REPORT TO THE U.S. CONGRESS ON FINANCING MECHANISMS FOR OPEN ACCESS PUBLISHING OF FEDERALLY FUNDED RESEARCH

A Report by the

WHITE HOUSE OFFICE OF SCIENCE AND TECHNOLOGY POLICY

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Contents

About This Report

The White House Office of Science and Technology Policy (OSTP) prepared this report to the Appropriations Committees of the Senate and the House in fulfillment of the requirement in the Committee Report accompanying the Consolidated Appropriations Act, 2023 (P.L. 117-328) on financing mechanisms for open access publishing of federally funded research.

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of federal research and development in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the federal government. More information is available at http://www.whitehouse.gov/ostp.

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Executive Summary

The White House Office of Science and Technology Policy (OSTP) submits this report to the Appropriations Committees of the Senate and the House in fulfillment of the requirement in the Committee Report accompanying the Consolidated Appropriations Act, 2023 (P.L. 117-328) for financing mechanisms for open access publishing of federally funded research.[1] According to that Report, "The Committee recognizes the considerable progress made by OSTP" and "encourages OSTP to continue its efforts to coordinate the implementation of public access policies across Federal departments and agencies and to identify additional opportunities to enhance access to the results of Federally funded research." At the same time, the Committee expressed concern about how mechanisms for financing open access publishing "may present growing barriers to knowledge generation and sharing," noting that there are "limited data on the subject."

As defined by UNESCO, the term "open access publishing" refers to "the provision of free access to peer reviewed, scholarly and research information to all. It requires that the rights holder grants worldwide irrevocable right of access to copy, use, distribute, transmit, and make derivative works in any format for any lawful activities with proper attribution to the original author."[2] Recent technological and policy changes around the world have enabled free and immediate access to publicly funded research. OSTP, in collaboration with its federal partners and in consultation with external stakeholders, has been tracking the trends in opening public access to federally funded research, including trends in open access publishing. These efforts illustrate a highly complex, rapidly evolving, and vitally important scholarly communication ecosystem. Within this system, academic publishers can be viewed as a platform that matches research readers with research writers. By providing distributional and certification services, these publishers help mediate research incentives, interactions, and impact.

For research readers, substantial progress has been made in making new articles available to everyone quickly and without charge through various models for open access publishing. These readers include students, researchers, policymakers, advocates, and members of the broader public, who may not have access to paywalled articles through institutional subscriptions or who may not be able to pay to read an article. In its 2022 public access guidance, OSTP holds that: "Financial means and privileged access must never be the pre-requisites to realizing the benefits of federally funded research that the American public deserves."[3] The goal of federal public access policies is therefore to ensure that federal investments go towards unlocking knowledge supported by American taxpayers so the benefits of federally supported research can benefit all of America.

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[1] H.Rept. 117-395 (Committee Report to accompany Commerce, Justice, Science, and Related Agencies Appropriations Bill, 2023), p. 116 (as incorporated by reference in the Joint Explanatory Statement to accompany Division B of the Consolidated Appropriations Act, 2023). Retrieved from https://www.congress.gov/congressional-report/117th-congress/house-report/395/1

[2] Swann, A. (2012). Policy guidelines for the development and promotion of open access. UNESCO. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000215863

[3] OSTP. (2022). Ensuring Free, Immediate, and Equitable Access to Federally Funded Research. Retrieved from The White House Office of Science and Technology Policy: https://www.whitehouse.gov/wp-content/uploads/2022/08/08-2022-OSTP-Public-Access-Memo.pdf

For research writers, the evolution of the scholarly communication and publishing landscape has enabled faster and broader knowledge dissemination. In general, publishers receive two of their most important inputs — article drafts and peer reviewers to review those drafts — for free; however, there are costs associated with the sorting, editing, curation, marketing, administration, outreach, training, and other functions they perform. These costs are generally opaque and vary significantly depending on the publisher and the services they provide. Over the last two decades, publishers have experimented with different financing mechanisms to deliver their services in an increasingly open-access environment, including those specifically mentioned in the Committee Report: Article Processing Charges (APCs) that publishers levy on authors, and transformative agreements (TAs) that publishers negotiate with institutions. As documented by OSTP and by many other reports, such trends may impact who gets to publish, where, and how. As the global landscape of scholarly communication continues to develop, OSTP remains committed to ensuring the health, vitality, diversity, and fairness of the research system.

To help the federal government monitor and maximize the benefits of investments in scientific research, OSTP has prepared this report on the requested aspects of open access publishing by drawing on open datasets, analytic literature, and extensive consultation with a range of stakeholders. Sections include:

1. An overview of federal public access policies
2. Trends in academic publishing, describing a variety of business models to enable public access to federally funded research, including models that rely on APCs and those that do not
3. Approaches to public and access policies from around the world, underscoring the truly global nature of the move towards free and immediate access to scholarly literature
4. Estimated APC fees paid to publish federally funded research between 2016 to 2021
5. Limitations associated with calculating fees associated with TAs
6. Potential impacts on publishing behaviors for researchers at different institution types, career stages, and domains of research
7. Data needs for continued investigation into this important topic

Also included is an appendix on economic concepts of relevance to the financing of open access publishing, which may provide additional context to consider in considering this report.

1. U.S. Government Public Access Policies

Broad and expeditious sharing of federally funded research is fundamental for accelerating discovery on critical science and policy questions. New insights into pandemic preparedness, national security, climate change, energy, cancer, economic justice, as well as other research and development priorities of the federal government all depend on reliable access to the latest state-of-the-art advances in these fields. Moreover, American taxpayers make investments in science for the benefit of all of society, so public access policies help ensure that the returns on those investments are open, equitable, and available for general and specialized uses alike.

The federal government has a long-standing commitment both to expanding access to the results of research that American taxpayers fund and to sustaining United States global leadership in research

and development. This spirit of openness was reinforced in a National Security Directive issued by President Ronald Reagan in 1985 to maximize unrestricted access to the products of federally funded basic and applied research because "the free exchange of ideas" is vital to American science.[4] In 2013, OSTP issued a Memorandum to Agency Heads entitled "Increasing Access to the Results of Federally Funded Research" (2013 Memorandum).[5] The memorandum directed all federal departments and agencies with more than $100 million in annual research and development expenditures to develop a plan to support increased public access to the results of federally funded research, with specific focus on access to scholarly publications and digital data resulting from such research. The 2022 OSTP Memorandum on "Ensuring Free, Immediate, and Equitable Access to Federally Funded Research" (2022 Memorandum) strengthens the 2013 guidance by:

- Expecting agencies to provide free and immediate public access to peer-reviewed scholarly publications resulting from federally funded research, removing any embargo periods;
- Expanding the scope of the policy to include all executive agencies that fund research;
- Expanding guidance on data sharing;
- Promoting accountability through scientific integrity; recommending the use of persistent digital identifiers, consistent with federal research security policy guidance and federal data repository best practices; and
- Establishing an implementation process coordinated across agencies by the National Science and Technology Council (NSTC) Subcommittee on Open Science.[3,6]

Enabling greater public access to federally funded research can also support the competitiveness of U.S. investigators, increasing the visibility, consumption, and potential impact of their work. Many studies have found that articles made freely and immediately accessible offer greater impact through better readership and generate more citations than subscription-based articles.[7] Some studies have found that the increase in citations of publicly accessible articles by other researchers is modest, likely because these researchers already had access to articles published behind a paywall through subscriptions bought by their institutions.[8] The goal of public access policies, however, is broader than the academic community. Indeed, the impact of publicly accessible literature is more pronounced in industry, public policy, and among the broader public — audiences that may not have access through their institutional affiliations. For example, studies have found a notable increase in citations of publicly accessible literature in patents. A 2021 study found that after the National Institutes of Health's (NIH) 2008 Public Access Policy was implemented, patents cited NIH-funded research 12 to 27% more often,

[4] See National Science Decision Directive 189 (1985), National Policy on the Transfer of Scientific, Technical and Engineering Information: https://www.reaganlibrary.gov/public/archives/reference/scanned-nsdds/nsdd189.pdf
[5] OSTP. (2013, February 22). Increasing Access to the Results of Federally Funded Scientific Research. Retrieved from The White House Office of Science and Technology Policy: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf
[6] See National Science and Technology Council Subcommittee on Open Science charter: https://www.whitehouse.gov/wp-content/uploads/2022/08/08-2022-SOS-NSTC-CHARTER.pdf
[7] Piwowar, H., Priem, J., Larivière, V., Alperin, J. P., Matthias, L., Norlander, B., . . . Haustein, S. (2018, February 13). The state of OA: a large-scale analysis of the prevalence and impact of Open Access articles. *PeerJ*. doi:10.7717/peerj.4375
[8] Staudt, J. (2020, November 17). Mandating access: assessing the NIH's public access policy. *Economic Policy*, 35(102), 269-304. doi:10.1093/epolic/eiaa015

and a 2023 study found that publications made publicly accessible under the Department of Energy's (DOE) public access policy were cited on average 42% more in patents.[9,10] Further, the 2023 study found small businesses were the primary beneficiaries of publicly accessible DOE-funded literature. The study notes that this impact on inventions may increase with the future elimination of the 12-month embargo period that currently applies to DOE and other agency public access policies.

Since the release of the 2022 Memorandum, OSTP has been coordinating with and assisting agencies to support the development and strengthening of their public access plans and policies. While such policies are expected to be publicly posted by December 31, 2024, some agencies have publicly posted their plans both to socialize them across their research communities and to provide opportunities for stakeholder engagement and feedback.[11]

Interagency coordination efforts around public access plan and policy development have included extensive discussions across agencies and with external stakeholders of all sorts around the shifting landscape of scholarly communications, peer-review processes, and scientific data sharing. Most directly related to this report, OSTP and its federal partners are mindful of how scholarly publishing practices have been evolving rapidly and globally. Fundamental adjustments continue today and are the result of various factors, including: the continued shift from print to digital distribution; public and open access policies enacted by governments and private funders; exploration of new business models for expanding access to peer-reviewed literature; discussions around reforming academic and other research incentives; and the increasing recognition of other forms of scholarly communication, including preregistration and preprints. Because of this complexity and evolution, OSTP has not prescribed particular business models for meeting public access goals.

2. Overview of Business Models Associated with Increasing Public Access to Scholarly Publications

OSTP and federal agencies draw distinctions between the terms "public access" and "open access." Public access refers to the free availability of federally funded scholarly materials to the public and is a policy term, whereas open access refers to a broad set of publication sharing principles and practices

[9] Bryan, K. A., & Ozcan, Y. (2021, December). The Impact of Open Access Mandates on Invention. *The Review of Economics and Statistics*, 103(5), 954-967. doi:10.1162/rest_a_00926

[10] Probst, B., Lohmann, P. M., Kontoleon, A., & Diaz Anado, L. (2023, October 20). The impact of open access mandates on scientific research and technological development in the U.S. *iScience*, 26(107740). doi:10.1016/j.isci.2023.107740

[11] Agencies that have publicly posted their plans include the Agency for Healthcare and Research Quality (https://grants.nih.gov/grants/guide/notice-files/NOT-HS-23-011.html), Department of Energy (https://www.energy.gov/doe-public-access-plan), National Aeronautics and Space Administration (https://www.nasa.gov/sites/default/files/atoms/files/nasa_ocs_public_access_plan_may_2023.pdf), National Institutes of Health (https://osp.od.nih.gov/policies/public-access/), National Institutes of Standards and Technology (https://www.nist.gov/open), National Science Foundation (https://new.nsf.gov/public-access), U.S. Department of Agriculture (https://www.nal.usda.gov/services/public-access), and the U.S. Geological Survey (https://www.usgs.gov/office-of-science-quality-and-integrity/public-access-results-federally-funded-research-us). While the Department of Transportation has not publicly posted their plan at the time of this report, the department did issue a request for public comment in March 2023 (https://www.federalregister.gov/documents/2023/03/28/2023-06373/increasing-public-access-to-the-results-of-usdot-funded-transportation-research).

as adopted by the research and publishing communities. Open access (OA) publishing generally refers to a publishing model whereby digital articles are made available to readers at no cost, in contrast to subscription or other models that require payment to access and use content locked behind paywalls. While the 2013 and 2022 OSTP Public Access Memoranda encourage agencies to provide free public access to federally funded scholarly publications, there are a number of open access business models to achieve this recommendation. To provide context concerning the complexities involved in assessing the costs borne by federally-supported researchers, this section provides an overview of the various financing models associated with open access publishing, some of which involve fees to publish and others that do not. It also provides information about other fees associated with publishing. Importantly, this report distinguishes between the publishing "fees" and "charges" levied on authors or institutions on the one hand and "costs" borne by publishers to deliver their services on the other.[12]

While OSTP has been asked to analyze fees associated with article processing charges (APCs) and transformative agreements in particular, these fees should be placed in the broader context of charges associated with scholarly publications. Even before the rise of open access publishing, authors have paid to publish their work behind paywalls. These fees have come in many different forms and combinations, including: per-page charges, submission fees charged whether or not a paper is accepted following peer review, charges for printing color figures, rapid processing fees, and charges for including supplementary information.[13] As outlined in OSTP's 2022 Economic Analysis of Federal Public Access Policy, American taxpayers have supported fees associated with scholarly publishing in at least five direct and indirect ways:[14]

1. **Federal agencies fund the research.** Taxpayers directly support research and development funding agencies, which in turn provide financial awards to nongovernment researchers or employ and support federal researchers who produce research results that are ultimately disseminated in scholarly publications.
2. **Researchers pay to publish their articles.** A researcher can generally include publication fees as an "allowable expense" in their research budgets (funded by federal agencies), which is reinforced by the 2022 Memorandum. Publication fees can include per-page charges of publication in subscription-based or open access journals.
3. **Libraries pay for journal subscriptions and transformative agreements.** Taxpayers indirectly fund institutional libraries and directly fund federal libraries to pay for access to journal content through journal subscriptions. These charges count as "indirect costs" that can be partially covered by federal research grants. Similar considerations apply to transformative agreements negotiated between institutions or consortia and publishers.

[12] Grossman, A., & Brembs, B. (2021, July 1). Current market rates for scholarly publishing services. *F1000 Research*. doi:10.12688/f1000research.27468.2

[13] Panter, M. (2011, December 31). Understanding Submission and Publication Fees. Retrieved from AJE: https://www.aje.com/arc/understanding-submission-and-publication-fees/

[14] OSTP. (2022). Economic Landscape of Federal Public Access Policy. The White House Office of Science and Technology Policy. Retrieved from https://www.whitehouse.gov/wp-content/uploads/2022/08/08-2022-OSTP-Public-Access-Congressional-Report.pdf

4. **Researchers dedicate unpaid time to review research articles and serve on editorial boards.** Taxpayers indirectly provide financial support to researchers whose salaries may partially paid by federal research grants or directly to federal researchers, but whose time spent serving as peer reviewers and editorial board members for journals is generally uncompensated by publishers.
5. **Americans pay direct costs to access content behind paywalls.** Individuals or organizations who do not have specialized access, such as through institutionally supported research libraries, must pay out of pocket for access to federally funded research articles that are paywalled.

There are a number of different business models to enable public access to publications, some of which involve APCs and others of which do not. These models can be categorized by the *color system*, outlined in Table 1; the definitions for the colors may vary slightly depending on the source. In this system, different OA colors represent a different copyright, payer, and access combination, allowing authors flexibility to choose how their research becomes openly accessible.

OA Model	Description	Associated Fees
Green OA	Refers to the author or a third party archiving the author-accepted manuscript (AAM)[15] by depositing the paper into a freely available public access repository, such as an agency-designated repository.	No fee.
Gold OA	Refers to the final version of record (VOR)[16] of an article published in a fully open access journal that makes all articles immediately, permanently, and freely available on the journal's website.	APCs charged to the author or may be covered by the publisher or a third-party sponsor. If APCs are covered, this is often referred to as "Diamond OA."
Diamond OA	Refers to the publisher, or the publisher's sponsor, providing immediate and free public access to the version of record. Diamond OA is at times considered a subset of Gold OA and may also be referred to as "Platinum OA."	No fee.
Bronze OA	Refers to the version of record being made temporarily available by the publisher, who can grant and remove access at any time without warning. Bronze OA publications may have limited or unclear reuse rights. Licensing also varies for Bronze OA publications; some have open licenses attached to them, others may not.	No fee, but not everyone considers this contingent arrangement to be OA.
Hybrid OA	Refers to articles that are published in a subscription journal, but whose version of record is nevertheless made freely available based on the author's payment of an APC to the publisher or journal.	APCs charged to the author.

Table 1. The color system describing publisher business models for providing OA to scholarly literature.

[15] The author-accepted manuscript (AAM) is the author's final manuscript of a peer-reviewed paper as accepted for journal publication, including all modifications from the peer-review process.
[16] The version of record (VOR) is the publisher's authoritative copy of a paper, including all modifications from the publishing peer review process, copyediting, stylistic edits and formatting changes.

The 2022 Memorandum provides for a number of routes to making scholarly publications resulting from Federally funded research publicly accessible. Importantly, implementation of the 2022 Memorandum *does not require* expense on the part of a researcher; the policy can be followed through the deposit of a researcher's author-accepted manuscript in an agency-designated repository, also known as the Green OA route (Table 1). The 2013 Memorandum instructed agencies to designate a specific repository in which agency-funded research is to be made publicly available. In the intervening decade, a network of agency repositories has been established across the federal government to fulfill this requirement. This network includes the following, among others:

- The Centers for Disease Control and Prevention (CDC) Stacks,[17] an instance of which powers the National Oceanic and Atmospheric Administration (NOAA) Institutional Repository[18]
- The Department of Defense's (DOD) PubDefense: Public Access Search Interface[19]
- The Department of Education Research Information Center (ERIC)[20]
- The Department of Energy's (DOE) Public Access Gateway for Energy and Science (PAGES)[21]
- The Department of Transportation's (DOT) Repository and Open Access Portal (ROSA)[22]
- The National Aeronautics and Space Administration's (NASA) PubSpace[23]
- The National Institutes of Health's (NIH) PubMed Central,[24] used by other agencies and offices in the Department of Health and Human Services (including the Food and Drug Administration (FDA) and CDC), the Department of Homeland Security (DHS), the Department of Veterans Affairs (VA), the National Institute for Standards and Technology (NIST), and the Environmental Protection Agency (EPA)
- The U.S. National Science Foundation's (NSF) Public Access Repository (PAR)[25]
- The U.S. Agency for International Development (USAID) Development Experience Clearinghouse (DEC)[26]
- The U.S. Department of Agriculture's (USDA) PubAg[27]
- The U.S. Geological Survey (USGS) Publications Warehouse[28]

Should researchers choose to publish via the Gold or Hybrid OA, which may require payment of APCs, the 2022 Memorandum allows researchers to include publication and data sharing costs in their research budget proposals. The memorandum also recommends that agencies work with the Office of Management and Budget (OMB) to allow researchers to include reasonable publication costs and costs associated with submission, curation, management of data, and special handling instructions as

[17] CDC Stacks: https://stacks.cdc.gov/
[18] NOAA IR: https://repository.library.noaa.gov/
[19] PubDefense: Public Access Search Interface https://discover.dtic.mil/pubdefense/
[20] Education Resources Information Center https://eric.ed.gov/
[21] Public Access Gateway for Energy and Science https://www.osti.gov/pages/
[22] Repository and Open Access Portal https://rosap.ntl.bts.gov/
[23] PubSpace https://ntrs.nasa.gov/collections/pubspace
[24] PubMed Central http://www.ncbi.nlm.nih.gov/pmc/
[25] National Science Foundation Public Access Repository https://par.nsf.gov/
[26] The USAID Development Experience Clearinghouse: https://dec.usaid.gov/dec/home/Default.aspx
[27] PubAg https://search.nal.usda.gov/discovery/search?vid=01NAL_INST:MAIN
[28] USGS Publications Warehouse: https://pubs.usgs.gov/

allowable expenses in all research budgets. What constitutes reasonable costs is a matter of continuing discussion; through their updated public access plans, most agencies have committed to monitoring OA fees and their impact on affected communities.

In addition to the models described in Table 1, publishers are exploring other business models, such as Subscribe to Open (or S2O), which provides an alternative to APCs.[29] This model uses subscription revenues to convert paywalled journals to full open access for one year at a time. If enough institutions subscribe to the journal for a given year, the articles for that year are free to access and authors are not charged an APC to publish; if the journal does not receive enough subscriptions for a given year, journal articles for that year are paywalled and authors do not have an opportunity to publish open access, though they may make their articles publicly accessible through routes like Green OA. Publishers, including university, society, and commercial presses, have begun adopting this model.[30]

There has also been growing interest in the Diamond OA model, also called Platinum OA, in which articles are free to read and free to publish. The need for individual APCs is mitigated by bulk support from a third-party (e.g., through grant funding, institutional support, or endowment). Such journals may be run by universities or other research institutions, societies, traditional publishers, volunteers, or a combination thereof.[31] In 2022, Science Europe developed an Action Plan for Diamond Open Access to further develop and expand a sustainable and community-driven approach to advancing Diamond OA, in collaboration with cOAlition S and other partners.[32] cOAlition S is an initiative supported by the European Commission and the European Research Council to advance free and immediate open access to publications, coordinated through a group of national research funders, European and international organizations, and charitable foundations. Diamond OA has proven successful in Central and South America with publicly supported platforms like the Scientific Electronic Library Online (SciELo) and the Network of Scientific Journals from the Latin American and Caribbean Region, Spain, and Portugal (Redalyc). The U.S. government also supports journals that could be considered Diamond OA journals, including NOAA's *Fishery Bulletin*,[33] the National Institute of Environmental Health Sciences' (NIEHS) *Environmental Health Perspectives*,[34] CDC's *Emerging Infectious Diseases*, [35] and NIST's *Journal of Research of the National Institute of Standards and Technology*.[36] Recently, the MIT Press was awarded an NSF Early-Concept Grant for Exploratory Research (EAGER) award to expand their shift+OPEN initiative to flip two of their high-impact subscription-based journals to Diamond OA.[37]

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[29] Crow, R., Gallagher, R., & Naim, K. (2020). Subscribe to Open: A practical approach for converting subscription journals to open access. *Learned Publishing*, 181-185. doi:10.1002/leap.1262

[30] See Subscribe to Open Community of Practice: https://subscribetoopencommunity.org/

[31] Bosman, J., Frantsvåg, J., Kramer, B., Langlais, P.-C., & Proudman, V. (2021). *The OA Diamond Journals Study*. doi:10.5281/zenodo.4558704

[32] Ancion, Z., Borrell-Damián, L., Mounier, L., Mounier, P., Rooryck, J., & Saenen, B. (2022). *Action Plan for Diamond Open Access*. doi:10.5281/ZENODO.6282402

[33] *Fishery Bulletin* https://fisherybulletin.nmfs.noaa.gov/fb.htm

[34] *Environmental Health Perspectives* https://ehp.niehs.nih.gov/

[35] *Emerging Infectious Diseases* https://wwwnc.cdc.gov/eid/

[36] *Journal of Research of the National Institutes of Standards and Technology* http://www.nist.gov/nvl/jres.cfm

[37] See shift+OPEN: http://mitpress.mit.edu/shiftOPEN/

Institutions have also begun to explore financial instruments called transformative agreements that shift subscription expenditures to cover charges associated with OA publishing. Transformative agreements are discussed in greater detail in Section 5. Transformative agreements were developed to address two chief concerns around financing mechanisms to read and publish scholarly literature:

1. **Rising subscription and access fees to read scholarly literature.** Subscription fees for scholarly journals have increased at rates that outpace library budgets and inflation. For example, according to survey data collected by the Association of Research Libraries (ARL) from 1986 to 2022, the median ongoing library materials expenditures (e.g., subscription and licensing fees) for a given research library increased by 195% — from $4.2 million in 1986 to $10.4 million in 2020 — when adjusting for inflation (Figure 1). In response to the COVID-19 pandemic, many of the large publishers offered libraries a 0% increase or a decrease in their agreements, recognizing libraries were under severe budget constraints, which accounts for the decrease in subscription expenditures from 2020 to 2022. Subscriptions may therefore rise again in the coming years. By comparison, the median total expenditures for a surveyed research library increased by 39% — from $23.5 to $27.8 million in 2022, when adjusting for inflation. In the late 1990s, academic and research libraries began negotiating so-called "Big Deals" with publishers, bundling journals together for discounted rates. One study found that while these bundles decrease the average per-journal price, the cost per cited article has increased, with publishers bundling less valuable or more niche titles with those more widely read by the community.[38] Big Deals also spurred market consolidation, creating incentives for smaller publishing houses to partner with larger publishers to increase the likelihood their journals would be sold through bundling.[39] Over the last decade, libraries have begun cancelling these Big Deals.[40]
2. **Rising APCs to publish open access.** APCs for a number of publishers have also outpaced inflation.[41] As discussed further in Section 4.1, how APCs are set is generally opaque and often influenced by how much the community is willing to pay to publish in a particular title. The 2016 "Pay it Forward" study of the financial sustainability of open access through an APC-based model found that research-intensive institutions that publish a large volume of articles may eventually pay more in APCs than their current library budgets.[42] Importantly, the study is premised on the entire scholarly publishing landscape flipping to a fully Gold OA model, though OSTP has not mandated a particular business model for complying with public access policies.

[38] Shu, F., Mongeon, P., Haustein, S., Siler, K., Alperin, J., & Larivière, V. (2018, September). Is It Such a Big Deal? On the Cost of Journal Use in the Digital Era. *College & Research Libraries*. doi:10.5860/crl.79.6.785

[39] Frazier, K. (2001, March). The Librarians' Dilemma: Contemplating the Costs of the "Big Deal". *D-Lib Magazine*, 7(3). Retrieved from http://www.dlib.org/dlib/march01/frazier/03frazier.html

[40] SPARC. (n.d.). Big Deal Cancellation Tracking. Retrieved 2023, from https://sparcopen.org/our-work/big-deal-cancellation-tracking/

[41] Khoo, S.-S. (2019). Article Processing Charge Hyperinflation and Price Insensitivity: An Open Access Sequel to the Serials Crisis. *Liber Quarterly*, 29(1), 1-18. doi:10.18352/lq.10280

[42] Smith, M., Anderson, I., Bjork, B.-C., McCabe, M., Solomon, D., Tananbaum, G., . . . Willmott, M. (2016). Pay It Forward: Investigating a Sustainable Model of Open Access Article Processing Charges for Large North American Research Institutions. UC Office of the President: University of California Systemwide Libraries. Retrieved from https://escholarship.org/uc/item/8326n305

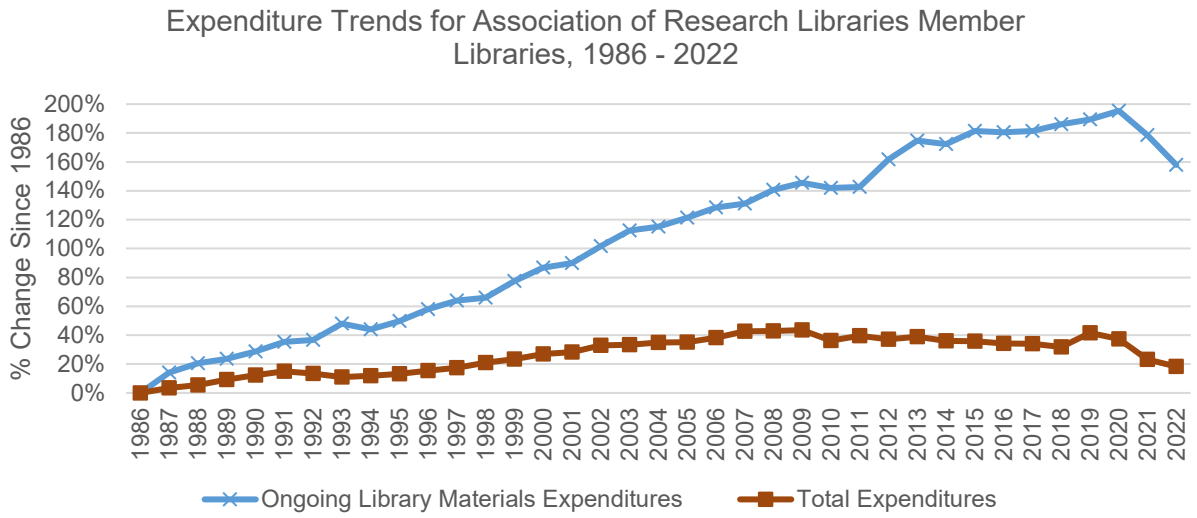

Figure 1. Expenditure trends for the Association of Research Libraries (ARL) member libraries from 1986 to 2022, illustrating the percent change in expenditures compared to 1986 for both ongoing library materials expenditures (these were formerly referred to as "Serials Expenditures" in surveys conducted before 2011), which includes subscription and licensing fees, and total library expenditures. Expenditures in inflation-adjusted dollars.

In addition, some academic and research libraries have created dedicated funds to support open access publishing for their members. Within the humanities and social sciences, strategic partnerships between libraries and publishers have formed to support open scholarship through joint funding of infrastructure, including initiatives like Open Library for the Humanities and Project MUSE.[43,44]

3. Overall Trends in Scholarly Publishing

The global output of scholarly publications in science and engineering has grown over the years, nearly tripling from 1996 to 2020 from just under 1 million to 2.9 million articles published per year.[45,46] Trends in the volume of scholarly publications in science and engineering are shown in Figure 2 for the top six article-producing countries in the world. Worldwide growth in publications over the last decade has been led by China, India, and the United States. Increases in the global volume of science and engineering literature may be attributed to a number of factors including digitization of scholarly publication, incentives around publication as an indicator of research productivity, increased

[43] Wise, A., & Estelle, L. (2020, January 13). How society publishers can accelerate their transition to open access and align with Plan S. *Learned Publishing*, 14-27. doi:10.1002%2Fleap.1272

[44] See ProjectMUSE: https://muse.jhu.edu/

[45] National Science Board, National Science Foundation. (2021). Publications Output: U.S. and International Comparisons. In *Science and Engineering Indicators* 2022. Alexandria, VA. Retrieved from https://ncses.nsf.gov/pubs/nsb20214/

[46] Data on publications from science and engineering fields were collected from Scopus, a database of scientific literature with English-language titles and abstracts. Articles include conference papers and research articles published in conference proceedings and peer-reviewed scientific and technical journals. The search excluded editorials, errata, letters, working papers, and preprints.

investments and resulting capacity in science and engineering research, and growth in the number of journals in which to publish.

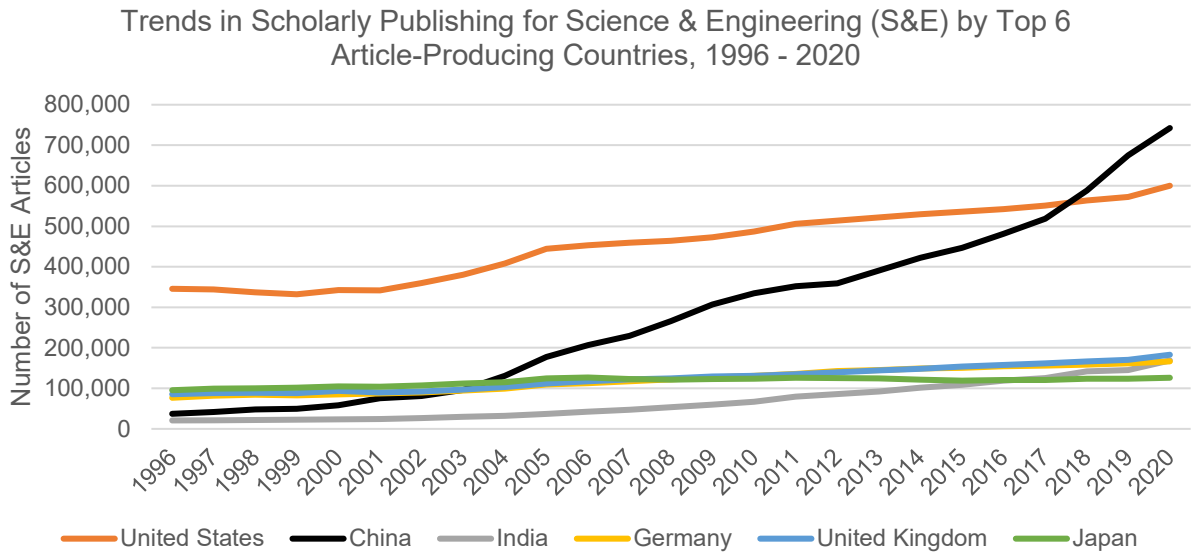

Figure 2. Trends in the volume of science and engineering (S&E) publications for the top six countries for producing publications from 1996 to 2020.[45]

The proportion of articles that are publicly accessible has also increased significantly for the most productive countries, doubling or nearly doubling for five of the countries and quadrupling for China (Figure 3). This growth is likely driven in part by public access and open access policies by funders and research organizations around the world.[47]

[47] For public and open access policies in the U.S. and around the world, see Registry of Open Access Repositories Mandatory Archiving Policies (ROARMAP): https://roarmap.eprints.org/

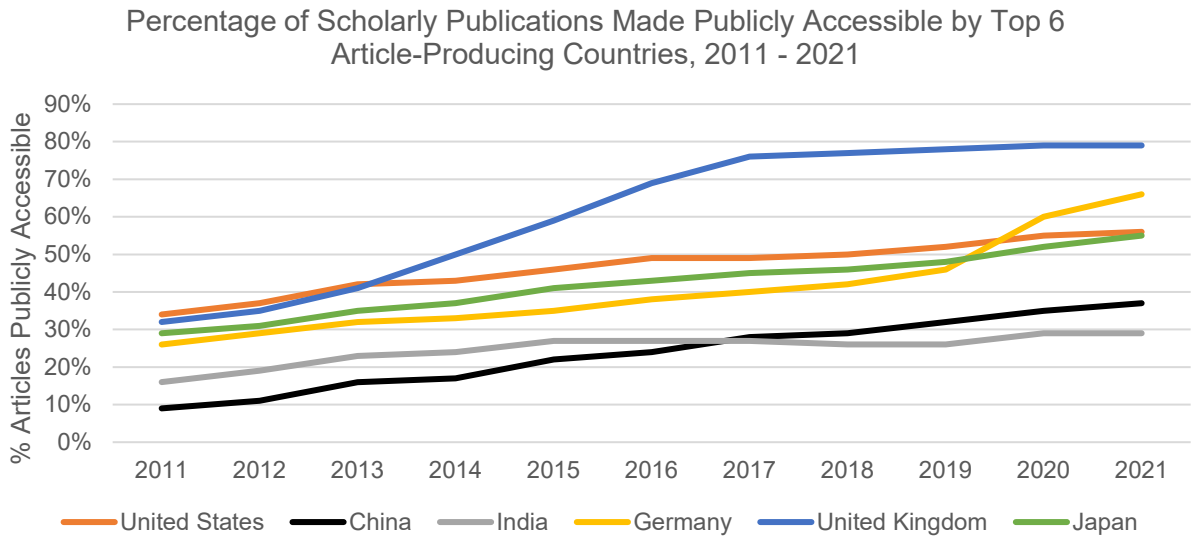

Figure 3. The share of scholarly publications made open access through the Gold, Bronze, Green, or Hybrid OA models for the top six countries for producing publications. Data from the International Association of Scientific, Technical and Medical Publishers (STM) Open Access Dashboard.[48,49]

In the U.S., five publishers — Elsevier, Springer Nature, Wiley, the American Chemical Society (ACS), and Oxford University Press (OUP) — account for 51.4 percent of the volume of federally funded publications from 2016 to 2021, according to data retrieved from Clarivate's Web of Science.[50] Similarly, five publishers — Elsevier, Spring Nature, Wiley, OUP, and MDPI — account for 51.4 percent of the volume of openly accessible federally funded articles from 2016 to 2021.

In the last decade, there has also been an increased adoption of publishing in fully open access journals, whether Gold OA (with APCs) or Diamond OA (with no APCs), both for federally funded research and for research globally. This rise may be due to a variety of factors, including the growth of fully open access journals (Figure 4) and exploration of transformative agreements (Section 5). To help the research community navigate this changing landscape, organizations have established best practices for open

[48] STM, International Association of Scientific, Technical and Medical Publishers. 2023. *The STM Open Access Dashboard.* https://www.stm-assoc.org/oa-dashboard/

[49] The STM Open Access Dashboard uses Scopus data analyzed by Microsoft PowerBI. It also does not differentiate between papers made available through Gold, Diamond, or Hybrid OA models.

[50] Publication data was retrieved from Web of Science in September 2023. OSTP collected all "Articles" and "Review Articles" published between 2016 and 2021, filtering the field for "Funding Organization" with federal funding agencies covered by the 2013 Memorandum. Notably, this analysis relies on accurate reporting of funding information, which is self-reported by authors and supplied by publishers. There is great variability in how funding sources are reported (or not reported), which affects the counts of publications. Web of Science supplements funding information provided through structured metadata from publication data sources like Crossref and PubMed with text-mining of the "Acknowledgments" and "Funding" sections of papers. In addition, different bibliometric tools and databases are known to have different interpretations of the same funding information. [See: Gibson, D., van Honk, J., & Calero-Medina, C. (2021, December 1). *Acknowledging the Difficulties: A Case Study of a Funding Text*. Retrieved from Leiden Madtrics: https://www.leidenmadtrics.nl/articles/acknowledging-the-difficulties-a-case-study-of-a-funding-text]

access publishing.[51] Funders, such as NIH, have issued guidance to their grantees for identifying and choosing credible journals as the publishing industry continues to grow and evolve.[52]

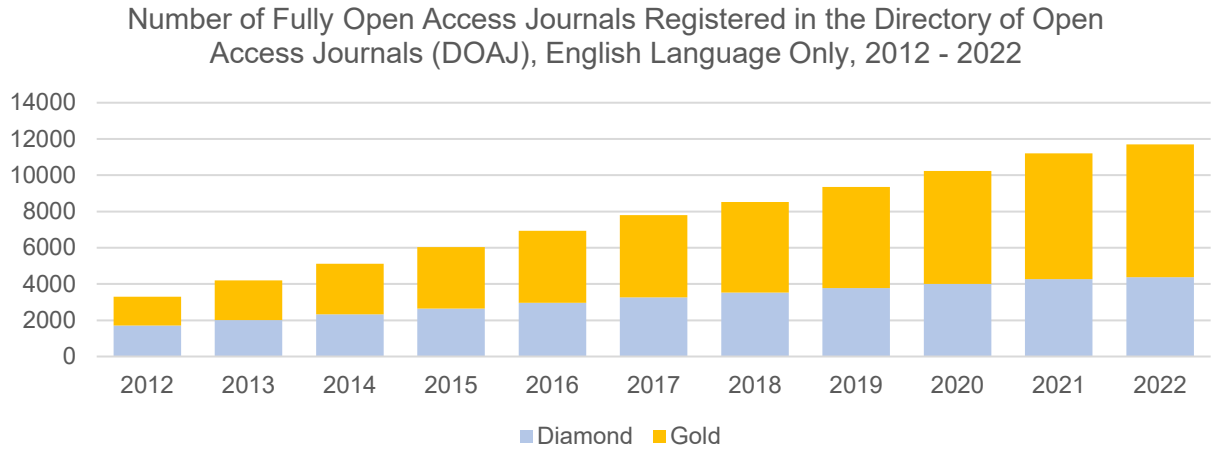

Figure 4. The number of English-only fully open access journals registered in the Directory of Open Access Journals (DOAJ) from 2012 to 2022. Gold OA journals charge an APC and Diamond OA journals do not.[53]

Outside of peer-reviewed publications, there has been an increased adoption of preprints as a form of scholarly communication in recent years. A preprint is a version of a scientific paper that is publicly posted and free to read before formal peer review. Preprints have been widely adopted in physics, mathematics, and economics; in 2020, over one-third of all physics publications and one-quarter of mathematics publications were preprints.[54] In recent years, preprints have experienced increasing popularity in biology and computer science. The growth of preprints in biomedical research may be attributed in part to a 2017 NIH guide notice encouraging investigators to use interim research products, such as preprints, to speed the dissemination and enhance the rigor of their work.[55] NIH has taken additional steps to increase the discoverability of preprints by exploring the feasibility of adding preprints into PubMed Central, one of the most widely accessible biomedical resources globally, through their Preprint Pilot.[56] Phase 1 of the pilot focused on preprints associated with NIH-supported research on SARS-CoV-2 and COVID-19. Between June 2020 and June 2022, over 3,300 preprint records were added; approximately 72% of added preprints had been linked to a peer-reviewed journal version by December 2022.

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[51] COPE, DOAJ, OASPA, & WAME. (2013, December). Principles of Transparency and Best Practice in Scholarly Publishing, 4.0. Retrieved from DOAJ: https://doaj.org/apply/transparency/

[52] See NOT-OD-18-011, Statement on Article Publication Resulting from NIH Funded Research: https://grants.nih.gov/grants/guide/notice-files/NOT-OD-18-011.html

[53] Data retrieved from https://doaj.org/csv in September 2023. While federally funded researchers may publish in non-English-language journals, the vast majority of articles are published in English-only journals.

[54] Xie, B., Shen, Z., & Wang, K. (2021, February 17). Is preprint the future of science? A thirty year journey of online preprint services. *arXiv*. doi:10.48550/arXiv.2102.09066

[55] See NOT-OD-17-050, Reporting Preprints and Other Interim Research Products: https://grants.nih.gov/grants/guide/notice-files/NOT-OD-17-050.html

[56] Funk, K., Zayas-Cabán, T., & Beck, J. (2022, December 13). Phase 1 of the NIH Preprint Pilot: Testing the viability of making preprints discoverable in PubMed Central and PubMed. *bioRxiv* [Preprint]. doi:10.1101/2022.12.12.520156

Some members of the scholarly communication and research communities have proposed leveraging the growing adoption of preprints to streamline and increase transparency of the peer review process.[57] For example, some have proposed adopting models in which articles are first published as preprints, after which journal editors may invite authors of preprints that have gained traction in their communities to submit their articles for peer review and potential publication.[58] Already, some publishers have used preprint servers to identify manuscripts that may be a good fit for their audience.[59]

4. Estimated OA Fees Paid by Federally Funded Researchers from 2016 to 2021

Limited data are available to estimate the total APCs federal researchers and grantees[60] paid from 2016 to 2021, as true APC expenditure records rest with the authors or institutions that pay these fees and the publishers that invoice them. It is even more difficult to estimate the percentage of these expenditures that are drawn from federal grants, as researchers draw on a variety of sources to make these payments, some of which are supported by federal funds while others are not. OSTP's 2022 report to Congress on the economic landscape of federal public access policies provided an estimate of between $390 to $789 million in APC expenditures per year, assuming the landscape of scholarly publishing transitions to a fully open access environment with APCs ranging from $2,000 to $3,000.[14] To arrive at an updated estimate of APC expenditures between 2016 and 2021, OSTP asked the following questions: (1) What is the average APC fee for hybrid and fully open access journals in which federally funded researchers publish? (2) How many articles were published with federal funding support between 2016 and 2021, and through what open access financing mechanism (e.g., Green, Gold, Hybrid, Bronze, Diamond), which have different charges associated with them? (3) Based on these estimates, how much did federally funded researchers spend to publish in these years?

4.1 What is the average APC fee for hybrid and fully open access journals in which federally funded researchers publish?

While researchers may comply with federal public access policies through the no-fee Green OA option, the U.S. government promotes author choice for publishing route, including the Gold and Hybrid options that incur APCs. Some journals, such as those published by F1000 Research,[61] EMBO Press,[62] and the Public Library of Science (PLoS),[63] have taken steps to implement pricing transparency

[57] Avissar-Whiting, M., Belliard, F., Bertozzi, S. M., Brand, A., Brown, K., Clément-Stoneham, G., . . . Williams, M. (2023, April 3). Advancing the Culture of Peer Review with Preprints. *OSF Preprints*. doi:10.31219/osf.io/cht8p

[58] Green, T. (2019). Is open access affordable? Why current models do not work and why we need internet-era transformation of scholarly communications. *Learned Publishing*, 13-25. doi:10.1002/leap.1219

[59] Barsh, G. S., Bergman, C. M., Brown, C. D., Singh, N. D., & Copenhaver, G. P. (2016, December 1). Bringing PLOS Genetics Editors to Preprint Servers. *PLOS Genetics*. doi:10.1371/journal.pgen.1006448

[60] While Congress has requested an analysis of fees paid by federal grantees, OSTP has expanded the analysis to include fees paid by both grantees (extramural researchers) and researchers working within the federal government (intramural researchers) to provide a more complete picture of possible federal expenditures that go towards APCs.

[61] APC pricing breakdown for F1000 Research: https://f1000research.com/for-authors/article-processing-charges

[62] EMBO Press Finances, 2022: https://www.embopress.org/pb-assets/embo-site/images/EMBO_Press_financial_transparency_2022-graphic-v02-screen-1685084219.pdf

[63] PLoS Price Transparency Update 2021: https://theplosblog.plos.org/2023/02/plos-price-transparency-update-2021/

frameworks.[64] Nevertheless, there is limited public information on per-article publication costs generally, such as those associated with content acquisition, production, and dissemination, on the revenues collected by the publishing industry, and on how such factors affect APCs. Most publishers consider these data to be proprietary information. Further, there is great diversity among publishers — and even across titles held by a given publisher — depending on a variety of factors including the volume of articles they publish, the level of curation that goes into the review and dissemination process, and the degree to which the review and dissemination processes are automated that impact production costs associated with publication. Publishers that hold a number of journal titles are also able to employ "cascading" or "transfer" systems for submission and review, further complicating the calculation of per-article production costs. Under this system, if a submitted paper is rejected by the original journal, the publisher will offer to send the article for consideration at a slightly less prestigious journal owned by the same publisher. If the original submission was rejected after peer review, the reviews may also be bundled with the manuscript, so the article may not need to undergo another round of review, expediting the time to publication and negating additional costs for peer review.

The three biggest predictors of APC fees are: (1) whether the article is published in a Hybrid or Fully OA journal, (2) the prestige of the journal, as determined by its impact metrics such as citation rates, and (3) the domain of research.[65,66]

APCs for both Hybrid and Fully Open journals have risen over the years. An analysis of the four largest fully OA publishers found that the rate of APC increases outpaced that of inflation between 2012 and 2018.[41] Notably, researchers using the Hybrid OA option tend to pay higher APCs than those who publish in fully open access journals. There is also a perception of "double dipping" associated with the Hybrid OA route, with publishers charging an APC to publish open access while also charging a subscription fee to access non-OA content in the rest of the journal.[65,67]

OSTP retrieved APCs associated with the top 100 journals in which federally funded researchers published from 2016 to 2021, according to data from Clarivate's Web of Science (Figure 5). There was a high degree of overlap between the top 100 journal titles identified by OSTP and those identified by other studies, despite differences in methodological approach.[68] While these journals were selected to reflect the publishing behaviors and preferences of federally funded researchers, this set biases the preferences of domains that publish more on average, namely the biological and life sciences. APCs

[64] Wise, A., & Estelle, L. (2020). *Plan S Price Transparency Framework: Implementation Guide for Publishers. Information Power*. Retrieved from https://www.informationpower.co.uk/the-plan-s-price-transparency-framework-implementation-guide/

[65] Borrego, Á. (2023, July 3). Article processing charges for open access journal publishing: A review. *Learned Publishing*, 36(3), 359-378. doi:10.1002/leap.1558

[66] Schönfelder, N. (2020, February 1). Article processing charges: Mirroring the citation impact or legacy of the subscription-based model? *Quantitative Science Studies*. doi:10.1162/qss_a_00015

[67] Kingsley, D. A. (2014, September 3). Paying for Publication: Issues and Challenges for Research Support Services. *Australian Academic & Research Libraries*, 45(4), 262-281. doi:10.1080/00048623.2014.945135

[68] Schares, E. (2023). Impact of the 2022 OSTP memo: A bibliometric analysis of US federally funded publications, 2017–2021. *Quanitative Science Studies*, 1-21. doi:10.1162/qss_a_00237

were separated by Hybrid or Fully OA journals and the average APC was calculated for each model using rates retrieved in August 2023, which are likely higher than those charged from 2016-2021.[65,69]

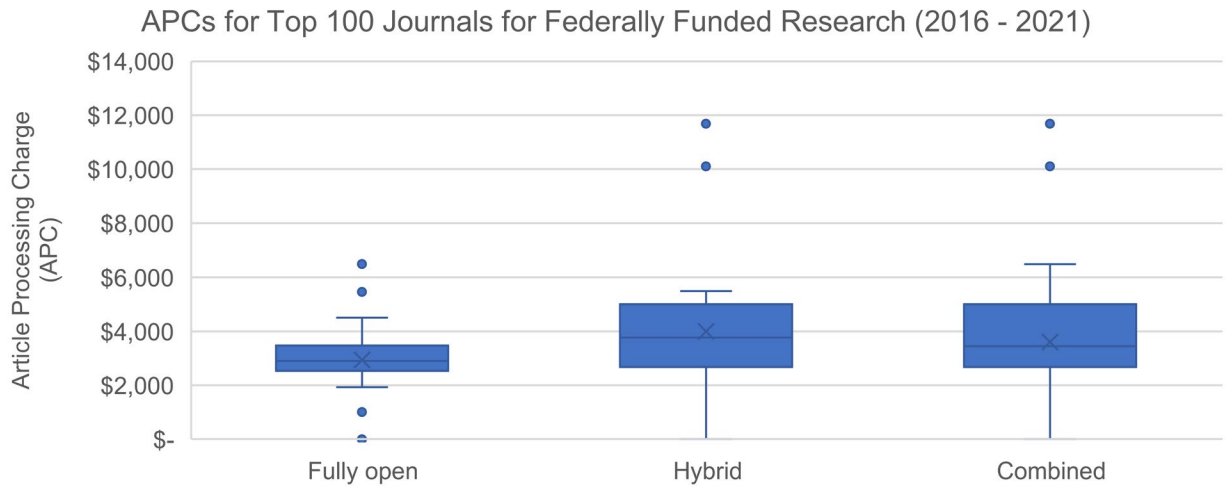

Figure 5. Distribution of APCs associated with the top 100 journals for federally funded research from 2016 to 2021, based on data from Web of Science. Journals were separated by Fully Open and Hybrid journals. APCs reflect fees posted in August 2023, which are likely higher than those charged from 2016-2021.

The average APC for Fully Open journals was $2,937.05 and for Hybrid journals was $3,999.23. The range of Hybrid APC fees varied more widely than APCs for Fully Open journals.[70] The mean Fully Open APC value calculated by OSTP is higher than calculated by other sources, which analyze the entire set of fully open access journals listed in the DOAJ, not taking into account the preferences of certain groups of researchers, such as those funded by federal agencies.[71]

APCs also vary by research discipline. Given different federal agencies support different domains of research, these discipline-specific variations in APCs may also affect the APC charges borne by federally supported researchers. To illustrate this variation in an agency-specific context, OSTP retrieved from Web of Science the top 50 journals in which DOD-, DOE-, NASA-, NIH-, NSF-, and USDA-supported research was published from 2016 to 2021 (Figure 6). These six agencies account for 94 percent of the approximately $150 billion in funds obligated to federal research and development.[14] OSTP retrieved

[69] These estimates reflect the maximum total charges, and do not account for discounts and waivers provided by publishers, APC discounts resulting from transformative agreements, or lower charges for certain article or review types. In addition, some journals, such as those published by the American Astronomical Society (AAS), charge different rates based on the length of the article (OSTP assumed an average article length of 10 pages). Others, such as those published by the American Chemical Society (ACS), charge different rates based on the embargo period and licensing. To avoid underestimating the total APCs associated with publishing Federally funded research, OSTP used the highest possible APC charged by a publisher. Because these calculations are based on available APC data from 2023, they are likely higher than APCs charged between 2016 to 2021.

[70] It is worth noting that a researcher may publish in a Hybrid journal that allows researchers to publish their work behind a paywall, but archive the author-accepted manuscript in an agency-designated repository at no cost, making their work accessible through the Green OA route. In other words, publishing in a Hybrid journal does not mean that a researcher must pay to make their work openly accessible.

[71] Crawford, W. (.-0.-4.-1. (2023). *Gold Open Access 2017-2022: Articles in Journals (GOA8)*. Livermore, CA. Retrieved from https://waltcrawford.name/goa8.pdf

APCs based on August 2023. The average Hybrid OA fee ranges from $3,634.44 (NASA) to $4,824.48 (NIH), and the average Fully Open fee ranged from $1,685.08 (DOE) to $3,372.45 (NIH). Notably in this sample, six of the 19 Fully Open journals in which DOE-supported researchers publish and four of the 22 Fully Open journals in which NSF-funded researchers publish charge no APCs. NIH- and USDA-funded researchers also tend to publish in journals that charge higher APCs.

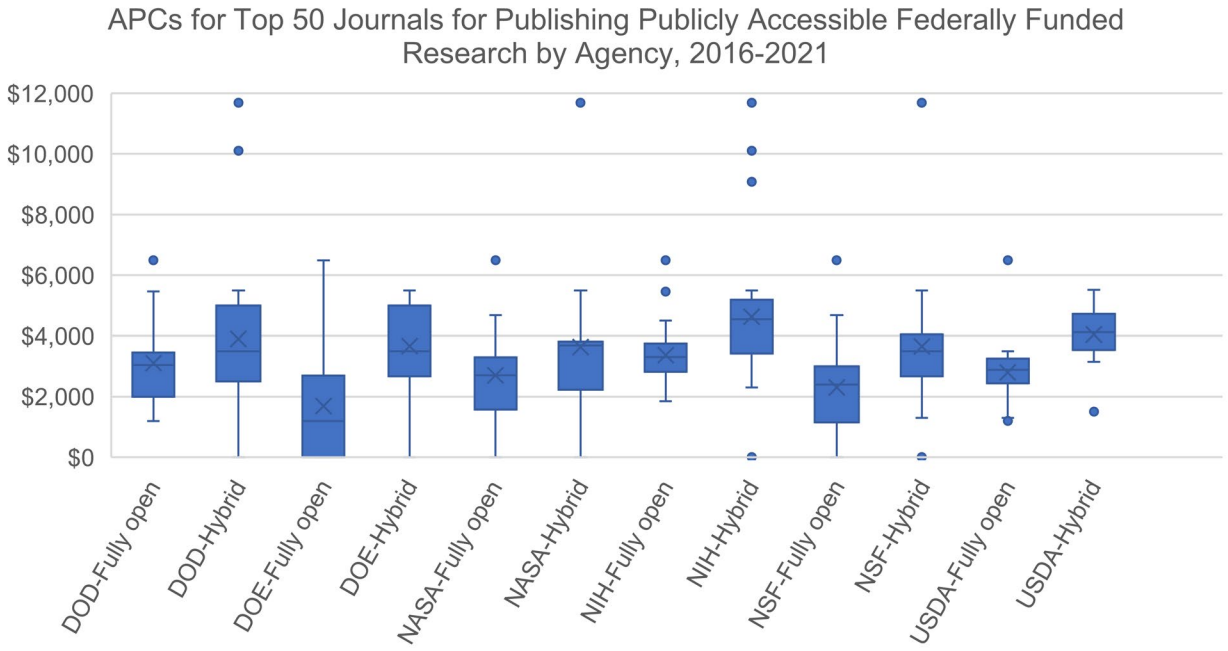

Figure 6. APCs for the top 50 journals for DOD-, DOE-, NASA-, NIH-, NSF-, and USDA-sponsored research from 2016 to 2021, separated by Fully Open and Hybrid journals.

4.2 How many articles were published with federal funding support between 2016 and 2021, and through what public access financing mechanism?

To estimate the number of articles published with federal support, OSTP drew on data underlying a 2023 analysis of U.S. federally funded publications from 2017 to 2021, as well as additional analysis undertaken by its author in the months following publication.[68,72] From 2000 to 2021, the share of publicly available publications resulting from federally funded research doubled (Figure 7).[73]

[72] The analysis was conducted with data from Dimensions; OA mode is reported to Dimensions by the open database Unpaywall. There are a number of limitations to the study, many of which are documented in Schares, 2023, including those described in footnote 50. Schares's analysis estimates federally funded research produced on average 265,000 articles per year from 2017-2021, on the high end of OSTP's estimate of 195,000-263,000 articles published in 2020, as reported to Congress in 2022.[14]

[73] OSTP recognizes that despite great progress over the years, this analysis shows there are still many publications that remain closed (i.e., available behind a paywall), which may be attributed to a number of reasons, including those

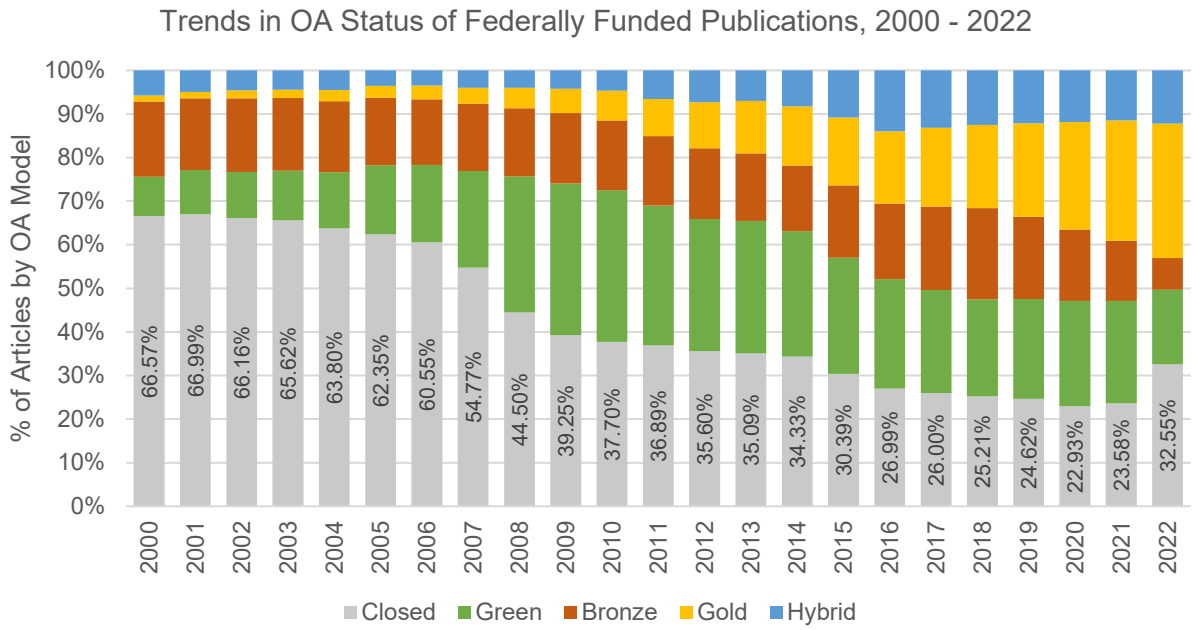

Figure 7. The proportion of federally funded research made publicly accessible through various OA models from 2000 to 2022 based on data from Schares, 2023.[74]

The first notable increase in public accessibility occurred between 2007 to 2009 — with the percentage of publications available behind a paywall declining from 55% to 40% — due to NIH's 2008 Public Access Policy, which applied to articles published after April 7, 2008, in accordance with the Consolidated Appropriations Act of 2008 (Division G, Title II, Section 218, PL 110-161).[75] Since then, the public accessibility of articles has steadily increased as federal departments and agencies with over $100 million in annual research and development expenditures have adopted policies to promote public access to federally funded research in response to the 2013 Memorandum. Importantly, the nine-point difference in Closed OA articles between 2021 and 2022 is likely an effect of the current 12-month embargo period.[76] In other words, federal public access policies currently allow for articles to be published behind a paywall for up to a 12-month period, after which they should be made publicly

inherent to Schares's analysis, as well as those related to policy implementation. First, this analysis includes all federal agencies, not only those with over $100 million in research and development expenditures, which were covered by the 2013 Memorandum. Second, articles are often published after completion of a grant's funding period. While researchers are expected to make these publications publicly accessible, the government has limited enforcement mechanisms once the period of performance has ended, which may lead to a higher rate of "Closed" access. Third, OA status is reported to Dimensions through Unpaywall, which provides the current OA status of a given publication at the time the analysis was run. Given the current embargo period on publication, there are more publications in 2022 reported as "Closed," which may eventually be archived in agency-designated repositories after the embargo period, at which point they will be reported as "Green" OA. Unpaywall also does not distinguish between Gold OA journals (those that charge an APC) and Diamond OA journals (those that do not).

[74] Schares, E. (2023). *OSTP Impact*. Retrieved from https://github.com/eschares/OSTP_impact/tree/main

[75] See NOT-OD-08-033, Revised Policy on Enhancing Public Access to Archived Publications Resulting from NIH-Funded Research: https://grants.nih.gov/grants/guide/notice-files/NOT-OD-08-033.html

[76] The 2022 OSTP Public Access Memorandum advises agencies to remove this embargo period; policies implementing this guidance should go into effect by December 31, 2025.

accessible in an agency-designated repository (i.e., through Green OA). Articles published in 2022 may still be Closed access as a result.

OSTP performed a complementary analysis to estimate the number of articles published with federal funding support, retrieving articles from Web of Science published between 2016 and 2021 by OA status that note funding support from those agencies covered under the 2013 Memorandum.[77] Data compiled by OSTP agree within a few percentage points with those produced by Schares's analysis.

4.3 Based on these estimates, how much did federally funded researchers spend to publish in these years?

To estimate total APC charges borne by federal grantees and researchers from 2016 to 2021, OSTP used the mean APCs associated with Hybrid and Fully Open journals and the number of federally funded publications (Articles and Review Articles) indexed by Web of Science and analyzed by OSTP for those years by OA type (Figure 8). To provide an additional point of comparison to OSTP's estimates, OSTP used Schares' analysis to estimate the number of federally supported articles published through the Green, Bronze, Gold, and Hybrid OA routes from 2000 to 2022.[74] Importantly, these data do not capture other publishing fees not associated with open access publishing, including page charges, submission fees, and others discussed in Section 1. These fees depend on many variables, including the number of pages and figures for a given article, and are not easily estimated even when price lists are available.

[77] Unlike the analysis conducted by Schares, OSTP used Clarivate's Web of Science to retrieve data on publications resulting from Federally funded research. Any discrepancies in OSTP and Schares's analysis are likely due to the use of different sources for data collection and analysis. For example, the Web of Science Core Collection indexes articles from >21,894 journals (~10-12% of journals), books, and conference proceedings, compared to Dimensions, which indexes articles from 107,000 journals. Notably, each journal covered in the Web of Science core collection is evaluated for quality prior to selection for indexing. Given federally funded researchers generally publish in high-quality journals indexed by Web of Science, any differences between Schares's analysis and OSTP's are likely minimal. In addition, as mentioned in footnote 72, different bibliometric sources have different interpretations of the same funding information. OSTP also restricted its search to include only publications classified as "Article" or "Review Article" by Web of Science to narrow the scope to articles appearing in peer-reviewed journals.

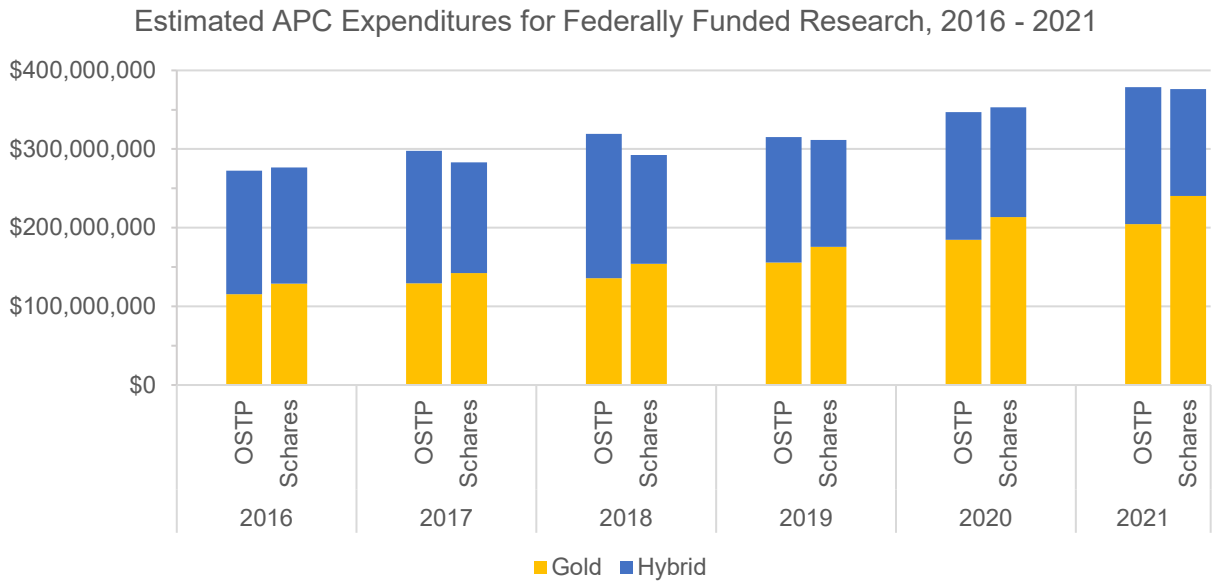

Figure 8. Estimated APC expenditures for scholarly publications resulting from federally funded research, using the number of articles published with federal support from 2016 to 2021, as estimated by OSTP and Schares.[74] Estimates were calculated based on mean APC values for Fully Open and Hybrid journals based on August 2023 APC rates. Articles published through other OA routes, such as Green and Bronze, incur no APCs.

Estimates of APC expenditures for the requested years (2016 to 2021) based on this additional analysis are shown in Table 2. The estimated APC expenditures agree well with one another, with the most substantial difference calculated for 2018. Again, these figures may be overestimates, given they utilize the maximum APC charge for a given title, not taking into account any waivers (discussed further in Section 5), discounts, or reduced pricing for shorter articles.

Year	Gold — OSTP	Gold — Schares	Hybrid — OSTP	Hybrid — Schares	Total — OSTP	Total — Schares
2016	$115,390,820	$128,968,803	$157,093,754	$147,459,609	$272,484,574	$276,428,411
2017	$129,115,655	$142,138,535	$168,423,572	$140,884,874	$297,539,227	$283,023,409
2018	$135,844,437	$154,289,111	$183,312,706	$137,997,430	$319,157,142	$292,286,541
2019	$155,543,231	$175,847,058	$159,677,256	$135,865,841	$315,220,487	$311,712,898
2020	$184,481,985	$213,488,290	$162,548,703	$139,697,103	$347,030,689	$353,185,394
2021	$204,506,792	$240,324,116	$174,154,469	$135,865,841	$378,661,260	$376,189,957

Table 2. Estimate of annual expenditures on APCs, calculated based on the mean 2023 APC rate (Figure 2) and data from OSTP's Web of Science analysis compared to data from Schares 2023 on volume of federally funded publications by open access type from 2016 to 2021.

To understand the proportion of federal research and development expenditures that go towards APC fees, recognizing the previously discussed caveats associated with OSTP's estimates, OSTP compared the charges tabulated in Table 2 with total federal research and development budgets from FY2016 -

2021.[78] Estimated APC expenditures averaged less than quarter a percent for this time period (between 0.18 to 0.23 percent).

5. The Role of Transformative Agreements in the Open Access Landscape

Transformative agreements (TAs) are negotiated between institutions or consortia and publishers. Importantly, "transformative agreements" are an umbrella term that encompass a range of different kinds of contracts that may include traditional subscription licenses and APC discounts or waivers that may cover a certain number of articles that may be published in hybrid or fully open journals.[79] These agreements can be classified in a number of different ways, including transitional, transformational, offsetting, read-and-publish, and publish-and-read agreements.[43] As discussed in Section 1, such contracts were developed to address two chief concerns around financing mechanisms to read and publish scholarly literature: (1) rising subscription fees to read the scholarly literature and (2) rising APC fees to publish in the scholarly literature.

A 2015 report by the Max Planck Society posited: "All the indications are that the money already invested in the research publishing system is sufficient to enable a transformation [to open access publishing] that will be sustainable for the future".[80] Transformative agreements are one effort to shift fees from readers to authors and are meant to be transitional in nature — moving publishing away from subscription payments and towards an end state of fully open access publishing.[81] The first TA was negotiated in 2014 between the Austrian Academic Consortium and IOP Publishing to offset hybrid APCs against subscription and license fees. Since then, there has been a rapid evolution in the space, making it difficult for OSTP to forecast the impacts of this open access financing model. The number of transformative agreements has predominantly grown in Europe, in part because of open access mandates like those put in place by cOAlition S, an international consortium of research funding and performing organizations. The first TA in the United States was negotiated in 2019 between Cambridge University Press and the University of California (UC) system, whose researchers produce nearly 10 percent of United States academic publications. The UC system uses a multi-payer model, combining library subscription funding with grant funding for researchers with grants; for researchers without grant funding, UC will fully cover APCs.[82] Today, there are 48 active TAs in place in the United States, representing agreements between 22 academic libraries or consortia and 22 publishers (Figure 9).

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[78] National Center for Science and Engineering Statistics (NCSES). (2023). *Federal R&D Funding, by Budget Function: Fiscal Years 2021–23.* Alexandira, VA: National Science Foundation. Retrieved from https://ncses.nsf.gov/pubs/nsf23324

[79] Borrego, Á., Anglada, L., & Abadal, E. (2020, December 3). Transformative agreements: Do they pave the way to open access? *Learned Publishing*. doi:10.1002/leap.1347

[80] Schimmer, R., Geschuhn, K., & Vogler, A. (2015). Disrupting the subscription journals' business model for the necessary large-scale transformation to open access. Max Planck Digital Library. doi:10.17617/1.3

[81] Hinchliffe, L. J. (2019, April 23). *Transformative Agreements: A Primer*. Retrieved from The Scholarly Kitchen: https://scholarlykitchen.sspnet.org/2019/04/23/transformative-agreements/

[82] UC Publisher Strategy and Negotiation Task Force. (2019). *Negotiating with scholarly journal publishers: A toolkit from the University of California.* Retrieved from https://escholarship.org/uc/item/8cn0q1nw

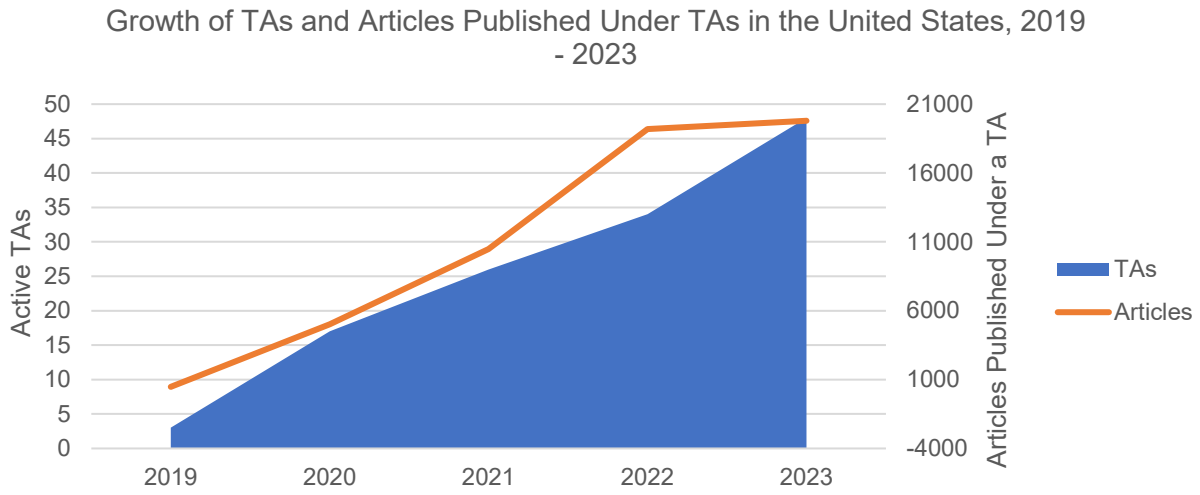

Figure 9. The growth of transformative agreements (represented by the solid blue fill) and articles published under transformative agreements (represented by the orange line) in the United States between 2019 and 2023. Data was retrieved from Efficiency and Standards for Article Charges (ESAC) Initiative's Market Watch in August 2023.[83] Articles represented in this figure are not necessarily articles resulting from federal support.

For a variety of reasons, it is difficult to estimate U.S. federal expenditures that have gone towards transformative agreements. In the United States, these agreements are typically negotiated between publishers and research libraries or consortia; expenditures for these organizations are distributed across complex organizational budgets and, as in the case of consortial licensing and agreements, are often inter-organizational. Further, funds used to finance such agreements may be drawn from federal grants (or state grants for state public institution) in the form of indirect costs; the exact share of grants that go towards transformative agreements, however, is unclear in much the same way it is difficult to assess the share of federal expenditures that go towards traditional subscriptions. Similarly, it is unclear by how much these agreements offset federal funds that go towards paying subscriptions and APCs. In a 2022 report, the Association of Research Libraries estimated U.S. research library expenses in Fiscal Year 2021-2022 dedicated to open services, collections, staff, and infrastructure ranged between 0.2 and 11% with an average of 2.26% of their budgets.[84] These expenditures include those for transformative agreements, APCs, non-APC-based OA publishing models, institutional repository services, OA journal hosting and publishing services, and open monographs. Of the 46 responding research libraries, 38 indicated that they have some form of a transformative agreement in place with expenditures on these agreements ranging from $16,000 to $2,125,791, with an average of $683,627 spent per institution in FY2021.[85]

In principle, transformative agreements are meant to be cost-neutral. There is little evidence, however, that these agreements are truly containing costs as it is unclear how much U.S. institutions have been

[83] See ESAC Market Watch: https://esac-initiative.org/market-watch/
[84] Hudson Vitale, C., & Ruttenberg, J. (2022). Investments in Open: Association of Research Libraries US University Member Expenditures on Services, Collections, Staff, and Infrastructure in Support of Open Scholarship. Washington, DC: Association of Research Libraries. doi:10.29242/report.investmentsinopen2022
[85] The survey specifically asked respondents whether they had a read-and-publish or transitional agreement in place.

paying into the publishing system in the first place.[79] As discussed in Sections 2 and 4.1, such spending has significantly outpaced the rate of inflation. Evaluation studies of the first transformative agreements in the United Kingdom caution that these agreements "are flawed through their implicit acceptance and strengthening of the current costly and opaque market for journal subscriptions".[86,87] Nevertheless, some institutions have worked to implement frameworks and principles for transformative agreement negotiations, such as a 2019 toolkit developed by the University of California.[82] Efficiency and Standards for Article Charges (ESAC), an initiative coordinated by the Max Planck Digital Library, has also compiled negotiation principles from various international entities.[88] These frameworks address costs, author's copyright retention, and transparency, for example, while also emphasizing that such agreements should be transitional in nature.

The consortium cOAlition S that is sponsored by the European Commission and the European Research Council has announced the end of its support for transformative agreements beyond 2024. This decision has been taken out of concern that sustained support would risk making these agreements a permanent fixture in the economic landscape of scholarly publishing.[89] Individual funders participating in cOAlition S may continue to support transformative agreements; however, it is unclear what impact this policy may have, if any, on the viability of such agreements in the United States.

Were TAs to become a more permanent arrangement, this financial mechanism runs the risk of replicating the same trends it was designed to alleviate. Given the time and administrative effort it takes to negotiate, transformative agreements may favor larger and more established publishers that hold more journal titles and have greater access to resources. They may also incentivize smaller publishers to partner with larger ones to promote sales.[90] In this way, such agreements may replicate the pitfalls of the Big Deals. Because TAs typically include APC discounts or waivers, researchers at institutions with these contracts in place may have an incentive to publish in journals covered by those agreements.

In addition, academic institutions with fewer resources, including minority serving institutions, may find it difficult to negotiate similar contracts with publishers to support open access publishing as their larger counterparts. Smaller institutions may, however, leverage consortia to negotiate such agreements. For example, the University of California worked with the California State University (CSU) system the Statewide California Electronic Library Consortium (SCELC) to negotiate a TA with the American Chemical Society in 2022, marking the first California-wide agreement.[91]

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[86] Earney, L. (2017, March 10). Offsetting and its discontents: challenges and opportunities of open access offsetting agreements. *Insight*, 11-24. doi:10.1629/uksg.345

[87] Lawson, S. (2019). *Evaluating UK offset agreements (2015–17).* doi:10.5281/zenodo.3256642

[88] ESAC Initaitive. (n.d.). *Negotiation Principles*. Retrieved from https://esac-initiative.org/guidelines/

[89] cOAlition S. (2023, January 26). *cOAlition S confirms the end of its financial support for Open Access publishing under transformative arrangements after 2024*. Retrieved from cOAlition S: https://www.coalition-s.org/blog/transformative-journals-analysis-from-the-2022-reports/

[90] Crotty, D. (2021, December 14). *Market Consolidation and the Demise of the Independently Publishing Research Society*. Retrieved from https://scholarlykitchen.sspnet.org/2021/12/14/market-consolidation-and-the-demise-of-the-independently-publishing-research-society/

[91] See press release: https://osc.universityofcalifornia.edu/2022/05/uc-csu-scelc-acs-new-transformative-agreement/

6. Potential Impacts on Publication Decisions

Many factors influence how and where researchers prefer to publish. These include domain-specific expectations and norms, journal prestige, services or benefits provided by different publishers, and considerations around how best to reach intended audiences. Pricing also plays a role, especially among those who may not have federal funding to cover publication fees, including open access fees, page charges, submission fees, and other assessments discussed in Section 2. There are concerns that funds available to pay rising APCs create a two-tiered system between funded and unfunded researchers where only funded researchers — or those at institutions with transformative agreements — can publish their research in APC-based journals.[92]

Consistent with public access policy, OSTP and its federal partners remain committed to promoting each author's right to choose where and how to publish, as well as encouraging innovation in publishing models and services. Options for making their results publicly accessible continue to include self-archiving in an agency-designated public access repository for free. While no one can predict precisely how financing mechanisms will affect the publishing decisions made by different kinds of researchers, this section discusses some benchmarks against which to evaluate whether the reading and publishing of scholarly literature becomes more equitable, fair, and impactful. This section provides overarching context around existing inequities in the ability to publish (Section 6.1) and illustrates some trends and behaviors in publishing by different institution types (Section 6.2), among early career researchers (Section 6.3), and across different domains of research (Section 6.4).

6.1 Existing Inequities in Publishing

The ability to publish — and all the benefits that come with publication, including the dissemination of knowledge to different audiences, the opportunity for other researchers to validate, build on, and innovate using existing work, pathways for forming collaborations, and the chance to build recognition and reputation — are central to a healthy and equitable research enterprise. Nevertheless, disparities have long existed in the research ecosystem, including in institutional access to resources needed to conduct research, documented bias in the peer review system in publishing and awarding grants, inequities in decisions around hiring and promotion, availability of funds across different research disciplines, and impacts of cumulative advantage.[92] A 2021 report of the National Science Board analyzes how publication output varies by gender, demographic group, and discipline.[45]

OSTP and its federal partners are committed to ensuring equitable participation in and access to research and innovation. Public access implementation does not exist in a vacuum. It connects with other interagency efforts to increase participation in science, technology, engineering, and mathematics (STEM), including several provisions in the CHIPS & Science Act of 2022. Along with the federal government, many publishers, research institutions, and advocacy groups are taking steps to reduce biases that may lead to inequitable outcomes by, for example, reforming peer review, diversifying editorial boards, and targeting outreach and building capacity. Some journals have also

[92] Ross-Hellauer, T., Reichmann, S., Cole, N. L., Fessl, A., Klebel, T., & Pontika, N. (2022, January 19). Dynamics of cumulative advantage and threats to equity in open science: a scoping review. *Royal Society Open Science, 9*(1). doi:10.1098/rsos.211032

implemented waiver and discount systems to help cover APCs for those who might not be able to afford them otherwise. The effects of such programs are limited due to cumbersome applications, slow processing, and payments that may not fully cover the APC.[93,94]

6.2 Publishing by Different Institution Types

Different types of academic institutions exhibit different publishing patterns. To understand these variations, OSTP examined contrasts among R1 and R2 universities under the Carnegie classification scheme, Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), and colleges and universities in Established Program to Stimulate Competitive Research (EPSCoR) jurisdictions.[95] For authors with institutional affiliations in each of these categories, OSTP used Web of Science to retrieve publications that acknowledge federal funding from agencies covered under the 2013 Memorandum. OSTP analyzed articles published in two windows of time: both the requested period of 2016-2021 and 2006-2011 for comparison, before there were U.S. government-wide efforts to increase public access (Figure 10). The share of research published by all institution types except R1 universities increased between these two time periods, but the differences in all cases were small.

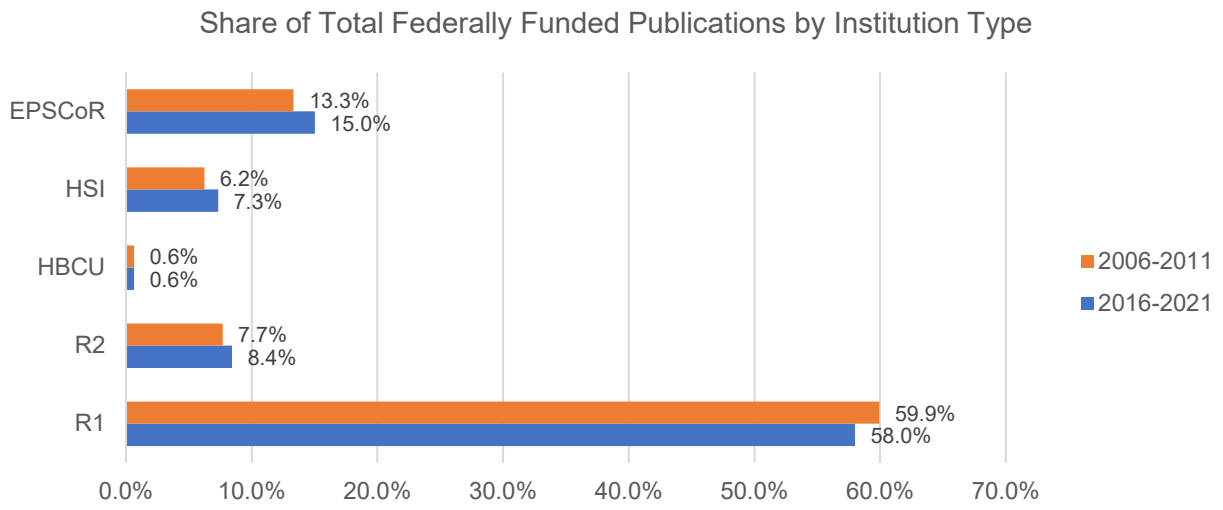

Figure 10. Share of total publications acknowledging federal support both from 2006-2011 (before any U.S. government-wide public access policies) and 2016-2021 (the requested period resulting from federally funded research by institution type. Note that there may be overlap in publications because, for example, some R1 institutions are also in EPSCoR jurisdictions.

OSTP then analyzed how different institutional types employed different routes to make federally funded publications publicly accessible between 2016 to 2021 (Figure 11). OSTP also retrieved from Web of Science the titles of the top ten journals in which authors at these different institution types published during that period. Notably, authors from HBCUs appear to utilize the Green and Bronze open

[93] Vervoort, D., Ma, X., & Bookholane, H. (2021, December 31). Equitable Open Access Publishing: Changing the Financial Power Dynamics in Academia. *Global Health Science and Practice, 9*(4). doi:10.9745%2FGHSP-D-21-00145
[94] Rouhi, S., Beard, R., & Brundy, C. (2022, February 21). Left in the Cold: The Failure of APC Waiver Programs to Provide Author Equity. *Science Editor*. doi:10.36591/SE-D-4501-5
[95] EPSCoR jurisdictions can be found at https://new.nsf.gov/funding/initiatives/epscor/state-websites

access routes less frequently and utilize fully open access journals (Gold or Diamond) more frequently than researchers at other institutions. Seven of the top ten journals in which authors from HBCUs publish are fully open access journals, one of which does not charge APCs.

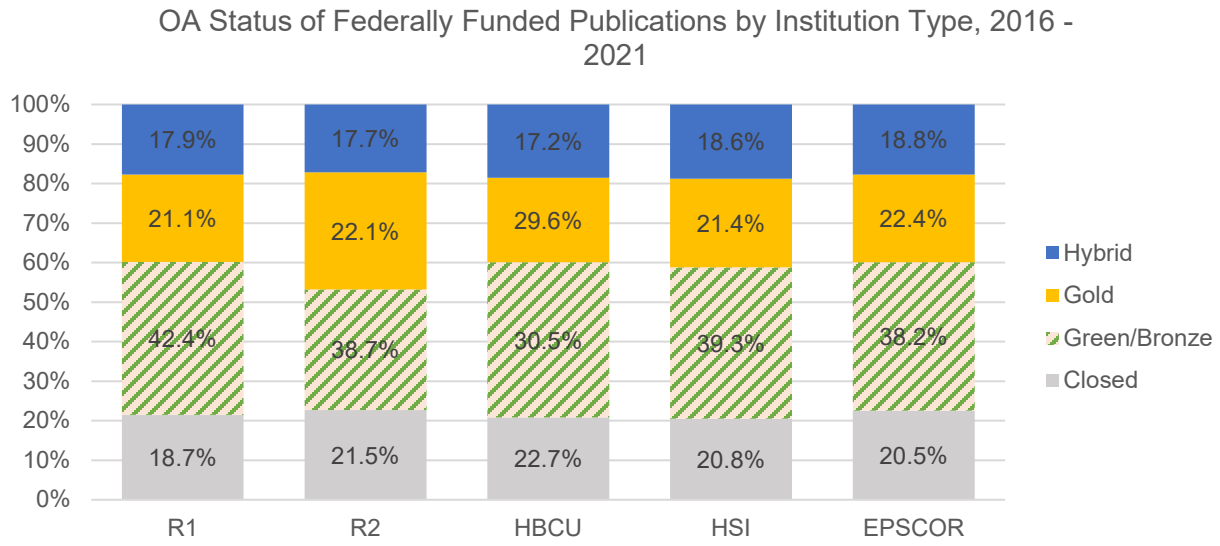

Figure 11. Share of publications by open access type from 2016 to 2021 broken out by institution type. Publications made publicly accessible through the Green and Bronze OA route were combined.[96]

6.3 Publishing by Early Career Researchers

Congress has also requested an analysis of publishing preferences of early career researchers (ECRs), but OSTP found that scholarship in this area is limited. A longitudinal study from the sciences, including social sciences, in seven countries found that, for ECRs in the United States, their choice of where to publish is heavily influenced by their supervisors and mentors.[97,98] The study also found this choice is influenced most by the journal impact factor and general prestige, as well as journals that are most relevant to their field. Survey respondents shared a variety of perceived benefits to making their publications open, including opportunities to: share new ideas more rapidly to spur further research; increase visibility immediately following publication; obtain a larger audience for their work; and garner more citations, in turn enhancing their reputations.

To further understand the perspectives of the early career researcher community, OSTP hosted a series of four listening sessions with early career researchers around their needs, experiences, and priorities

[96] While Web of Science also uses Unpaywall to report open access mode, OSTP found that some articles were classified as being made openly available through both the Bronze and Green OA routes. To avoid double-counting, OSTP combined articles made publicly accessible through means other than Gold and Hybrid publishing in the "Green/Bronze" category.

[97] Nicholas, D., Rodríguez-Bravo, B., Watkinson, A., Boukacem-Zeghmouri, C., Herman, E., Xu, J., . . . Świgoń, M. (2017, March 29). Early career researchers and their publishing and authorship practices. *Learned Publishing*. doi:10.1002/leap.1102

[98] Nicholas, D., Watkinson, A., Boukacem-Zeghmouri, C., Rodríguez-Bravo, B., Xu, J., Abrizah, A., . . . Eti. (2019, March 21). So, are early career researchers the harbingers of change? *Learned Publishing, 32*(3), 237-247. doi:10.1002/leap.1232

for advancing a future of open science.[99] The U.S. government defines open science as "the principle and practice of making research products and processes available to all, while respecting diverse cultures, maintaining security and privacy, and fostering collaborations, reproducibility, and equity." Over 1,000 participants representing approximately 250 organizations joined these sessions; participants included early career researchers, faculty, administrators, research scientists, librarians, and publishers. The feedback offered in the sessions covered three overarching topics: the benefits of open science, obstacles to participation in open and reproducible research, and ideas for action. While open science is broader than open access publishing, enhancing access to scholarly communications is an important component of open science and considerations around publishing intersect with sharing of other research outputs. Indeed, participants discussed these connections over the course of the listening sessions.

A number of participants spoke about the advantages of open science, offering examples of their own work, such as using public data to develop powerful diagnostic tools and to measure the effects of climate change. Several participants also highlighted the role of open science in promoting equitable access to educational and professional development opportunities through open-source lectures and publications; some speakers also stressed that the needs of traditionally marginalized communities must be considered when developing open science practices to avoid amplifying disparities. Finally, participants argued that open science leads to better science by promoting competition, subjecting research to peer scrutiny, and facilitating consensus-building, and strongly advocated for more sharing of negative results to further increase transparency and steer research in productive directions.

While expressing enthusiasm about the potential of open science, the ECR community noted that the pressure to "publish or perish," which values the volume of peer-reviewed publications above other contributions, is an obstacle to adoption of open science principles. The pressure here can be intense. Some departments, for example, make an ordered list of journals in their field and then announce how many publications in the top tiers that junior faculty need in order to qualify for tenure. This severely limits how much shopping among alternative publication routes that ECRs can afford to do without jeopardizing their academic careers.

A related concern — mentioned in more than a dozen comments — was high publishing costs, particularly for those prestigious journals in which they are expected to publish if they are to succeed in academia. In their remarks, some participants mentioned low-cost and free journals as alternatives to commercial publishers. Library leaders from two universities noted that the government and research institution should educate scientists about different publishing venues and avenues for public access compliance, including self-archiving in agency-designated public access repositories. Participants also shared their ideas for alternatives to existing publishing practices and to support publishing costs, should researchers choose to publish in fee-based fully open access journals. These suggestions included: investing in infrastructure to host preprints, exploring preprint review (as discussed in Section 3), promoting transparency in APCs, and raising more awareness of how authors

[99] OSTP. (2023, July 11). *Readout of OSTP Open Science Listening Sessions with Early Career Researchers*. White House Office of Science and Technology Policy. Retrieved from https://www.whitehouse.gov/ostp/news-updates/2023/07/11/readout-of-ostp-open-science-listening-sessions-with-early-career-researchers/

can retain rights for self-archiving when utilizing the Green OA route for compliance, as well as exploration of other more equitable models of making articles publicly accessible.

Listening session participants also shared ideas for alleviating the pressure to "publish or perish," as well as the pressure to publish in prestige journals that may charge high APCs. Some focused on moving away from opaque indicators of journal prestige, such as the journal impact factor.[100] Others discussed elevating the sharing of other research outputs, such as scientific data and open-source software, as a first-class research object, on the same level as publications. Many speakers noted that the federal government can help change academic culture by spearheading various initiatives that support public access, such as publication repositories, and by incentivizing the scientific community to adopt open science practice, for example, by recognizing the value of data sharing in grant evaluations.

Efforts are underway to reform how research is evaluated and researchers rewarded. The Declaration on Research Assessment (DORA), for example, is developing more meaningful and transparent metrics.[101] Related initiatives include both the community-led organization Make Data Count,[102] which focuses on development of open and responsibly created metrics for research data, as well as the Higher Education Leadership Initiative for Open Scholarship (HELIOS),[103] a cohort of colleges and universities coordinating to advance open scholarship. OSTP and its federal partners will continue to track the impact of such efforts and their role in advancing the careers of ECRs.

6.4 Publishing by Different Research Disciplines

The culture of scholarly publishing differs between research domains, as do attitudes around and adoption of open access publishing.[104,105] To illustrate discipline-specific trends in open access publishing by federally funded researchers, OSTP retrieved scholarly publications from 2016 to 2021 from Web of Science that reference support from federal agencies covered under the 2013 Memorandum; all publications were included in this analysis, including monographs and conference proceedings not necessarily covered by these agencies' public access policies. OSTP analyzed these articles by open access status and by their categorization under Web of Science's "Research Areas," as broken out into five high-level categories (Figure 12).[106] The data illustrate differences in publication behaviors between disciplines. For example, researchers in the life sciences and biomedicine, as well as the social sciences, utilize the non-APC-based Green and Bronze OA route more than technology

[100] Lariviere, V., & Sugimoto, C. R. (2018, January 26). The Journal Impact Factor: A brief history, critique, and discussion of adverse effects. *arXiv*. doi:10.48550/arXiv.1801.08992
[101] DORA. (2012). DORA – San Francisco Declaration on Research Assessment (DORA). Retrieved from https://sfdora.org/read/
[102] See Make Data Count: https://makedatacount.org/
[103] See HELIOS: https://www.heliosopen.org/
[104] Severin, A., Egger, M., Eve, M. P., & Hürlimann, D. (2018, December 11). Discipline-specific open access publishing practices and barriers to change: an evidence-based review. *F1000Res*. doi:10.12688%2Ff1000research.17328.2
[105] Olejniczak, A. J., Savage, W. E., Wheeler, & Richard. (2022, January 25). The Rhythms of Scholarly Publication: Suggestions to Enhance Bibliometric Comparisons Across Disciplines. *Frontiers in Research Metrics and Analytics, 7*(812312). doi:10.3389/frma.2022.812312
[106] See Web of Science Core Collection's Research Areas (Categories/Classification): https://images.webofknowledge.com/images/help/WOS/hp_research_areas_easca.html

researchers. Social science researchers publish through the APC-based Gold and Hybrid routes considerably less than researchers in Technology, Physical Sciences, and Life Sciences and Biomedicine. Federally funded Arts and Humanities researchers published an average of only 370 articles per year during the period under study and published more paywalled content than other disciplines.[107]

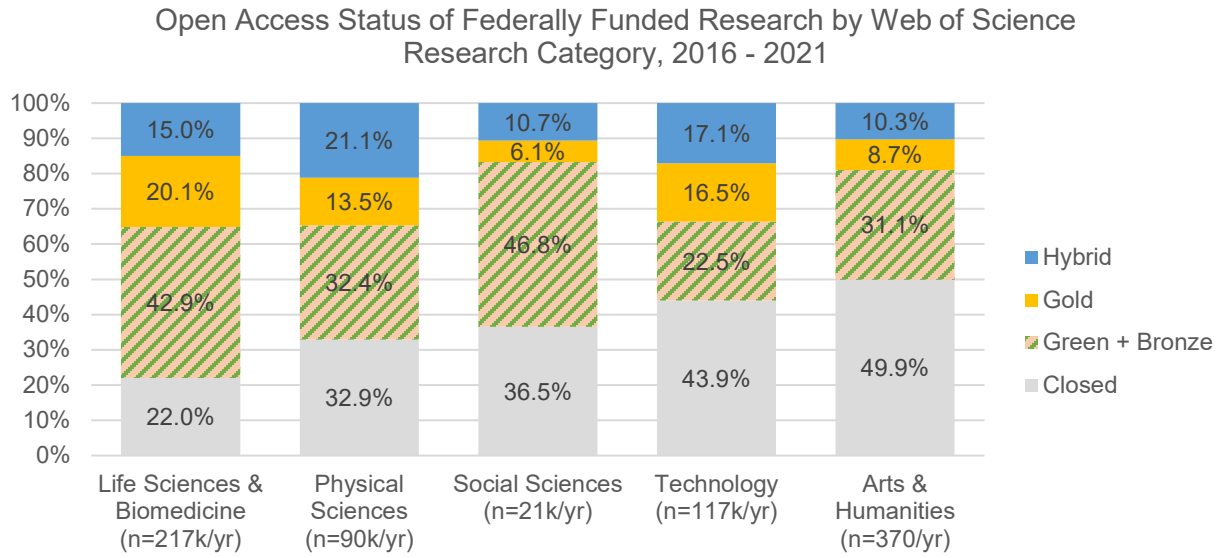

Figure 12. OA status of federally funded publications published between 2016 to 2021 by research category. Research resulting from funding from only agencies covered by the 2013 Memorandum were included in this analysis. The number of articles published per year for each category is provided in parentheses in the x-axis.

As an additional point of comparison, OSTP used data from Schares of federally funded research published between 2016 to 2022 by open access status and categorized by the Australian and New Zealand Standard Research Classification (ANZSRC) Field of Research (FoR) codes (Figure 13).[74,108,109] The trends are generally consistent with those found by OSTP, though FoR codes provide more sub-discipline specific trends. For instance, the Chemical Sciences, which are generally grouped into Life Sciences and Biomedicine, have more paywalled content than Biomedical and Clinical Sciences. Notably, Schares analysis includes papers acknowledging funding from any federal agency, not only those covered by the 2013 Memorandum, so Closed access articles may be those that were funded by agencies with less than $100 million in annual R&D expenditures, including the National Endowment

[107] The 2013 Memorandum covered agencies with over $100 million in annual research and development expenditures, many of which do not provide funding to the Arts and Humanities. This figure is likely an undercount of federally funded Arts and Humanities publications.

[108] See ANZSRC system: https://www.abs.gov.au/statistics/classifications/australian-and-new-zealand-standard-research-classification-anzsrc/latest-release

[109] There are a few key differences between Schares's analysis and OSTP's worth noting: (1) Schares's analysis includes publications from 2022 that may be under embargo, so the proportion of "Closed" access articles may decrease as embargo periods lift. (2) Articles were retrieved from Dimensions, which may lead to different results, as explained in footnotes 72 and 77. (3) Schares's analysis also includes articles published with support from any Federal agency, not only those covered under the 2013 Memorandum, which may lead to a higher proportion of "Closed" access publications for articles supported by an agency not covered by the original public access guidance.

for the Humanities (NEH) and the Institute of Museum and Library Services (IMLS). These agencies are now developing public access policies in response to the 2022 Memorandum.

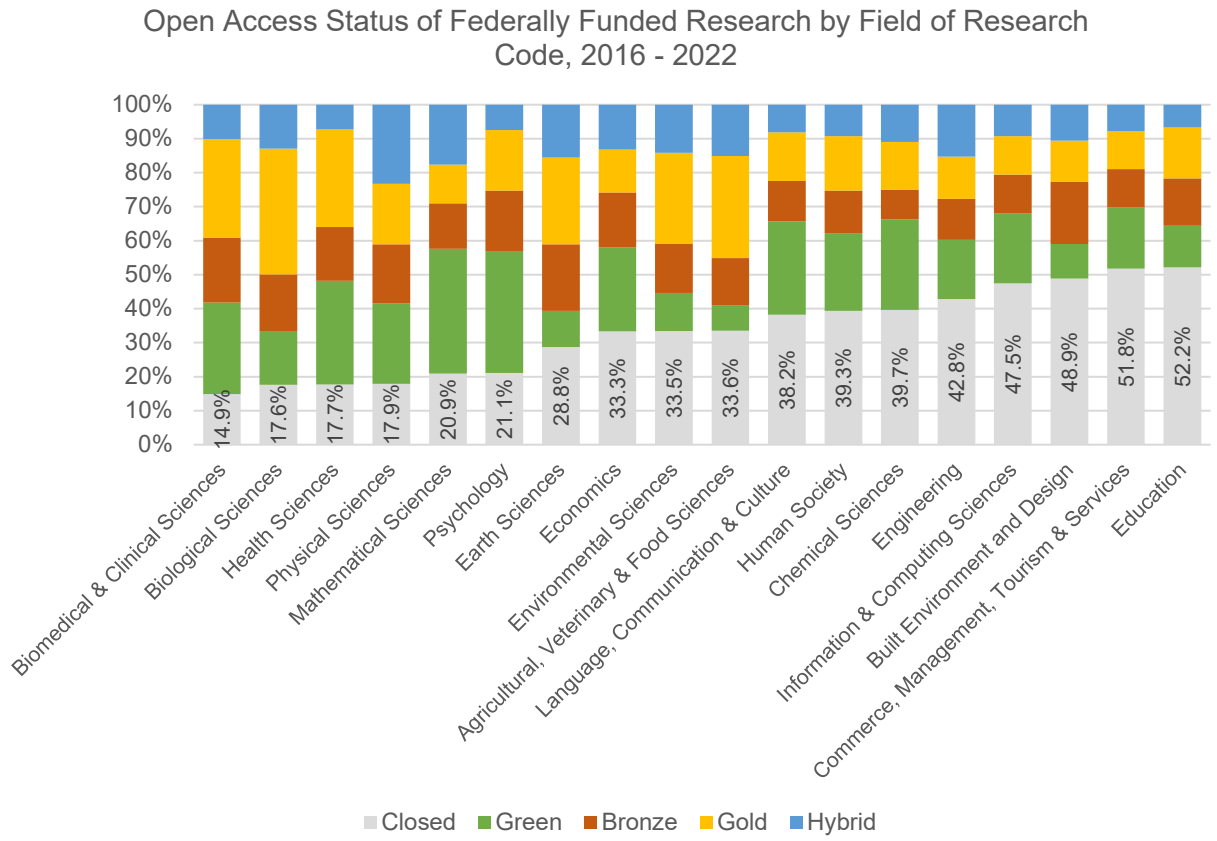

Figure 13. Open access status of federally funded publications authored between 2016 and 2022 broken out by Field of Research, using data from Schares.[74]

Both analyses point to possible domain-specific differences in routes to public access compliance. Uptake of open access publishing is much higher in the biomedical and life sciences than in technology and the arts and humanities. These differences may be due to a variety of factors including:

- **Funding support for a given area of research.** Federal funding support for various research disciplines varies, though researchers may of course have access to funding from non-federal sources. Figure 14 illustrates trends in federal research funding by discipline from FY2016 - 2021.[78] Disciplines with less funding may publish a smaller number of publications, irrespective of open access business models.[110] In addition, researchers in the social sciences and humanities — fields with less federal grant funding — more frequently publish monographs, which may impact the rate of publication, as described later in this section. While the categories used by NCSES do not directly map to those from Web of Science or ANZSRC, OSTP did find some correlation between levels of

[110] Segado-Boj, F., Prieto-Gutiérrez, J.-J., & Martín-Quevedo, J. (2022, May 10). Attitudes, willingness, and resources to cover article publishing charges: The influence of age, position, income level country, discipline and open access habits. *Learned Publishing, 35*(4), 489-498. doi:10.1002/leap.1455

funding and volume of publications, though there does not appear to be a correlation between level of funding and mode of open access publishing.

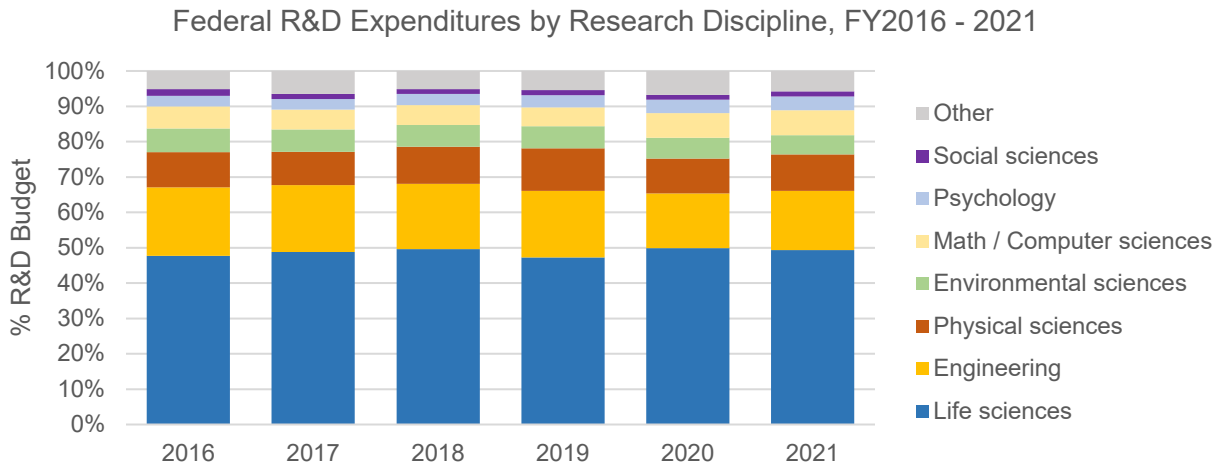

Figure 14. Proportion of federal research obligations by field of science and engineering for 2016 to 2021. Note that the proportion of obligations for 2021 are preliminary.

- **Availability of established fully open access journals** for publishing in a given discipline (Figure 15). There are relatively fewer open access journals in the social sciences and in the arts and humanities, for example, so researchers in these fields may be more likely to opt for self-archiving their publications through the Green open access route to comply with public access policies.

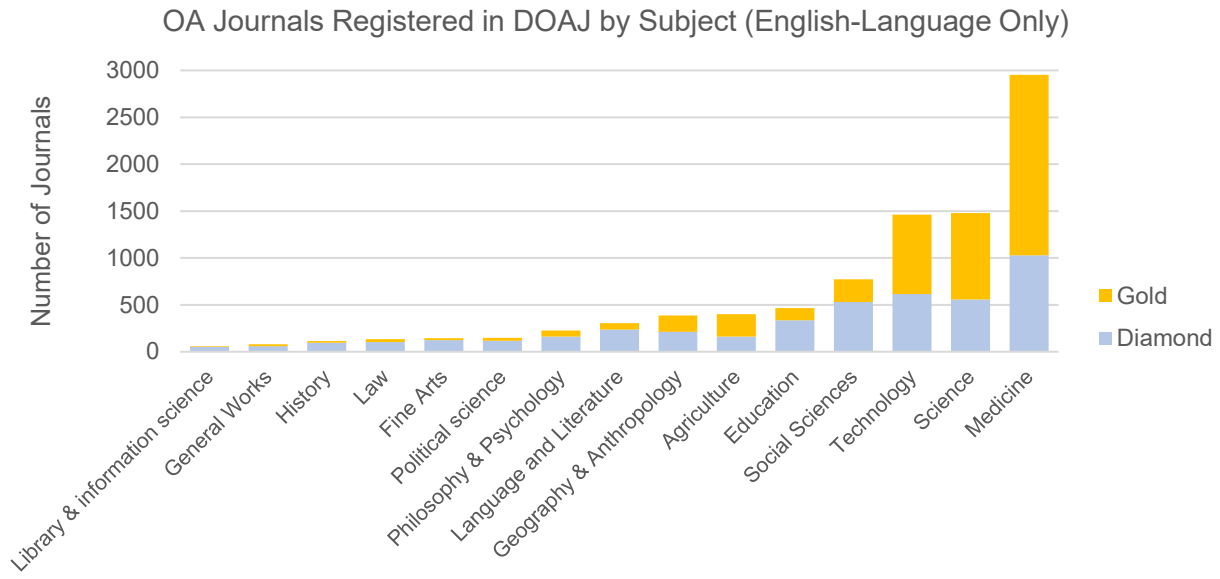

Figure 15. The number of English-language only open access journals registered in the Directory of Open Access Journals (DOAJ) by subject area.[111] "Gold OA" journals charge an APC and "Diamond OA" journals do not.

[111] DOAJ lists 529 subjects in their directory. For simplicity, OSTP used the highest-level term for subject area to arrive at the 15 subject areas in Figure 20.

- **Experience complying with public access policies.** NIH-funded researchers have more experience with public access policies, as NIH's original public access guidance went into effect in 2008.[75] These researchers may therefore have more familiarity with the open access landscape, including business models for enabling public access, as well as options for compliance with public access policies, including rights retention strategies to enable Green open access.
- **Publication format.** While STEM researchers tend to publish articles in journals, scholars in the arts, humanities, and parts of the social sciences commonly publish their research as monographs, which are not currently covered by federal public access policies. While this report has focused on peer-reviewed articles published in journals, open access monographs come with a unique set of considerations and challenges beyond the scope of this report.[104] Other disciplines, such as the computer sciences, tend to publish their research as juried conference proceedings, which are covered by some agency public access policies. Still other researchers with more of a focus on community engagement may choose to publish in non-academic outlets for greater accessibility of their work; these publications are not covered by public access policies.
- **Disciplinary expectations.** Different disciplines have different expectations around how much and how often a researcher should publish, influenced by a variety of factors including level of funding, length of publication (such as the length of an article versus that of a monograph), and other domain-specific norms. Different fields of research also have differing delays between submission of a manuscript and completion of the peer review process, which may also impact the volume of publications by discipline.[112]
- **Trends in preprint publishing** Long a part of information dissemination in mathematics, physics, and economics, preprints are currently gaining popularity in computer science and the biological sciences, as discussed in in Section 2.[54,56] While public access policies only apply to peer-reviewed scholarly communication, using preprints as a demonstration of productivity may ease the pressure to publish in journals. Of course, the peer review process and publication in journals lends a sense of authority and approval from the community; nevertheless, opportunities for the research community to weigh in on preprints can help authors increase the quality of their work — or pursue a different line of inquiry — before an article is submitted for formal peer review.

7. Data Needs for Further Analyses

In the generation of this report, OSTP has identified a number of limitations in available data to undertake the analysis Congress has requested. As noted in the Executive Summary, the lack of publicly available and consistently collected information on fees paid to publishers — whether to read or publish scholarly literature — makes it difficult to track federal expenditures that go towards the scholarly publication industry. These limitations are echoed in similar analyses undertaken by research institutions and policymakers around the world to monitor financing trends in scholarly publishing.[42,113]

[112] Björk, B.-C., & Solomon, D. (2013, October 4). The publishing delay in scholarly peer-reviewed journals. *Journal of Infometrics, 7*(4), 914-923. doi:10.1016/j.joi.2013.09.001

[113] United Kingdom Research and Innovation. (2021). *Economic Implications and Benefits of Updated UKRI Open Access Policy.* UKRI. Retrieved from https://www.ukri.org/publications/economic-implications-and-benefits-of-updated-ukri-open-access-policy/

In addition, there is limited self-reported demographic information available to develop a comprehensive understanding of who is publishing, from which institutions, and through what routes of compliance for public access policies. Some of these data needs may be addressed by requirements around digital persistent identifiers (PIDs)[114] and metadata, as outlined in Section 4 of the 2022 Memorandum. For example, PIDs for authors may include self-reported demographic information, fields of research, and institutional affiliations to provide a clearer picture of who gets to publish and how. Other data needs, such as those described below, present opportunities for collaboration with external stakeholders.

7.1 Tracking expenditures on APC fees and transformative agreements

In the United States, open access fees — as well as other fees associated with publishing, including page charges — to publish scholarly literature come from many different sources, including individual researchers, libraries, and other institutional funds. These expenditures may be offset in a number of ways including through discounts and waivers, as well as transformative agreements. Further, these fees are not centrally reported to funders. To better capture and track these expenditures, there are opportunities for:

- **More standardized and structured funding disclosures associated with publications.** Currently, there is a great degree of variability in how funding sources are reported to publishers. This analysis required utilizing databases that infer funding information in part from text-mining the free-text Funding and Acknowledgements sections of articles. Such text-mining analysis may miss nuances of cited funding; for example, an author may reference a reagent developed with NIH funding, though NIH may not have funded any of the authors. These sections could also note the funding source for APCs or whether a discount was applied, in the case of articles made publicly accessible through the APC-based Gold or Hybrid OA routes, to understand how these fees were financed. Such reporting on the publishing side can provide for more accurate estimates.
- **Direct budgeting and reporting of publishing fees by researchers.** The 2022 Memorandum recommends agencies allow researchers to include reasonable publication costs as allowable expenses in all research budgets. Agencies could also request grantees and agency researchers (i.e., intramural researchers) specifically estimate these fees either as a line item in their budget requests or as part of their final reporting.
- **Systematic collection of data on expenditures towards publishing fees by research institutions.** As noted throughout this report, researchers can finance publishing fees by drawing on a number of different sources, ranging from federal or private grants to library or other institutional funds. In addition, researchers at different institutions who co-author a given article may choose to split APC fees among contributing authors, further complicating OSTP's ability to track federal expenditures that have financed APCs. OSTP's calculations in Section 4.3 are therefore likely to overestimate the fees paid through federal research support. To arrive at more precise estimates and track these expenditures over time, research institutions could systematically collect data on fees their researchers pay and the sources of funding to cover those fees. Developing

[114] See the NSPM-33 Implementation Guidance for definition: A digital identifier that is globally unique, persistent, machine resolvable and processable, and has an associated metadata schema

centralized and consistent definitions of such information remains a challenge, however. A potential vehicle for such data collection is the Institute for Research on Innovation and Science (IRIS), a consortium of 42 research universities that share administrative data, including transactions from grant funding, for research and reporting.[115]

- **Systematic collection of data about transformative agreements made by libraries, consortia, and research institutions.** OSTP was unable to estimate accurately how much federal funding has gone towards financing transformative agreements because these agreements are typically negotiated between research institutions and publishers, rather than being financed directly from grants. While some transformative agreements follow principles of price transparency, it is difficult to tease out exactly how much of federal investments have gone towards financing such agreements. Libraries, consortia, and research institutions negotiating these agreements may register some of this information with the ESAC Initiative;[116] however, this reporting does not include the exact number of articles published, whether the articles were published by federal grantees, and the degree to which federal funds were used to support these agreements.

Federal agencies are also supporting research on what constitutes a reasonable cost for publishing. For example, NSF has funded an Early-Concept Grant for Exploratory Research (EAGER) award to investigate costs involved in making research outputs publicly accessible, including investigating how much U.S. researchers and institutions pay directly or indirectly to make federally funded outputs publicly accessible and how these publishing fees align with the costs of publishing.[117] In addition, NIH has supported a multiday National Academies public workshop to discuss steps that Health and Human Services (HHS) agencies can take to ensure public access policies promote equity in publishing opportunities for their supported researchers.[118] There is also a need for greater pricing transparency to understand what is included in publishing charges; some publishers, like EMBO Press, have taken steps to increase financial transparency, as discussed in Section 4.

7.2 Tracking subscription expenditures

In addition to more data on expenditures to publish scholarly literature, there is a need for a more comprehensive understanding of how much money has flowed to publishers through subscriptions. As discussed in Section 5, some have posited that there is enough money invested in the scholarly publishing system to enable a sustainable transition to free and immediate access to scholarly publications resulting from federally funded research.[80] It is unclear, however, how much has flowed into the subscription system, the extent to which these investments come from federal dollars, and the degree to which these money flows align with the cost of publishing and the additional services different publishers provide — from commercial publishers to nonprofit scholarly or professional

[115] See Institute for Research on Innovation & Science (IRIS): https://iris.isr.umich.edu/
[116] See ESAC Transformative Agreement Registry: https://esac-initiative.org/about/transformative-agreements/agreement-registry/
[117] See NSF Award Abstract #2330827, "EAGER: Investigating reasonable costs to achieve public access to federally funded research and scientific data": https://www.nsf.gov/awardsearch/showAward?AWD_ID=2330827
[118] See National Academies workshop on "Enhancing Public Access to the Results of Research Supported by the Department of Health and Human Services": https://www.nationalacademies.org/event/40741_11-2023_enhancing-public-access-to-the-results-of-research-supported-by-the-department-of-health-and-human-services-a-workshop

society publishers. As more literature around the world becomes freely and immediately accessible, libraries may reduce spending on traditional subscription fees, opening up institutional budgets to support APCs, as well as non-APC-based publishing alternatives, such as community-driven publishing initiatives (e.g., Diamond OA journals) and Subscribe to Open (S2O).

To understand how money is flowing within institutions requires understanding subscription expenditures over time. In general, subscription pricing deals are protected by non-disclosure agreements, though organizations like the Association of Research Libraries (ARL) and the Association of College and Research Libraries (ACRL) do collect data on aggregate subscription expenditures. This report has specifically leveraged longitudinal data collected by ARL on its member libraries (see Section 2); however, OSTP was unable to locate comprehensive publicly available data on subscription expenditures at various institutions, including primary schools, colleges, public libraries, and hospital and health sciences libraries. Further, it would be useful to understand how much different institutions — including MSIs, HBCUs, HSIs, R1 or R2 universities, liberal arts colleges, and technical colleges — pay as more research becomes publicly accessible. Understanding these trends in tandem with expenditures related to open access publishing will provide a more complete picture of how money flows are changing over time in response to federal public access policies.

7.3 Understanding researcher behaviors and attitudes

As OSTP and federal agencies continue collaborating and coordinating on public access policy development and implementation, engaging with impacted communities — including researchers, librarians, research institutions, and publishers — remains a top priority. Several agencies, including NIH, NASA, and AHRQ, have issued opportunities for public comment on draft public access plans; a number have hosted town halls, webinars, and listening sessions, including NSF, USDA, and OSTP. Agencies have also collaborated with external communities on joint webinars and listening sessions.

As the U.S. government continues to promote a more open, equitable, and secure research ecosystem, there are also opportunities for collecting and synthesizing more qualitative and quantitative data to understand researcher behaviors around publishing and public access policies. Of particular interest:

- **Leveraging OSTP's expectations around the use of persistent identifiers** for individual researchers and grant awards, as outlined in Section 4 of the 2022 Memorandum, to better track publishing patterns as they relate to individuals, research domains, particular research institutions, and federal granting institutions over time. While bibliometric studies have been conducted to understand such patterns, there are limitations to these studies based on inferring, for example, demographic characteristics and funding sources from names or free text.
- **Surveying or conducting focus groups with a representative sample of federal researchers** and grantees on their awareness and attitudes around different models for making research freely and immediately available, including through non-APC-based publishing models (i.e., Green and Diamond OA). In addition, there is a need for further study on how APC rates may — or may not — influence decisions around where to publish, and how these decisions may vary based on a researcher's discipline, career status, institutional affiliation, and level of funding support.

Ultimately, what causes researchers to read, write, or publish as they do cannot be fully explained by counting articles or dollars. Those numbers are the aggregated results of such decisions and only give

hints about what researchers, funders, and publishers are thinking. To understand trends in those attitudes and behaviors better will require carefully designed surveys and focus groups.

Conclusion

A major theme cutting across this report is that the landscape of scholarly publishing is changing rapidly. The reasons not only pertain to global policy developments, but also changes in communications technology, research culture, scientific practice, funding patterns, market factors, university expectations, and more. OSTP and its federal partners will continue to monitor trends and developments in this landscape and explore opportunities for meeting the data needs described in Section 7. OSTP greatly appreciates the commitments of the Appropriations Committees of the House and the Senate to the deliberate, effective, and equitable implementation of federal public access policy, and to making government-supported research more accessible and useful to the public, industry, and the research community. Collaborative implementation of the 2022 Memorandum, led by agencies across the federal government, engaged with diverse stakeholders, and working closely with OSTP and the NSTC Subcommittee on Open Science, will ensure that all Americans benefit from access to and use of federally funded research and data in discovery, innovation, and policymaking.

Appendix A. Economic Concepts and Context

To interpret the economic data requested, some concepts and context may be helpful:

A.1. Cost Estimates

Businesses incur costs when delivering goods and services. Publishers of academic papers, for example, have traditionally provided both quality control as well as product distribution.

a. **Marginal Costs** are the change in total costs due to an extra increment in the quantity produced. Technology has, for example, made the marginal cost of distributing a paper to one more reader nearly zero. The marginal cost of considering one more paper for acceptance can also be small, particularly since peer reviewers and academic editors are almost all unpaid. While professional editors at high quality journals may put considerable time and effort into improving and preparing a draft paper, there are predatory journals that will publish nearly anything for a fee.
b. **Fixed Costs** are the expenditures to stay in business independent of the quantity of goods or services produced. Often called overhead or indirect costs, these are the other component of total costs. Their recovery cannot be ignored even though discussions often focus on marginal costs. Many economic challenges concern how society pays for items with high fixed costs but low marginal ones. Pharmaceuticals, newspapers, music, infrastructure, and transportation are all examples that are expensive to produce but cheap to reproduce in this way.
c. **Cross Subsidies** exist when a firm uses money from one product or source to pay the costs of a different product. These make it especially hard to estimate fixed or marginal costs accurately, even for firms with access to their own proprietary data. Cross-subsidization is common both in large for-profits and small non-profit businesses. While non-profits can make a profit, whether from conference fees, membership fees, or other revenues, they have to re-invest excess earnings to further the organization's purpose rather than simply distributing them to shareholders.

A.2. Fee Payers

Though sometimes also referred to as costs, the payments made in order to publish an academic paper are better thought of as fees and distinguished according to who can, at least in principle, negotiate the amount.

a. **Author Payments** to publishers have traditionally been fees associated with, for example, color figures and the number of pages. An article processing charge (APC) refers to the payment required to make an article open access, though other publication fees may still be levied even for articles that appear behind a paywall. Authors may be able to negotiate discounts or licensing guarantees, and can sometimes retain copyright to their own work. Their payments can therefore vary widely.
b. **University or Institutional Payments** to publishers include payments from libraries for subscriptions, either individually or in bundles. There is a growing trend among some publishers and institutions to negotiate transformative agreements, an umbrella term that encompasses a range of different kinds of contracts that may include traditional subscription licenses and APC discounts or waivers that may cover a certain number of articles that may be published in hybrid or fully OA journals. These agreements are described in further detail in Section 5.

c. **Funders' Payments** for the dissemination of research results are traditional budget lines in most grant proposals. The amounts requested may rise, both for federal and philanthropic research sponsors, as some publishers seek to replace subscription fees that libraries may have less reason to pay. Some private grant-makers have taken to funding publishers directly either to keep non-profits in business or to support workstreams of particular programmatic interest. Again, these arrangements are idiosyncratic and not easy to track.

A.3. Price Determination

The determination of publishing charges is, as in many other contexts, determined by market forces.

a. **Market Prices** balance supply and demand without directly depending on either cost or benefit considerations alone. In perfectly competitive situations, with many buyers and sellers of the same product under ideal conditions, the equilibrium price will equal the marginal cost of production (P=MC). That outcome will also exhibit desirable properties both for individual agents and for society as a whole. Perhaps that is one reason why, as the marginal cost of distributing an article online has effectively dropped to zero, many have concluded that the price for reading it should also be zero. But even if P=MC makes sense in certain settings, firms still have fixed costs to recover in order to stay in business and this will not be possible without revenue. Note also that behavioral economists have emphasized that people deal in practice with zero prices quite differently from other price levels, even vanishingly small ones.
b. **Market Power** occurs in less competitive markets, allowing firms to change their behavior to increase profits or advance other interests at the expense of consumers.[119] High levels of market power are associated with higher prices and lower quantities than desirable, as well as inefficiencies and lack of innovation. How much bigger the price P will be than MC depends on e, the price elasticity of demand, which measures the percentage change in quantity demanded when there is a one percent increase in price. The more inelastic the demand (i.e., the smaller |e|), the more sellers can charge. Arguably, the total demand for acceptances in top journals is rather insensitive to price changes and exceeds the supply in any case. By banding together to gain market power, for example, through transformational agreements, buyers can often try to negotiate collectively for lower prices and lower transactions costs than could be obtained individually.
c. **Price Discrimination** is the term for when a given provider sells very similar, if not identical, goods or services at different prices to different segments of a given market. This practice is incompatible with perfect competition but can boost profits for sellers that do have market power by setting prices higher than the competitive one. First-degree price discrimination occurs when the seller charges a different price to each buyer that approximates that individual's own reserve price (the highest he or she would be willing to pay). Second-degree price discrimination refers to varying the price of the same good according to the quantity demanded. And third-degree price discrimination means charging different groups according to their elasticity of demand by, for example, offering off-peak or senior discounts. In all three cases, there is a transfer to the seller of "consumer

[119] OIRA. (2023). *Guidance on Accounting for Competition Effects When Developing and Analyzing Regulatory Actions.* Office of Management and Budget. Retrieved from https://www.whitehouse.gov/wp-content/uploads/2023/10/RegulatoryCompetitionGuidance.pdf

surplus," that is, the aggregate benefit consumers would have enjoyed had they all been charged the competitive price. While such price discrimination may be perfectly legal, consumer surplus is a key factor that antitrust authorities take into account when conducting competition reviews. Price discrimination also makes it particularly difficult to report accurately on what *the* price is for a given good or service.

A.4. Platform Economics

Organizations that create value primarily by facilitating interactions between *two distinct groups of users* are called platforms. Examples include credit cards (cardholders and merchants), health maintenance organizations (doctors and patients), or academic publishers (article readers and article writers).

a. **Network Effects** come about when the value a user derives from a good or service depends on the total number of users of products that are the same or compatible. Gamers on a given platform experience positive network effects to the extent they enjoy interacting with more people Similarly, there may be more benefits to becoming a user of a common platform than one that is more niche. Network effects can also be negative in the case of overcrowding, for example.
b. **Two-Sided Markets** are platforms where, due to same-side or cross-side network effects, each group of users has preferences about the number of members either in their group or in the other group (or both). No consumer wants to hold a particular credit card unless it is accepted by lots of merchants, for example, and no merchant wants to accept that credit card unless it is held by lots of consumers. Similarly, no one wants to routinely read a particular journal unless it has good writers, and those writers will not want to publish in that journal unless it has lots of regular readers. In principle, platforms can set negative or positive prices for either side of such a market. Profit maximization, for example, requires subsidizing the more price sensitive (inelastic) side while charging the side whose demand increases more strongly in response to growth on the other side. Such pricing decisions can, in any case, have dramatic effects not just on demand but on market behavior generally.
c. **Market Dominance and Regulation** can be challenging in such situations. It is common for the winner to take all in two-sided markets with positive network effects, especially if consumers incur considerable costs by affiliating with more than one platform (multihoming). Strategies for regulating two-sided markets are underdeveloped, both in theory and in practice, if the goal is to improve social benefits rather than business profits. Controlling prices, mergers, or multihoming costs when viewed from one side can have complicated and unexpected repercussions when viewed from both sides. Data needs to devise policies that are socially optimal are also difficult to pinpoint. To estimate the effect of changing one variable on another, routine observational data can only provide hints rather than reliable causal inferences in any case.

A.5. Financing Public Goods and Club Goods

The public good is a different concept from *a* public good. To an economist, the latter is a technical term for a kind of commodity with two defining characteristics: it is *nonrival*, meaning that one user does not deplete the good's availability to others; and it is *nonexcludable*, meaning that usage is hard to prevent once the good is available. Examples include lighthouses, unfenced parks, unpatented discoveries, and

national defense. There are basically two and a half ways to support a public good: taxes, philanthropy, and bundling its provision with an excludable good when possible. An example of this last strategy is charging park visitors for parking a car. A club good, by contrast, is nonrival but excludable. Viable ways to charge user fees are possible in that case.

Information as a Commodity fits the definition of a public good. Besides being nonrival and nonexcludable under normal circumstances, it also has another challenging economic property. In contrast to other commodities, estimating the value of a particular piece of information is difficult until after you have taken possession of it. For example, one may pay to retrieve an article from behind a paywall only to find it does not meet their needs. The idea that each consumer has a reserve price reflecting maximal willingness to pay is therefore especially hard to pin down in this context.

A.6. Academic Incentives

For routine consumer purchases, shoppers decide whether or not an item is worth buying at a given price based on introspection about the satisfaction it is expected to deliver. The value of publishing an article, in contrast, depends on expectations about what others will think of it. Higher prices usually lower demand for most commodities. Cases where that does not hold because of social status considerations are called positional goods.

a. **Prestige Economies** are what anthropologists call social systems where the pursuit and conferral of approbation explains actions as much, if not more, than the pursuit and conferral of money. Familiar intuitions about economics need not apply. Consider, for example, Merton's observation that the academic marketplace for ideas is the only economic sector in which you come to own something only by giving it away.
b. **Quality Proxies** are ways of gauging status. Reputation may be a kind of currency in the academic world, but it is hard to quantify because it depends on judgements made by the broader community. Time and effort pour into peer, hiring, tenure, and proposal reviews, so quality proxies are useful to guide these processes. The research community thus relies on relative rankings, determined through metrics such as citation rates, impact factors, and publication counts, though these are known to be imperfect — and even flawed — measures of research quality. There are currently efforts underway to better align research assessment with research quality and researcher impact.
c. **Curation Services** are arguably worth more attention and funding even though most discussion focuses on the ranking and distribution functions of academic publishing. As for the latter, distribution costs have dwindled due to digital technologies. Ranking processes are also evolving, but almost by definition, their legitimacy depends more on community leadership than on policy initiatives. Clearly desirable in any case would be to concentrate more on new curatorial incentives and mechanisms for delivering answers to important research questions in reliable, readable, and readily accessible ways.