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Unequal Access, Unequal Impact? The Role of Open Access Policies in Publishing and Citation Trends Across Three Countries

Shlomit Hadad [1,2,*], Daphne R. Raban [3] and Noa Aharony [4]

[1] Department of Digital Learning Technologies, The Israel Academic College in Ramat-Gan, Pinhas Rutenberg St 87, Ramat Gan 52275, Israel
[2] Department of Social Sciences, Ashkelon Academic College, Pinhas Rutenberg St 87, Ramat Gan 52275, Israel
[3] School of Business Administration, University of Haifa, Haifa 3498838, Israel; draban@univ.haifa.ac.il
[4] Department of Information Science, Bar-Ilan University, Ramat Gan 5290002, Israel; noa.aharony@biu.ac.il
* Correspondence: shsh3345@iac.ac.il

Abstract: This bibliometric study investigates Open Access (OA) publication and citation trends in Austria, Israel, and Mexico from 2010 to 2020—three countries with comparable research output but differing OA infrastructures. (1) Background: The study examines how national OA policies, funding mechanisms, and transformative agreements (TAs) shape publication and citation patterns across disciplines. (2) Methods: Using Scopus data, the analysis focuses on four broad subject areas (health, physical, life, and social sciences), applying both three-way ANOVA and a Weighted OA Citation Impact index that adjusts citation shares based on the proportional representation of each subject area in national research output. An OA Engagement Score was also developed to assess each country's policy and infrastructure support. (3) Results: OA publications consistently receive more citations than closed-access ones, confirming a robust OA citation advantage. Austria leads in both OA publication volume and weighted impact, reflecting its strong policy frameworks and TA coverage. Israel, while publishing fewer OA articles, achieves high citation visibility in specific disciplines. Mexico demonstrates strengths in repositories and Diamond OA journals but lags in transformative agreements. (4) Conclusions: National differences in OA policy maturity, infrastructure, and publishing models shape both visibility and citation impact. Structural limitations and indexing disparities may further affect how research from different regions and disciplines is represented globally, emphasizing the need for inclusive and context-sensitive frameworks for evaluating OA engagement.

Keywords: OA citation advantage; OA publication advantage; comparative bibliometric analysis across countries and disciplines; OA policy and involvement level

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1. Introduction

Open Access (OA) refers to the practice of providing unrestricted online access to scholarly publications, thereby removing financial and legal barriers to scientific knowledge (Archambault et al., 2014; Gold, 2021; Severin et al., 2018). Over the past two decades, OA has been championed for its potential to foster research rigor, replicability, and wider dissemination, with studies suggesting that OA publications may experience a citation advantage (Clayson et al., 2021; Piwowar et al., 2018). Despite these gains, the adoption of OA remains uneven. While some fields—notably STEM (science, technology, engineering, and mathematics)—have embraced well-established OA journals and repositories, others,

such as the humanities and social sciences, still face lower uptake (Hadad & Aharony, 2023b; Lanoue, 2020; Martín-Martín et al., 2018). Contributing factors include author-paid models, limited awareness of OA practices, and restrictive copyright policies (Halevi & Walsh, 2021; Shen et al., 2023; Van Vlokhoven, 2019), all of which can lead to inconsistent or delayed OA implementation (Pinfield et al., 2020; Sengupta, 2021; Wager, 2017; Yadav, 2023; Zia, 2021).

National OA policies, institutional mandates, and the presence of transformative agreements (TAs) with publishers significantly shape the extent and pace of OA adoption (Borrego et al., 2021; Moskovkin et al., 2021; Szprot et al., 2021; Thanos, 2017). While TAs are often seen as a way to repurpose subscription fees toward open publishing (Borrego et al., 2021), skeptics argue that such models may entrench inequalities if well-resourced institutions reap a disproportionate share of visibility and citations (Halevi & Walsh, 2021; Sengupta, 2021; Taylor, 2019). Moreover, coverage gaps in major databases and inconsistent policy frameworks across countries may compound these inequities, leading to underrepresentation of certain research outputs and introducing indexing biases (E. Kim, 2024; Mongeon & Paul-Hus, 2016; Vera-Baceta et al., 2019). In other words, differences in OA infrastructure or policy implementation can mean that some disciplines or regions are more readily discoverable and cited in global research databases, while others risk being overlooked (Bornmann et al., 2013; Ploder et al., 2020; Suber, 2015).

Against this backdrop, the present study investigates how varying OA policies and involvement levels influence research visibility and equitable representation in three countries—Austria, Israel, and Mexico. These nations were chosen for their comparable scientific output between 2010 and 2020 but differing OA policies. Austria's robust OA infrastructure includes national mandates and multiple TAs, while Israel's OA landscape is still evolving, and Mexico's engagement with OA is more recent (Moskovkin et al., 2021, 2022). By comparing the extent of OA publishing, citation patterns, and involvement of funding organizations in these countries, this study aims to shed light on whether discrepancies in policy frameworks and TA implementation translate into indexing biases or unequal research visibility. Ultimately, this study seeks to clarify how OA policies shape global scholarly dissemination and whether they advance—or inadvertently hinder—equitable access to scientific knowledge.

2. Literature Review

2.1. The Emergence of Open Access and Its Policy Foundations

The rise of the internet in the 1990s catalyzed a transformative era in scholarly publishing, culminating in foundational declarations such as the Budapest OA Initiative, the Bethesda Statement, and the Berlin Declaration (Suber, 2015; Velterop, 2003). These early calls for free and unrestricted research dissemination highlighted not only the moral imperative of sharing publicly funded outputs but also the potential benefits for visibility, impact, and replicability (Björk, 2013; Morillo, 2020). As the OA movement gathered momentum, a variety of routes emerged—particularly gold OA, with publishers providing OA upon publication, and green OA, in which researchers self-archive in repositories (Franzen, 2023; Thanos, 2017).

Funding organizations soon recognized the potential of OA to elevate the reach and citation of sponsored work, leading to mandates that authors deposit outputs in repositories or publish in OA journals (Colavizza et al., 2020; Robinson-Garcia et al., 2017). Over time, a "funding effect" surfaced, whereby grant-backed articles were more frequently OA and often exhibited a higher citation impact (Ploder et al., 2020). Yet, disparities in implementing these policies persist across regions (Ba et al., 2023; Solomon & Björk, 2012), underscoring the importance of consistent institutional support and robust policy frameworks (Yadav,

2023). At the same time, ethical considerations such as predatory publishing, intellectual property rights, and research misconduct remind scholars that OA must be coupled with responsible conduct and transparent editorial practices (Demir, 2018; Wager, 2017).

2.2. Transformative Agreements and the Potential for Bias in Indexing

In tandem with the proliferation of OA journals, Transformative Agreements (TAs) have emerged as a vehicle to accelerate the transition from subscription-based models (Borrego et al., 2021; Szprot et al., 2021). These agreements allow institutions to funnel subscription fees into Article Processing Charges (APCs) so affiliated authors can publish OA at no extra cost (ESAC Initiative, 2020). By streamlining OA workflows, TAs aim to increase transparency and encourage publishers to adopt fully OA policies over time (Borrego et al., 2021). However, critics caution that TAs may deepen global imbalances if wealthier institutions secure more comprehensive deals and thus reap greater visibility in indexing databases (Halevi & Walsh, 2021; Sengupta, 2021).

Such structural asymmetries align with broader concerns about indexing biases, wherein research from well-resourced settings is disproportionately discoverable and likely to be cited (Mongeon & Paul-Hus, 2016; Piwowar et al., 2018). Although advocates assert that TAs can reduce paywall barriers, the APC-based model also raises questions about quality control, especially with the rise of predatory journals seeking to exploit pay-to-publish mechanisms (Beall, 2015; Shen & Björk, 2015). For smaller presses, including university presses operating on limited resources, the complexities of managing a fully OA workflow across commissioning, peer review, and discoverability can further obstruct consistent indexing (Taylor, 2019). Consequently, effective TA implementation requires not just financial but also administrative and technical support, ensuring that economically or institutionally constrained authors do not remain sidelined (Borrego et al., 2021; Sengupta, 2021; Szprot et al., 2021; Taylor, 2019).

2.3. Cross-Country Variations, Disciplinary Challenges, and Equity

While some nations—particularly in Europe—have seen OA rates surpass 50–70% through strong mandates and TAs (Moskovkin et al., 2021; Pinfield et al., 2020), others lag behind due to limited funding and infrastructural barriers (Lee & Haupt, 2021; Mueller-Langer et al., 2020). Disciplinary norms also shape OA adoption: certain STEM fields, such as biomedical research, embrace OA driven by public interest and funder requirements, while many humanities and social sciences remain tethered to traditional, subscription-based models (Hadad & Aharony, 2023b; Momeni et al., 2021; Piwowar et al., 2018). These discrepancies can translate into unequal representation in major indexing databases, potentially reinforcing a Matthew effect where well-funded disciplines or regions receive more citations and visibility (Severin et al., 2018; J. Wang, 2014).

Moreover, the mechanics of how publications are indexed can exacerbate or mitigate these inequities. For instance, Scopus and Web of Science differ in coverage breadth and interface design, influencing both the raw citation counts and perceived impact of published work (Mongeon & Paul-Hus, 2016). Journals with continuous, uninterrupted coverage often gain a reputational advantage, while coverage gaps or omitted years can signal instability that hampers discoverability (E. Kim, 2024). On the data side, inconsistent open data standards and decentralized repositories may limit the usability and reusability of environmental and educational research outputs, further constraining the potential for truly "open" science (Lanoue, 2020; Thanos, 2017). Collectively, these challenges highlight that OA alone is insufficient if underlying inequalities in infrastructure, culture, or funding perpetuate indexing biases.

2.4. The Conceptual Research Framework

The literature consistently shows that OA can transform scholarly communication by eliminating paywalls, enhancing research visibility, and fostering broader academic collaboration (Björk, 2013; Morillo, 2020; Suber, 2015; Velterop, 2003). Yet, the pace of OA adoption remains highly uneven, often shaped by economic constraints, institutional capacity, and disciplinary norms—factors that can inadvertently reinforce indexing biases (E. Kim, 2024; Moskovkin et al., 2021; Pinfield et al., 2020). Transformative Agreements (TAs) have emerged as one strategy to move beyond subscription-based models (Borrego et al., 2021; Szprot et al., 2021), but concerns persist that wealthy institutions may benefit disproportionately, widening global disparities in research dissemination (Halevi & Walsh, 2021; Sengupta, 2021). Meanwhile, coverage gaps in major databases and inconsistent OA policies across countries compound these inequities, highlighting the risk that under-resourced disciplines or regions may remain underrepresented (Ba et al., 2023; E. Kim, 2024; Momeni et al., 2021; Solomon & Björk, 2012).

Extending cited research on leading countries, this study focuses on three countries selected based on the similarity in their scientific output according to SCImago (www.scimagojr.com/countryrank.php, accessed on 20 May 2023): Austria (ranked 24th), Israel (ranked 25th), and Mexico (ranked 26th). The total number of Scopus-indexed publications (2010–2020) further corroborates their comparable research output: Israel had 239,508 total publications, Mexico had 255,203, and Austria had 286,903 during this period. The rate of OA publications in Austria showed the highest growth (from 36.6% in 2010 to 65.77% in 2020), followed by Mexico (from 29.4% in 2010 to 53.04% in 2020), and Israel (from 31.74% in 2010 to 50.41% in 2020). Interestingly, Israel's ranking in terms of involvement in the OA movement, based on Moskovkin et al. (2021)'s index, stands at 96th. This lower ranking suggests that Israel's level of engagement in promoting OA is relatively lower compared to Mexico (31st) and Austria (28th), which have established national OA policies. However, according to the UNESCO Science Report (2021, www.unesco.org/reports/science/2021/en/countries-regions, accessed on 30 March 2025), between 2011 and 2018, Israel's GERD (Gross Expenditure on Research and Development) rose from about 4.02% to 4.94% of GDP (Gross Domestic Product). Over the same period, Austria maintained levels around 3.1–3.2%, while Mexico fluctuated between 0.3% and 0.5%. This highlights not only their overall differences in research investment but also how each nation's commitment evolved over nearly a decade.

Therefore, the current study seeks to investigate how national OA policies, funding mandates, and disciplinary variations influence both OA publication rates and citation outcomes in these three distinct countries—Austria, Israel, and Mexico. By examining how these factors converge to shape research visibility, the study aims to determine whether differences in OA uptake translate into potential biases in how scholarship is indexed and cited. Specifically, two questions guide the inquiry:

RQ1. *How do the "OA citation and publication advantages" vary across subject areas (health, physical, life, and social sciences) and countries (Austria, Israel, and Mexico)?*

RQ2. *How do Austria, Israel, and Mexico differ in their official OA policies and levels of engagement, and how do these differences affect the overall extent of OA publication?*

3. Method

To address the research questions, this study conducted a bibliometric investigation, focusing on how potential indexing biases might manifest when analyzing trends in OA publishing across various subject areas in Austria, Israel, and Mexico over an eleven-year period.

3.1. Procedure, Instruments and Study Samples

The primary focus of this bibliometric study was to examine whether the level of OA involvement in each country—reflected by funding mandates, repository infrastructure, and policy engagement—correlated with differences in scholarly visibility. This study investigated publications spanning the years 2010 to 2020, utilizing data extracted from the Scopus database. Central to the analysis was the fundamental assumption that publication published in both OA and closed (subscription/toll-based) channels fulfill comparable peer-review standards, rendering them broadly comparable in quality (Shen et al., 2023). The process encompassed several key stages:

A. List of total publications—The list of publications, encompassing articles, conference papers, book chapters, and other document types, was compiled from the Scopus database (https://www.scopus.com, accessed on 31 May 2023). The search for publications was conducted independently for each country from 2010 to 2020, and data collection took place in May–June 2023. Scopus, commonly utilized in bibliometric studies alongside Web of Science and Google Scholar (Ennas & Di Guardo, 2015; Martín-Martín et al., 2018; Mongeon & Paul-Hus, 2016), was selected based on a comparative investigation. This assessment revealed that Scopus offers broad and relatively global coverage, making it a suitable and user-friendly choice (Bakhmat et al., 2022). Moreover, using Scopus provides a broad coverage baseline, allowing us to explore whether any potential underrepresentation (i.e., indexing bias) emerges across countries or disciplines, even within a well-established database.

B. Disciplinary classification—In this study, the study adopted a stratified sampling method to capture the dominant patterns of OA adoption in each country. Stratified sampling involves dividing the population into subgroups or strata based on certain characteristics relevant to the research, a well-established method in bibliometric studies (Jain et al., 2021; Sweileh et al., 2016). The population of interest, which comprises scholarly publications, was stratified into four broad subject areas—health sciences, physical sciences, life sciences, and social sciences—using the classification system applied in the Scopus database.

To ensure feasibility and consistency in cross-country comparisons, one "leading discipline" within each subject area per country was selected, defined by the highest publication volume. Subsequently, all publications included in these leading disciplines were collected comprehensively for the bibliometric analysis. This choice enables a focus on the most representative research areas in each field, ensuring robust coverage of major output while acknowledging that smaller or emergent disciplines may exhibit different OA patterns (see "Limitations"). Table 1 presents an overview of the subject areas, their respective classifications in Scopus, and the top four disciplines (one for each area) with the highest number of publications in each country.

According to the Scopus classification outlined in Table 1, the health sciences subject area is represented by Medicine across all three countries. In the physical sciences category, Engineering serves as the representative discipline in Austria and Mexico, while in Israel, Physics and Astronomy are the representative disciplines. In the life sciences subject area, Biochemistry, Genetics, and Molecular Biology are the representative disciplines in both Israel and Austria. For Mexico, Agricultural and Biological Sciences represent this area. By focusing on the discipline with the largest share of publications in each broad subject area, the study captures the most significant output in each field for each country, thereby providing a snapshot of how OA and potential indexing disparities manifest where research activity is most concentrated.

C. Calculating publication and citation counts; conducting statistical analysis—After identifying the leading discipline in each of the four subject areas per country, the

overall number of publications and citations for both open-access and closed-access modes was extracted for each year from 2010 to 2020. The citation variables were computed using the formula $\langle x \rangle = \sum x/N$, where $\langle x \rangle$ represents the average number of citations per publication. This involves summing the total number of citations to publications in the discipline in a specific year and dividing by the total number of publications for that year.

Methodological Considerations: Inclusion and Exclusion Criteria

Table 1. Subject area categories, Scopus classifications, and the top four disciplines in Austria, Israel, and Mexico.

Scopus Classifications		**Top 4 Disciplines**		
Subject Area	**Subject Area Classifications**	**Austria**	**Israel**	**Mexico**
Health Sciences	Medicine; Nursing; Veterinary; Dentistry; Health Professions; Multidisciplinary	Medicine 75,880 (86.6%)	Medicine 65,234 (87.1%)	Medicine 53,581 (91.6%)
Total publications in the subject area:		87,528 (100%)	74,878 (100%)	58,484 (100%)
Physical Sciences	Chemical Engineering; Chemistry; Computer Science; Earth and Planetary; Sciences; Energy; Engineering; Environmental Science; Material Science; Mathematics; Physics and Astronomy; Multidisciplinary	Engineering 44,426 (29.7%)	Physics and Astronomy 32,720 (30.9%)	Engineering 42,230 (31.4%)
Total publications in the subject area:		149,308 (100%)	105,865 (100%)	134,282 (100%)
Life Sciences	Agricultural and Biological Sciences; Biochemistry, Genetics and Molecular; Biology; Immunology and Microbiology; Neuroscience; Pharmacology, Toxicology and Pharmaceutics; Multidisciplinary	Biochemistry, Genetics and Molecular 35,749 (53.6%)	Biochemistry, Genetics and Molecular 30,371 (55.5%)	Agricultural and Biological Sciences 42,861 (56.5%)
Total publications in the subject area:		66,646 (100%)	54,688 (100%)	75,751 (100%)
Social Sciences	Arts and Humanities; Business, Management and Accounting Decision Sciences; Economics, Econometrics and Finance Psychology; Social Sciences; Multidisciplinary	Social Sciences 24,591 (54.3%)	Social Sciences 31,731 (59.4%)	Social Sciences 22,820 (63.5%)
Total publications in the subject area:		45,249 (100%)	53,347 (100%)	35,919 (100%)

Note: The percentages denote the share of publications in relation to the overall number of publications within the specified subject area.

Scopus offers various filters to categorize documents by OA status:

- Closed/Non-OA: Traditional closed-access journals that require subscription fees for access.
- All Open Access: A comprehensive category encompassing publications flagged by Scopus as OA; this classification includes publications from exclusively gold OA journals that publish only OA content, hybrid-gold OA journals publishing both OA and subscription content, bronze OA journals that are free to read online without a specific license, and green OA publications that have been self-archived in repositories.

In this analysis, "All OA publications" refers to any document flagged by Scopus as OA, including gold, hybrid, bronze, and green OA types. However, for citation analysis, green OA publications were excluded to minimize the risk of double-counting, as the same article may appear in both a repository and a journal platform.

Scopus applies publication-level OA flags using data from several authoritative sources, including DOAJ, CrossRef, and DOAR. Despite this comprehensive approach, some OA routes—particularly green OA—may be underrepresented due to incomplete or inconsistent repository metadata. While this methodological choice might slightly underestimate total OA citations, it ensures greater consistency in cross-route comparisons.

Importantly, the analysis prioritizes classification at the publication level rather than at the journal level. Thus, any individual OA article published in a hybrid journal is included as OA if Scopus flags that specific document accordingly. This enables a more nuanced assessment of scholarly communication by recognizing OA accessibility on a per-publication basis, regardless of the journal's broader access model.

To assess variations in OA engagement across countries and subject areas, average citation counts were calculated using the following formula:

$$C_{\text{avg,mode,area,country}}\ (y) = \frac{\sum_{i=1}^{N_{\text{mode,area,country}}(y)} C_i}{N_{\text{mode,area,country}}(y)}$$

where C_i is the citations for each publication i, and N represents the number of publications for the given mode, area, country, and year. This formula allows standardized comparisons of citation performance across publishing modes (OA vs. closed), subject areas, and countries. Table A1 (Appendix A) presents descriptive statistics for each OA route by country and subject area (2010–2020), while Table 2 provides summary statistics for publications and citations in both open and closed-access modes.

Table 2. Descriptive statistics of publication and citation in each mode (open and closed access) between 2010 and 2020 by countries and subject area.

Country	Publication and Citation	Subject Areas							
		Health Sciences		Physical Sciences		Life Sciences		Social Sciences	
		Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Austria	Closed Publication	3662.64	485.56	3036.73	243.07	1250.82	249.41	1505.09	214.38
	Closed Citation	21.36	7.65	11.34	3.44	26.00	9.85	10.95	4.53
	All OA Publication	3220.45	1397.76	990.00	547.15	2018.45	584.73	702.27	505.63
	All OA Citation	55.61	19.63	29.13	9.51	55.41	18.09	26.13	8.57
Israel	Closed Publication	3668.82	142.65	1367.45	179.52	1229.73	119.15	2452.09	348.15
	Closed Citation	19.85	7.74	14.76	5.48	27.48	9.65	11.44	5.16
	All OA Publication	2233.91	756.16	1602.27	353.61	1543.00	284.33	409.64	188.74
	All OA Citation	43.49	16.61	29.99	17.71	40.83	20.68	15.95	8.73
Mexico	Closed Publication	2699.45	115.84	2969.91	353.06	2291.09	236.63	1229.55	279.47
	Closed Citation	10.89	3.35	9.88	2.14	14.64	4.99	7.21	2.68
	All OA Publication	2176.27	1143.54	864.27	497.36	1609.27	682.67	826.73	616.90
	All OA Citation	37.09	13.98	17.26	5.04	21.23	8.61	9.84	3.35

3.1.1. Preliminary Analyses—Normality Tests

In line with standard bibliometric practices, prior studies often opt for non-parametric tests due to the skewness of citation data (Hadad & Aharony, 2023b; Langham-Putrow et al., 2021; Pislyakov, 2022). However, parametric analyses were employed here to explore relationships among the dependent and independent variables. For large samples (N > 300),

H. Y. Kim's (2013) recommendation was followed to inspect histograms and rely on the absolute values of skewness and kurtosis (|2| for skewness, |7| for kurtosis) rather than z-values. The data for each subject area are presented in Table 3.

Table 3. Descriptive statistics of the study variables.

Variable	Descriptive Statistics				Normality Test Within Each Subject Area							
					Health		Physical		Life		Social	
	Min.	Max.	Mean	SD	Z. Skew	Z. Kurt	Z. Skew	Z. Kurt	Z. Skew	Z. Kurt	Z. Skew	Z. Kurt
Closed Publication	813	4207	2280.28	942.48	−0.22	−1.88	−1.28	−1.79	1.66	0.099	1.38	−0.83
Closed Citation	3.55	44.79	15.48	8.64	1.2	−0.83	2.12	0.98	1.07	−0.79	1.64	−0.18
Total OA Publication	130	6061	1516.38	1032.78	2.38	1.26	0.27	−1.42	1.12	0.06	3	0.92
Total OA Citation	4.33	83.89	32.56	20.27	0.14	−1.38	3.22	2.24	0.38	−1.51	1.68	−0.18

Notes: (1) Z. Skew/Z. Kurt = Z-score for the skewness/kurtosis values. (2) Z = skew value/$SE_{skewness}$, Z = excess kurtosis/$SE_{excess\ kurtosis}$. (3) The Z critical value is 3.29.

According to Table 3, most variables remain within these thresholds, confirming that parametric analyses are appropriate. After these preliminary checks and noting the limitations of the green route, statistical tests were performed to examine variance across publication modes, subject areas, and countries, in line with the research questions and objectives.

3.1.2. Supplementary Data for 2021–2023 Publication Trends

To contextualize post-2020 developments in OA publishing, a supplementary bibliometric search was conducted for the years 2021–2023, using the same Scopus search parameters and representative disciplines established in the main analysis. While the shorter citation window limits inclusion of these data in statistical modeling, descriptive statistics were compiled for both OA and closed-access publications and their associated citation counts. These data, presented in Table 4, provide a snapshot of recent trends in OA uptake across Austria, Israel, and Mexico. Although not included in inferential analyses, these findings offer additional context for understanding the trajectory of OA publishing in the aftermath of key policy shifts.

Preliminary findings (Table 2) suggest that all three countries experienced growth in the share of OA publications and citations compared to the 2010–2020 period. Austria continues to exhibit comparatively high OA visibility, particularly in health and life sciences. Israel shows improved OA citation shares in several fields, including social sciences, while Mexico demonstrates modest gains, especially in OA citations within life sciences and social sciences. Although the relative positioning of countries remains broadly similar to that of the previous decade, the observed gap in citation performance—particularly between Mexico and the others—appears to have slightly narrowed. However, given the short citation window for these more recent years, these patterns should be interpreted cautiously. The full impact of evolving OA policies and infrastructures may become clearer over a longer timeframe.

Table 4. OA and closed access publications and citations by country and discipline (2021–2023).

Country	Subject Area	OA Publications	OA Citations	OA Mean	CA Publications	CA Citations	CA Mean	OA % of Publications	OA % of Citations
Austria	Health Sciences	22,232	320,338	14.41	7610	65,710	8.635	74.5%	83.0%
	Physical Sciences	7537	74,557	9.89	8191	40,288	4.919	47.9%	64.9%
	Life Sciences	10,870	163,198	15.01	2080	20,330	9.774	83.9%	88.9%
	Social Sciences	6516	61,643	9.46	5531	19,383	3.504	54.1%	76.1%
Israel	Health Sciences	15,379	242,564	15.77	10,572	73,471	6.950	59.3%	76.8%
	Physical Sciences	6704	87,912	13.11	3165	20,271	6.405	67.9%	81.3%
	Life Sciences	7541	116,768	15.48	2637	28,224	10.703	74.1%	80.5%
	Social Sciences	3844	26,560	6.91	8639	38,816	4.493	30.8%	40.6%
Mexico	Health Sciences	13,516	157,442	11.65	7964	40,826	5.126	62.9%	79.4%
	Physical Sciences	6105	47,619	7.80	10,462	52,093	4.979	36.9%	47.8%
	Life Sciences	10,009	69,895	6.98	7234	44,176	6.107	58.0%	61.3%
	Social Sciences	7540	35,854	4.76	5917	17,284	2.921	56.0%	67.5%

3.2. Comparing the Level of Involvement in OA in Austria, Israel, and Mexico

Next, this study assessed each country's OA involvement, including institutional, national, and funding-level policies, in November-December 2023. Three criteria (A, C, D) from Moskovkin et al. (2021) were first adopted to evaluate countries' active participation by counting OA policies, repositories, journals, and publishers. Two unique criteria were then added—(B) OA policies among top funders and (E) Transformative Agreements (TAs)—detailed below:

A. Country-Level OA Policies—Used ROARMAP: Registry of Open Access Repositories Mandatory Archiving Policies (https://roarmap.eprints.org/dataviz2.html, accessed on 21 November 2023), an international database tracking institutional/funder mandates requiring peer-reviewed publications to be deposited in OA repositories.

B. OA Policies among Top Ten Funding Organizations—Building on evidence of a "funding effect" (Hadad et al., 2024), this study identified the top ten funders in each country (2010–2020) via Scopus, and then checked each funder's OA policy in Sherpa Juliet (https://v2.sherpa.ac.uk/juliet/search.html, accessed on 24 December 2023), which provides comprehensive information on funders' OA mandates.

C. OA Repositories—Counted repositories using ROAR: Registry of Open Access Repositories (http://roar.eprints.org/) and OpenDOAR: Directory of Open Access Repositories.

D. OA Journals and Publishers—Examined OA journals indexed by SCImago Journal and Country Rank (https://www.scimagojr.com/journalrank.php?openaccess=true, accessed on 22 December 2023), based on Scopus indicators. Also consulted Sherpa Romeo (https://v2.sherpa.ac.uk/view/publication_by_country/) for global OA publisher and journal policies.

E. Transformative Agreements (TAs)—Reviewed the ESAC Transformative Agreement Registry (https://esac-initiative.org/about/transformative-agreements/agreement

-registry/, accessed on 12 November 2023) for contracts converting subscription models into fully OA.

To analyze disparities in OA involvement, chi-square "goodness of fit" tests were conducted for each criterion. Standardized residuals (SRs) exceeding ±2 were considered statistically significant (Haberman, 1973; Sharpe, 2015), indicating a deviation from what would be expected if OA engagement were evenly distributed across countries. Building on these results, this study developed an OA Engagement Score, calculated using the following formula:

$$\text{OA\_Engagement}_{\text{country}} = \sum_{i=1}^{k} w_i \times SR_{criterion_i}$$

where $SR_{\text{criterion}i}$ represents the standardized residual for each criterion i, and W_i is the weight assigned to that criterion. In this study, all weights were set to 1, reflecting the equal importance of each metric (e.g., policies, repositories, journals, transformative agreements). Although introduced as a composite indicator, the OA Engagement Score is not intended as a definitive ranking, but rather as a heuristic tool to summarize national involvement in OA infrastructure. It highlights relative strengths and gaps in standardized indicators while acknowledging structural and philosophical differences in national OA strategies. The score also supports exploration of whether higher OA engagement corresponds with greater discoverability and citation visibility, potentially reflecting reduced indexing bias. Conversely, lower scores may signal policy or infrastructure gaps that could limit the global impact of a country's OA outputs.

4. Results

For each of the scientific impact measures—citations and publications—a Univariate Analysis of Variance (ANOVA) was conducted. The two models (citations model and publications model) included the subject area, country, and publishing mode (closed/open), and their interaction effects. Publishing-mode interactions were the primary focus, aiming to determine whether changes in the outcomes across subject area and country (treated as repeated measures variables) depended on different publishing modes. To account for country and subject areas, simple interaction effects were then examined within each publishing mode.

4.1. An "OA Citation and Publication Advantage" Effect Across Countries and Subject Areas

According to the first research question, the existence of an "OA citation and publication advantage" was investigated, examining whether it varied by publishing mode, country (Austria, Israel, Mexico), and subject area (health, physical, life, social sciences). The main effects analysis indicated that publishing mode, subject area, and country significantly influenced both citation and publication counts. Additionally, most two-way and three-way interactions were significant, as shown in Table 5, except for a non-significant interaction between publishing mode and country for publication count.

Table 5. Publishing mode (closed vs. open access) by subject area (health, physical, life, and social sciences) and country (Austria, Israel, and Mexico): main effects and interaction effects.

	Main Effects			Interaction Effects		
	Publishing Mode *F*(1,240)	**Country *F*(2,240)**	**Subject Area *F*(3,240)**	**Pub.Mode * Subject *F*(3,240)**	**Pub.Mode * Country *F*(2,240)**	**Pub.Mode * Subject * Country *F*(12,240)**
Citations	212.75 *** $\eta^2_p = 0.470$	70.14 *** $\eta^2_p = 0.369$	56.82 *** $\eta^2_p = 0.415$	12.43 *** $\eta^2_p = 0.135$	17.87 *** $\eta^2_p = 0.130$	3.54 ** $\eta^2_p = 0.151$
Publications	133.40 *** $\eta^2_p = 0.357$	5.17 ** $\eta^2_p = 0.041$	126.85 *** $\eta^2_p = 0.613$	22.88 *** $\eta^2_p = 0.222$	1.74 $\eta^2_p = 0.014$	15.34 *** $\eta^2_p = 0.434$

Notes: (1) OA citations include only gold, hybrid, and bronze. OA publications include all four routes (gold, hybrid, bronze, and green). Green OA was excluded from the citation count to avoid potential double counting. (2) * $p < .05$, ** $p < .01$, *** $p < .001$.

4.1.1. Publishing Mode and Country

A significant interaction effect emerged for citation count, indicating that changes in citation depend on both publishing mode and country (Table 5). However, while there was a significant main effect of country on number of publications, the interaction with publishing mode was not significant. All three countries showed higher citation counts in OA vs. closed access (p's < 0.001), while the number of closed publications typically exceeded the number of OA publications. Figure 1 provides a visual representation of the interaction between publishing mode and country:

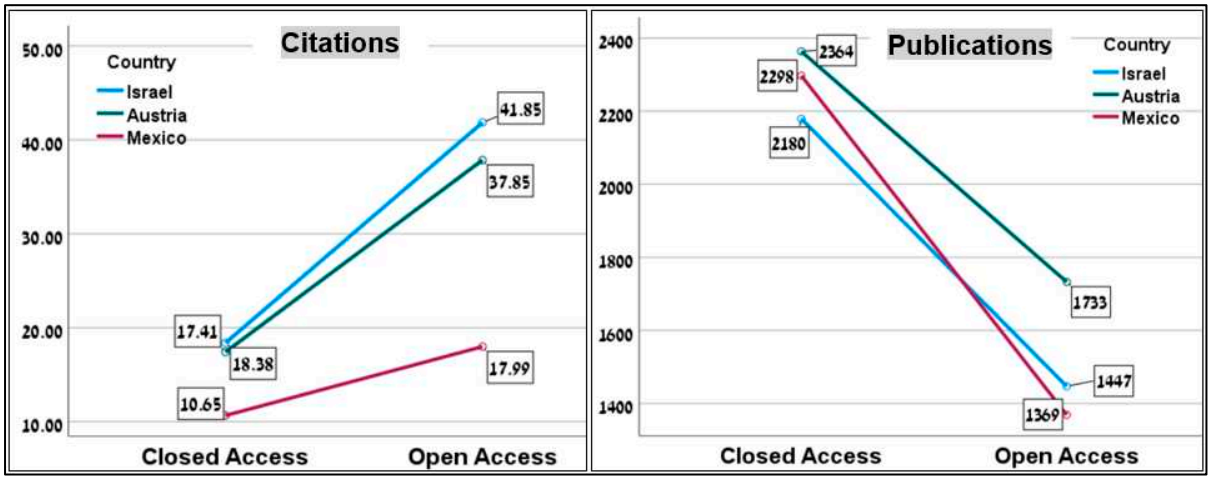

Figure 1. Citation vs. Publication: Interaction effect between publishing mode and country. Note: The (**Left panel**) displays the average number of citations per publication (2010–2020), comparing closed vs. open access for each country. The (**Right panel**) shows the mean number of publications during the same period, broken down by country and publishing mode.

As shown in Figure 1, Austria has a comparatively high volume of OA publications, whereas Mexico and Israel have lower levels of OA output. Nevertheless, Israel's OA citation counts do not differ significantly from Austria's in most subject areas—suggesting that even a smaller number of OA publications can achieve substantial visibility under certain conditions. This outcome may reflect indexing practices (e.g., the prominence of key OA journals) rather than merely the overall scale of OA output. Post hoc Bonferroni tests reveal that Mexico has significantly lower citation counts than Austria and Israel in both closed ($F(2,129) = 12.23$, $p < 0.001$, $\eta^2_p = 0.159$) and OA mode ($F(2,129) = 25.64$,

$p < 0.001$, $\eta^2_p = 0.284$). No significant differences were observed between Austria and Israel, underscoring distinct citation dynamics related to OA publications.

4.1.2. Publishing Mode and Subject Areas

Significant interaction effects emerged, suggesting that changes in citation and publication counts depend on both publishing mode and subject area across countries. For both OA and closed access, subject areas differed significantly in citation count ($F(3,128) = 18.921$, $p < 0.001$, $\eta^2_p = 0.307$) for OA; ($F(3,128) = 21.54$, $p < 0.001$, $\eta^2_p = 0.336$) for closed. Similarly, the number of publications varied by subject area in both OA ($F(3,128) = 37.755$, $p < 0.001$, $\eta^2_p = 0.469$) and closed access ($F(3,128) = 52.309$, $p < 0.001$, $\eta^2_p = 0.551$). As depicted in Figure 2, OA citations generally exceeded those of closed access, whereas closed-access publications often outnumbered OA publications.

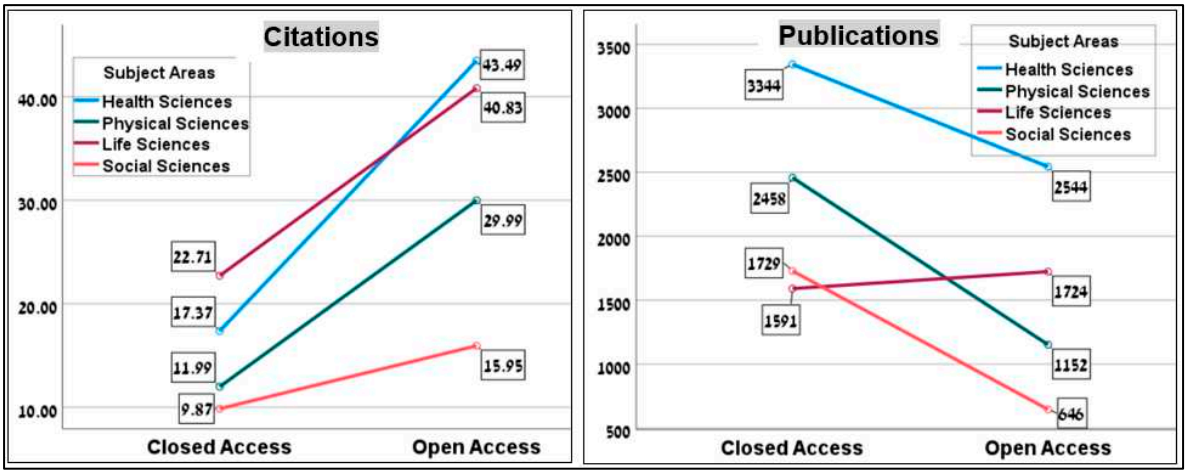

Figure 2. Citation vs. Publication: Interaction effect between publishing mode and subject areas. Note: (**Left panel**): Average citations per publication (2010–2020), comparing closed vs. open access across four subject areas. (**Right panel**): Mean number of publications for each subject area and publishing mode over the same period.

The post hoc Bonferroni pairwise comparisons revealed the following (Figure 2): (1) Citation Count: Under closed access, the social and physical sciences had the lowest citation rates, while health and life sciences were significantly higher. Under OA, the social sciences again had the lowest citation counts, whereas health and life sciences were significantly higher (with no significant difference between those two fields). (2) Number of Publications: In both closed and OA modes, the health sciences produced the highest publication counts. Except for the life sciences, all other fields had more closed than OA publications. No significant difference emerged between the numbers of closed publications in life and social sciences.

4.1.3. Publishing Mode, Subject Areas, and Country

Significant three-way interactions show that both citation counts and publication volumes depend on publishing mode (closed vs. OA), subject area (health, physical, life, social), and country (Austria, Israel, Mexico). Post hoc Bonferroni tests were performed to compare multiple subject-area pairs within each publishing mode and country, as illustrated in Figure 3 (citations) and Figure 4 (publications).

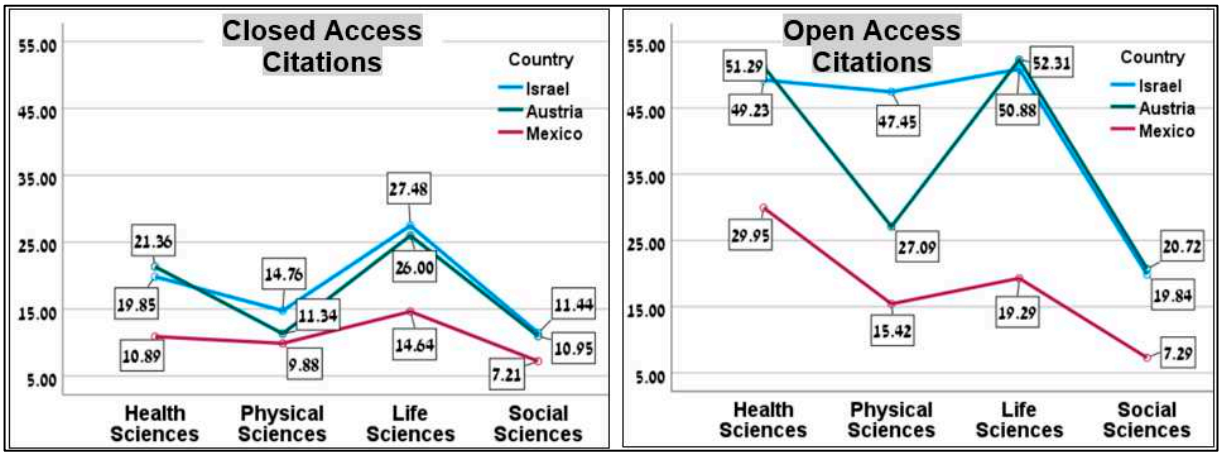

Figure 3. Closed access citation vs. OA citation across the subject areas and countries: Three-way interaction effect. Note: The (**Left panel**) shows the average number of closed access citations per publication (2010–2020) for each country across four subject areas. The (**Right panel**) shows the average number of open-access citations per publication over the same period, categorized by country and subject area.

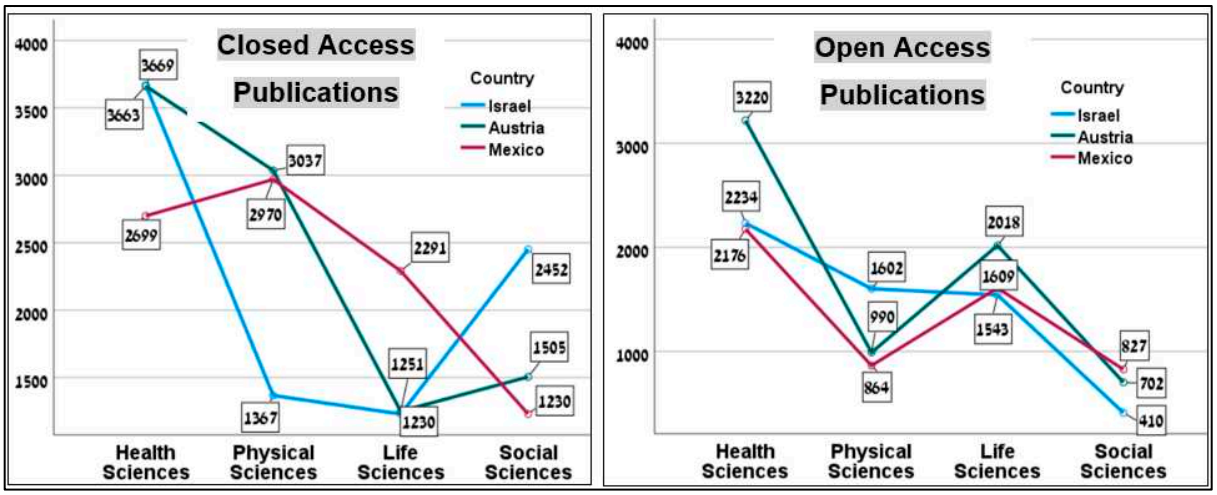

Figure 4. Closed access publication vs. OA publication across the subject areas and countries: Three-way interaction effect. Note: The (**Left panel**) displays the mean number of closed access publications (2010–2020) for each country by subject area. The (**Right panel**) shows the mean number of open access publications over the same period, also grouped by country and subject area.

From Figure 3, Mexico's citation counts under closed access were lower than those of Israel and Austria in health, life, and social sciences, and lower than Israel in physical sciences. In OA mode, Mexico still ranked lowest in all four subject areas. Austria and Israel showed minimal and non-significant differences, except in physical sciences, where Israel's OA citation counts exceeded Austria's. These patterns may reflect variations in repositories, OA journal availability, or indexing practices favoring particular countries or disciplines.

Regarding publication volume (Figure 4), Israel led in closed-access social sciences, while Mexico surpassed both Israel and Austria in closed-access life sciences. Austria dominated OA publications in health sciences, while Israel led in OA physical sciences. Across all three countries, social sciences continued to exhibit comparatively low OA output.

4.1.4. Weighted OA Citation Impact Analysis

To facilitate meaningful and context-aware comparisons of Open Access (OA) citation patterns, we calculated a Weighted OA Citation Impact index. This metric adjusts OA citation proportions by the subject area's share in each country's total research output, accounting for national research priorities and disciplinary scale. The index is defined as:

Weighted OA Citation Impact = (OA Citations/Total Citations) × Subject Area Proportion × 100. Table 6 presents these values alongside OA and closed access publication and citation percentages by country and subject area. The results indicate that OA citation shares often surpass OA publication shares, highlighting the disproportionate visibility and reach of OA content.

Table 6. Weighted OA citation impact by country and subject area (2010–2020).

Country	Subject Area	% of National Research	Publications		Citations		Weighted OA Citation Impact
			OA % of Publications	CA % of Publications	OA % of Citations	CA % of Citations	
Austria	Health Sciences	42.02%	46.79%	53.21%	58.36%	41.64%	24.52
	Physical Sciences	24.58%	24.59%	75.41%	30.28%	69.72%	7.45
	Life Sciences	19.93%	61.74%	38.26%	69.12%	30.88%	13.78
	Social Sciences	13.47%	31.81%	68.19%	36.15%	63.85%	4.87
Israel	Health Sciences	40.74%	37.85%	62.15%	51.76%	48.24%	21.05
	Physical Sciences	20.44%	53.95%	46.05%	62.42%	37.58%	12.77
	Life Sciences	19.10%	55.65%	44.35%	62.10%	37.90%	11.86
	Social Sciences	19.72%	14.31%	85.69%	12.44%	87.56%	2.46
Mexico	Health Sciences	33.24%	44.63%	55.37%	62.81%	37.19%	20.88
	Physical Sciences	26.15%	22.54%	77.46%	24.21%	75.79%	6.33
	Life Sciences	26.59%	41.26%	58.74%	41.81%	58.19%	11.10
	Social Sciences	14.02%	40.21%	59.79%	36.53%	63.47%	5.13

Note: Percentages for citations and publications represent the share of total citations and publications attributed to Open-Access (OA) or Closed-Access (CA) sources within each subject area.

The results in Table 6 reveal substantial variation in Weighted OA Citation Impact across countries and disciplines. Austria's health sciences exhibited the highest impact score (24.52), reflecting both strong OA uptake and high citation volume in this key national research area. Israel's health and life sciences also showed elevated values (21.05 and 11.86, respectively), suggesting substantial OA citation visibility in those domains. In contrast, Israel's social sciences recorded the lowest score (2.46), consistent with their limited OA presence and smaller share of national research. Mexico's physical sciences and social sciences also reported lower scores (6.33 and 5.13), indicating that OA citations in these areas remain less proportionally represented. These corrected figures align with the three-way ANOVA results (Section 4.1.3), reinforcing that OA citation patterns are shaped by a combination of publishing mode, subject area, and country-level research priorities.

4.2. OA Involvement Effect Across Subject Areas, Discipline Groups, and Countries

The second research question explored how official OA policies and broader national involvement influence the extent of OA publishing in Austria, Israel, and Mexico. To assess these effects, this study evaluated each country using a set of standardized criteria reflecting institutional, funding, and infrastructural dimensions of OA engagement. Table 7 presents the results of chi-square "goodness of fit" tests, standardized residuals (SRs) for each criterion by country, and the resulting OA Engagement Scores—composite indicators summarizing each country's relative involvement in the OA landscape.

Table 7. Open-access involvement in Austria, Israel, and Mexico.

	Criteria	Portal	Austria		Israel		Mexico		Chi-Square Test
			No	*SR*	No	*SR*	No	*SR*	
1.	**Number of OA-registered mandatory policies**	ROARMAP	8	+1.07	--	--	3	−1.07	$\chi^2(2) = 1.46$, $p = 0.226$
2.	**Number of OA policies among the top ten funding organizations**	Scopus and Sherpa Juliet	10	+0.84	8	+0.12	5	−0.96	$\chi^2(2) = 1.65$, $p = 0.438$
3.	**Number of OA repositories**	ROAR	29	+0.19	1	−5.1	54	+4.91	$\chi^2(2) = 50.21$, $p < 0.001$
		OpenDOAR	56		--	--	56		--
4.	**Number of OA journals and publishers**	SCImago	30	−1.9	2	−6.2	95	+8.1	$\chi^2(2) = 107.54$, $p < 0.001$
		Sherpa Romeo	52	+4.72	1	−5.04	29	+0.32	$\chi^2(2) = 47.73$, $p < 0.001$
5.	**Number of transformative agreements**	ESAC TA Registry	53	+5.39	10	−3.09	14	−2.3	$\chi^2(2) = 43.97$, $p < 0.001$
OA Engagement Scores by Country			**+10.31**		**−19.31**		**+9.00**		

Notes: (1) Standardized Residuals (SRs) cells which exceed an absolute value of two (+/−2) are considered to contribute to a statistically significant degree in the omnibus chi-square test. (2) OA Engagement Scores by Country were calculated using the following formula: $\text{OA\_Engagement}_{\text{country}} = \sum_{i=1}^{k} w_i \times \text{SR}_{\text{criterion}_i}$.

Table 7 reveals distinctive patterns in OA involvement across the three countries based on standardized criteria:

Austria demonstrated robust OA involvement, with a higher number of national policies, repositories, journals, and transformative agreements compared to Israel and Mexico. The OA Engagement Score for Austria was calculated as follows: $\text{OA\_Engagement}_{\_Austria} = (1 \times 1.07) + (1 \times 0.84) + (1 \times 0.19) + (1 \times -1.90) + (1 \times 4.72) + (1 \times 5.39) = +10.31$. This positive score reflects Austria's broad involvement across all evaluated indicators and may partly explain its stronger OA citation performance observed in earlier sections.

- Israel showed significantly fewer OA repositories, journals, publishers, and transformative agreements, and no formal national OA policies. The OA Engagement Score for Israel is: $\text{OA\_Engagement}_{\_Israel} = (1 \times 0.12) + (1 \times -5.10) + (1 \times -6.20) + (1 \times -5.04) + (1 \times -3.09) = -19.31$.
  This negative score corresponds with Israel's lower OA publication volume, despite achieving comparable citation performance in some disciplines—suggesting that indexing or citation dynamics may play a role beyond policy structure alone.
- Mexico exhibited notable strengths in OA repositories and journals, though it has relatively few transformative agreements. Its positive score underscores pockets of strong OA infrastructure but also points to variability across sources (e.g., SCImago vs. Sherpa Romeo). Such inconsistencies in data may reflect different indexing criteria, also hinting at potential biases in how OA venues are tracked or recognized. Due to the lack of data for Mexico in the ESAC TA Registry, an independent search through other web sources and publishers was required. The OA Engagement Score for Mexico was calculated as follows: $\text{OA\_Engagement}_{\_Mexico} = (1 \times -1.07) + (1 \times -0.96) + (1 \times$

4.91) + (1 × 8.10) + (1 × 0.32) + (1 × −2.30) = +9.00.
This positive score indicates that Mexico shows strength in areas such as repositories and journals. However, the variability across different OA measures and discrepancies between sources highlight inconsistencies in OA engagement.

In summary, Austria recorded the highest OA Engagement Score (+10.31), with strong performance across most indicators. Mexico followed closely with a score of +9.00, showing particular strengths in OA repositories and journals. Israel had the lowest score (–19.31), reflecting minimal presence in key infrastructure components such as repositories, transformative agreements, and national OA mandates. These scores quantify national differences in OA-related infrastructure across standardized metrics and provide a comparative overview of each country's involvement based on available data.

5. Discussion

A decade after the seminal BBB declarations, growth in OA publications seemed promising (Björk, 2013; Joseph, 2013; Laakso et al., 2011). While milestones were achieved, 20 years later, universal adoption of OA publishing across nations and institutions remains a challenge (Moskovkin et al., 2021; Mueller-Langer et al., 2020; Pollock & Michael, 2019). Economic, cultural, and logistical hurdles persist, exacerbating disparities in OA engagement (Gasparyan et al., 2019; E. Kim, 2024; Price & Puddephatt, 2017; Sengupta, 2021). This study investigated OA publication trends in Austria, Israel, and Mexico, countries with similar mid-range standings in scientific output but divergent OA policy involvement. Unlike studies that focus on leading scientific nations, this analysis emphasizes the role of OA policy frameworks in influencing scientific impact and indexing visibility (E. Kim, 2024; Mongeon & Paul-Hus, 2016).

5.1. Publishing Modes, Country Impact, and OA Policy Repercussions

Findings highlight the significant effect of publishing mode, subject area, and country on citation and publication counts. Across all countries, closed-access publications were more numerous than OA publications, yet OA publications consistently received higher citation counts, reinforcing the well-established OA citation advantage (Hadad et al., 2024; Piwowar et al., 2018; X. Wang et al., 2018). However, disparities emerged across the three countries: Austria had the highest OA publication rate, while Israel and Mexico lagged behind, with Israel demonstrating higher citation counts despite lower OA publication volumes. Israel's OA underperformance aligns with previous studies noting its lack of national and institutional OA policies and fewer registered repositories compared to Austria and Mexico (Moskovkin et al., 2021; Yadav, 2023). While funding organizations in Austria enforce OA mandates, Israel's largest research funding body, the Israel Science Foundation (ISF), lacks an OA policy, which may explain the lower proportion of OA publications (Hadad et al., 2024). These findings align with previous rankings of OA involvement, where Austria, Mexico, and Israel were ranked 28th, 31st, and 96th, respectively, in their engagement with OA (Moskovkin et al., 2021).

The significant presence of transformative agreements (TAs) in Austria, reflected in its higher number of OA publications, supports prior research indicating that such agreements facilitate increased OA publishing (Borrego et al., 2021; Moskovkin et al., 2021). In contrast, Israel and Mexico have implemented fewer transformative agreements, limiting researchers' ability to publish in OA venues without incurring financial costs. These differences underscore the pivotal role that institutional and national-level funding structures play in driving OA adoption. Expanding the reach of transformative agreements in underrepresented regions could help reduce disparities in OA publishing rates. Prior research suggests that journals originating from less-established or underrepresented regions often

face challenges in achieving consistent indexing in major citation databases, which can negatively impact their discoverability and visibility (E. Kim, 2024; Mongeon & Paul-Hus, 2016). While differences in citation performance may partly reflect variation in research quality or disciplinary impact, inconsistencies in indexing practices can further exacerbate inequities in OA engagement and citation reach across countries. OA infrastructure and policies evolved throughout 2010–2020, with countries like Austria adopting mandates and transformative agreements earlier than Israel or Mexico. These timeline differences help explain variations in OA engagement. While the analysis focuses on an 11-year period for citation stability, a 2023 review of national OA initiatives was included to contextualize each country's development.

However, structural comparisons must be interpreted with caution. Mexico's OA model is shaped by a longstanding tradition of supporting Diamond OA journals—platforms that provide OA without article processing charges, typically sustained through public or institutional funding. While Austria's OA infrastructure is anchored in transformative agreements, which are often temporary and subject to renegotiation, Mexico's approach emphasizes non-commercial, publicly funded frameworks that promote equitable access for both authors and readers. These divergent strategies are not always fully captured by international indexing platforms such as Sherpa, SCImago, or OpenDOAR, which tend to prioritize more formalized and commercially visible OA infrastructures. Consequently, although Mexico's OA engagement may appear lower in conventional metrics, it reflects a structurally distinct and philosophically grounded model of OA. Recognizing this variation is critical for a more inclusive and accurate understanding of global OA practices.

5.2. Publishing Modes, Subject Areas Impact, and OA Policy Repercussions

Disciplinary differences in OA adoption persisted. Health sciences exhibited the highest OA publication rates, while social sciences had the lowest. This finding supports earlier studies indicating higher OA engagement in STEM fields due to established OA journals and repositories (Bosman & Kramer, 2018; Momeni et al., 2021; Shen et al., 2023). The social sciences showed significantly fewer OA publications and lower citation counts compared to other disciplines, underscoring the limited OA infrastructure in the field (Lanoue, 2020; Taylor, 2019).

Repository and journal availability also varied across countries. Austria and Mexico had strong OA repository infrastructures (ROAR registry and OpenDOAR), while Mexico demonstrated strength in OA journals (SCImago) but lagged in transformative agreements (ESAC TA registry). The green OA route remains an underutilized strategy across countries, as institutional policies, publisher restrictions, and lack of awareness hinder self-archiving practices (Franzen, 2023; Hadad & Aharony, 2023a, 2023b). These disciplinary and national disparities in OA involvement point to systematic challenges in indexing and discoverability. If certain fields and regions publish disproportionately in closed access, their research remains less visible in citation databases, perpetuating citation inequality (E. Kim, 2024; J. Wang, 2014). The stark contrast in OA publication rates between health, life, and physical sciences and social sciences highlights the challenges faced by the latter. Limited access to established OA journals and repositories hinders social science and humanities disciplines, emphasizing the crucial need for equal access and supportive environments for researchers across all fields (Hadad & Aharony, 2023b; Hadad et al., 2024).

To extend the temporal scope of the analysis and address recent OA developments, updated publication data from 2021 to 2023 were collected across the same countries and disciplinary fields. The findings show continued leadership by Austria in OA publication rates, particularly in life and health sciences. Israel displayed notable gains in OA publishing, especially in the physical sciences, while Mexico's OA publication rate in-

creased significantly in the health sciences. These improvements appear to coincide with the ongoing implementation of transformative agreements (TAs), particularly in Austria, and to some extent in Israel. The strengthened alignment between national OA policies and publication output suggests that policy instruments such as TAs play an increasingly important role in shaping OA availability and infrastructure development across countries and disciplines.

5.3. Effects of Publishing Modes, Country, and Subject Areas on OA Engagement

When examining the interplay of publishing mode, subject area, and country, significant patterns emerged. OA publication rates were highest in health and life sciences, particularly in Austria. In physical sciences, Israel demonstrated a strong citation advantage, outperforming Austria and Mexico in OA citations despite its lower publication volume. This may reflect the influence of disciplinary culture and funding support, as eight out of Israel's ten leading funding organizations have OA policies, particularly in the exact sciences (Hadad et al., 2024).

Conversely, Mexico had the lowest citation rates across all subject areas. While green OA repositories are widely available in Mexico, they appear underutilized for scholarly dissemination. The "Matthew Effect," where highly cited journals and nations continue to accumulate more citations while others struggle for visibility, may further disadvantage research output from Latin American countries (Merton, 1968; Mongeon & Paul-Hus, 2016; J. Wang, 2014). Database indexing biases may also contribute to these disparities, as journals from certain regions or disciplines are less likely to be included in high-impact databases like Scopus and Web of Science (E. Kim, 2024; Vera-Baceta et al., 2019).

Importantly, this study revealed the prominence of transformative agreements (TAs) in Austria, showing significantly higher numbers compared to both Israel and Mexico. Findings reveal that Austria not only excelled in the sheer quantity of TAs but also showcased substantial OA publications in key subject areas. Hence, in addition to the effect of funding support, the current findings emphasize the intricate relationship between TAs and the volume of OA publications. The strong association between funding, TAs, and OA adoption suggests that economic and institutional factors shape research visibility (Taylor, 2019; Yadav, 2023). Furthermore, equity in journal indexing must be addressed. Some studies have shown that journals with fewer citations or from less-established regions may experience indexing exclusion, which affects global knowledge dissemination (Bornmann et al., 2013; E. Kim, 2024). Although citation disparities partly reflect variations in research impact, inconsistent indexing policies further limit the reach of OA research in certain countries and disciplines.

Moreover, the Weighted OA Citation Impact analysis provided additional nuance by contextualizing OA citation shares relative to each discipline's national research footprint. Austria's health sciences exhibited the highest weighted impact score, suggesting strong OA uptake in a dominant national research field. Israel's health and life sciences also performed well, while its social sciences recorded the lowest score (2.46), consistent with limited OA presence. Similarly, Mexico's physical sciences and social sciences scored lower, indicating a gap between OA citation visibility and disciplinary scale. These results reinforce the earlier ANOVA findings, emphasizing that OA citation advantages are both statistically and proportionally significant within each country's research ecosystem.

6. Conclusions and Implications

This study examined the influence of national Open-Access (OA) policies and funding structures on research visibility and impact, while also considering potential indexing biases that affect global knowledge dissemination. Across Austria, Israel, and Mexico, OA

publications consistently received higher citation counts than their closed-access counterparts, reaffirming the well-documented OA citation advantage. However, disparities in OA publication volume suggest that economic and institutional barriers continue to restrict OA adoption in certain disciplines and regions. Health and life sciences exhibited the highest levels of OA uptake, while social sciences remained markedly underrepresented.

The findings underscore the importance of comprehensive national OA strategies, particularly in countries with lower levels of OA infrastructure and support. Austria's extensive use of transformative agreements (TAs) contributed to its leading OA publication rates and citation impact. These agreements may serve as scalable models for expanding OA participation in other regions. Conversely, limited implementation of TAs in Israel and Mexico constrains OA publishing opportunities, particularly in disciplines with high publishing costs. Indexing disparities present an additional challenge. Journals from less-established regions or disciplines with lower citation metrics may face obstacles to consistent inclusion in major databases such as Scopus or Web of Science. These inconsistencies hinder discoverability and skew global citation visibility. While some citation disparities are attributable to variations in research quality or disciplinary norms, inconsistent indexing practices and database coverage raise concerns about how OA research is represented across different contexts.

This study provides actionable insights for policymakers, institutions, and researchers. Strengthening national OA mandates—particularly in underrepresented regions—is critical for reducing inequities in access and visibility. Countries lacking binding OA policies, such as Israel's Israel Science Foundation (ISF), may benefit from clearer mandates. Expanding the scope and reach of transformative agreements can further level the publishing landscape, as demonstrated by Austria's success. In addition, promoting awareness of and support for self-archiving practices could improve green OA uptake in countries like Mexico, where repository usage remains low. A globally inclusive OA framework must integrate both financial and infrastructural support mechanisms. Only by addressing systemic barriers—including indexing biases and uneven policy enforcement—can OA publishing become a more equitable channel for knowledge dissemination across disciplines and regions.

Limitations and Further Research

This study has several limitations. First, while Scopus OA flags were used to classify publications, distinctions between OA routes (gold, hybrid, bronze, green) were not analyzed separately. Green OA was excluded from citation analysis to avoid double-counting, but may be underrepresented due to inconsistent repository metadata. Future research could enhance classification by cross-referencing additional sources like DOAJ and improving repository tracking. Second, although parametric methods were deemed appropriate based on normality tests, citation data often exhibit skewed distributions. Supplementary non-parametric analyses and regression models could better account for confounding factors such as institutional collaboration, journal prestige, or funding levels. Third, focusing on one leading discipline per subject area per country allowed for comparability but limited disciplinary breadth. Including a wider range of fields and institutions would provide a more comprehensive view of OA adoption. Fourth, the OA Engagement Score, while useful as a summary indicator of national involvement, does not reflect policy strength, enforcement, or repository indexing quality. It is intended as a heuristic tool rather than a definitive ranking. Future studies should differentiate between policy types and examine their implementation. Lastly, unmeasured contextual variables—such as language, funding systems, and local publishing norms—likely influence OA participation and visibility.

Including these in future analyses would support more equitable assessments of global OA trends.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Descriptive statistics of publications and citations between 2010 and 2020 by the subject area, publication route, and country.

Country	Route: Publications and Citations	Subject Areas							
		Health Sciences		Physical Sciences		Life Sciences		Social Sciences	
		Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Austria	Gold Pub.	907.18	663.47	265.45	226.32	782.18	406.54	235.73	203.59
	Gold Cit.	36.62	14.67	22.07	7.65	44.03	14.43	15.23	2.59
	Hybrid Pub.	678.09	533.79	193.00	171.19	480.27	198.51	163.91	193.03
	Hybrid Cit.	65.59	25.24	57.37	61.10	54.07	15.54	36.39	19.80
	Bronze Pub.	1022.73	113.28	209.45	62.62	391.82	28.95	112.45	55.63
	Bronze Cit.	55.65	14.15	18.16	7.28	62.23	21.62	17.15	9.99
	Green Pub.	2368.00	1169.73	669.00	360.71	1741.73	526.51	486.64	324.71
	Green Cit.	54.91	28.64	35.69	11.69	57.85	18.74	31.36	9.01
Israel	Gold Pub.	697.64	443.97	380.73	255.23	583.91	275.16	97.91	82.97
	Gold Cit.	31.10	12.37	35.01	7.99	43.02	14.18	13.25	4.86
	Hybrid Pub.	203.09	101.50	121.64	61.85	187.27	47.57	35.64	25.55
	Hybrid Cit.	83.70	35.05	71.21	28.36	60.75	13.64	39.91	31.51
	Bronze Pub.	821.18	142.97	323.82	59.38	431.27	34.57	100.64	47.85
	Bronze Cit.	54.65	13.42	45.82	25.35	55.39	17.88	16.95	7.74
	Green Pub.	1639.27	635.16	1434.36	307.94	1278.27	253.58	269.45	105.13
	Green Cit.	63.64	18.40	42.73	13.00	56.77	19.21	30.57	14.45
Mexico	Gold Pub.	1137.64	793.04	433.82	346.14	928.45	513.27	526.73	469.16
	Gold Cit.	19.13	8.10	14.40	3.42	15.06	5.50	6.23	1.61
	Hybrid Pub.	214.45	106.65	45.45	20.98	123.18	40.76	69.91	27.03
	Hybrid Cit.	62.23	35.04	35.60	29.67	29.53	7.73	14.34	7.36
	Bronze Pub.	562.82	188.64	199.45	84.02	378.36	111.19	134.18	97.08
	Bronze Cit.	36.63	11.54	11.27	5.16	25.06	10.80	7.28	2.50
	Green Pub.	1470.73	712.06	545.64	259.49	1079.73	426.03	583.64	408.00
	Green Cit.	46.15	16.33	21.22	6.39	23.24	10.09	11.10	3.59

Note: the mean and standard deviation values presented for the citations in the green route variable are provided for illustrative purposes only. It is important to mention that this variable was not included in the statistical calculations conducted in the current study.

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