



Open access in Ukraine: Characteristics and evolution from 2012 to 2021

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Citation: Kaliuzhna, N., & Hauschke, C. (2024). Open access in Ukraine: Characteristics and evolution from 2012 to 2021. *Quantitative Science Studies*, 5(4), 1022–1041. https://doi.org/10.1162/qss_a_00324

DOI: https://doi.org/10.1162/qss_a_00324

Peer Review: https://www.webofscience.com/api/gateway/wos/peer-review/10.1162/qss_a_00324

Received: 18 September 2023
Accepted: 24 July 2024

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Handling Editor:
Vincent Larivière

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Keywords: academic publishing, open access, scholarly communication, Ukraine

ABSTRACT

This study investigates the development of open access (OA) to publications produced by authors affiliated with Ukrainian universities and research organizations in the period 2012–2021. To get a comprehensive overview we assembled data from three databases: Dimensions, Web of Science (WoS), and Scopus. Our final data set consisted of 186,000 unique records. To determine the OA status of each article, this study utilized Unpaywall data, which was obtained via API. It was determined that 71.5% of all considered articles during the observed period were openly available at the time of analysis. Notably, 60.9% of the OA papers were disseminated through national journals. Furthermore, our findings indicate that the rate of OA papers was highest in the Humanities, at 89.7%, with 74.8% of papers disseminated through national communication channels. The share of OA papers published in national journals surpassed OA papers in foreign journals across all research areas except Natural Sciences. Another noteworthy finding was that Gold OA emerged as the predominant type of OA over the 10-year period of analysis. We underscore the critical importance of ensuring the FAIRness of national scholarly communication infrastructure for monitoring OA uptake and state support of national publishers.

1. INTRODUCTION

Open access as “the practice of providing access to peer-reviewed scientific research articles from all academic disciplines that is cost-free for users and can be reused” (European Commission, 2017) is steadily changing its perception from being a mere alternative to the subscription publishing model to a widely acknowledged and integral element of research culture. However, the decades-long battle over how best to achieve comprehensive open access implementation continues. It has become evident that successful OA adoption requires the establishment of sustainable business models and implementation of robust policies to enforce it (Borrego, Anglada, & Abadal, 2021). Among the latest policies is the mandate by the White House Office of Science and Technology Policy, which requires that publications and their supporting data from federally funded research must be accessible immediately upon publication, with the deadline set for the year 2026 (Horder, 2023). Similar to the well-known European collective initiative of cOAlition S funders, Plan S, this US policy allows researchers to disseminate their findings through self-archiving (the so-called green road) as well: scientists contributing to subscription-based journals could potentially meet requirements by submitting peer-reviewed and accepted draft to publicly accessible repositories or another outlet approved by the relevant authority (Brainard & Kaiser, 2022). It is also pertinent to consider

the European Council Conclusions on high-quality, transparent, open, trustworthy and equitable scholarly publishing.” This document calls on the member states to back policies that promote a nonprofit and diverse scholarly publishing approach, free for both authors and readers (European Council, 2023).

With the increasing importance of open science and open access on the policy level, it is also gaining prominence in research evaluation. For instance, starting from 2019, the Leiden University Ranking¹ introduced open access indicators to their methodology. Another example is the ongoing Open and Universal Science Project (OPUS)², supported by the European Union, aiming to revamp the research evaluation system that encourages, acknowledges, and rewards open science practices. Another initiative is the Coalition for Advancing Research Assessment (CoARA)³, which includes a dedicated Ukrainian chapter.

In this context, it is of paramount importance to keep a watchful eye on the expansion of open access literature. To effectively accomplish this task, the European Commission launched the Open Science Monitor (OSM), which aimed to systematically oversee the ongoing transformation to openness in research practices, with a particular emphasis on OA. This study encompassed 28 EU member states, the G8 countries, and several key international partners of the EU countries. Ukraine was not included in this investigation. However, another European initiative, the OpenAIRE Open Science Observatory, provides data on Ukraine, as does the COKI Open Access Dashboard, developed and supported by Curtin University (Diprose, Hosking et al., 2023). The OSM initiative was soon followed by the establishment of national Open Access Monitors in a number of countries (Barbers, Stanzel, & Mittermaier, 2022; Jeangirard, 2019). Moreover, governments around the world have strategically aligned their path towards OA by introducing national strategies and action plans tailored to the unique domestic research landscapes and needs of their respective countries. Noteworthy examples include Ireland, Spain, Slovenia, Colombia, and Ukraine.

To date, empirical research on open access in Ukraine remains limited. In the scientific literature, there are occasional studies on OA at the level of single universities (Kostyrko & Korolova, 2021) or journals (Yaroshenko & Yaroshenko, 2021). There are also studies on research data sharing practices (Boiko, Kramarenko, & Shabanov, 2021) and black open access analysis (Nazarovets, 2018). Awareness and perceptions of open science practices, including open access publishing of Ukrainian researchers, were partially explored by the Eurodoc study focusing on early career researchers (Berezko, Medina et al., 2021). The open access status of papers resulting from funding of the National Research Foundation of Ukraine has been highlighted as well (Tsiura & Tsybenko, 2022). Finally, the landscape of Ukrainian scientific journals was touched on in a number of research endeavors (Hladchenko & Moed, 2021; Moed, de Moya-Anegón et al., 2021).

Against this background, the aim of this paper is twofold: to fill the gap and explore open access uptake in Ukraine, its patterns, and growth in order to lay a foundation for evidence-based policy development; and to contribute to the body of literature on open access by illustrating the journey of a country that has cultivated an open access culture without a financial strategy on OA, big transformative agreements, and national funders’ mandates.

¹ CWTS Leiden University Ranking <https://www.leidenranking.com/>.

² Open and Universal Science (OPUS) Project <https://opusproject.eu/>.

³ Coalition for Advancing Research Assessment <https://coara.eu/>.

Our study addresses the following research questions:

- RQ1: How did the share of OA publications produced by researchers affiliated with Ukrainian institutions develop over the period 2012–2021?
- RQ2: What are the characteristics of Ukrainian OA publication fractions?

2. BACKGROUND

The adoption of open access practices varies across European countries. In the United Kingdom, the high share of OA papers is attributed to the existence of open access mandates. In Nordic countries, the pivotal role was played by OA policies implemented in the 1990s, while the Eastern European countries had their own distinct approach (Maddi, Lardreau, & Sapinho, 2021). After the collapse of the Soviet Union and the regaining of their independence, the Eastern European countries faced several fundamental challenges related to both socioeconomic changes and the reorganization of their science and research systems. Due to insufficient funding and inability to procure literature, the libraries of these countries allocated their limited resources toward the development of local infrastructures. These efforts aimed to maintain and enhance access to information resources (Donabedian & Carey, 2011; Johnson, 2013). There were a number of international initiatives that came to help and aimed at fostering development and implementation of electronic systems, improving access to scientific literature, training librarians, and promoting open access movement. For example, Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan received access to full-text databases of scientific literature from Springer, Blackwell Science, Zentralblatt Mathematik etc. as part of the Electronic Library program of the International Association for the promotion of cooperation with scientists from the independent states of the former Soviet Union (INTAS) (Yaroshenko, 2009). Estonian, Lithuanian, and Latvian librarians benefited from the CELIP (Project Central and Eastern European Licensing Information Platform) and increased their knowledge of electronic content licensing (Žumer, 2001). The Electronic Information for Libraries (EIFL) initiative emerged as a prominent advocate, providing substantial support to library consortia in Estonia, Latvia, Lithuania, Poland, Serbia, Slovenia, and Ukraine. Through the allocation of grants, EIFL facilitated the implementation of comprehensive national and institutional open access advocacy campaigns, aimed at engaging and informing research communities about the significance of OA practices (Schmidt & Kuchma, 2012).

Later, in 2013, the Hungarian Academy of Sciences issued its open access mandate, requiring researchers to make their scientific output freely accessible either by self-archiving or by publishing in Gold or Hybrid OA journals. Besides this, the Law of Higher Education was enacted, mandating open access to Ph.D. dissertations (Karácsony & Görögh, 2017). In Poland, 2013 was also marked as important concerning OA implementation. In that year, the representative body of academic institutions—the Conference of Rectors of Academic Schools and the Polish Academy of Sciences—fully adopted the European Commission Recommendation on access to and preservation of scientific information. Within 2 years, the Polish Ministry of Science and Higher Education issued guidelines of the OA policy in Poland (Wałek, 2017). The National Science Centre Poland, the largest funding agency for basic research in the country, endorsed Plan S, and worked on its implementation (Korytkowski & Kulczycki, 2021). Likewise, Slovakia, which joined the European Union in 2004, was firmly set on the path of OA. In line with this commitment, the Slovak Center of Scientific and Technical Information was established to serve as a center for national OA coordination. Later on, in 2017, the government approved the National Action Plan of the Slovak Republic (Pendse, 2019).

It is important to note that European Union policy has played an important role in driving the implementation of open access in its member states (Karácsony & Görögh, 2017), in particular, via the PASTEUR4OA project, which aimed at harmonizing open access and open data policies within the EU (Picarra, Angelaki et al., 2015). Other noteworthy examples are the Horizon 2020 and Horizon Europe funding schemes with explicit OA mandates. Additionally, the Open Research Europe publishing platform is designed for and limited to researchers funded within the Research and Innovation program. Finally, there are several initiatives, including OpenAIRE and European Open Science Cloud, which have specific sets of requirements and specifications for those who want to participate in them.

The evolution of open access in Ukraine can be traced through a dual perspective: first, through the external efforts and grassroots endeavors of libraries and universities, and second, through governmental policies and measures.

2.1. Open Access Initiatives in Ukraine

As in other countries, Ukrainian academic libraries took an early lead in advancing the availability of freely accessible resources within the country. Supported by donors such as the Kyiv-Mohyla American Foundation, “Vidrodzhennya” Foundations, USAID, and the aforementioned EIFL, several initiatives were undertaken to facilitate licensed access to electronic resources, establish institutional repositories, and promote knowledge about open access journals (Yaroshenko, 2011b).

Notably, in January 2008, the universities in the border regions of Ukraine, Belarus, and the Russian Federation announced the “Belgorod Declaration on Open Access to Scientific Knowledge and Cultural Heritage.” The signatories of the declaration declared their intention “to stimulate the step-by-step development of online open access to scientific knowledge and cultural heritage, the search for legal solutions for the development of existing legal and financial grounds to accelerate the optimal use of open access” (The action plan of the principles of the Belgorod declaration on open access to scientific knowledge and cultural heritage on the university area of border regions of Belarus, the Russian Federation and Ukraine for 2008–2013, 2008.). Later, in 2012, another declaration, the “Crimean Declaration of Open Access” was announced (Yaroshenko, 2012). Both declarations expressed a preference for Green OA, highlighting the significance of institutional repositories in enhancing the visibility and recognition of national research.

The ideas of openness did not go unnoticed by higher education institutions as well. In 2009, a coalition of 26 Ukrainian and foreign universities signed the “Olvia Declaration,” declaring their commitment to foster collaboration and facilitate unrestricted scientific communication. They aimed to achieve this through the establishment of institutional repositories and OA journals (Yaroshenko, 2014).

It is also important to note that Ukraine faced a challenge of recognition of electronic licenses during its transition to electronic publishing. EIFL initiated a dialog to align legislative regulation with the use of free public licenses in Ukraine. Specifically, EIFL advocated for revisions to the national copyright law to establish a legal framework for authors to share their results and enable libraries to meet the needs of their end users. Another significant contribution of EIFL was through agreements with publishers, granting authors in Ukraine the opportunity to publish in OA journals with waived or discounted article processing charges (APCs). Ukraine is included in five of EIFL’s transformative agreements listed in the Transformative Agreement Registry (ESAC)⁴. The earliest of these agreements dates back to 2020, while the most recent is from 2024.

⁴ ESAC Transformative Agreement Registry <https://esac-initiative.org/about/transformative-agreements/agreement-registry/>.

2.2. Emergence and Development of Open Access Policies in Ukraine

The first steps towards acknowledging the principles of open access in Ukraine at the state level can be traced back to 2007 with the enactment of the Law of Ukraine “On the Basic Principles of Information Society Development in Ukraine for 2007–2015”. This law covered themes such as the creation of electronic information resources, protection of intellectual property rights, implementation of electronic document management, and enhancing information security. Importantly, it emphasized the need for mandatory storage of research papers in a unified electronic format and ensuring free access to publicly funded research output (Government of Ukraine, 2007; Sokolova, 2019). To achieve this, the Ukrainian Scientific Periodicals depository was established. Subsequently, national publishers of academic journals were required to submit full-text articles in HTML or PDF, along with journal cover and publication metadata to the Vernadsky National Library, which developed and maintained that portal (Government of Ukraine, 2007).

Going one step further, in 2015, the Ministry of Education and Science issued a mandate stipulating that dissertations and abstracts must be accessible to the public via institutional websites for three months (Ministry of Education and Science of Ukraine, 2015). This measure was implemented to facilitate public access and promote transparency in scientific research conducted within the country. Subsequently, in January 2022, following the introduction of a new procedure for awarding the Doctor of Philosophy degree, this requirement underwent a revision. A new law required that the electronic version of a dissertation should be archived within a local repository and submitted to the Ukrainian Institute of Scientific and Technical Expertise of Information, when it would then be made available through the National Repository of Academic Texts (NRAT) (Ministry of Education and Science of Ukraine, 2022). It is important to emphasize that the launch of NRAT in 2018 marked a significant milestone in developing national scholarly communication infrastructure. Functioning as a multidisciplinary repository designed for the storage and dissemination of diverse scientific research documents, NRAT opened up opportunities to work towards integration with the European Open Science Cloud (EOSC) and OpenAIRE (Chmyr, 2019). In 2022, the NRAT granted permission to index its content to anyone and enriched records with metadata needed for publication validation (National Repository of Academic Texts, 2022).

Key issues of OA implementation were further reflected in the updated “Roadmap for integrating Ukraine’s research and innovation system into the European Research Area (ERA).” In particular, this document highlighted the need for supporting institutions to cover APCs in international OA journals, establishing agreements with publishers, strengthening national publishing infrastructure, and increasing Ukrainian participation in international initiatives and working groups (Go FAIR, DORA, Research Data Alliance, etc.) (Ministry of Education and Science of Ukraine, 2021). Continuing this progressive stride towards the embracement of open access practices, Ukraine adopted its National Open Science Action Plan in 2022, declaring its commitment to align national legislation in consonance with European Union standards and norms for data sharing and open access (Government of Ukraine, 2022).

3. METHODOLOGY

3.1. Data Collection

In studies examining the share and number of open access publications at a national level, results could be influenced by the data source chosen and the coverage of publications it indexes. The most comprehensive sources include national bibliographic databases and current research information systems (CRIS), which capture rich metadata on publications that are usually not included

in proprietary bibliometric databases, do not have a DOI, or are published in small national journals (Pölonen, Laakso et al., 2020). The completeness and accuracy of the data provided by a data source as well as the way in which the data is made available and can be reused are also of crucial importance (Waltman & Larivière, 2020). It would be logical and valuable to use national Ukrainian scholarly communication infrastructure to study the uptake of OA, but this was not possible for several reasons. First, the metadata from the National Depository of National Periodicals is completely locked and not reusable because it does not provide an API or other means of exporting data. Second, the two major information sources on institutional publication data—the Ukrainian Research Information System (URIS) and National Repository of Academic Text—are currently under development and could not be used for data collection either (Kaliuzhna & Auhunas, 2022). Therefore, to obtain a detailed profile of OA publications by authors affiliated with Ukrainian institutions, we decided to assemble data from three widely used bibliographic databases: Dimensions, WoS, and Scopus. The choice of WoS and Scopus is justified by their firm embedding in the Ukrainian research assessment framework. In particular, since 2013, publications indexed in Scopus and WoS have become a requirement for obtaining a doctoral degree⁵. Starting in 2016, these publications have also been necessary for granting the academic titles of Associate Professor and Professor. Since 2018, Scopus/WoS-indexed articles have been introduced as a criterion for the state certification of Ukrainian higher education institutions. Finally, in 2019, Scopus/WoS publications were included among the criteria for evaluating research projects seeking state funding (Abramo, D’Angelo, & Hladchenko, 2023). The Dimensions database was selected to complement the aforementioned databases due to its broader coverage of smaller national academic journals and higher inclusion of non-English publications in comparison to Scopus and WoS (Basson, Simard et al., 2021; Visser, van Eck, & Waltman, 2021).

Data collection took place in November 2022. The search strategy was developed to accommodate each database’s features and functionalities. The SciVal web interface was used to extract data from Scopus. An advanced search was performed based on the following query:

```
AFFILCOUNTRY( ukraine ) AND ( LIMIT TO (DOCTYPE, "ar") LIMIT TO (PUBYEAR, 2021)
OR LIMIT TO (PUBYEAR, 2020) LIMIT TO (PUBYEAR, 2019) OR LIMIT TO (PUBYEAR,
2018) OR LIMIT TO (PUBYEAR, 2017) OR LIMIT TO (PUBYEAR, 2016) OR LIMIT TO
(PUBYEAR, 2015) OR LIMIT TO (PUBYEAR, 2014) OR LIMIT TO (PUBYEAR, 2013) OR
LIMIT TO (PUBYEAR, 2012)
```

SciVal’s capabilities allow exporting 100,000 publications at a time. Data from WoS (Core Collections) was retrieved via InCites by splitting the query

```
CU = Ukraine and Article (Document Types)
```

into two time periods from 2012 to 2017 and from 2021 to 2018 to cope with the data export limitation of up to 50,000 records. In the case of Dimensions, the data was extracted via an API that allows advanced research data analysis using a specific Domain Specific Language (DSL). However, there is also a limit for data extraction of up to 50,000 records. To gather data for the studied period, the following query was run four times, from 2012 to 2015, from 2016 to 2018, from 2019 to 2020 and for 2021:

```
""search publications
where research_org_country_names = "Ukraine"
```

⁵ Prior to January 2022, a prerequisite for obtaining a doctoral degree was publication in Scopus/WoS indexed journals. A new procedure for conferring the Doctor of Philosophy degree accepts publications in national journals as sufficient to fulfill the criteria.

and year in [2012 : 2015]

and type = "article"

return publications [id+title+doi+year+journal+issn+publisher+times_cited+category_for_2020+category_bra]""")

Although all searches in the databases were limited to the publication type "articles," it is important to highlight some discrepancies in the classification of the records. In Dimensions, the classification of publication types is broad and consists of five content types: article, book, chapter, monograph, and proceedings. The type "article" includes "articles from a scientific journal or trade magazine, including news and editorial content"⁶. Scopus has a more detailed approach, dividing publications into 13 categories. "Article" is defined as peer-reviewed original research or opinion. It also includes case reports, technical and research notes, and short communications, but editorials, letters, reviews, and (in some cases) notes are treated as separate types. The Scopus editorial team is responsible for these classifications (Elsevier, 2023). Finally, WoS offers 40 document types for refining search results, but their availability depends on the type of subscription. The version of WoS used for this study offered six types, including the Early Access type. "Article" is defined as "report on new and original works, including research papers, brief communications, technical notes, chronologies, full papers, and case reports." Additionally, WoS supports dual classification for some records—articles and proceedings papers—whereas InCites only supports one document type per publication^{7,8}.

To further elaborate on the importance of data source choices, we matched publications based on DOI across the databases to determine the overall number of unique and duplicate publications by Ukraine-affiliated researchers in each data source (Figure 1). This analysis revealed that 44,914 publications were present in all three databases, representing 29.6% of the relevant articles in Dimensions, 54.1% in Scopus and 61.7% in WoS. The largest proportion of exclusive publications was observed in Dimensions, with 55.7% of its content not indexed in WoS and Scopus. In comparison, the exclusive share in Scopus was 17.6%, while WoS had an exclusive share of 16.4%.

3.2. Journal Mapping

To identify articles published in national journals, we mapped records from all three databases based on the ISSN to journals listed in the List of Professional Publications of Ukraine. This list is an official registry of publication venues recognized as scientific by the Ministry of Education and Science of Ukraine. At the time of mapping (February 2024), the list comprised 1,630 journal titles. Because the list lacks ISSNs and exists in analog format, a prior mapping of journal titles to ISSNs was performed. We used ISSN search for this task. Additionally, a screening of journal titles was conducted to identify those containing "Ukrainian" or "Ukraine," as well as Ukrainian city names in the titles (e.g., *Ukrainian Mathematical Journal*, *Zaporozhye Medical Journal*). This was necessary for the sake of comprehensiveness, given that the number of Ukrainian academic journals exceeds the number of journals listed in the List of Professional Publications of Ukraine (Novikov, 2020). The results of this preliminary analysis are shown in Table 1.

We also were able to identify that Dimensions indexed publications from 692 national journal titles, Scopus from 111 and WoS from 92.

⁶ What exactly is covered in the "Publications" in Dimensions? <https://dimensions.freshdesk.com/support/solutions/articles/23000018859-what-exactly-is-covered-in-the-publications-in-dimensions->

⁷ Clarivate, Incites Help. <https://incites.help.clarivate.com/Content/Indicators-Handbook/ih-doc-types.htm>.

⁸ Clarivate, Web of Science Help <https://webofscience.help.clarivate.com/en-us/Content/document-types.html>.

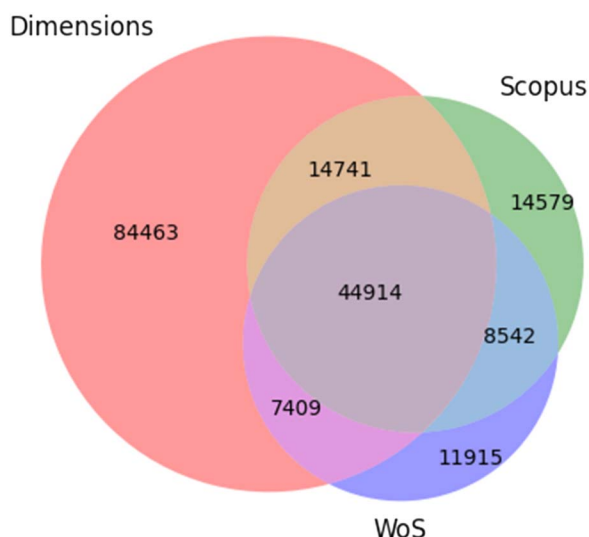


Figure 1. Venn diagram showing the number of exclusive and duplicate publications produced by Ukraine affiliated researchers (2012–2021) between Dimensions, WoS, and Scopus.

3.3. Data Processing

The next step was to merge the retrieved data into a single data set, which resulted in 337,849 records. For publications without a DOI, which accounted for 9% ($n = 30,542$) we queried Crossref Metadata Search by article title and were able to retrieve DOIs for 17% ($n = 5,199$) of the publications. Then, duplicate records were removed based on DOI using OpenRefine 3.7.3 (OpenRefine, 2023). The data set comprising 189,776 records was subsequently matched with Unpaywall data using its API to obtain OA status and additional metadata (OA subtype, publisher, presence of a copy in a repository, name of a repository). As a result, OA status was obtained for 186,000 unique publications. The data collection and processing are shown in Figure 2.

The following definitions for OA subtypes were used in this study to ensure clarity and avoid any ambiguity or misinterpretations:

- Bronze: articles are free to read on the publisher’s website, without a license that grants any other rights
- Gold: publication published in a full OA journal (including diamond OA)
- Green: articles are published in toll-access journals, but archived in an OA archive, or repository
- Hybrid: publication freely available under an open license in a paid-access journal

Table 1. Distribution of articles in national and foreign journals across Dimensions, WoS, and Scopus databases

Data source	Published in national journals	% Published in national journals	Published in foreign journals	% Published in foreign journals
Dimensions	76,816	50.1	76,483	49.9
WoS	26,886	31.3	58,981	68.7
Scopus	31,559	32	67,124	68

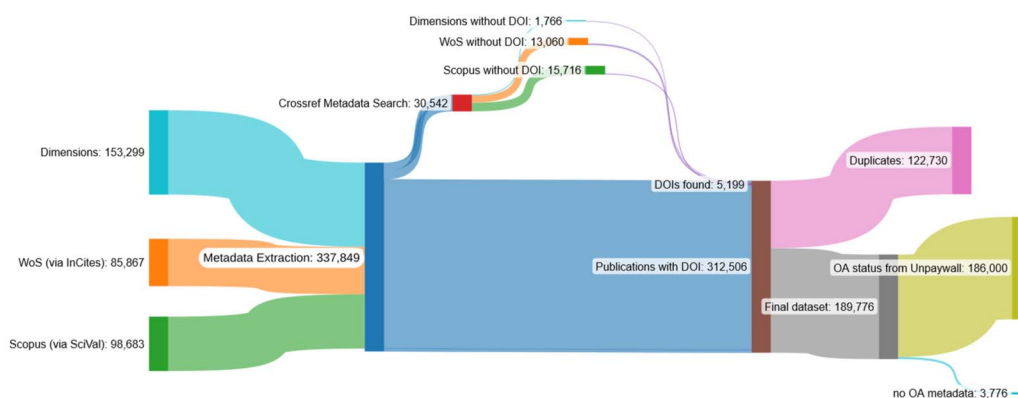


Figure 2. Sankey diagram showing the workflow of retrieving, gathering, deduplicating, and processing data.

- Closed: an OA version of the article has not been found, also referred to as non-OA (Piwowar, Priem, & Orr, 2019).

3.4. Discipline Mapping

To carry out analysis at the level of disciplines, we mapped those being used in our data sources to the OECD's Fields of Science and Technology classification (FOS) (Stahlschmidt & Stephen, 2020). The revised FOS classification consists of 40 subcategories of six major fields, namely Natural Sciences, Engineering and Technology, Medical and Health Sciences, Agricultural Sciences, Social Sciences, and Humanities. For Dimensions we used the two-digit code of the Australian and New Zealand Standard Research Classification (ANZSRC) 2020, for Scopus the four-digit code of the All Science Journal Classification Codes (ASJC), and for WoS its native Research Area scheme. Dimensions makes use of machine-learning approaches to classify research objects in its database at the publication object level rather than at the journal level (Porter, Hawizy, & Hook, 2023). Given that the Scopus and WoS databases do not provide exclusive research category assignments to individual publications, but rather to journals, publications that received two or more research codes were grouped under the seventh Multidisciplinary category. Our experience with Dimensions data corroborates the findings of Visser et al. (2021), revealing a proportion of publications without disciplinary categorization. Specifically, 11.3% ($n = 17,339$) of the extracted records exhibited this issue. In our final data set, 7.1% ($n = 13,213$) of papers retained their uncategorized status in terms of research discipline. Consequently, these papers were excluded from the analysis of research areas.

4. RESULTS

4.1. What Is the Fraction of Open Access Publications?

Between 2012 and 2021, Ukraine-affiliated authors published 186,000 unique publications. Of these, 51.2% ($n = 95,227$) were published in national journals, while 48.8% ($n = 90,773$) found their way into foreign outlets. The study revealed a remarkable increase in output, with the number of publications increasing significantly from 7,365 in 2012 to 35,463 in 2021, reaching its highest growth rate of 26.3% in 2015. Figure 3 displays the number (A) and the proportion (B) of open access papers published, with the overall OA share of 71.5% ($n =$

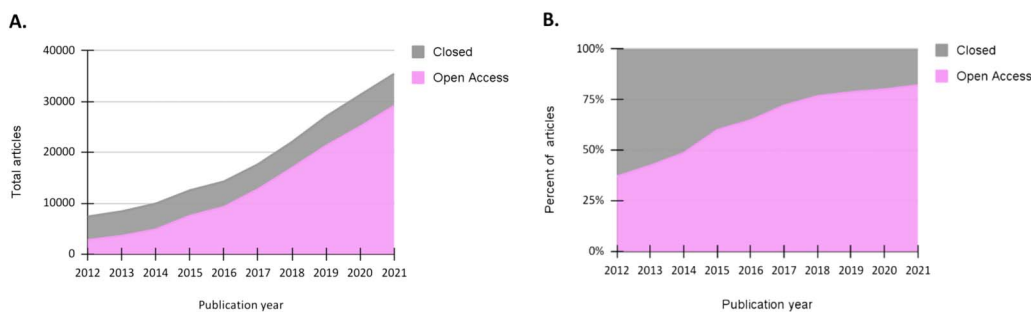


Figure 3. Number of articles (A) and proportion of articles (B) with OA copies produced by authors affiliated with Ukrainian institutions from 2012 to 2021.

133,003), ranging from 37.1% ($n = 2,730$) in 2012 to 82.1% ($n = 29,131$) in 2021. Throughout the study period, the prevalence of paywalled publications showed a steady decline, from 62.9% ($n = 4,635$) in 2012 to 17.9% ($n = 6,332$) in 2021.

To deepen the understanding of OA within the Ukrainian research context, the fraction of OA papers, in both national and international journals, was calculated. The results indicate that 60.9% ($n = 81,026$) of all OA publications were published in national journals, constituting 43.6% of all papers of the final data set. Publications in national journals began to surpass those in foreign venues, commencing in the year 2017, with OA rate of 63.2% ($n = 8,040$) of all OA papers published in this year. The number of OA papers published in national journals peaked in 2018, reaching 67.1% ($n = 11,361$) of all OA papers in this year, steadily declining to 61.6% ($n = 17,955$) in 2021.

4.2. What Is the Prevalence of Open Access Subtypes?

Figure 4 illustrates that 48.4% ($n = 89,939$) of all OA papers were available under the Gold road. The second most frequent subtype was Bronze OA, accounting for 12.6% ($n = 23,471$). Hybrid OA and Green OA categories were the least commonly used with 5.6% ($n = 10,473$) and 4.9% ($n = 9,120$) of articles published in these categories, respectively. The share of Green OA publications dropped from 8.7% ($n = 642$) in 2012 to 3.4% ($n = 1,193$) in 2021, while the prevalence of gold OA increased dramatically from 12.1% ($n = 892$) in 2012 to 60.1% ($n = 21,309$) in 2021. It is important to note that 64.8% ($n = 58,245$) of all Gold papers published between 2012 and 2021 were published in national journals.

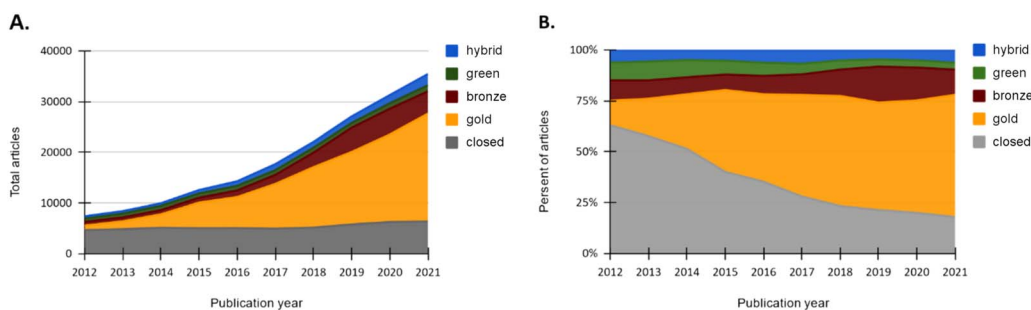


Figure 4. Number of articles (A) and proportion (B) of open access subtypes by publication year.

4.3. How Does Open Access Vary by Research Fields?

Investigation of the OA distribution across different research fields revealed the highest percentage of OA publications in Humanities, with a rate of 89.7% ($n = 10,237$), closely followed by Social Sciences at 88.5% ($n = 33,862$). Medical and Health Sciences ($n = 17,694$) and Agriculture Sciences ($n = 3,596$) categories also exhibited a high level of OA publications, representing 76.1% within each category. This was followed by the Multidisciplinary field with a rate of 67.8% ($n = 10,802$) of OA papers. The lowest proportion of OA articles was observed in Natural Sciences and Engineering and Technology areas, with rates of 57.3% ($n = 14,914$) and 55.7% ($n = 29,634$) respectively.

Figure 5 provides a more granular view of how different research fields were represented in terms of open access subtypes. Gold OA was dominant in each category, ranging from the highest of 65.4% ($n = 7,463$) in Humanities to the lowest of 30% ($n = 15,978$) in Natural Sciences. The second largest share was attributed to the Bronze subtype, accounting for 20.1% ($n = 7,672$) in Social Sciences, 14.9% ($n = 1,699$) in Humanities, 14.1% ($n = 3,278$) in Medical and Health Sciences, 12.8% ($n = 2,041$) in Multidisciplinary, 9.7% ($n = 5,183$) in Natural Sciences, 8.7% ($n = 412$) in Agricultural Sciences, and 5.7% ($n = 1,473$) in Engineering and Technology. Regarding Green OA, our data revealed the following distribution within research fields: 9.8% ($n = 5,219$) in Natural Sciences, 4.9% ($n = 1,280$) in Engineering and Technology, 4.7% ($n = 756$) in Multidisciplinary research, 2.9% ($n = 680$) in Medical and Health Sciences, 2.2% ($n = 838$) in Social Sciences, and 1.2% ($n = 138$) in the Humanities.

The analysis of OA articles published in national and foreign journals within each research category sheds light on the publishing preferences of Ukrainian researchers (Table 2). The share of OA papers published in national journals surpassed OA papers in foreign journals across all research areas except Natural Sciences. Notably, in Humanities, 74.8% ($n = 7,654$) of all OA papers within the category, were published in national journals. In Social Sciences this indicator was 64.2% ($n = 21,742$), in Engineering and Technology 61.6% ($n = 9,187$), in Agricultural Sciences 60.1% ($n = 2,161$), in Multidisciplinary 52.2% ($n = 6,287$), and in Medical and Health Sciences 50.9% ($n = 8,998$).

4.4. How Does Open Access Vary by Publisher?

Out of 186,000 publications investigated in our study, publishers were identified for 185,964 records. Figure 6 shows that among publishing houses distributing Ukrainian research output,

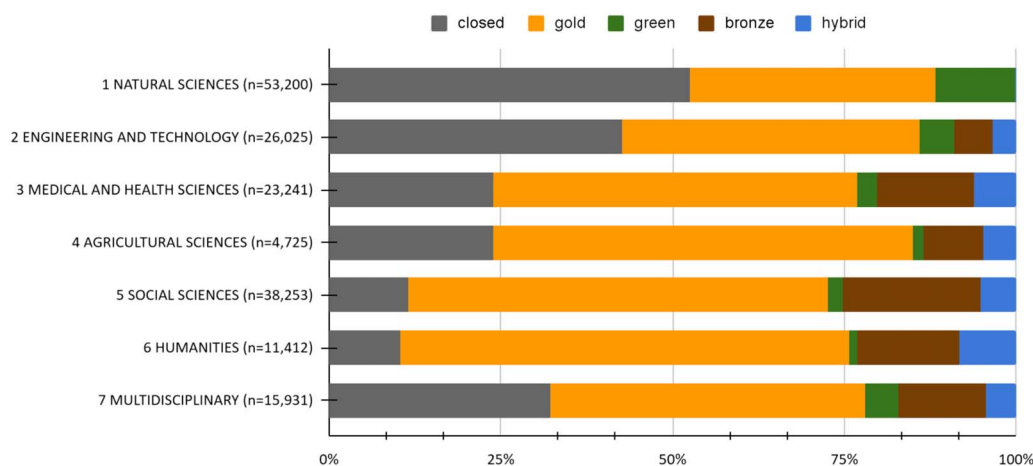


Figure 5. Percentage of different open access subtypes per research category.

Table 2. Distribution of publications in national and foreign journals per research field

Research area	Published in national journals	% Published in national journals	OA published in national journals	% OA published in national journals	Published in foreign journals	% Published in foreign journals	OA published in foreign journals	% OA published in foreign journals
Natural Sciences	19,603	36.8	14,341	48.4	33,594	63.2	15,290	51.6
Engineering & Technology	11,912	45.8	9,187	61.6	14,121	54.2	5,730	38.4
Medical and Health Sciences	10,553	45.4	8,998	50.9	12,688	54.6	8,696	49.1
Agricultural Sciences	2,907	61.5	2,161	60.1	1,818	38.5	1,435	39.9
Social Sciences	23,477	61.4	21,742	64.2	14,776	38.6	12,120	35.8
Humanities	8,068	70.7	7,654	74.8	3,339	29.3	2,583	25.2
Multidisciplinary	7,510	47.1	6,287	52.2	8,421	52.9	4,515	41.8
Total	84,030		70,370		88,757		50,369	

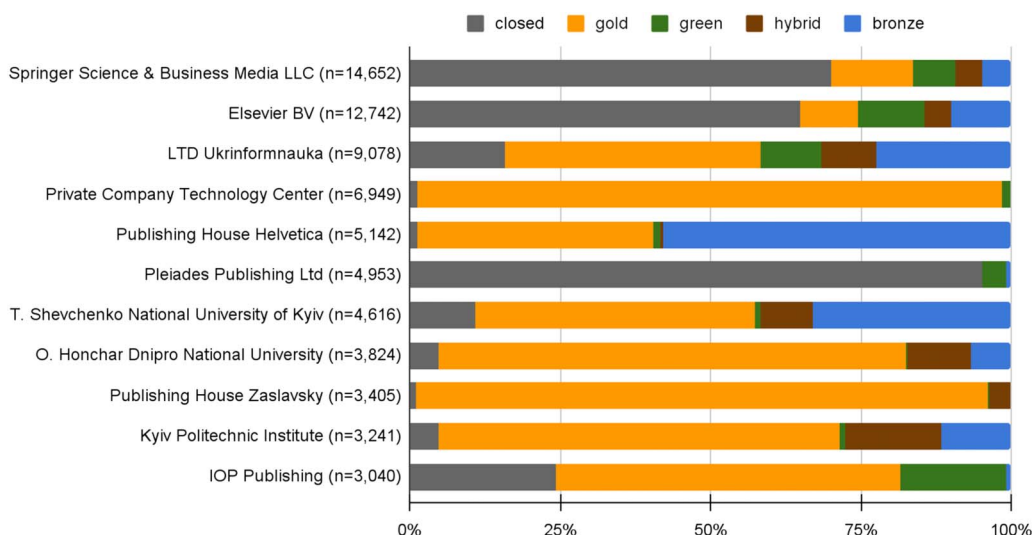


Figure 6. Top 10 publishers of distribution research output produced by Ukrainian researchers and open access subtypes provided by them.

large commercial publishing houses emerged as leaders. Specifically, Springer accounted for 7.9% ($n = 14,652$) of the 185,964 articles, followed by Elsevier with 6.9% ($n = 12,742$). These publishers' articles were predominantly paywalled, accounting for 70.1% of Springer's and 64.9% of Elsevier's shares respectively. The highest percentage of toll access, 95.2% ($n = 4,717$), was observed within Pleiades Publishing, which ranks sixth among the most frequently chosen publishers by Ukrainian researchers. Seven out of 10 of the most popular publishers were identified to be national publishers and university presses with a high level of OA publications. For instance, Ukrinform Nauka accounted for 4.9% ($n = 9,078$) had rates of 42.6% ($n = 3,865$) Gold OA, 22.5% ($n = 2,039$) Bronze OA, 10% ($n = 906$) Green OA, and 9.2% Hybrid OA ($n = 833$). Private Company Technology Center, representing 3.7% ($n = 6,949$), had 97.1% ($n = 6,750$) Gold OA and only 1.3% ($n = 87$) closed. University presses of Taras Shevchenko National University of Kyiv, Oles Honchar Dnipropetrovsk National University, and Kyiv

Table 3. Top 10 repositories for self-archiving by Ukrainian researchers

Repository	n of papers	% of papers
arXiv (Cornell University)	3,376	39.6
The scientific electronic library of periodicals of the National Academy of Sciences of Ukraine	1,206	14.1
Electronic Sumy State University Institutional Repository	377	4.4
Europe PMC	367	4.3
HAL—Hyper Articles en Ligne	199	2.3
RePEc: Research Papers in Economics	90	1.1
eNTUKhPIIR (Kharkiv Polytechnic Institute)	86	1
Repository of the Academy Library (Library of the Hungarian Academy of Sciences)	87	1
Red Federada de Repositorios Institucionales de Publicaciones Científica—LA Referencia	73	0.9
MPG.PuRe (Max Planck Society)	63	0.7
Other	2,603	30.5

Polytechnic Institute each represented mostly freely available content. The fractions of pay-walled content were 10.9% for Taras Shevchenko National University of Kyiv, and 4.8% for both Oles Honchar Dnipropetrovsk National University and Kyiv Polytechnic Institute.

4.5. What Are the Most Popular Repositories for Self-Archiving?

In our data set, 8,527 publication records possessed metadata on repositories Table 3. The most preferred choice among Ukrainian researchers for self-archiving their works was Cornell University's arXiv, which held a significant share of 39.6% ($n = 3,376$) of all self-archived articles. Among the top repositories, three out of 10 were domestic: The scientific electronic library of periodicals of the National Academy of Sciences of Ukraine, which accounted for 14.1% of the records ($n = 1,206$), followed by two institutional repositories of Ukrainian universities—Sumy State University Institutional Repository with 4.4% ($n = 377$) and Kharkiv Polytechnic Institute eNTUKhPIIR with 1% ($n = 86$).

5. DISCUSSION AND CONCLUSION

This study represents the first comprehensive empirical investigation of the adoption of open access publications in Ukraine. Based on our data set, the share of OA publications at the national level from 2012 to 2021 was 71.5%, which is a high rate considering the absence of national funders' OA mandates and big transformative agreements within the country (except those negotiated on the behalf of EIFL). Notably, this percentage is significantly higher than the global average of 31% reported by Piwowar et al. (2019), as well as their projected estimate of 44% by 2025. In fact, Ukraine is steadily approaching the leading nations in Europe regarding their share of OA publications, very close to the United Kingdom, with a median share of OA publications of 74% in 2020 (Robinson-Garcia, Costas, & van Leeuwen, 2020) and the Netherlands with 89% in 2022 (Puylaert & Kooistra, 2023).

An important finding was that 60.9% of all OA publications were published in national journals, constituting 43.6% of all papers of the final data set. The rationale for researchers to select national journals may vary, and it would be valuable to conduct empirical studies to identify these reasons. However, valid reasons could include the broad thematic coverage and affordability of national journals, as well as the domestic requirement to publish in these outlets for career advancement (e.g., obtaining a doctoral degree, granting academic titles of Associate Professor and Professor). Despite the vital role that national scholarly journals play in disseminating research, there has been a lack of financial support from the government. In light of this gap, on July 24, 2024, the Ministry of Education and Science of Ukraine released a resolution titled "On Approval of the Procedure for Providing State Support to Ukrainian Scientific Professional Publications Indexed by International Citation Databases." This initiative is designed to provide financial support to national journals to enhance publishing standards and promote the internationalization of local journal titles (Ministry of Education and Science of Ukraine, 2024). Similar supportive mechanisms exist in other Central and Eastern European countries such as Bulgaria, Croatia, Poland, Serbia, Slovenia, and Romania, which allocate funding for journal publishing, as outlined by Laakso and Multas (2023). The rise of Ukrainian journals can also be attributed to the utilization of the open source journal management software Open Journal System (OJS) (Khanna, Ball et al., 2022). For example, a national technology platform called "Scientific Periodicals of Ukraine" (<https://journals.uran.ua/journals>), based on OJS and managed by the nonprofit URAN Association, hosts 782 journals while also offering publishers editorial processing, publication, and postpublication services. A similar set of services is available via another organization called "Open Science in Ukraine."

Such services are popular among academic institutions because universities often lack the expertise or face time constraints when it comes to maintaining journals. Interestingly, in the case of Ukraine, 85% of national journals are published by research institutions and universities, according to the Ulrichsweb database (Nazarovets, 2024).

Our study further substantiates the phenomenon observed by Maddi et al. (2021), which highlights the high adoption of open access in some Eastern European countries. This success can be attributed primarily to the active involvement of institutions in advocating for open access principles. Regarding the distribution of the different subtypes of OA, our analysis revealed that Gold OA was the dominant category, constituting 67.6% of all OA papers. It is important to clarify that Diamond OA is also included within the Gold OA subcategory. The growth of the Gold subtype was observed to increase consistently throughout the entire study period, ranging from 12.1% of all OA papers in 2012 to 60.1% in 2021. This tendency can be explained by the fact that Ukrainian researchers tend to publish their papers predominantly in national OA journals. According to our findings, 64.8% of all Gold papers were published in national journals. There is an analogous situation within the breakdown of OA papers across research areas. The proportion of OA papers published in national journals exceeded those in foreign journals across all research domains except Natural Sciences. Particularly noteworthy is the exceptionally high percentage of OA publications in the Humanities, constituting 89.7%, closely followed by Social Sciences at 88.5%. This finding is surprising, considering the common assumption that OA prevalence in Humanities is not as pronounced as in other fields (Pölönen et al., 2020; Simard, Ghiasi et al., 2021; Torres-Salinas, Robinson-García, & Aguillo, 2016).

Looking at the major commercial publishers favored by Ukrainian researchers, we found that Springer and Elsevier were the top publishers in terms of the number of papers published with them. The popularity of Springer can be partially explained by the fact that its portfolio includes a number of English-translated Ukrainian journals. Nevertheless, the content published with those two publishers was predominantly paywalled, accounting for 70.1% of Springer's and 64.9% of Elsevier's shares respectively. This is because neither the Ministry nor the National Funding Agency have dedicated funds to support researchers and cover APCs. Such a situation very often forces authors to pay from their own pockets if they wish to publish in a particular Gold OA journal. While some institutions have internal policies to reward researchers for publications in prestigious international journals, regardless of publication OA status, the financial rewards provided are typically much lower than APCs. Unaffordable APCs also explain the low percentage (0.9%) of papers published by Ukrainian researchers with the MDPI during the studied period, despite the recent increase of authors from Eastern Europe with the publisher (Csomós & Farkas, 2022).

It is important to emphasize that the first OA initiatives in Ukraine were specifically focused on Green OA and had a positive impact on the establishment of institutional repositories. According to Yaroshenko (2011a), there were 28 Ukrainian institutional repositories in 2011. This number grew to 98 by 2024, as listed by OpenDOAR. Nevertheless, it remains relatively low, considering that Ukraine has over 200 universities. This could be due to low demand from researchers for such services, coupled with a lack of support for launching and maintaining repositories and the availability of international alternatives.

A notable difficulty was the selection of data sources for such an analysis. Our study provides further evidence of the limited and biased coverage of Scopus and WoS databases for use as a single data source in bibliometric research at the national level. We found that 55.7% of Dimensions content was not indexed in either WoS or in Scopus. Dimensions indexed papers from 692 national journals, compared to 111 by Scopus and 92 by WoS, which aligns with the findings of Basson et al. (2021). Although Dimensions is a more inclusive database, it still lacks

a substantial number of national journals, which results in an underestimation of national journal output and their contribution to science. In our case, the content of around 1,000 national journals was not covered by Dimensions. Checks of a random sample of 10 unindexed journals revealed that they publish a small number of articles per issue. Another possible reason for the absence of these journals in Dimensions could be linked to the quality of the metadata, particularly its inconsistency or the fact that it is in a language other than English. We are convinced that further research is needed to identify the common characteristics of journals not covered by Dimensions that may explain their exclusion.

We sought the possibility of reusing national publication data provided by domestic bibliographic sources. The current state of the Ukrainian scholarly communication infrastructure is characterized by partial noncompliance with the FAIR principles for research information and the ongoing development of new components (Hauschke, Nazarovets et al., 2021). These factors hinder the effective leveraging of scholarly metadata on Ukrainian research output. The development of a national research information system with a module for systematic OA monitoring has the potential to significantly improve the situation and accurately display the research outputs of authors affiliated with Ukraine, as the figures obtained in this study may to some extent underestimate Ukraine's actual contribution.

The data sources used for this investigation, due to the lack of a national CRIS, have their own shortcomings. Specifically, there are different definitions of research output categories. Another challenge in the data collection and processing was the inconsistent and incomplete usage of country affiliations of authors in the chosen data sources. Mryglod and Nazarovets (2023) investigated this phenomenon for Scopus and WoS while our experiences indicate that Dimensions metadata has the same or a similar issue. However, due to the constraints imposed on the scope of this paper, this aspect remains unexplored. Further in-depth research is needed.

The conclusions drawn from our study indicate the important role of Ukrainian academic institution-led publishing infrastructures in fostering the dissemination of national research in a freely available way. Future research is needed to investigate institutional spending on OA publication fees in Ukraine, as well as public and institutional spending on national Diamond OA journals. This would offer more clarity on whether it is reasonable for Ukraine to engage into negotiation with large commercial publishers for nationwide "read and publish" agreements. Such agreements have been proven effective mechanisms for increasing the share of OA research; however, they are not sustainable and can severely affect market competition, potentially leaving national publishers behind (Haucap, Moshgbar, & Schmal, 2021). In this regard, it is also valuable to investigate the effect of EIFL's TA agreements, which include Ukraine. On the other hand, transformative agreements could enhance the readership of Ukrainian research, particularly considering that at present a significant proportion of the papers published in national journals are in the Ukrainian language.

Furthermore, the ongoing war waged by the Russian Federation against Ukraine cannot be overlooked in this context, too, as it significantly underscores the detrimental effects on the scientific domain. Recent research has already highlighted a decrease in the number of publications and a decline in research collaboration networks among Ukrainian authors (Damaševičius & Zailskaitė-Jakštė, 2023). While a number of major international publishers have waived APCs for Ukrainian authors, it remains challenging for researchers to sustain their scientific work due to various factors related to the ongoing conflict. These include the loss of funding from the National Research Foundation of Ukraine (NRFU), the mental strain affecting researcher's ability to focus on research, and instances where researchers have had to make the difficult choice to leave academia to volunteer or join the armed forces of Ukraine (Fiialka, 2022). In a separate

investigation, Ukrainian editorial personnel of scientific publishers reported notable impediments in the organization of their editorial workflows. Specifically, 50% of the respondents reported encountering difficulties in this regard, while 3.2% of participants reported temporary suspension of publishing or cessation of publications (Zhenchenko, Izarova, & Baklazhenko, 2023).

In this context, it is worth noting initiatives launched to keep Ukrainian scholarly publishing afloat. Among these are Supporting Ukrainian Editorial Staff (SUES), which provides mentoring and financial support to Ukrainian publishers; the Supporting Ukrainian Publishing Resilience and Recovery (SUPRR) initiative, aimed at supporting Ukrainian publishing both now and after the war; and the Electronic Preservation Project for Ukrainian OA Journals (EPP UA), which aims to create a digital archive of Ukrainian OA journals in the Natural Sciences (Auhunas, Erner et al., 2024; Quiñones, 2023; Stoddard, 2022).

6. LIMITATIONS

This study has a number of limitations. First, it focuses exclusively on the publication type “articles,” not taking into account other research output types. This exclusion may have introduced potential influences on the results that were not accounted for in this analysis. However, due to the fact that WoS has a dual research types classification for some records, conference proceedings can be included in our data set. Second, taking into consideration the fact that the List of Professional Publications of Ukraine, which was used for journal mapping, is subject to revision and exclude journals, some outlets might be omitted during the mapping process due to this reason. Overall, these limitations should be considered when interpreting the results and applying ongoing efforts related to the implementation of the Open Science plan in Ukraine.

ACKNOWLEDGMENTS

We thank Marco Tullney for shaping this study through valuable discussions. We thank Ludo Waltman for advice on discipline mapping. We are grateful to Iryna Kuchma for providing the original text of the Belgorod Declaration on Open Access. We thank our anonymous reviewers for their constructive comments, which helped to improve the manuscript. Nataliia Kaliuzhna is also grateful to Franziska Altemeier and Sabina Auhunas for their moral support.

AUTHOR CONTRIBUTIONS

Nataliia Kaliuzhna: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing—original draft, Writing—review & editing. Christian Hauschke: Conceptualization, Methodology, Supervision, Writing—review & editing.

COMPETING INTERESTS

The authors have no competing interests.

FUNDING INFORMATION

The publication of this article was funded by the Open Access Publishing Fund of Leibniz Universität Hannover. No funding was received to conduct this study.

DATA AVAILABILITY

The data used in this paper may be found at Kaliuzhna, N. (2024). Open Access in Ukraine: characteristics and evolution from 2012 to 2021: Supplementary data. *Zenodo*. <https://doi.org/10.5281/zenodo.11236064>.

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