Policy Shaping the Impact of Open-Access Publications: A Longitudinal Assessment

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Abstract

This study investigated the longitudinal impact of Open-Access (OA) publication in Israel, a country which has not yet adopted a formal OA policy. We analyzed bibliometric indicators of Israeli researchers across all academic disciplines, focusing on OA publications published in journals and repositories from 2010 to 2020. Data extracted from Scopus reveal a consistent "OA citation advantage" (OACA) throughout the study period, suggesting the influence of OA publication on citation rates beyond time and scientific novelty. Despite the highest number of publications in the green route, steadily increasing over the years, and a recent rise in gold route publications, the hybrid route demonstrates a significantly higher citation advantage, highlighting an "OA subtype citation effect". Furthermore, our study uncovers a "funding effect" on OA grant-funded publications, indicating a doubled likelihood of publishing in OA when research is funded, contingent on the funder's OA policy. The findings offer comprehensive insights into OA publishing trends in Israel, serving as a case study for assessing the impact of OA policy. The study underscores the importance of both funder-specific OA policies and broader initiatives by the global scientific community and intergovernmental organizations to promote OA publishing and address potential disparities in research dissemination. Efforts to combat the "rich get richer" effect can foster equitable access to scientific knowledge.

Keywords

Open-Access (OA) citation advantage, OA subtype citation advantage, OA funding effect, OA publication policy

Introduction

Open Access (OA) ensures unrestricted online access to scientific articles, making scientific knowledge more accessible to the public (Archambault et al., 2014; Piwowar et al., 2018). Over the years, countries, funders, and research institutions worldwide have committed to open access, developing well-defined OA policies (Gasparyan, 2019). The proposition is that OA can enhance research rigor, validity, replicability, and availability (Clayson et al., 2021). The Covid-19 pandemic tested this premise, with publishers making Covid-19 research freely accessible through open articles, emphasizing the importance of public access to literature (Lee & Haupt, 2021). This initiative has inspired optimism about new approaches to open up scientific research outputs (Wang et al., 2020).

OA publishing not only benefits the public but also holds potential advantages for individual authors (Mueller-Langer et al., 2020). One of the most widely discussed benefits is the potential increase in citation impact for OA articles due to their enhanced visibility and accessibility (Piwowar et al., 2018). However, concerns include rising article processing charges (APCs) in OA journals (Halevi & Walsh, 2021) and lower impact factors (IF) index in certain disciplines compared to subscription-based journals (Pollock & Michael, 2019). These limitations affect young researchers, especially in the social sciences and humanities (Blankstein & Wolff-Eisenberg, 2019). An additional challenge is the concern surrounding copyright infringement when depositing articles in open repositories (Bosman & Kramer, 2018). The proliferation of predatory journals also negatively impacts researchers' perception of OA publishing (Beall, 2015; Shen & Björk, 2015).

Open Access facilitates global research participation, especially for underrepresented regions. However, the adoption and motivation for OA practices vary among countries and researchers (Iyandemye & Thomas, 2019; Mueller-Langer et al., 2020; Lee & Haupt, 2021; Pinfield et al., 2020; Zia, 2021). According to the *European Open Science Cloud* (EOSC) Portal, Israel currently lacks an official OA policy at both the national and institutional levels. Implementing clear OA policies has positively impacted OA publications in many countries. Furthermore, several studies indicate a funding effect on OA publication, emphasizing funding's impact on the decision to publish in OA formats. (e.g., Andreoli-Versbach & Mueller-Langer, 2014; Ploder et al., 2020; Solomon & Björk, 2012). Consequently, implementing a policy initiative is necessary to change scientific publishing practices among Israeli scientists (Bosman and Kramer, 2018; Moskovkin et al., 2021; White et al., 2021). The absence of an OA policy in Israel offers a unique case study to compare the impact of government OA policies with funding bodies' policies. This study focuses on analyzing bibliometric indicators of Israeli researchers' scientific publications in OA journals and repositories from 2010 to 2020, conducting

longitudinal, large-scale, up-to-date, and reproducible research to assess OA publishing prevalence, characteristics, and effectiveness within the country.

Literature review

Open access development and routes

The OA movement originated in the 1990s, coinciding with the widespread availability of the Internet and the increasing prevalence of online publishing (Laakso et al., 2011). During this time, a series of influential institutional statements were issued, including The Budapest OA Initiative (2002), The Bethesda Statement on OA Publishing (2002), and The Berlin Declaration on OA (2003). Collectively referred to as the BBB declarations, these initiatives outlined the ideological foundation of the OA movement (Gasparyan, 2019). Velterop (2003) proposed three criteria for Open Access (OA): free accessibility, further distribution, and proper archiving. Piwowar et al. (2018) classified OA publications into four categories:

1. Gold OA: Articles published in open-access journals, funded through Article Processing Charges (APCs) instead of subscription fees. This model can pose challenges for authors who need funding for APCs, and there are concerns about it becoming more of a business model than promoting open access (Halevi & Walsh, 2021; Tennant et al., 2019). Access can vary depending on authors' resources and research fields, impacting social sciences, humanities, and early-career researchers (Olejniczak & Wilson, 2020; Natale, 2019; Zhu, 2017).
2. Green OA: Articles initially published in subscription-based journals but also shared in OA repositories, like ArXiv or institutional repositories (IRs), after an embargo period. The decision to make an article openly available depends on various factors and policies from publishers, institutions, funders, and authors themselves (Laakso, 2014; Tennant et al., 2016). STEM journals usually have embargo periods up to 12 months, while SSH journals can be up to 36 months (Martín-Martín et al., 2018).
3. Hybrid OA: Articles freely available and licensed for reuse in paid subscription journals. Authors pay APCs to make these articles openly accessible, but the journals are not classified as fully OA by the Directory of Open Access Journals (DOAJ).
4. Bronze OA: Articles freely accessible for reading on publishers' websites but lack a clear license and extended reuse rights. The decision to provide free access rests with the publisher, though these articles are not considered fully OA by the DOAJ.

Open Access (OA) offers researchers and institutions increased visibility and a significant advantage known as the "open access citations advantage" (OACA). This advantage refers to the higher citation rates that OA articles typically receive, elevating the impact and recognition

of researchers' work (Piwowar et al., 2018). Countries also benefit from OA publication as it boosts the impact of research funded by public money (Moskovkin et al., 2021). The past two decades have witnessed a steady increase in OA publications, driven by green, gold, and hybrid routes (Maddi, 2019; Piwowar et al., 2018). OACA has drawn considerable attention, particularly because citation metrics play a pivotal role in decisions related to retention, promotion, and tenure (Langham-Putrow et al., 2021). Numerous studies have noted higher citation counts for OA publications, further emphasizing the impact and visibility associated with OA (Pollock & Michael, 2019; White et al., 2021). For instance, Piwowar et al. (2018) reported an 18% advantage, Young and Brandes (2020) found a 28.5% advantage, and Ottaviani (2016) found a 19% advantage in citation counts for OA publications. However, Langham-Putrow et al. (2021) conducted a review and found that 47.8% of studies confirmed OACA's existence, 27.6% found it non-existent, and 23.9% found OACA present only in certain disciplines. Moreover, research has suggested that factors such as article quality, journal impact factor, and disciplinary considerations are stronger predictors of high citation rates than OA itself (Craig et al., 2007; Tahamtan et al., 2016).

OA publication rate in different countries and as a result of funders' policies

Since the Budapest, Bethesda, and Berlin (BBB) Open Access declarations, many prominent research institutions in Australia, China, France, Germany, Greece, Hungary, Italy, Norway, Portugal, Switzerland, the United Kingdom, and the United States have committed to open access for their research output (Edwards, 2016; Sanjeeva & Powdwal, 2017). A systematic analysis by Moskovkin et al. (2021) assessed countries' involvement in the OA movement based on various factors, such as their participation in OA initiatives, presence of OA policies in registers, number of OA repositories, and OA journals. The top five countries in the OA movement represent a mix of developed and developing nations. According to *SCImago Journal and Country Rank* data (www.scimagojr.com/countryrank.php), OA publication rates have increased over the years in these top five countries (retrieved on 01.01.2023): United States (2010: 35.18%, 2020: 53.71%), United Kingdom (2010: 33.64%, 2020: 71.73%); Germany (2010: 32.1%, 2020: 59.56%); Indonesia (2010: 31.02%, 70.08%) and Brazil (2010: 53.67%, 2010: 55.47%). Notably, the UK, where OA publishing exceeds 70%, has a government requirement for publicly funded research outputs to be freely accessible to the public.

Funding bodies are increasingly promoting open access to research publications due to its recognized impact and advancement (Morillo, 2020). According to the *Sherpa Romeo* (https://v2.sherpa.ac.uk/romeo/), more than 100 funding organizations in Europe, including Plan S, Horizon Europe, and the Europe PMC Funders' Group, require freely available peer-

reviewed research outputs. The European Commission's Open Research Europe platform facilitates access to scientific papers funded by Horizon Europe - Horizon 2020 (https://open-research-europe.ec.europa.eu/). Studies have reported evidence of funding influencing OA publishing, with OA articles often acknowledging international and EU sources and receiving more citations (Morillo, 2020; Ploder et al., 2020; Solomon & Björk, 2012). Furthermore, funded articles, especially in life sciences, have steadily increased over time (Ploder et al., 2020), and funding amounts and sources vary significantly across disciplines and countries (Solomon & Björk, 2012). Institutions, journals, and publishers are also adopting policies to encourage transparent sharing of research data (Colavizza et al., 2020).

Open access and the Israeli context

Studies have indeed shown that the development and use of open access (OA) vary across countries, as indicated by Lee & Haupt (2021), Moskovkin et al. (2021), Pinfield et al. (2020), and Zia (2021). In the case of Israel, the rate of OA publications has increased from 31.74% in 2010 to 50.41% in 2020, according to SCImago Journal and Country Rank data. However, the increase is relatively smaller compared to European countries that have similar levels of general scientific publications, such as Austria (36.6% in 2010 and 65.77% in 2020) and Denmark (31.4% in 2010 and 62.12% in 2020). Furthermore, in terms of the involvement in the OA movement, Israel is ranked 96th according to Moskovkin et al.'s (2021) index, while countries like Finland (27th) and Austria (28th) have national OA policies in place.

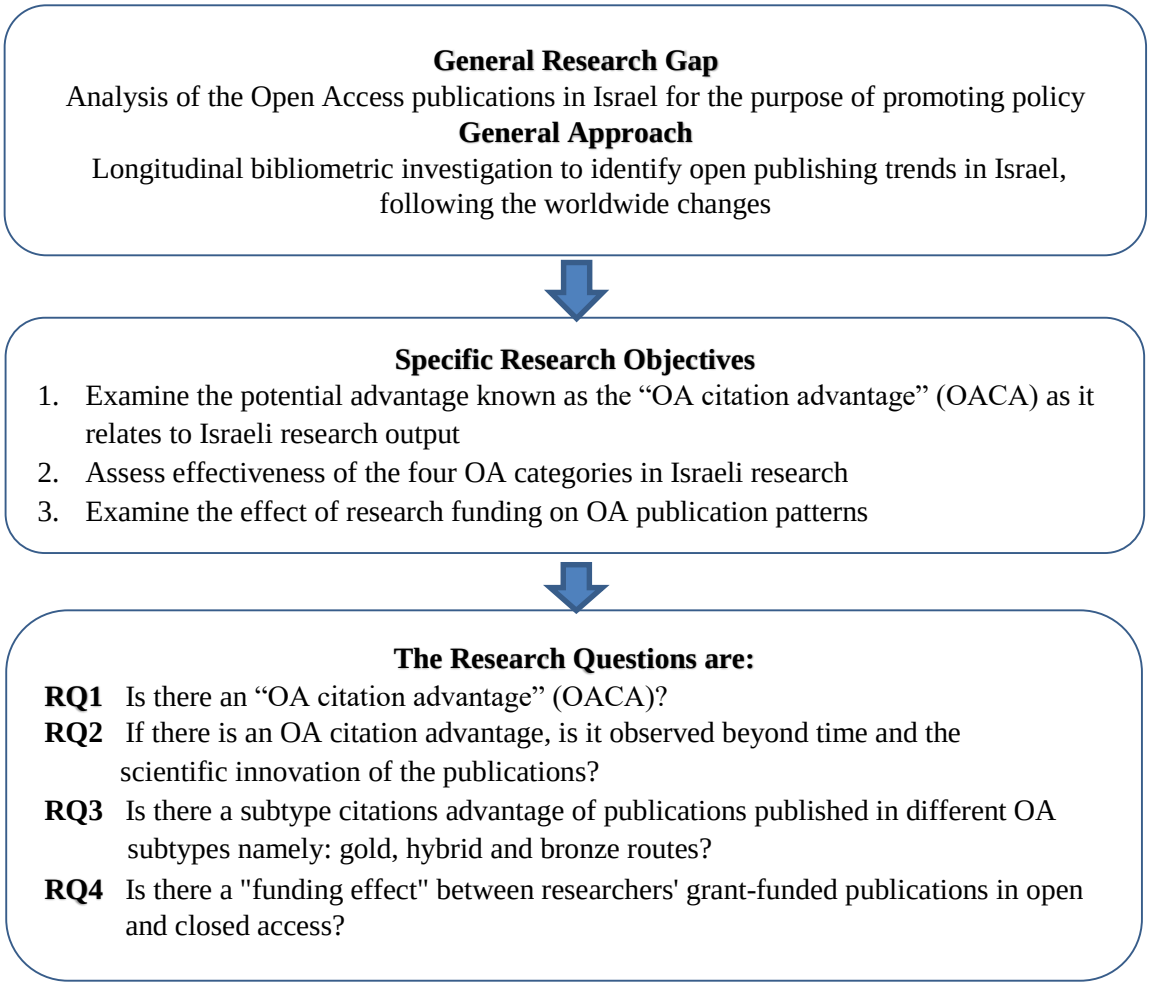
As mentioned earlier, according to the *EOSC Portal*, Israel currently lacks an official open access (OA) policy at the national or institutional level. However, there have been some developments in this regard. The Israel Science Foundation (ISF), the national funding agency in Israel, launched the ISF Gateway on the *F1000Research* OA platform for ISF-funded beneficiaries (Elliott, 2020). Research findings indicate that the successful implementation of OA policies at both national and institutional levels in various countries has proven to significantly enhance OA publication rates (Andreoli-Versbach & Mueller-Langer, 2014; Bosman & Kramer, 2018; Moskovkin et al., 2021; White et al., 2021). This evidence suggests a similar potential impact could be realized in Israel as well. In Israel, the absence of a declared OA policy is accompanied by a notable dearth of scientific studies investigating this phenomenon within the country. One of the pioneering studies conducted by Hadad and Aharony (2022) revealed a low level of awareness and a high level of anxiety among Israeli researchers regarding OA publication. The study also indicated that a researcher's decision to publish in OA depends not only on their attitudes, performance expectancy, and social influence but also on the presence of supportive conditions and disciplinary affiliation, particularly in

STEM fields. These conditions motivate researchers to voluntarily publish their work in both green and gold OA, indicating a personal choice and willingness to make their research openly accessible.

Based on the literature review, there is a recognized need for a comprehensive and longitudinal study in Israel to evaluate the development of OA. The current study analyzes bibliometric indicators of scientific publications by Israeli researchers in OA journals and repositories from 2010 to 2020. Figure 1 presents a funnel starting from the identification of research gaps, progressing to the formulation of research objectives, and culminating in the development of research questions.

Figure 1

The research gap, research objectives and research questions



Method

To address the research questions, we employed a bibliometric investigation which provided the current perspective regarding open publishing trends in Israel, following the worldwide changes. The study received approval from the Institutional Ethics Committee.

Procedure and Instruments and study samples

In this bibliometric study, the focus was on the publications of Israeli researchers across all academic disciplines (26 disciplines + multidisciplinary category). The study examined publications from the years 2010 to 2020 using data from the Scopus database. By conducting a longitudinal analysis, the study aimed to mitigate the influence of factors such as research innovation, author reputation, and journal prestige, thereby exploring the presence of any advantage associated with open access (Langham-Putrow et al., 2021). The assumption made in the study was that articles published in either open access or closed (subscription/toll-based) channels are of similar quality.

The analysis consisted of several stages:

1. The Scopus database was utilized (https://www.scopus.com) to compile the list of publications for the study. The search for publications was performed separately for each year between 2010 and 2020, and the data were collected in September 2022. Scopus is a commonly used database in bibliometric studies, along with Web of Science (Pranckutė, 2021). In a comparative study conducted by Bakhmat et al. (2022), which assessed the capabilities of Web of Science, Scopus, and Google Scholar, it was found that Scopus offers broader and more comprehensive content coverage, making it a suitable choice for researchers and user-friendly for practical purposes as well. Scopus's rigorous content selection and advisory board ensure high-quality data, while continuous quality assurance processes improve data elements (Baas et al., 2020). Scopus provides enriched metadata records, and precise author and institution profiles, making it a trusted source for bibliometric data in research assessments, science policy evaluations, and university rankings (Bakhmat et al., 2022). However, access to Scopus requires a subscription, and individuals or institutions usually need to pay for access to its content and features. While some universities, research institutions, and libraries might have subscriptions that grant their members access to Scopus, it is not freely available to the general public. Free access to Scopus is typically limited to certain promotional periods or trials offered by Elsevier or other organizations (Baas et al., 2020; Pranckutė, 2021).

The data obtained from Scopus was sorted using the "Cited by" option, which allowed the documents (both open and closed access) to be listed based on the number of citations they

have received. The distribution of open-access and closed-access publications and citations for 2010-2020 are presented in Table 1.

Table 1

Distribution of open and closed publications and citations between 2010-2020

Year	Publications			Citations		
	Open-Access	Closed-Access	Total	Open-Access	Closed-Access	Total
2010	5242 (29%)	12863 (71%)	18105	311155 (47%)	348251 (53%)	659406
2011	5581 (30%)	13068 (70%)	18649	306757 (48%)	338316 (52%)	645073
2012	6160 (31%)	13696 (69%)	19856	329075 (54%)	281459 (46%)	610534
2013	6501 (32%)	13622 (68%)	20123	293591 (52%)	269607 (48%)	563198
2014	6903 (34%)	13637 (66%)	20540	304026 (54%)	259322 (46%)	563348
2015	7618 (36%)	13578 (64%)	21196	329969 (59%)	228483 (41%)	558452
2016	8145 (37%)	13776 (63%)	21921	328453 (62%)	201629 (38%)	530082
2017	8902 (40%)	13607 (60%)	22509	292534 (64%)	167460 (36%)	459994
2018	9616 (41%)	13865 (59%)	23481	267592 (65%)	144295 (35%)	411887
2019	10050 (42%)	13775 (58%)	23825	187328 (64%)	104895 (36%)	292223
2020	11727 (48%)	12783 (52%)	24510	179501 (74%)	64448 (26%)	243949
Total	86445 (37%)	148270 (63%)	234715	3129981 (57%)	2408165 (43%)	5538146

Note: The percentage rates for citations and publications are presented on a yearly basis, with each row representing data for a specific year.

According to Table 1, publications originating from Israel have demonstrated a consistent growth trend over the years, encompassing both open and closed access categories. Nevertheless, a discernible shift in publishing patterns has emerged. Specifically, open access publications witnessed a remarkable 19% upsurge from 2010 to 2020, with a corresponding decline of 19% in closed access over the same time period. A similar pattern is observed in the number of citations for both approaches. In total, Israeli researchers published 234,715 scientific publications between 2010-2020, with 63% (148,270) published in closed access, receiving 43% (2,408,165) of the total citations. Conversely, 37% (86,445) of the publications were in OA, receiving 57% (3,129,98) of the total citations.

2. The next step involved collecting data from Scopus for publications and citations in each OA route: gold, hybrid, bronze and green, from 2010 to 2020. The data for OA green and gold documents in Scopus is sourced from *Unpaywall*, a reputable non-profit organization that aggregates OA content from over 50,000 publishers and repositories. Unpaywall

ensures content is harvested only from legitimate sources, including open indexes like Crossref and DOAJ, as well as institutional and disciplinary repositories. However, Unpaywall explicitly avoids sources of questionable legality, such as ResearchGate or Sci-Hub (https://unpaywall.org/faq). Table 2 illustrates the publication and citation rate in each OA route between 2010 and 2020, with a percentage computed on the actual total number of publications (OA and Closed). The data was collected in September 2022.

Table 2

Distribution of the OA routes for publications 2010-2020 and related citations rate

Year		Gold	Hybrid	Bronze	Green	Total OA+Closed
	Publications	3%	2%	11%	23%	18105
2010	Citations	5%	3%	18%	41%	659406
	Publications	4%	2%	11%	24%	18649
2011	Citations	5%	3%	17%	41%	645073
	Publications	6%	2%	11%	25%	19856
2012	Citations	6%	5%	20%	46%	610534
	Publications	7%	2%	10%	26%	20123
2013	Citations	8%	4%	17%	46%	563198
	Publications	9%	2%	10%	27%	20540
2014	Citations	9%	7%	18%	46%	563348
	Publications	10%	2%	11%	29%	21196
2015	Citations	13%	6%	18%	52%	558452
	Publications	11%	3%	11%	30%	21921
2016	Citations	12%	10%	21%	56%	530082
	Publications	12%	3%	11%	32%	22509
2017	Citations	14%	10%	20%	57%	459994
	Publications	13%	3%	11%	33%	23481
2018	Citations	15%	13%	20%	58%	411887
	Publications	15%	4%	9%	35%	23825
2019	Citations	17%	10%	16%	57%	292223
	Publications	19%	6%	10%	38%	24510
2020	Citations	18%	16%	21%	67%	243949
Total	Publications	10%	3%	11%	30%	234715
	Citations	10%	7%	18%	50%	5538146

Table 2 reveals an upward trend in publications and citations for the gold and hybrid routes over the years. In contrast, the bronze route, which lacks an open license, displays an unstable distribution trend. The green route exhibits consistent growth in publications and citations rate over the years. It is essential to note that according to Scopus database (McCullough, 2022), an OA document in Scopus can be tagged with more than one OA status as one article van be available in different OA version (e.g. “Gold and Green”).

However, according to Scopus, there is no duplicate counting for publisher-enabled OA documents (Gold, Hybrid-Gold and Bronze categories). In addition, the green route includes published version or manuscript accepted for publications which may have been published in closed-access sources and available at repositories. Thus, due to the duplication issues in the green route, our study, designed to highlight publication route disparities, excludes green route citations from the statistical tests conducted in our analysis.

3. Confounding variables and "funding effect" - In the context of the Open Access Citation Advantage (OACA) study, it is important to consider potential confounding variables that may influence citation rates and are associated with whether an article is published in OA or closed-access formats, such variables are:

(a) Document type: Different types of documents, such as research articles, reviews, and conference papers, may exhibit diverse citation patterns. In the dataset obtained from Scopus for Israel between 2010 and 2020, a majority of publications (75%, n=176732) were research articles and reviews, with a small portion being conference papers (13%, n = 30862). Articles and reviews represent a higher part of the open access publications (90%) than of the closed access publications (62%). However, the prevalence of other publication types, such as books and letters, was minimal in both approaches (with a distinct advantage to the closed access), minimizing their potential impact as alternative explanations for the findings. (b) Disciplines and international collaboration: Citation practices can significantly vary across academic disciplines, and collaborations involving researchers from multiple institutions and countries can influence citation rates. Studies have found a citation advantage for OA articles in STEM (Science, Technology, Engineering, Math) fields compared to SSH (Social Sciences and Humanities) fields (Langham-Putrow et al., 2021; Natale, 2019; Paul-Hus et al., 2017). This difference may be attributed to the social impact and support received by researchers in their environments, which can influence their decisions to publish in OA (Hadad & Aharony, 2023a; Zhu, 2017) Additionally, OA articles with international collaboration have been found to have a citation advantage (Hadad & Aharony, 2023b; Morillo, 2020). However, the current study aims to investigate a citation advantage for the entire sample, regardless of disciplinary or collaboration differences. Since the primary focus is on the influence of funding and funders' OA policies in shaping OA publishing, this study primarily concentrates on the funding variable.

4. Funding effect - we examined the number of funded publications and their citation counts in each publication route. Table 3 presents the count of grant-publications. Scopus lists the number of grant publications for each year in a specific country. As a result, some publications may have been counted multiple times by Scopus due to receiving funding from multiple sources. Despite this potential duplication, the average rate of these publications remains consistent over the years and across different publication methods (open and closed access). To ensure a comprehensive analysis of the data, these duplicated publications were included in the statistical calculations of the study. Table 3 presents the distribution of grant-funded publications for both open access and closed access from 2010 to 2020.

Table 3

Distribution of OA and closed-access grant-funded publications published between 2010-2020

Year	OA grant-funded publications		Closed-access grant-funded publications		Total grant-funded publications
2010	3567	60%	2386	40%	5953
2011	5207	65%	2810	35%	8017
2012	7962	72%	3092	28%	11054
2013	7490	70%	3233	30%	10723
2014	6990	69%	3099	31%	10089
2015	9192	75%	3104	25%	12296
2016	14628	76%	4673	24%	19301
2017	15426	74%	5316	26%	20742
2018	20656	75%	6987	25%	27643
2019	18300	71%	7506	29%	25806
2020	17928	70%	7528	30%	25456
Total	127346	72%	49734	28%	177080

Note: The count of grant-publications represents the number of publications that have declared receipt of funding

Table 3 reveals that from 2010 to 2020, a total of 177,080 grants have been declared. Among these, 127,346 articles (72%) were published in open access (including publications in the green route due to funding organizations' demands), while 49,734 articles (28%) were published in closed access. This number of publications is based on a Scopus report that provides the count of publications per year (both in closed and open access) according to the funding source. Further analysis concentrated on the top ten funders of Israeli research during this period, using data from the Scopus database and assessing the OA policies implemented by each organization according to *Sherpa Juliet* database. The distribution of publications funded by these ten

organizations in open access and closed access formats was examined to assess the significance of the differences in OA publications among these funders. Together, these ten funders accounted for 53.2% of all funded publications in Israel, encompassing both open and closed-access formats.

Statistical analysis

This study conducted an analysis of bibliometric data characterized by a continuous scale that deviates from a normal distribution. Following the methodology of previous studies (Bornmann & Marx, 2014; Langham-Putrow et al., 2021; Pislyakov, 2022), non-parametric tests were selected as the analytical approach. Non-parametric tests are robust and can tolerate certain violations of assumptions that parametric tests necessitate, particularly the assumption of normality. The analysis embraced a comprehensive evaluation, encompassing all available data within the specified years. To investigate variations in citations between open access (OA) and closed-access publications over the years, a Wilcoxon test was executed. To investigate variations in citations between the OA routes, Friedman's ANOVA tests with repeated measures were employed. Pairwise comparisons, accompanied by adjusted p-values (utilizing Bonferroni correction to address multiple tests), were conducted to elucidate and establish relative preferences. Additionally, a binomial logistic regression was employed to anticipate the likelihood of publishing in OA based on the funding researchers received.

Results

An "OA citation advantage" (OACA) effect

To explore the first research question regarding the existence of an OACA, we conducted a Wilcoxon test to compare the number of citations received by OA publications with those received by closed-access publications. Additionally, Wilcoxon effect sizes were calculated. The detailed test results are shown in Table 4.

Table 4

Statistical analysis results: Comparing OA and closed-access citations for publications published between 2010-2020

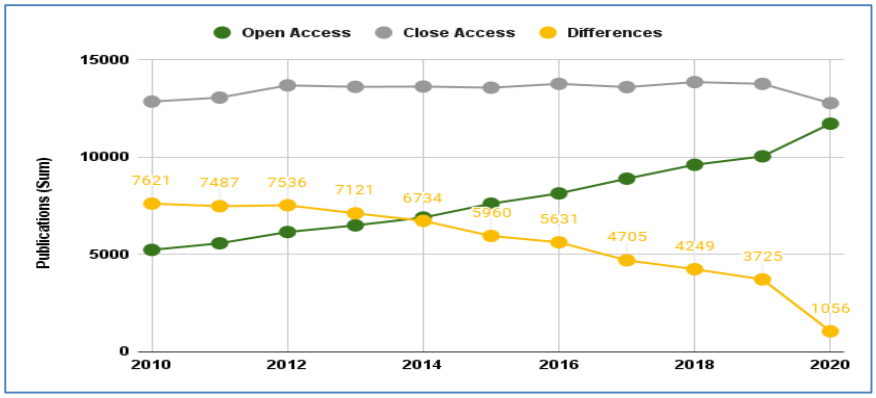
Variable	Open/Closed	Median	Wilcoxon signed-rank Test
2010	Open Access Closed Access	24.0 9.0	*T*= 3432053.50**,** z= -29.525, *p*<**.001**, *r* = -.22
2011	Open Access Closed Access	22.0 9.0	*T*= 3757704.00**,** z= -31.159, *p*<**.001**, *r* = -.23
2012	Open Access Closed Access	19.0 7.0	*T*= 4807328.00, z=-31.172, *p*<**.001**, *r* = -.22
2013	Open Access Closed Access	18.0 7.0	*T*= 5887652.50**,** z=-28.639, *p*<**.001**, *r* = -.20
2014	Open Access Closed Access	16.0 7.0	*T*= 6461653.50, z=-30.139, *p*<**.001**, *r* = -.21
2015	Open Access Closed Access	16.0 6.0	*T*= 8554765.00**,** z=-27.926, *p*<**.001**, *r* = -.19
2016	Open Access Closed Access	14.0 6.0	*T*= 9551823.50**,** z=-29.459, *p*<**.001**, *r* = -.20
2017	Open Access Closed Access	12.0 5.0	*T*= 11565169.00**,** z=-29.766, *p*<**.001**, *r* = -.20
2018	Open Access Close Access	10.0 4.0	*T*= 13719795.00, z=-29.459, *p*<**.001**, *r* = -.19
2019	Open Access Closed Access	8.0 3.0	*T*= 13736463.00, z=-33.238, *p*<**.001**, *r* = -.22
2020	Open Access Closed Access	5.0 2.0	*T*= 15524858.00, z=-40.526, *p*<**.001,** *r* = -.26

Notes: 1) *T* = Test statistic – sum of the positive ranks; 2) *z*=Standardized test statistic (Z score);
3) Effect size $(r) = Z/\sqrt{N}$

The results indicated a statistically significant difference in favor of OA publications' citations in all years. The Wilcoxon test indicates that OA publications are cited more, with a small (.30<) effect size over the years. Figure 2 and Figure 3 illustrate the changes and differences between the number of OA and closed-access publications and the median of their citations over the years.

Figure 2

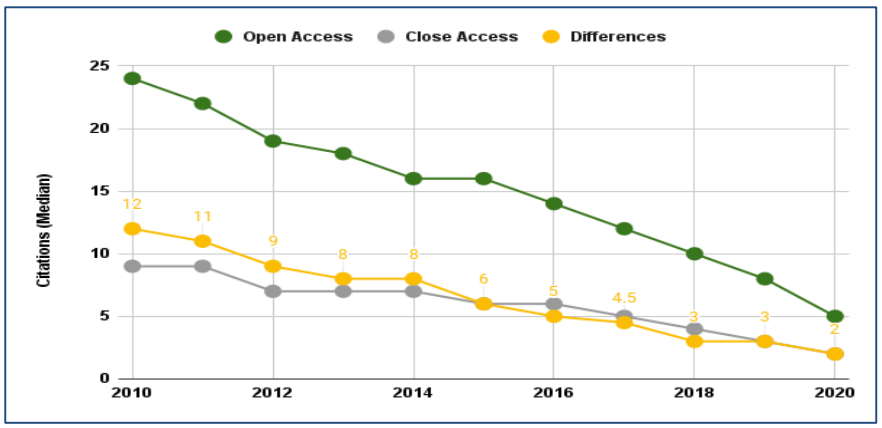
Comparison of OA and closed-access publications from 2010 to 2020



Note: The yellow line indicates the annual differences between closed and open publications.

Figure 3

Comparison of OA and closed-access citations from 2010 to 2020



Note: The yellow line indicates the annual differences between closed and open citation.

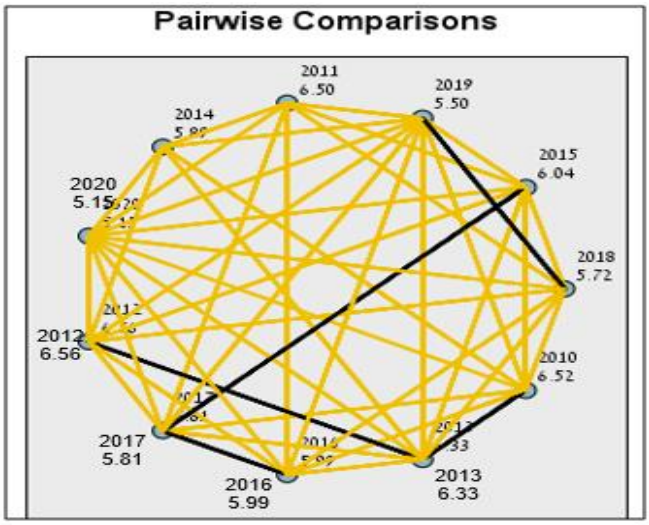
As depicted in Table 4 and demonstrated by Figures 2 and 3, recently-published publications (e.g. published in 2020) exhibit a significant OACA early on. As time progresses and the publications are available for citation for longer periods, the OACA significantly increases. While the disparities between the number of closed and open access (OA) publications decrease over the years, OA publications consistently increase their OACA. The disparity in citation counts becomes increasingly noticeable as time from publication progresses. Assuming that open and closed-access publications are of the same quality, the null hypothesis is that their citation rate would be comparable, however, we observe an increasing OACA.

OACA beyond time and the scientific innovation effect

In light of the widening backward gap in citation counts between OA and closed-access publications over time, as evident in Figure 3, the second research question aimed to investigate the significance of the citation effect over time. The objective was to differentiate the impact of time from the influence of OA publishing on citation differences and extend beyond the scientific innovation of the articles. To achieve this, we created 11 new variables representing the *citation differences* between OA and closed-access publications for each year from 2010 to 2020. We employed Friedman's ANOVA test with repeated measures, which yielded a significant result ($\chi^2(10)$ = 750.083, p =.**000**). Subsequently, we conducted pairwise comparisons using adjusted p-values (Bonferroni correction for multiple tests). The detailed findings are presented in Figure 4:

Figure 4

Citation differences: Pairwise comparisons to determine the OACA effect over the years for publications between 2010-2020



Notes: Pairwise comparisons: 1) Significance values have been adjusted by the Bonferroni correction for multiple tests. 2) Each node shows the sample average rank (Mean Rank). 3) Yellow connecting lines indicate significant differences, while the black lines indicate non-significant differences.

The data analysis reveals that most of the year-to-year differences are statistically significant, with a few exceptions for adjacent years (2012-2013, 2015-2017, 2016-2017, and 2018-2019). Moreover, the differences between OA and closed-access publications are not consistent across the years, contradicting the null hypothesis, which suggests no differences between the two types of scientific publications, as they are assumed to be equal in quality and scientific innovation. The pairwise comparisons show an increasing trend in the Mean Rank value, indicating that the differences extend beyond the scientific innovation of the articles. These differences can be attributed to the publication method in OA, suggesting that open access plays a significant role in driving greater citation advantages for research articles published by Israeli scientists.

Subtype citations advantage: differences between the citations and publications published in the OA subtypes

To examine the third research question regarding the differences between the citations and publications published in the OA routes namely: gold, hybrid and bronze (the green route was excluded in the citations analyses due to the duplication limit discussed in the method section), Friedman's ANOVA test was conducted on the data. Additionally, for measuring the effect size, Kendall's coefficient of concordance (Kendall's W) was calculated. The test results of pairwise comparisons with adjusted p-values (Bonferroni correction for multiple tests) are presented in table 5.

Table 5

Differences in open access routes for publications (2010-2020): statistical analysis results

Year	OA subtype						Friedman Test	Pairwise Comparisons
	A Gold		B Hybrid		C Bronze			
	Mdn	***MR***	***Mdn***	***MR***	***Mdn***	***MR***		
2010	22.0	1.94	**31.0**	2.12	24.0	1.94	$\chi^2(2)$ = 6.086, p=**.048**, w =.011	B>A, B>C
2011	22.5	2.05	**29.0**	2.07	21.0	1.89	$\chi^2(2)$ = 6.195, ***p*=.045**, w =.009	B>A, B>C
2012	19.0	1.86	**30.0**	2.23	19.0	1.91	$\chi2(2)$ = 25.023, p<**.001**, w =.039	B>A, B>C
2013	18.0	1.92	**26.0**	2.11	19.0	1.97	$\chi^2(2)$ = 7.949, p=**.019**, w =.009	B>A**,** B>C
2014	16.0	1.83	**26.5**	2.16	17.0	2.01	$\chi^2(2)$ = 22.170, p<**.001**, w =.028	B>A, B>C
2015	16.0	1.93	**22.5**	2.14	15.0	1.93	$\chi^2(2)$ = 13.765, p=**.001**, w =.015	B>A, B>C
2016	14.0	1.94	**22.0**	2.28	14.0	1.78	$\chi^2(2)$ = 69.960, p<**.001**, w =.066	B>A, B>C
2017	12.0	1.92	**21.0**	2.23	11.0	1.85	$\chi^2(2)$ = 52.134, p<**.001**, w =.043	B>A, B>C
2018	10.0	1.97	**17.0**	2.21	9.0	1.82	$\chi^2(2)$ = 61.466, p<**.001**, w =.039	B>A, B>C
2019	7.0	1.97	**13.0**	2.22	7.0	1.81	$\chi^2(2)$ = 79.769, p<**.001**, w =.045	B>A, B>C
2020	4.0	1.87	**9.0**	2.24	4.0	1.89	$\chi^2(2)$ = 124.727, p<**.001**, w =.046	B>A, B>C

Notes: 1) *Mdn=Median* 2) *MR=Mean Rank.* 3) w = the effect size, Kendall's w

The findings presented in Table 5 reveal significant differences in citation counts among the OA routes for each year spanning from 2010 to 2020. Although a modest effect size was noted throughout the years, detailed pairwise comparisons with adjusted p-values underscore that publications within the hybrid route consistently garnered significantly higher citation counts than those within the gold and bronze routes across the entire temporal span. Notably, no significant distinctions were observed between the gold and bronze routes in terms of citation counts. To provide visual representations of the publications' distribution across each OA route

(gold, hybrid, bronze, and green) and their corresponding citation numbers (gold, hybrid, and bronze) over the years, we have included Figure 5 and Figure 6. These figures show the median valuesfor each OA route and the corresponding citations, offering insights into the trends and distributions over time.

Figure 5

Comparison of Publications in Gold, Hybrid, Bronze, and Green Routes from 2010 to 2020

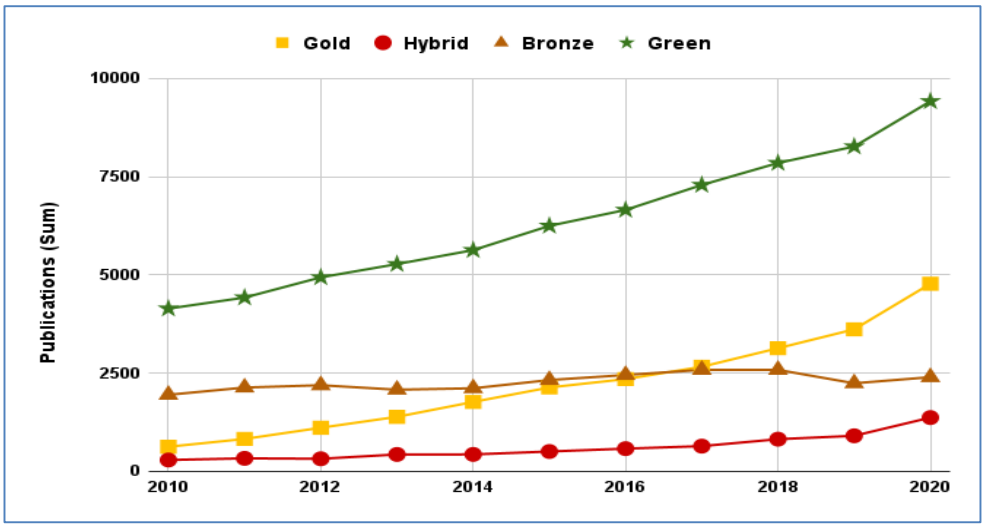
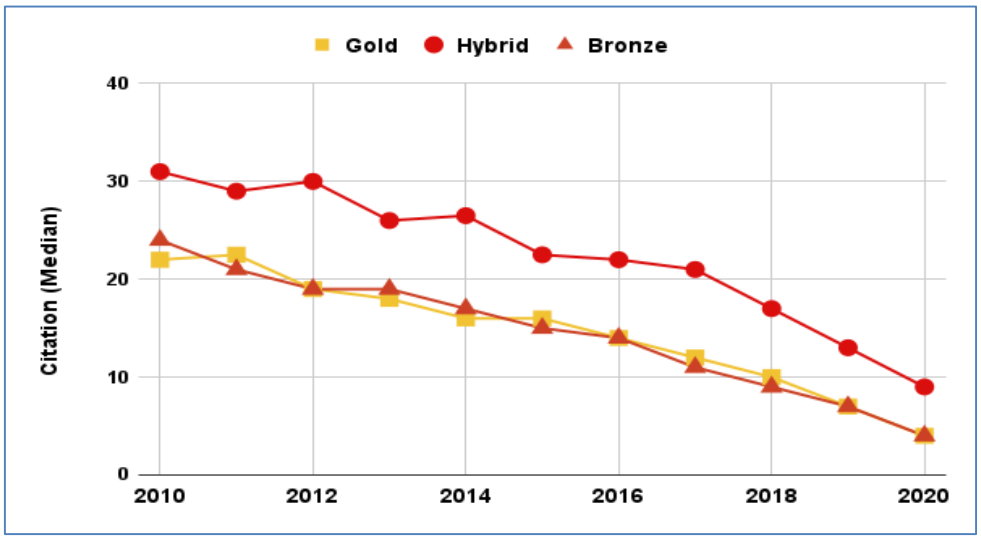


Figure 6

Comparison of citations in Gold, Hybrid and Bronz Routes from 2010 to 2020



As evident from Table 4 and depicted in Figures 5 and 6, the green route had the highest number of publications, and this number steadily increased over the years. The gold route also saw an increase in publications in recent years. The hybrid route, which had the smallest number of publications among the four routes, consistently received significantly higher citation rates than the other routes.

As previously mentioned, the green route was excluded from the analysis due to the duplication issue with the other routes. However, for illustrative purposes, Figure 7 displays the ratio of citations for this route to highlight the hybrid route's superior citation performance.

Figure 7

Comparison of citations in Gold, Hybrid, Bronze, and Green Routes from 2010 to 2020

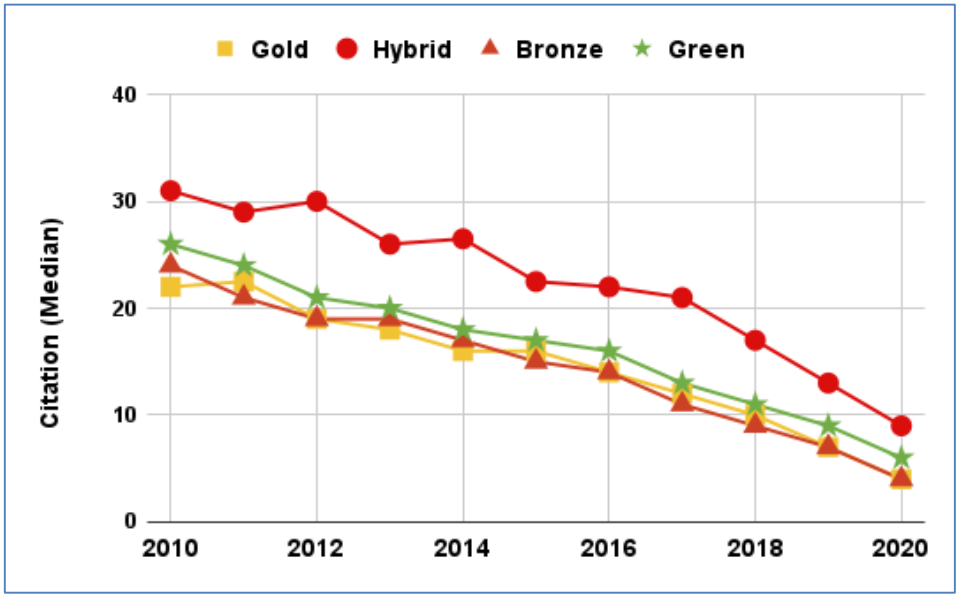


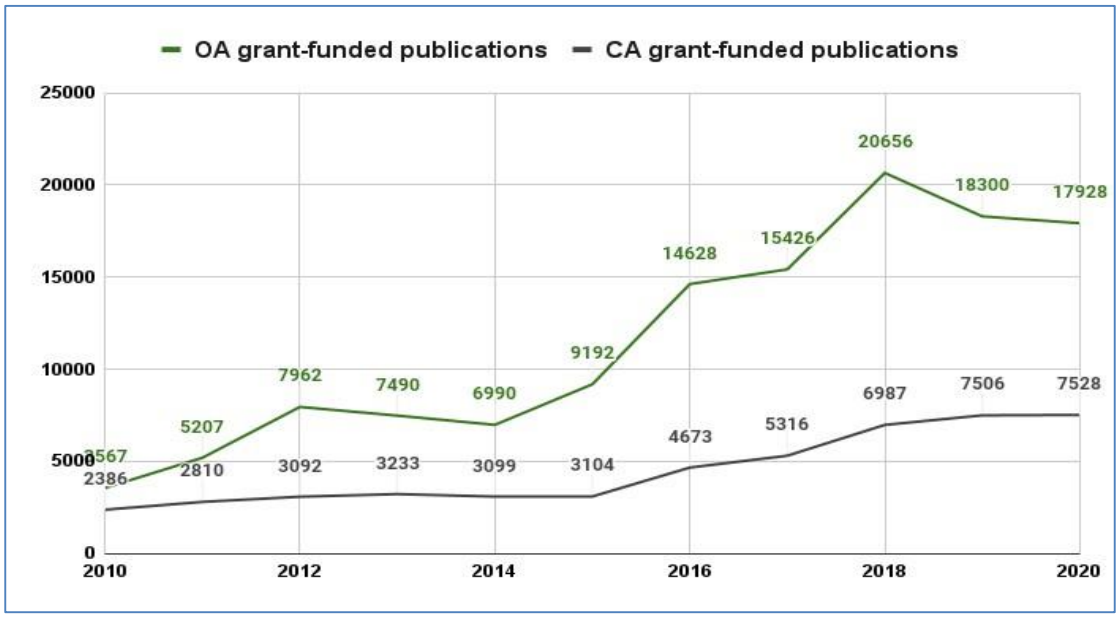
Figure 7 demonstrates that even when considering the green route, the hybrid route maintains its lead. Statistical analysis validates that the hybrid route consistently exhibits significantly higher citation rates than the green route for each year from 2010 to 2020 (*ps'*<.001).

Funding effect and the OA policy impact

To examine the third research question which concerned a funding effect for OA grant-funded publications, a Mann-Whitney U test with the effect size was utilized. The test revealed significant differences between the proportion of the publications that reported receiving funding that published in OA compared to funded research published in closed-access, U = 13.00, z = -3.119, p = .002, r = .66. The number of grant-funded publications published in OA was significantly higher (Median = 9,192.00) than the grant-funded publication that published in closed-access (Median = 3233.00), with a large effect size (.66) according to Cohen's (1988) criteria. Figure 7 illustrates the distribution of the differences between grant-funded publications published in OA and those published in closed-access between the years 2010-2020.

Figure 8

Differences between grant-funded publications published in OA (open-access) and CA (closed-access) for the years 2010-2020



Note: The count of grant-publications represents the number of publications that have declared receipt of funding

Figure 8 shows that the proportion of funded OA publications has increased over the years and was significantly higher than the funded publications that were published in closed-access. In 2010, there were 3,567 (19.7%) scientific publications categorized as funded publications and published in open access (OA). By 2020, this number had risen significantly to 17,928 (73.15%) publications. Please be aware that this total encompasses publications from the green route. Additionally, certain publications may have received funding from multiple sources, resulting in their inclusion more than once in this count. This applies to both open access (OA) and closed access (CA) publications. Next, a logistic regression was performed to ascertain the effects of the funding on the likelihood that publication will be published in OA. The logistic regression model was statistically significant, $\chi^2(1) = 12.702$, $p = .000$. The model explained 43.9% (Nagelkerke R^2) of the variance in the publication status and correctly classified 77.3% of cases. Funded publications were 1.99 times more likely to be published in OA than in closed-access.

Finally, we retrieved from Scopus the ten leading organizations who provided funding to Israeli research between 2010-2020. Using the *Sherpa Juliet* database which provides information concerning funders' OA policies, we examined the policies of those ten funding organizations. Table 6 presents the findings:

Table 6

OA policies of the top ten leading funding organizations for publications of Israeli researchers published between 2010-2020

Funding organization	Total Publications	OA Publications	Green Policy - OA Archiving	Gold Policy -OA Publishing
Israel Science Foundation	22048	11661 (52.9%)	None	None
National Science Foundation, USA	8260	6226 (75.4%)	Requires (including data)	Not required
Seventh Framework Programme, EU	8038	5953 (74.1%)	Requires (encourages data archiving)	Not required
European Research Council	6259	4595 (73.4%)	Requires (encourages data archiving)	Encourages OA Publishing
National Institutes of Health, USA	4925	4308 (87.5%)	Requires (including data)	Not required
Horizon 2020 Framework Programme, EU	4231	3321 (78.5%)	Requires (encourages data archiving)	Encourages OA Publishing
U.S-Israel Binational Science Foundation	3968	2427 (61.2%)	None	None
German Research Foundation	3407	2512 (73.7%)	Encourages OA Archiving	Encourages OA Publishing
European Commission	2703	1741 (64.4%)	Requires (including data)	Not required
National Cancer Institute	2582	2379 (92.1%)	Requires (including data)	Not required

As presented in Table 6, two organizations out of the top ten do not have an OA policy. The first is the Israel Science Foundation, which is the largest funding agency in Israel and the other is the U.S-Israel Binational Science Foundation. The rate of OA publications in these two organizations is lower than in the organizations that have an OA policy.

Discussion

Open-Access (OA) publication has led to profound changes in the scholarly publication world. However, despite its distinct advantages, OA has not become the norm in the publication of scientific outputs among all countries, research institutions, and researchers. In this study we presented a constructed comparative analysis framework to assess the prevalence and characteristics of OA in a specific country, Israel. Due to the lack of a declared OA policy at the national and institutional levels in Israel, this study examined bibliometric indicators of Israeli researchers concerning scientific publications in OA journals and repositories between 2010-2020, in order to provide a comprehensive understanding of the publishing trends in open access in Israel and their scientific impact.

Since the most discussed potential advantage related to OA is the “OA citation advantage” (OACA), the first research question examined whether OA publications received more citations than closed-access publications. We found that the rate of OA publications increased over the years. Regarding the citation advantage, the results indicated a significant difference in favor of OA publications' citations over the years. Every year from 2010 to 2020, regardless of the publication rate, the number of citations of those articles published in OA was significantly higher than those published in closed-access. These findings reinforce previous findings that showed evidence of OACA (e.g. Bosman & Kramer, 2018; Maddi, 2019; Piwowar et al., 2018; Young & Brandes, 2020). Moreover, our study's outcomes shed light on a distinct and expanding "citation backward gap" as time advances. Specifically, this gap between citations accrued by OA and closed publications widens notably in the earlier years, with the widest differential observed in 2010. This observed trend highlights the dynamic evolution of the OACA phenomenon over time, prompting us to question whether these variations can be attributed to the choice of publication method. Based on a priori assumptions and consistent with earlier longitudinal studies (e.g., Delgado López-Cózar et al., 2019; Harzing & Alakangas, 2016), one might expect the number of citations to grow steadily over the years while the differences between scientific articles would remain relatively stable without significant changes. However, the results of this longitudinal study reveal a growing and widening citation gap, indicating that these differences extend beyond the scientific innovation of the articles and can be attributed to the publication method in open access (OA). In other words, making scientific publications openly accessible achieves an increased and prolonged impact for research published by Israeli scientists. The OA publication approach seems to play a significant role in driving higher citation rates and broader visibility for their research findings.

Alongside research such as the current study, which has provided evidence for the OACA, there are some studies that have cast doubt on the magnitude of this phenomenon. Ottaviani's study (2016) puts forth the idea that the enduring impact of an article is shaped by its intrinsic quality, implying that not all OA articles inevitably accumulate a significant number of citations. Yet, higher-quality articles published in an OA format tend to amass more citations when contrasted with high-quality articles published in a closed-access format (Gargouri et al., 2010). Another aspect is the disciplinary differences which may play a significant role in the open access citation advantage (OACA). Some studies have suggested a positive association between studies spanning multiple disciplines and OACA, while others have proposed that OACA exists only within certain disciplines (Hadad & Aharony, 2023a; Langham-Putrow et al., 2021). In the present study, we have observed evidence of a growing OACA over the years in the context of Israeli researchers' open access publications across all disciplines. A future study may undertake to examine disciplinary OACA evolution over the years.

Previous studies have examined OACA by comparing OA articles with non-OA articles, ignoring the differences between OA routes. Our second research question aimed to determine whether there is *a subtype citation advantage* for publications in different OA routes. The findings revealed a significant citation advantage for the Hybrid route. Consistent with previous studies (e.g. Archambault et al., 2014; Martín-Martín et al., 2018), we observed a considerable number of publications in the green route, which showed a steady increase over the years. Gold publications have grown in recent years, likely due to the rise of gold and hybrid OA journals since 2000 (Björk, 2017). Previous studies suggested that the most cited articles are those published in the green and hybrid routes (Piwowar et al., 2018; Young & Brandes, 2020). However, as discussed in the method section, we excluded the green route from the citation analysis due to duplication limitations with the other routes. Nevertheless, when comparing the citations of gold, bronze, and hybrid routes, the hybrid route, despite having the lowest number of publications among the four routes, exhibited a significantly higher citation count. Previous research on hybrid open access (HOA) referred to the phenomenon of a citation advantage as the "hybrid open access citation effect" (Laakso & Björk, 2016; Mueller-Langer & Watt, 2014). Purely open access (OA) journals generally have lower impact compared to leading academic journals. The latter typically follow a hybrid model, which involves a "double dipping" fee, where authors pay article processing charges (APCs) to make their articles openly accessible, and institutions or individuals pay subscription fees to access the journal content (Valderrama-Zurián et al., 2019). This is the reason why funding organizations often strongly discourage the hybrid route in open access (OA) policies, as exemplified by initiatives like Plan S. According to the present study findings, funding organizations typically prefer the green

track, which aligns with the core principles of open access. In the green track, scientific articles are made freely available to both readers and authors, without any charges.

While the hybrid model is more prestigious and user-friendly than green OA, it does come with higher costs (Björk, 2017). The current findings indicate that despite challenges in adhering to publishers' policies and complexities involved in uploading articles to databases, Israeli researchers prefer self-archiving articles in free OA repositories. This preference aligns with earlier research (Morillo, 2020; Martín-Martín et al., 2018) suggesting that self-archiving could be a viable solution to address the rising costs of OA. However, Mueller-Langer & Watt (2014), focusing solely on economics articles, found that after controlling for institution quality and citations to OA pre-prints repositories, the HOA citation advantage diminished. Nevertheless, the present longitudinal study discovered a consistent trend of the citation effect favoring the hybrid route across all scientific disciplines over the years.

OA policy by government and funders is considered as having a positive influence on OA publishing, leading to the third research question examining if there is a "funding effect" for OA grant-funded publications. Findings reveal significant differences between the proportion of the grant-funded publications - publications that have declared receipt of funding and were published in OA, compared to publications that reported on funding and were published in closed-access. This echoes previous studies (Morillo, 2020; Ploder et al., 2020; Solomon & Björk, 2012), that reported that the proportion of the publications that received funding and were published in OA increases over the years. However, in order to reveal the OA policy impact, we examined OA policies of the ten leading Israeli funding organizations and found that two of them do not have an OA policy. Unfortunately, one of these two is the Israel Science Foundation (ISF), which is the biggest funding agency in Israel. Only 52% of the publications funded by this organization were published in OA, a low rate compared to the other organizations that have an OA policy. However, recently, according to *EOSC Portal*, ISF has started discussion on implementing an OA policy. The research findings point to the benefits of OA publishing and the benefits of OA policies by funding organizations. However, the benefits are not uniformly distributed. Early-career researchers may take years until they enjoy the citation advantage. Social sciences and especially humanities faculties have lower citation rates which can be a disadvantaged position to begin with (Andreoli-Versbach & Mueller-Langer, 2014; Natale, 2019; Paul-Hus et al., 2017, Zhu, 2017). Having an OA policy is likely to be helpful for early-career researchers and for disciplines with naturally lower citation rates. However, such policy will be helpful mainly if accompanied by corresponding financial support and “Read & Publish” library subscription models.

OA publishing has become an important target policy for many countries and institutions, following the requirements of research funders, often with such lofty goals as increasing speed, collaboration and innovation in research (Bosman & Kramer 2018; Valderrama-Zurián et al., 2019). The regression findings in this study suggested that an article written following a funded project has twice the chance of being published in one of the OA channels than be published in closed-access journal. According to Moskovkin et al. (2021), many countries have a low degree of involvement in the OA movement and lack a stated OA policy at the national level. Funding organizations play a vital role in promoting open access, so regardless of the OA route, they push the academic world to open scientific articles, and research data as well, on the public podium.

Conclusions, limitations and further research

The current study found evidence for an "OA citation advantage" (OACA), for Israeli publications, every year from 2010 to 2020. The uniqueness of this longitudinal study is the identification of a growing gap over the years. This increasing citation gap over the years indicates that the OACA extends beyond the time and article's scientific innovation. Yet, this study is limited to formal academic citations as they appear in the Scopus database. Citation indices are concerned with the scientific impact of research in the academic world rather than with the societal impact of research (Langham-Putrow et al., 2021). To make science accessible to the public, some researchers publish their work in places such as social media platforms, which may not result in subsequent citations in academic publications, but such publication is valuable to the OA movement. Future research could focus on altmetric and network-based indicators. Furthermore, potential future research directions, which were not addressed in this study, could involve investigating the OACA across different disciplines (Hadad & Aharony, 2023a; Tokmachev, 2023). Additionally, other variables that could be explored in further studies include gender differences, seniority and rank of authors, document types, and the influence of international collaboration (Hadad & Aharony, 2022, 2023b; Morillo, 2020). These factors might play a significant role in impacting citation rates and could be related to the decision of whether an article is published in OA or closed-access formats.

Regarding the OA routes, this study revealed that significant number of publications in Israel are deposited in green repositories either as pre-prints or post-prints. Yet, when it comes to pure OA publications, we detected a clear citation advantage for the hybrid route. Following this, we recommend addressing solutions such as "Read & Publish" agreements and 'offsetting'

deals with major publishers to avoid double payment for the same publication. However, funding principles such as Plan S require that publication must be done in OA-compliant journals/platforms in terms of copyright. Hybrid OA generally does not meet these conditions. Therefore, it is important to reach agreements with hybrid journals regarding the preservation of authors' copyrights. Further studies can supplement the quantitative bibliometric research with qualitative research, to reveal researchers' views and attitudes regarding the publication in OA and its routes.

According to the present findings, probably due to demands from the research funders and the self-archiving patterns of the researchers, there was a 19% increase in the rate of OA publications between the years 2010 and 2020 (29% and 48% respectively) in Israel. This is a low rate compared to European countries that are similar to Israel in terms of scientific output. At the time of writing this work, the Israel Science Foundation (ISF) does not have an OA policy, which directly affects the OA rate. This study shows that not only funding affects OA publication but mainly the funder's policy that does not require OA. The relatively low rate of OA publications by the largest funding organization in Israel (ISF), compared to the other funders, indicates that the lack of an OA policy leads researchers to publish in closed access, and therefore, the state, the institution, and the authors do not enjoy the full advantage of OA citations. Implementing a national or at least a funded-research policy favoring OA would benefit the Israeli scientific community. As indicated by our study's results highlighting the efficacy of hybrid publication, the implementation of an OA policy would necessitate dedicated financial resources to ensure widespread OA accessibility for all researchers in Israel, irrespective of their funding status from external organizations.

Finally, although this longitudinal study involved one country (Israel), the methodology for assessing trends and characteristics in the Open Access movement through the actual level of publishing, can serve as a blueprint for other countries and institutions across the world. Future strategies should consider the annual construction of tables to evaluate the distribution of OA outputs across different routes. This methodology offers a structured framework for conducting comparative analyses, enabling the selection of target countries or academic institutions within a specific country. By leveraging this framework, strategies can be devised to help lagging countries and institutions achieve their OA goals.

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