cannot test if they are relevant in our dataset. While the latter two features seem poorly related to research quality, the number of authors and institutions can have some relation to the level of collaboration in each research.

From our analysis, it is clear to see that the increase in gold OA publications in the last 5 years is dominated by two relatively new publishing companies: MDPI and Frontiers, with 38 and 10% of all the gold OA articles leaded by Chilean authors published in 2023, respectively (Figure 3). These large publishing companies contain a very large number of journals that cover practically all areas of knowledge. All their journals are gold OA with varying but-always-increasing APC fees (Figure 9). Although publications in all publishers increase steadily over time, none shows such steep growth slopes, especially compared to MDPI.

This fast growth in MDPI and Frontiers publications have been documented in other cases. MDPI is a major growing publisher in the world, being the third largest in 2021, only behind Elsevier and Springer-Nature (Csomos & Farkas, 2023). However, the meteoric career of MDPI has not been free of problems, because this firm has been involved in a number of

controversies, most related to poor peer-review process[1]. Even, it has been accused of being a predatory publisher (Oviedo-García, 2021). Others large gold-only publishers, like Frontiers or, Hindawi have also been involved in controversies regarding their peer-review and in some countries articles published in several of their journals do not count as valuable as scientific output[2].

A surprising elevated number of MDPI papers has been documented for Central and European countries (Csomos & Farkas, 2023) and recently, for Chile (Fonturbel & Celiz-Diez, 2025). In Fonturbel & Celiz-Diez (2025) a strong concern is raised about the high amount of money (most from public sources) spent for paying MDPI articles. In Csomos & Farkas, (2023) the short turnaround time of MDPI journals together with the high pressure to publish have been one of the possible explanations for the high proportion of MDPI articles in Central and Eastern Europe. The elevated number of special issues has also been suggested (Hanson et al., 2024) as well as the high number of promotional emails sent to authors (Lund & Wang, 2020)

Regarding cost, we analyze the APC of the articles leaded by Chilean authors. We see that three quarters of total APC payments are for gold journals. Most of this cost is in the Natural Science area, more than it would be expected from their article number (Figure S1), indicating that high-APC journals are concentrated in this area. Of course, the APCs could be overestimated because there are a number of articles which receive discounts for the APC, this discount is sometimes offered directly to the authors, or it came from agreements made by some institutions. However, the analysis is good enough to have a picture of the situation.

The most shocking data is the amount of money given to MDPI during 2023, which reached the amount of 4 millions USD, which is almost 40% of all costs in APC paid during the same year. Frontiers with 1 million USD and 10% of the total, is the second individual publisher with higher APC cost. An analysis of the historical trend of this data shows that these very high values are explained by two reasons: increasing number of publications in both publishers and increasing APC per article.

The high cost in APC paid for other editorials seems low in comparison with MDPI and Frontiers, but it must not be underestimated. Hybrid gold OA articles are still low in proportion,

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[1] de Vrieze, J. (2018) Open-access journal editors resign after alleged pressure to publish mediocre papers. *Science*. https://www.science.org/content/article/open-access-editors-resign-after-alleged-pressure-publish-mediocre-papers
Marcus, A. (2020). Failure fails as publisher privileges the privileged. *Retraction Watch.* Accessed in Jan, 2025. https://retractionwatch.com/2020/06/16/failure-fails-as-publisher-privileges-the-privileged/
Wadman, M. (2021) Scientists quit journal board, protesting 'grossly irresponsible' study claiming COVID-19 vaccines kill. *Science*. https://www.science.org/content/article/scientists-quit-journal-board-protesting-grossly-irresponsible-study-claiming-covid-19. Accessed in Jan, 2025.
Perron, B. E. (2021) 'Our deepest apology': Journal retracts 30 likely paper mill articles after investigation published by Retraction Watch". *Retraction Watch*. https://retractionwatch.com/2022/07/05/our-deepest-apology-journal-retracts-30-likely-paper-mill-articles-after-investigation-published-by-retraction-watch/. Accessed in Jan, 2025.
Oransky, I. (2019). "Prof who lost emeritus status for views on race and intelligence has paper flagged". *Retraction Watch*. https://retractionwatch.com/2019/08/08/prof-who-lost-emeritus-status-for-views-on-race-and-intelligence-has-paper-flagged/. Accessed in Jan, 2025.

[2] Norwegian list of journals and their rankings. https://kanalregister.hkdir.no/sok?option=journals&input= Accessed in Jan, 2025

but they are growing, and they have more expensive APC in average, which explains that 2 million USD is paid for this type of articles, which represent 25% of the total. This high cost of hybrid gold OA has been observed before (Pinfield et al., 2016). One important criticism to hybrid journals is that they receive a double payment: one for the APC, the other by the subscriptions contracts signed by institutions. As a reference, Chilean National Agency for Research (ANID) spent, in 2023, more than 13,000 millions Chilean pesos (more than 10 millions USD at exchange rate of 2023) in the program "Acceso a la Información Electrónica para Ciencia y Tecnología" (Access to Electronic Information for Science and Technology) which consists mainly in contracts with big publishers to access CA articles from public and private Chilean institutions related to research[3].

Conclusions

Our study shows that the increasing in OA is a reality in a peripheral country like Chile, and this increasing OA have been pushed mainly by English gold OA, specifically by two emerging for-profit editorial houses, MDPI and Frontiers. The increase of gold OA have been at expenses of non-OA, which is expected, but also it could be at expenses of SciELO articles. Gold OA articles have moderate indicators of citations, at the level of article and of journals, then the promise of higher visibility of OA is not fulfilled by gold OA.

While Chile has not signed the European Plan S, nor any authority have expressed the intention to, Chilean-lead articles appears to have followed the same gold route proposed by that plan. Two key factor that must be mentioned are the growing inclination for Northern hemisphere criteria in the evaluation of local research (i.e., preference of ISI articles over SciELO articles[4], several disciplinar groups only accept proposal in English language, international collaboration to Northern Hemisphere is preferred than to Latinoamerican countries) and the hyper-competitive environment of scientific funding in Chile (Fondecyt, the main grant for research, has an award rate in the 20-40% range[5]). Overall, these two factors push to other element of the systems to use the same indicators to evaluate research like Quality-assurance agencies[6], which in turn have pushed Universities to use the same criteria (with a growing number of local Universities awarding academics with cash for ISI/WoS-indexed articles).

Certainly, with our data we cannot confirm that SciELO articles decrease have been caused directly by English gold OA growing, but it is a reasonable hypothesis. SciELO, the main driver

[3] Taken from "Ley de Presupuestos 2023", pp 888, Ministerio de Hacienda, Chile. https://www.dipres.gob.cl/597/articles-316305_doc_pdf.pdf. Accessed in Jan, 2025

[4] Evaluation criteria used by "Grupos de Estudio" in FONDECYT to evaluate proposals. https://www.conicyt.cl/fondecyt/grupos-de-estudios/. Accessed in Jan, 2025

[5] ANID (2024). Concurso nacional de proyectos FONDECYT regular 2024. Proyectos y recursos totales por grupo de evaluación. https://s3.amazonaws.com/documentos.anid.cl/proyecto-investigacion/2024/regular/fallo/Proyectos-y-recursos-totales-por-Grupo-de-Evaluacion_ZfSxWcBnQaE4RvT6yU8iOaJ3mjG.pdf. Accessed in Jan, 2025.

[6] Comisión Nacional de Acreditación. (2020) Criterios y Estándares para la Acreditación de Doctorados Científicos/Académicos o Tecnológicos/Profesionales. https://www.cnachile.cl/SiteAssets/Paginas/consulta_criterios_y_estandares/doctorado.pdf. Accessed in Jan, 2025

of OA in Latin America, even before OA discussion in the Northern Hemisphere, appears to be a victim of the OA dynamic. Paradoxically, this decrease in SciELO and growth in English gold OA comes with meager visibility and cost millions of dollars to Chilean taxpayers every year, which should serve as a warning and as a case example for other Latinoamerican countries which want to seek for a route to OA.

Disclaimer

SBM and the rest of the users are the only responsible for the content of this article, and this not necessarily represents the orientation or policies of ANID or any other Chilean public agency.

Author's Contribution

AP and FV conceptualized the research. FV collected the data and performed methodological analysis. PM and SBM made critical analysis of the manuscript and help in redacting discussion and conclusions. All the authors read the final manuscript and approve it.

Conflict of Interest

Authors declare no conflict of interest.

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Open Access Dynamics in Latin America: Insights from the Chilean case

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Supplementary Figures

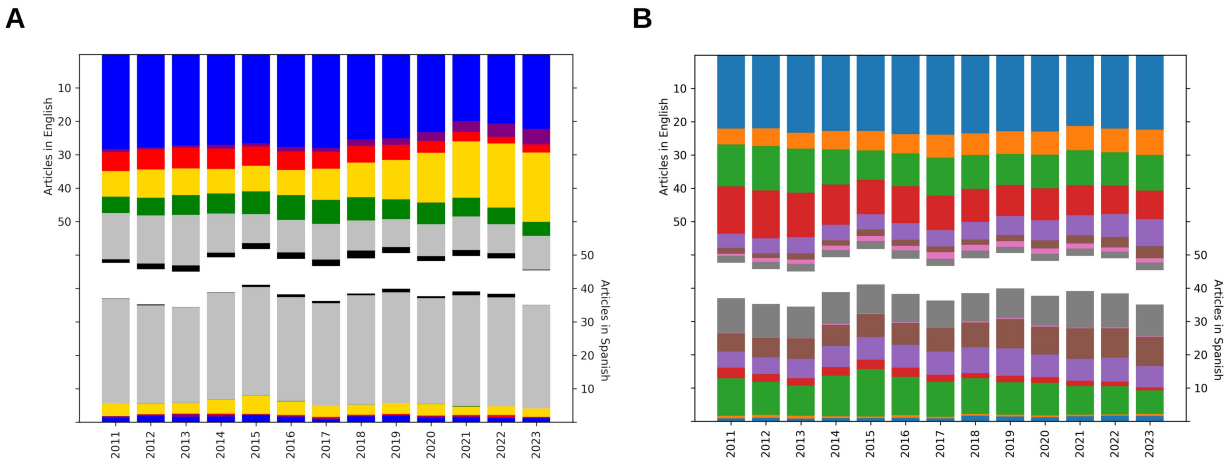

Figure S1. Percentage of publications in English and Spanish, classified by (A) OA model; and (B) area of knowledge. In the upper bars, the distribution for publications in English is observed (going from top to bottom, left y-axis), and in the lower bars, publications in Spanish (goin from bottom to up, right y-axis). Color code for A: blue, CA; red, bronze OA; purple, hybrid gold OA; yellow gold OA; green, green OA; grey, diamond OA; black, undefined. Color code for B: blue, Natural Sciences; orange, Engineering and Technology; green, Medical and Health Sciences; red, Agricultural and Veterinary Sciences; purple, Social Sciences; brown, Arts and Humanities; pink, Multidisciplinary; gray, undefined. Both OA and CA publications are included in both graphs.

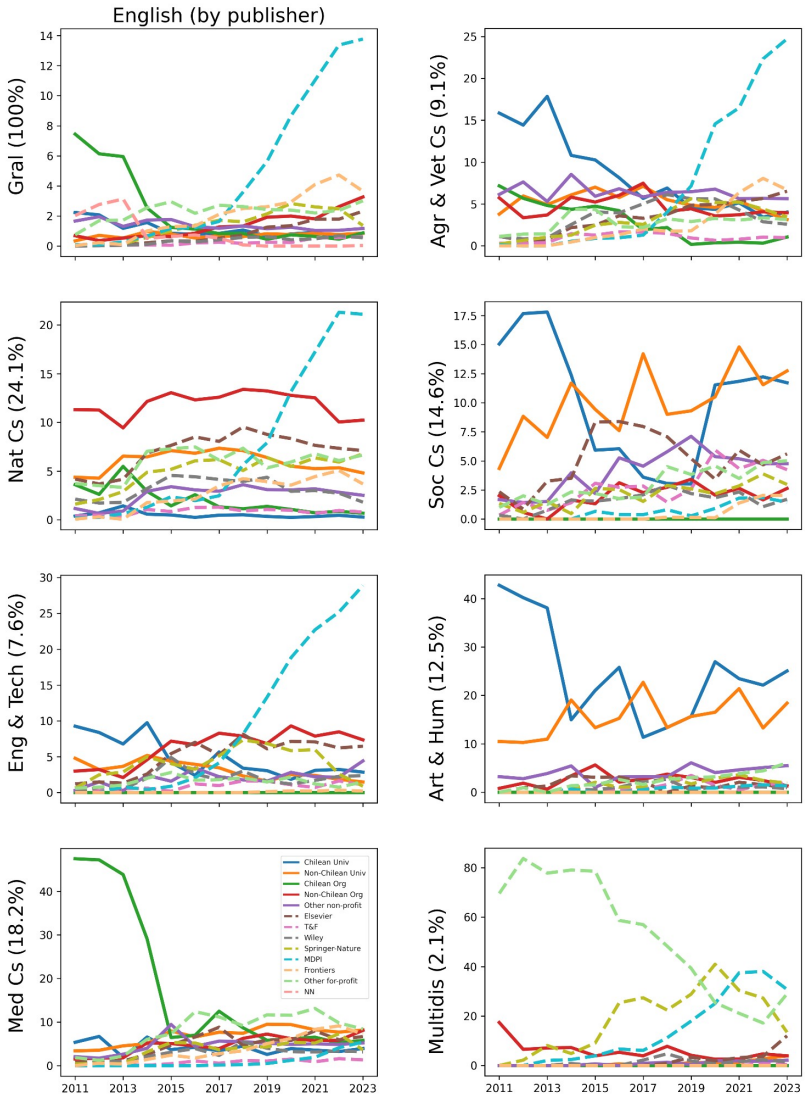

Figure S2. Behavior of the different publisher houses and area of knowledge, in English written OA articles. First column: Each row indicate the OECD area, being the first row an analysis of all articles. In parentheses, it is shown the percentage of articles of each area (including all languages). Color code are indicated in the legend at the bottom left plot.

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