Innovation in the public sphere:*
reimagining law and economics to solve
the National Institutes of Health
publishing controversy

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ABSTRACT
The National Institutes of Health (NIH) are responsible for the largest proportion of biological science funding in the United States. To protect the public interest in access to publicly funded scientific research, the NIH amended terms and conditions in funding agreements after 2009, requiring funded Principal Investigators to deposit published copies of research in PubMed, an Open Access repository. Principal Investigators have partially complied with this depository requirement, and the NIH have signaled an intent to enforce grant agreement terms and conditions by stopping funding deposits and engaging in legal action.

The global economic value of accessible knowledge offers a unique opportunity for courts to evaluate the impact of enforcing ‘openness’ contract terms and conditions within domestic and international economies for

* Jürgen Habermas, The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeois Society (Thomas Burger et al. trans., 1962). The turn of phrase, ‘public sphere’ (original German: Öffentlichkeit), is largely attributed to Habermas and his description of where and in which contexts unfettered, class-neutral, deliberative democracy has persisted, in particular, the 18th century French salons and German Tischgesellschaften. The author adopts this to reiterate the criticality of a public sphere, a place where ideas can be publicly exchanged without barriers.

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Electronic copy available at: http://ssrn.com/abstract=2587291
public and economic benefit. Through judicial enforcement of Open Access terms and conditions, the United States can increase economic efficiency for university libraries, academic participants, and public consumers, while accelerating global innovation, improving financial returns on science funding investments, and advancing more efficient scientific publishing models.

**KEYWORDS:** open access, efficiency, grant agreement, law and economics, National Institutes of Health, scientific research

**INTRODUCTION**

What Des-Cartes did was a good step. You have added much several ways . . . If I have seen further it is by standing on the shoulders of Giants.1

The scientific research community depends on open knowledge sharing to increase the speed and effectiveness of scientific research, yet current publishing models reduce both the speed and efficiency of knowledge dissemination. The scientific practice is one of the largest industries in the world, and the US federal government spends more resources on scientific research than any other country:2 the National Institutes of Health (NIH), National Aviation and Space Association (NASA), National Science Foundation (NSF), and Agriculture Research Service will collectively spend $54 billion3 in 2014 or roughly $300 per tax-paying family (See Figure 1).4 As of 2009, the US government provided about 60 per cent of national science funding,5 1.4 million articles resulting from research funded by the American public.6

Because the US government funds such a significant proportion of science funding, countries worldwide are attempting to advance models for retaining access to publicly funded research in order to encourage knowledge dissemination. In the United States, the NIH have taken more direct approach by amending grant funding terms and

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1 ISAAC NEWTON, THE CORRESPONDENCE OF ISAAC NEWTON 416 (2nd ed., Herbert W. Turnbull ed., 1959). Isaac Newton was corresponding with his rival, Robert Hooke. See JOHN OF SALISBURY, THE METALOGICON OF JOHN SALISBURY: A TWELFTH-CENTURY DEFENSE OF THE VERBAL AND LOGICAL ARTS OF THE TRIVIUM 167 (Daniel D. McGarry trans., 1159). Several others adapted an original quote by Bernard de Chartres, in conversation with John of Salisbury, ‘nos esse quasi nanos gigantum humeris insidentes’, (we are as dwarfs sitting on the shoulders of giants).

2 John F. Sargent, Jr., Federal Research and Development Funding: FY2013, Congressional Research Service, https://www.fas.org/sgp/crs/misc/R42410.pdf (last accessed Sep 13, 2014).

3 Id. Today, the United States invests a total of $465 billion in R&D activities. See also Jeffrey Mervis, U.S. Science Agencies Get Some Relief in 2014 Budget, SCIENCE MAGAZINE, Jan. 14, 2014, http://news.sciencemag.org/funding/2014/01/u.s.-science-agencies-get-some-relief-2014-budget (last accessed Sep 13, 2014). The proposed federal budget for 2013 includes $29.9 billion for NIH funding, $16.9 billion in funding for NASA, and 7.2 billion in funding for the NSF.

4 Jeanne Sahadi, 43% Pay No Federal Income Taxes, CNNMONEY, Aug. 29, 2013, http://money.cnn.com/2013/08/29/pf/taxes/who-doesnt-pay-federal-income-taxes/ (last accessed Sep 13, 2014). See also Chuck Marr & Chye-Ching Huang, Misconceptions and Realities about Who Pays Taxes, (2013), http://www.cbpp.org (last accessed Sep 13, 2014); U.S. Census Bureau, State and Country QuickFacts, U.S. Census Bureau Website, http://quickfacts.census.gov/qfd/states/00000.html (last accessed Sep 13, 2014). There are approximately 316 million families, and about 180 million of these families are taxpaying.

5 National Science Foundation, Chapter 5, Academic Research and Development, National Science Foundation Website, http://www.nsf.gov/statistics/seid12/c5/c5h.htm (last accessed Sep 13, 2014).

6 See Sahadi, supra note 4; National Science Foundation, supra note 5; and Cope & Kalantzis, infra note 7.
conditions to require funding recipients to deposit peer-reviewed research publications in PubMed, an Open Access (OA) repository, and are the first global government agencies aiming to legally enforce this contractual requirement.

Globally, the knowledge dissemination issue is just as pressing. As of 2008, nearly 5.7 million individuals worked in global R&D, publishing 7.6 million articles per year and consuming nearly 100 articles for every article published. Like the United States, governments around the world fund the vast majority of research resulting in these articles, about $1.62 trillion globally per year, 1.8 per cent of global gross domestic product (GDP). With an exponential increase in research conducted worldwide, especially in developing countries, existing models for knowledge dissemination cannot support efficient global knowledge sharing.

Scientific research agenda depend on efficient knowledge-sharing systems that not only maximize available resources, but also effectively organize resources for maximum overall accessibility, usability, and scientific verifiability. This paper investigates potential solutions for a global problem, analyzing the US NIH case to evaluate potential solutions and associated economic outcomes. In part I, the author describes the current state of scientific publishing: the role of impact factor, the traditional publishing model, and alternative OA models. Part II describes the NIH grant’s publishing terms and conditions and applicable public contract law in the United States surrounding this controversy.

In order to analyze the effect of court holdings on market conditions, part III analyzes the NIH publishing controversy using positive and normative law and economics analyses, including comparative market outcomes between enforcement and non-enforcement of grant terms and conditions. In part IV, the author recommends

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7. Bill Cope & Mary Kalantzis, Signs of Epistemic Disruption: Transformations in the Knowledge System of the Academic Journal, 14 First Monday (Bill Cope et al. eds., 2009). Nearly 1.8 million articles would have been produced in the United States, http://firstmonday.org/article/view/2309/2163 (last accessed Dec 9, 2014).

8. R&D Magazine, Global Funding of R&D, R&D Magazine, Dec. 9, 2013, http://www.rdmag.com/articles/2013/12/global-funding-r-d. This funding includes R&D investment, as well as governmental science funding, including defense investments. Global gross domestic expenditure on R&D (GERD) is $1576 billion, and the United States GERD is $465 billion (publishable science 13 per cent of total). See also International Monetary Fund, World Economic Outlook: Hopes, Realities, Risks, International Monetary Fund Org., http://www.imf.org/external/pubs/ft/weo/2013/01/pdf/text.pdf. Global GDP growth for 2014 is approximated at about 4 per cent from 3 per cent in 2013.
enforcement of open repository deposit provisions and evolution of knowledge dissemination models to improve global research market outcomes and enhance public benefit.

PART I. SCIENTIFIC PUBLISHING MODELS
Publishers have effectively maximized the traditional publishing business model for commercial gain, leveraging university library dependence on large commercial publishing titles, engaging academics to review articles for free, negotiating exclusive copyright licenses with authors, and purchasing smaller, successful journals. While the invention of the Internet has advanced alternative publishing models such as green OA self-archiving, non-peer-reviewed and peer-reviewed gold OA journals, externally funded and author-pays models, these alternative publishing models still occupy only one-tenth of scientific publishing today.\(^9\) Despite less market dominance, strong advocacy from the scientific community is slowly influencing traditional publishing, with hybrid and embargo models emerging for dominant publishing companies.

Impact factor
Eugene Garfield and his company, the Institute for Scientific Information (ISI), originally mapped references for all journals in science and technology to determine the criticality of journals to their respective fields, ‘impact factor’.\(^10\) By 1980, Thomson Reuters had purchased ISI and began using ‘impact factor’ as a marketing tool to sell the most cited journals from their collection.\(^11\) University tenure boards quickly began using the same measurement to evaluate tenure applicant contributions, counting ‘high-impact’ articles published,\(^12\) effectively incentivizing scientific authors to publish in ‘high-impact’ journals.\(^13\) This focus on impact factor mostly favored for-profit, large publishing companies with extensive distribution, over smaller publishing companies and university presses. As large publishing companies gained market share, these companies purchased remaining high-impact journals owned by smaller companies, retiring competitor journals and retaining highest impact titles to maximize returns.\(^14\)

\(^9\) Idea, Open Access Journals are 10% of Journals: Findings from SOAP, Idea.org Website (Apr. 4, 2011), http://www.idea.org/blog/2011/04/04/open-access-journals-stats-by-field-key-facts/. This publishing also includes self-archiving, which does not include peer review.

\(^10\) Eugene Garfield, Citation Analysis as a Tool in Journal Evaluation, 1 ESSAYS AM. SCIENTIST 527, 529 (1962–1973).

\(^11\) C. Dumontier, R. Nizard, & A. Sautet, Impact Factor or Do We Choose Between the Impact Factor and the Revue de Chirurgie Orthopedique? 87 REV. CHIR. ORTHOP. REPARATRICE APPAR. MOT. 115, 128 (2001), http://www.ncbi.nlm.nih.gov/pubmed/11319423. Impact factor was originally invented in the 1960s but did not enjoy wide appreciation by tenure committees for some time.

\(^12\) Per O. Seglen, Why the Impact Factor of Journals Should Not Be Used for Evaluating Research, 314 BMJ 498, 502 (1997), http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2126010/ (last accessed Sep 12, 2014). At the time, both the inventor of impact factor and the journal Impact Factor notified readers not to determine individual article success based on the impact criterion—it was primarily a measure for the journal, not the researcher. The impact factor for journals uses each article’s impact factor published in the journal and divides by the total number of articles.

\(^13\) Tenure committees gravitated to the heavy use of impact factor for journal subscriptions and began using impact factor to determine the degree of scholarly contribution. Impact factor is typically calculated for each article by calculating the times other authors cite the article in question within a limited time period or, more frequently, the impact factor of the journal where an article is published.

\(^14\) See Royal Society Publishing, infra note 18. This business strategy eliminated competition and allowed large publishing companies to control dissemination and increase prices.
Publishing companies also negotiated long licensing periods with authors as a condition of publication, extending the length of time they could charge an access fee for each work. These activities cemented large commercial publishers in the publishing industry and dramatically reduced competition.

Large commercial publishers and traditional publishing

Historically, large commercial publishers employed traditional publishing models, offering journal copies in print form, employing full paywalls for online versions of articles, using a selection process (typically peer review), and negotiating lengthy licensing terms with authors. Traditional publishing models use subscription fees to cover the cost of marketing, operations, and distribution, focusing on attracting individual downloads and subscriptions to cover costs. Traditional publishing companies today offer a hybrid publishing model, in particular dropping paywalls for archived articles or after embargo periods or adopting OA titles. Other journals give the authors a choice: authors may publish OA if they pay an upfront fee.

In the United States, scientific publishing products provide 52 per cent of overall scientific publishing revenue or $12.2 billion in gross revenue per year, making the United States the largest consumer of scientific publishing products. The four largest commercial scientific publishing companies include Reed Elsevier, Springer, Wiley, and Informa, accounting for nearly 53 per cent of global scientific publishing, with

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15 Most publishing contracts include ‘take it or leave it’ terms, leaving the academic unable to reuse, reproduce, or disseminate his/her own work. Academics who traditionally garner more citations (eg preeminent leaders in a field) tend to wield better bargaining power and often can negotiate better terms.

16 Paywalls are screens that provide limited information about an article (ie a citation, an abstract, or a few pages, but do not provide full article access unless payment is received, either by institutional access or direct payment). Paywalls are typically used with traditional journals with internet availability to prevent unauthorized access to journal articles.

17 John Willinsky & Laura Moorhead, Ch 8: How the Rise of Open Access is Altering Journal Publishing, Fut. Acad. J. 209 (2nd ed., Bill Cope & Angus Phillips eds., 2014).

18 See, eg, Royal Society Publishing, Open Access, Royal Society Publishing Website (2014), http://royalsocietypublishing.org/open-access (describing the OA options for traditional journals, listing OA journals, and listing a discount cost for institutions to publish OA); Royal Society of Chemistry, Open Access at the RSC, Royal Society of Chemistry (2014), http://www.rsc.org/publishing/journals/openaccess (describing the OA option for traditional journals, including paying a fee as an alternate to a traditional model); and Elsevier Website, Agreements, Elsevier Website (2014), http://www.elsevier.com/about/open-access/open-access-policies/funding-body-agreements (listing each journal and specific publishing options for each, for example self-archiving limitations and whether the journal is OA or OA friendly).

19 Mark Ware & Michael McCabe, The STM Report: An Overview of Scientific and Scholarly Journal Publishing, STM Association Webpage (Nov. 2012), http://www.stm-assoc.org/2012_12_11_STM_Report_2012.pdf

20 Heather Morrison, Freedom for Scholarship in the Internet Age (Jan. 21, 2012) (unpublished Ph.D. dissertation, School of Communication, Simon Fraser University) (on file with author), http://pages.cmns.sfu.ca/heather-morrison/open-thesis-draft-introduction-march-2011/. Morrison cites the following profits for the four largest publishers in 2010: Elsevier ($3 billion, 36 per cent), Springer ($1.3 billion, 34 per cent), Wiley ($380 million, 42 per cent), and Informa ($218 million, 32 per cent). Overall profits amounted to $4.9 billion, with a $1.8 billion margin (37 per cent margin). These margins are largely due to the publisher’s limited engagement in the publishing process. Because a publishing house is not able to effectively complete scientific reviews to identify if an experiment’s results are legitimate, peers are central to the process and often end up doing extensive work for free. While journals do manage the editing and publishing process, the writing and content review, usually uncompensated work, typically do not require heavy involvement from publishing companies.
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Margins of 35 to 40 per cent. Elsevier alone publishes 25 per cent of all scientific, technical, and medical articles. Despite hybrid and OA publishing models, many providing free or reduced price articles, journal subscription prices for hard science journals have increased 600 per cent between 1984 and 2001, and 11 per cent between 2011 and 2013 alone, causing some critics to accuse scientific publishers of anticompetitive and oligopolic practices, as commercial publishers attempt to offset reduced subscription volume amid library funding and space constraints.

Regardless of profits two to five times greater than publishers of periodicals or books, operating expenses have continued to rise for publishers, slowly reducing profit margin since 2000. This evidence seems to suggest that amongst OA competition and reduced library budgets, traditional and hybrid publishers have increased prices to compensate for reduced subscription volume. While only limited information on the larger scientific publishing industry exists to date, this inference seems to suggest that rising prices for high-impact journals could effectively reduce the journal subscriptions research libraries can afford.

Record profits aside, the traditional publishing model has its share of advantages and disadvantages. Traditional publishers are motivated by what will sell additional subscriptions, and these publishers know that academics influence research libraries to purchase subscriptions most necessary to their work. As a result, traditional publishers are economically motivated to provide well-written, peer-reviewed, and scientifically validated research, with novel contributions to the field. Without quality, journals would not maintain distribution and publishers would eventually retire them. Furthermore,

21 Library Journal, Coping with the Terrible Twins: Periodicals Price Study 2012, LIBRARY JOURNAL, Apr. 30, 2012, http://lj.libraryjournal.com/2012/04/funding/coping-with-the-terrible-twins-periodicals-price-survey-2012/#. In addition to financing concerns, libraries face space constraints, opting for digital versions often costing the same or more than print copies. See also E. Ray Dorsey et al., Finances of Publishers of the Most Highly Cited US Medical Journals, 99 J. MED. LIBR. ASS’N 255, 257 (2011), http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3133891/. Operating expenses for Reed Elsevier slightly reduced from 31.5 per cent operating margin in 2000 to 29.9 per cent operating margin in 2009, signaling very little change in operating expense despite significant journal price increases and reduced library operating funds.

22 David Litterick, Mps Damn Profits of Scientific Publishers, THE TELEGRAPH, July 20, 2004, http://www.telegraph.co.uk/finance/2890544/MPs-damn-profits-of-scientific-publishers.html

23 Bill Cope & Mary Kalantzis, Signs of Epistemic Disruption: Transformation of the Knowledge System of the Academic Journal, 14 FIRST MONDAY (2009), http://firstmonday.org/htbin/cgiwrap/bin/ojs/index.php/fm/article/view/2309/2163 see supra note 7.

24 Kenneth Rochel de Camargo, Jr., The Publishing Industry Against Open Access Journals, 46 REV. SAÚDE PÚBLICA SÃO PAULO (2012), http://dx.doi.org/10.1590/S0034-89102013005000006 (last accessed April 20, 2014). See also George Monbiot, Academic Publishers Make Murdoch Look Like a Socialist, THE GUARDIAN, Aug. 29 2011, http://www.theguardian.com/commentisfree/2011/aug/29/academic-publishers-murdoch-socialist. Overall, most call the market saturation of four primary scientific publishers evidence of an oligopoly, or a market where price reduction (and subsequent response by competitors) only reduces overall revenue, rather than increasing market share for the price reducer, the expected outcome of a competitive practice where a reduction in marginal cost should increase marginal supply, or the typical inverse behavior of supply and demand. Oligopolies in short represent a rational choice for members of the oligopoly—maximizing profits means stagnant or increasing prices, regardless of supply available.

25 E. Ray Dorsey et al., Finances of the Publishers of the Most Cited US Medical Journals, 99 J MED LIBR. ASS’N 255, 258 (2011), http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3133891/. Margin has only reduced from 31.5 to 29.9 per cent between 2000 and 2009, showing that the publishing model, while relatively stable, may have to incur more operating expense and raise prices to retain high historical margins.
inter-competition between journals incentivizes controlled expansion: if a publishing company like Elsevier has several journals with similar subject matter, selling more subscriptions reduces margin for their other journals, resulting in income cannibalization, unless effective 'bundling' can maximize subscription fees for the whole. Overall, the traditional publishing model has created a finely turned business model for maximizing profits.

The OA publishing model

Modern scientific publishing includes a variety of OA options including self-archiving repositories (green OA), author-pays and funded gold OA (peer-reviewed or non-peer-reviewed), and OA data repositories (often green OA). OA models, in particular gold OA, can be for-profit or non-profit, and owned by a small university press, non-profit organization, or large publishing company.

Scholars in the library sciences have championed OA as a solution to rising subscription costs amongst expense reduction agendas. Research universities can pay between $4000 to $20,000 per journal each year, and universities with large library budgets, like Harvard’s $150 million budget, devote half to journal subscriptions. As a result of these challenges, some universities have developed OA policies and started OA university presses. Large publishing companies have joined the OA movement, creating large OA journals like MedKnow, and megajournals like Springer Plus and SAGE Open. Despite the increasing number of OA journals each year, the OA journal model on its own cannot solve broader scientific publishing challenges.

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26 Gavin Simpson, *The Cost of Subscribing to Academic Journals*, From the Bottom of the Heap Blog (Mar. 4, 2012), [http://www.fromthebottomoftheheap.net/2012/03/04/the-cost-of-subscribing-to-academic-journals/](http://www.fromthebottomoftheheap.net/2012/03/04/the-cost-of-subscribing-to-academic-journals/). Bundling can obfuscate pricing—journals are sold together at a reduced price, though many journals bundled with popular titles are far less popular. This practice enables multiple titles to continue production, for libraries to negotiate for what appears to be a more cost-effective option, and for publishers to retain margin.

27 Peter Suber, *Open Access Overview*, Peter Suber Website (Dec. 16, 2013), [http://legacy.earlham.edu/~peters/fos/overview.htm](http://legacy.earlham.edu/~peters/fos/overview.htm)

28 Ted Bergstrom & Preston McAfee, *Journal Cost-Effectiveness 2011*, Journal Prices Website (2011), [http://journalprices.com/](http://journalprices.com/)

29 Harvard University, *Functional Classification of Operating Expenses*, Harvard University Financial Report Fiscal Year 2010 (2010), [http://cdn.wds.harvard.edu/fad/2010_full_fin_report.pdf](http://cdn.wds.harvard.edu/fad/2010_full_fin_report.pdf) (last accessed April 20, 2014).

30 Ian Sample, *Harvard University Says It Can’t Afford Journal Publishers’ Prices*, THE GUARDIAN, Apr. 24, 2012, [http://www.theguardian.com/science/2012/apr/24/harvard-university-journal-publishers-prices](http://www.theguardian.com/science/2012/apr/24/harvard-university-journal-publishers-prices)

31 Eric Priest, *Copyright and the Harvard Open Access Mandate*, 10 NW J. TECH. INTELL. PROP. 1 (2012), [http://scholarlycommons.law.northwestern.edu/cgi/viewcontent.cgi?article=1172&content=ntjip](http://scholarlycommons.law.northwestern.edu/cgi/viewcontent.cgi?article=1172&content=ntjip). Harvard’s arts and sciences faculty unanimously agreed to publish only in OA journals. See also Ray Delgado, *Faculty Senate Approves Resolution Regarding Pricey Journals*, Stanford Report, (Feb. 25, 2004), [http://news.stanford.edu/news/2004/february25/journals-225.html](http://news.stanford.edu/news/2004/february25/journals-225.html) (describing Stanford University’s Senate’s policy against publishing in Reed Elsevier titles); Paul S. Lapinski et al., *Supporting Public Access to Research Results*, 75 C. RES. LIBR. 20 (2014), [http://crllibrary.org/content/75/1/20.full.pdf+html](http://crllibrary.org/content/75/1/20.full.pdf+html) (describing broad research library involvement in championing the NIH OA mandate).

32 SPARC, *Open Access Funds*, SPARC Website, [http://www.sparc.arl.org/initiatives/funds](http://www.sparc.arl.org/initiatives/funds). The Scholarly Publishing and Academic Resources Coalition (SPARC) jump-started many university OA journals.

33 Wolters Kluwer, *About Medknow*, Wolters Kluwer Health Website, [http://www.medknow.com/aboutus.asp](http://www.medknow.com/aboutus.asp)

34 Richard Wellen, *Open Access, Megajournals, and MOOCs: On the Political Economy of Academic Unbundling*, SAGE OPEN (2013), DOI: 10.1177/2158244013507271.
OA models, whether green OA or gold OA, are not a panacea for all that ails scientific publishing. Though nearly 500 science and technology-specific repositories (outside of personal webpages and institutional repositories) provide self-publishing services for articles, green OA often is criticized for lacking quality control because authors can post any article or data without verification, peer or otherwise. Furthermore, the multiplication of data and articles over time perpetuates larger knowledge management issues: how to surface the most influential or relevant articles to a given audience amongst an exponentially growing knowledge base, especially when scholarly articles do not have a defined retention period.

Gold OA models have also been criticized for journal quality, fee-based revenue, and few industry controls over a growing global OA journal footprint. In particular, some gold OA journals have been accused of substandard quality due to few controls on the peer review process and absence of any legislative body or trade society to oversee OA journal operation and maintain integrity standards. Megajournals have emerged to solve this problem with a significantly different review formula: a threshold review based on scientific accuracy, validity, and soundness versus novelty or importance. This review results in greater volume of articles, at once scientifically accurate but not limited to novel contributions in a given scientific field.

Further, gold OA has been criticized for shifting article publishing from a good (consumer pays) to a service (institution or author pays): the ‘author-pays’ model. While a bit of a misnomer, author-pays models provide guaranteed cash flow, assuming that authors want to publish in a given journal: a funding body, the author’s institution, or the author pays the publishing fee upfront, rather than publishers having to market and otherwise attract an audience after publishing. While this model works relatively well for authors with funding sources, others with limited funding may have more difficulty.

Science and technology OA journals that do not use an author-pays model amount to about half of all OA journals and do not charge fees at all. For-profit publishing companies typically devote limited resources from other titles to pay for costs, while non-profit OA journals and institutions rely on charitable grants or corporate offset

35 OpenDOAR, Search or Browse Repositories, OpenDOAR Website (Aug. 8, 2014), http://www.opendoar.org/find.php. These scientific and technology article repositories represent 498 of 1611 article-specific repositories.

36 Jeffrey Beall, List of Predatory Publishers 2014, Scholarly Open Access: Critical Analysis of Scholarly Open-Access Publishing Website (Jan. 2, 2014), http://scholarlyoa.com/2014/01/02/list-of-predatory-publishers-2014/. Beall provides a list of journals and publishing houses engaging in deceptive activities related to OA.

37 See Wellen, supra note 34.

38 ‘Author-pays’ models turn typical concepts of supply/demand on its head. For one, very low storage costs for an article incentivize journals to accept more articles and, following, more fees. Because journals have less output in marketing cost, journals can charge lower fees and essentially retain existing margins of return, assuming that journals can attract enough articles to publish. While not all ‘author-pays’ gold OA journals attempt to maximize income in this way, many journals have been criticized for soliciting authors to publish in OA journals or accepting less than quality articles.

39 Theodore C. Bergstrom & Carl T. Bergstrom, Can ‘Author Pays’ Journals Compete with ‘Reader Pays?’ Nature Website (2004), http://www.nature.com/nature/focus/accessdebate/22.html

40 Directory of Open Access Journals, Search, DOAJ Website (2014), http://www.doaj.org/search. Medical, General Medical, Science, and Technology journals totaled 5614 as of August 2014, with 2919 of these journals charging no fees to the author.
income from other journals to fund these publications. While these editors might be less economically tempted to accept lower quality manuscripts, continuous funding may pose challenges for editorial boards who find the process of securing funding each year daunting.

Gold OA journals also have a variety of different copyright models: some permit or will negotiate to print articles with a Creative Commons license, some allow self-archiving a peer-reviewed article with proper attribution, and others bar self-archiving peer-reviewed articles or versions of the article other than originally submitted. Many journals require uncompensated, long-term licenses like the traditional publishing model, requiring authors to ask permission and explicitly reference the journal before republishing or creating a derivative work. Others explicitly limit any rights after an embargo period, most commonly 6 to 24 months. After embargo, authors may deposit the published article in an institutional green OA repository. Ultimately, while gold OA journals are open to the audience, they may restrict dissemination and flexibility for authors, reducing broader and timely access to necessary scholarship, depending on the model employed.

PART II. THE NIH FUNDING CONTRACT

Biological science and medical researchers funded by the NIH must deposit final, published articles in PubMed Central (‘PubMed’), a green OA repository, one of many funding terms required by the NIH. As the largest recipient of science funding outside of the Departments of Energy and Defense, the NIH set high standards to qualify for research funding. Grant proposals must pass a rigorous evaluation process including two rounds of peer review and scoring. Once the researcher becomes a Principal Investigator (PI), the PI must fulfill all of the obligations specific to the grant, including any terms and conditions required to use federal funds for research. These terms and conditions require depositing peer-reviewed, published articles in PubMed Central within

41 See, eg, Open Society Foundations, Open Access Initiative, OSF Website (Nov. 13, 2012), http://www.opensocietyfoundations.org/grants/open-access-initiative; Budapest Open Access Initiative, Grants, Budapest Open Access Initiative Website, http://www.budapestopenaccessinitiative.org/grants; Wellcome Trust, Wellcome Trust Open Access Funding, Wellcome Trust Website, http://www.wellcome.ac.uk/about-us/policy/spotlight-issues/Open-access/Guides/wtx036803.htm
42 Michael W. Carroll, Creative Commons and the Openness of Open Access, 368 NEW ENG. J. MED. 789, 791 (2013), http://www.nejm.org/doi/full/10.1056/NEJMp1300040
43 Id.
44 See generally, Mikael Laakso, Green Open Access Policies of Scholarly Journal Publishers: A Study of What, When, and Where Self-Archiving is Allowed, 99 SCIENTOMETRICS 475, 494 (2014) (finding that 80.4 per cent of peer-reviewed manuscripts may be uploaded to a green OA repository after one year of publication, though permissible repositories typically included personal webpages and institutional repositories versus other subject matter specific repositories).
45 Office of Extramural Research, National Institutes of Health, Grants & Funding: Award Management, NIH Website, http://grants.nih.gov/grants/managing_awards.htm#overview
46 A PI is typically responsible for meeting all of the requirements of the grant proposal, including terms and conditions, regardless of whether or not the PI himself/herself actually completes research or writes the resulting academic article.
47 See Office of Extramural Research, National Institutes of Health, supra note 45.
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often the PI chooses to publish in a traditional scientific journal, or an OA journal that limits the author’s use through licensing provisions.

Under the contract formed between the United States and each PI, each Institute may cease its own performance, funding the research, if the PI does not meet any of the terms and conditions of the grant. Because this grant agreement falls under public contract law with limited precedent and the status of the publishing requirement is unclear, courts could find that the NIH either cannot reclaim research articles or may delay recovery.

The NIH depository requirement

While in 2005, the NIH relied on voluntary PI deposits in PubMed Central, the Consolidated Appropriations Act of 2007 made depositing in PubMed a requirement. Researchers had voluntarily deposited at an initial rate of 7 per cent, but mandatory deposit requirements increased participation to 75 per cent by 2012. In November 2012, the NIH published a notice on their website that the institutes plan to delay funding payments until authors comply with the publishing terms and may ‘pursue actions’ to enforce NIH interests, depending on the ‘degree and duration of non-compliance’, beginning in March 2013.

By posting this notice, the NIH aimed to increase publication deposits and signaled the Institutes’ intent to treat the deposit requirement as a legal term or condition in a contract between the government as funder and the PI as funding recipient. Despite this requirement, the author may claim copyright over any published work, as long as the federal government is given royalty-free, non-exclusive, and irrevocable license to use, reproduce, or publish this information.

Government grants and contract law

All government grants, including NIH grants with PIs, are governed by a specific set of federal regulations for government contract rights. Until 1887, the US government could claim sovereign immunity and avoid contractual litigation. In 1887 Congress passed the Tucker and Little Tucker Acts, waiving a sovereign immunity defense in

Office of Extramural Research, National Institutes of Health, Grants & Funding: 8.2 Availability of Research Results: Publications, Intellectual Property Rights, and Sharing Research Resources, NIH Grants Policy Statement (2012), http://grants.nih.gov/grants/policy/nihgps_2012/nihgps_ch8.htm#Toc271264948

Public Access to NIH Research Made Law, Science Codex Website (2007), http://www.sciencecodex.com/public_access_mandate_made_law

See National Institutes of Health Public Access, infra note 53.

Executive Office of the President National Science and Technology Council, Interagency Public Access Coordination: A Report to Congress on the Coordination of Policies Related to the Dissemination and Long-Term Stewardship of the Results of Federally Funded Scientific Research, Whitehouse.gov Website (2012), at 12, http://www.whitehouse.gov/sites/default/files/microsites/ostp/public_access-final.pdf. Seventy-five per cent compliance illustrates a strong response of PIs to required versus ‘recommended’ terms and, likely, increased awareness through NIH monitoring and response to non-compliance.

Id.

National Institutes of Health Public Access, NOT-OD-12-160: Upcoming Changes to Public Access Policy Reporting Requirements and Related NIH Efforts to Enhance Compliance, NIH Website (2012), http://grants.nih.gov/grants/guide/notice-files/NOT-OD-12-160.html
contract when non-governmental entities have exhausted government administrative remedies.\footnote{28 U.S.C. §§ 1491 (1887), 1346. The Tucker Act applies to disputes over $10,000 and confers jurisdiction on the Court of Federal Claims. The Little Tucker Act applies to disputes under $10,000 and confers jurisdiction on the District Courts. Both eliminate a government’s complete defense of sovereign immunity from litigation in specific contractual relationships with the purpose of encouraging government contracts and enabling those who contract with the government to seek remedy when warranted. See also Joseph Sachter, The Court of Claims and the Wunderlich Act: Trends in Judicial Review, 1966 DUKE L.J. 372 (1966), http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=2031&context=dlj; Department of Health and Human Services, PA-13-347: NIH Support for Conferences and Scientific Meetings, NIH Website, http://grants.nih.gov/grants/guide/pa-files/PA-13-347.html; Alissa Marque, A New Appeals Board: Providing Consistency and Clarity in the Growing World of Grants and Cooperative Agreements, 41 PUB. CONT. L.J. 129 (2011). The Wunderlich Act of 1964 further established that administrative proceedings could not constitute final decisions on questions of law. Because government contracts do not evidence any bargained-for exchange, and are typically contracts of adhesion, and disputes are submitted to an arbitral board, appeal from arbitral decisions cannot be treated de novo, instead information is limited to the administrative record. Today, Wunderlich provisions are included in NIH grant agreement language.}

In response to continuing confusion over the use of legal instruments in a variety of government contracts, Congress passed specific legislation extending to government contracts under the Federal Grant and Cooperative Agreement Act of 1978 (FGCA).\footnote{31 U.S.C. §§ 6301-6308 (1977). See also Chris Jensen, Grants and Cooperative Agreements: Wolves in Sheep’s Clothing, Attorney.com, http://www.attny.com/gci01983.html. The FGCA requires specific legal instruments in government contracts, depending on the nature of the transaction, and differentiates between procurement contracts and grants or cooperative agreements.}

Until 2002, the Court of Federal Claims and the Federal Circuit had restricted Tucker Act coverage to government appropriation and procurement contracts, which left other government agreements with no legal remedy.\footnote{Jeffrey C. Walker, Enforcing Grant Agreements and Cooperative Agreements as Contracts under the Tucker Act, 26 PUB. CONT. L.J. 683, 696–700 (1997). In Trauma Service, the Court of Federal Claims reasoned that agreements are broader than contracts and ‘the word “agreement” contains no implication that legal consequences are or are not produced’. The Federal Circuit disagreed that all assistance agreements (including grants) would be considered agreements, rather than contracts, but also did not advance specific contractual construction of these agreements. The court restricted Tucker Act actions to ‘takeings’, or procuring goods.}

However, the Court of Federal Claims in \textit{Thermalon Industries, Ltd. v. the United States} held that other contract agreements, including grant agreements, could also qualify under the Tucker Act,\footnote{Thermalon Indus., Ltd. v. United States, 34 Fed. Cl. 411, 415 (1995). Thermalon Industries, Ltd. had responded to a grant solicitation from the NSF with a grant proposal, and the NSF awarded grant funding. The NSF did not approve some invoices and eventually cut off funding to Thermalon, prompting Thermalon to appeal to the NSF’s arbitral panel, later filing suit for breach of contract. The United States argued that the Federal Grants and Cooperative Agreement Act of 1977 (Grant Act), which separates government agreements into three categories (procurement, grant, and cooperative agreements), provided a ‘contract’ as the legal instrument for procurement and a ‘grant agreement’ as the legal instrument for grant and cooperative relationships. The Court of Federal Claims reasoned that although the Grant Act requires the use of different legal instruments, it does not mean that grant agreements and contracts are mutually exclusive, rather grant agreements could be contracts depending on factual circumstances. Instead, Congress intended for the Grant Act to address inconsistencies in legal instruments for procurement contracts.}

and that the NSF could terminate a grant contract if the grantee materially fails to comply with the ‘terms and conditions’ incorporated by reference.\footnote{Id. In Thermalon, the grant referenced provisions of NSF policy manuals and government ‘circulars’. The Court of Federal Claims did not identify the moment of contractual agreement yet reasoned that whether the grant proposal constituted the offer, or whether the NSF’s grant agreement constituted the offer, the NSF transferred funding dollars and Thermalon began performance, evidencing that consideration had passed between the parties. Furthermore, the parties illustrated mutual intent to enter into a contract through mutual}
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govern questions of contract formation of breach of contract.\textsuperscript{59} To date, the US
Supreme Court has not taken the opportunity to address the question of what degree
common law contract rules prevail in government contracts.

\textbf{NIH contract enforcement complications}
Assuming \textit{Thermalon} establishes a contractual common law standard, the NIH will
need to sufficiently characterize whether the depository requirement is a term or con-
dition within the contract. For example, if the NIH intended to treat this requirement
as a condition precedent to funding deposit,\textsuperscript{60} the NIH would not be required to per-
form required activities (depositing additional funding) until the funding recipient
deposited a published article.

Alternatively, if the NIH intended to treat this requirement as a contractual term,
and the NIH reasonably expected that the funding recipient would not perform within a
reasonable future time, the NIH could litigate for breach of contract and recover. How-
ever, if the publication deposit requirement is a non-material term,\textsuperscript{61} the NIH’s ability
to completely suspend performance and improve speed to recovery would be compar-
avatively limited.\textsuperscript{62}

\textbf{Copyright licensing risks}
Another complication includes the NIH’s limitations on copyright licensing. Traditionally,
an author would retain rights and transfer them at his/her discretion,\textsuperscript{63} or

\footnotesize{promises. Both parties bargained with the intent to receive the benefit of the other party: Thermalon offered its
research capacity and future intellectual property rights in exchange for NSF funding. See also 2 Government
Contract Awards: Negotiation and Sealed Bidding § 19:3 (Oct. 2013).

\textsuperscript{59} Restatement (Second) of Contracts § 241 (1981), retrieved from WestLaw Database. The circumstances that
influence materiality include: the extent to which the injured party will be deprived of reasonably expected
benefits, the extent to which the injured party can be compensated, the extent to which the party failing to
perform will suffer forfeiture, the likelihood of cure, and the extent to which the party failing to perform com-
ports with good faith and fair dealing. See also 17B C.J.S. Contracts § 753 (Dec. 2013). Materiality may be
less likely if the breaching party has breached early in the contract’s performance or if the breaching party
has substantially performed. The Court of Federal Claims reasoned that when the United States has contract-
ing authority and the parties have satisfied the common law contractual requirements of offer, acceptance,
and consideration, a grant agreement can fulfill the requirements for an express or implied contract under the
Tucker Act, even the court cannot determine which party offered and which party accepted.

\textsuperscript{60} Restatement (First) of Contracts § 250 (1932), retrieved from WestLaw Database. A condition precedent
‘must exist or occur before a duty of immediate performance of a promise arises’. See Restatement (Second)
of Contracts § 224 (1981). A condition ‘is an event, not certain to occur which must occur, unless its non-
ocurrence is excused, before performance under a contract becomes due’. In this case, if the courts construe
the depository requirements as a condition precedent, and the PI does not deposit the published work, then
the NIH are not legally obligated to follow through on its promise to fund the PI.

\textsuperscript{61} Restatement (Second) of Contracts § 374 (1981), retrieved from WestLaw Database.

\textsuperscript{62} 23 Williston on Contracts § 63:3 (4th ed.), retrieved from WestLaw Database. See Kayvan Kousha & Mike
Thelwall, \textit{Motivations for URL Citations to Open Access Library and Information Science Articles}, 68 SCIENTOMETRICS 501, 517 (2005). Fifty per cent of article citations are collected within the first year. For NIH-funded
science, the increasingly fast development of science requires that science is published and available within
a short time frame. Lengthy wait times, for example two years after publication, would prevent broad con-
sumption and use of critical scientific data and conclusions, the purpose of public deposit. This means that
any time wasted upon first identifying breach would result in less utility of the article itself. Scientific research
has a limited shelf life.

\textsuperscript{63} To mobilize the transfer of intellectual property rights, contract law is used. However, intellectual property
rights are still a key constitutional right (‘vested rights regime’), which can mean that when courts must decide
the work would be covered under an employment contract with the NIH, conferring complete copyrights as a work-for-hire agreement. In this case, the NIH funding agreement requires the transfer of non-exclusive licensing rights to the US government, limiting the PI’s legal right to transfer exclusive licensing rights to a publishing company through a future contract. If the PI promises to confer non-exclusive license to the US government, then later promises to confer exclusive licensing rights to the publisher, and both are treated as contracts, the PI may breach the NIH contract and be liable for damages.

This scenario creates problems when courts evaluate intellectual property rights as the basis for breach of contract allegations. When examining conflicts between a party’s copyright and the terms of the contract, courts may protect the copyright holder’s interest, especially when the transfer is required through an adhesive contract and rights transfer language is buried in hundreds of grant agreement pages or referenced vaguely as ‘additional terms’.64 It is, however, important to remember that funded parties under the NIH most typically are professional scientists and research institutions, rather than unsophisticated parties without prior knowledge of grant terms and conditions.

Furthermore, publishing companies, effectively negotiating for exclusive rights, may not be aware of previous commitments the PI has made, resulting in publishing companies not realizing the benefit of the bargain made, when they have contracted for non-exclusive licenses to an article.65 Despite these issues, failing to recognize a legally binding contractual agreement between the federal government and the PI creates an economically damaging outcome for the federal government as a custodian for the public interest.66

PART III. LAW AND ECONOMICS FOR POLICY RECOMMENDATIONS

In order to resolve conflicting scenarios like the NIH funding controversy, especially those with broad public and market impacts, courts often evaluate the policy reasons for enforcement, including legal analyses to identify and advance economic interests.

64 Raymond T. Nimmer, Breaking Barriers: The Relation Between Contract and Intellectual Property Law, 13 BERKELEY TECH. L.J. 827, 860 (1998). Although courts would not likely completely preempt contract law with intellectual property rights, when contractual provisions and rights conflict, courts often favor the vested intellectual property rights. See also Mark A. Lemley, Beyond Preemption: The Law and Policy of Intellectual Property Licensing, 87 CAL. L. REV. 111, 158–59 (1999). Contracts of adhesion, while concerning for courts, become increasingly suspicious the closer one contracts for Constitutional rights. That said, courts typically will not find contracts voidable unless the plaintiff can meet the standards of unconscionability.

65 Danny Kingsley, A Small Bill in the US, A Giant Impact for Research Worldwide, The Conversation Website (Jan. 26, 2012), http://theconversation.com/a-small-bill-in-the-us-a-giant-impact-for-research-worldwide-4996. Most commercial publishing companies had strongly opposed and lobbied against the NIH deposit requirement when the Research Works Act (RWA) was still active, so it is less likely that these companies negotiated without knowledge of the PI’s non-exclusive license requirements. Not all large publishing companies and journals supported the RWA, and amid a flurry of academic backlash, the bill was dropped by its original sponsors.

66 17 U.S.C. §§ 101–810 (1980). While the enforcement of non-exclusive government rights to the expression of a work should be similar to the enforcement of non-exclusive rights to the idea of an invention (as both confer intellectual property rights), the Bayh–Dole Act provides non-exclusive rights for the government by way of Congressional Act, while the NIH secure non-exclusive rights through an adhesive grant contract.
Economics has effectively created models to monetize actions and evaluate the efficiency of systems, and jurisprudes like Judge Richard Posner have championed the application of economic models to encourage efficient legal outcomes and policy, the law and economics movement.67

Law and economics aims to enhance allocative efficiency, the production of desirable goods in high demand.68 In the weaker application of law and economics,69 courts use economic analyses to determine which verdicts would result in net benefit to all parties.70 One of the most reliable approaches for evaluating a system within the context of adjudication includes investigating a market’s producers, consumers, and economic output to determine the best outcome.

In the NIH publishing controversy, the best outcome is defined as one that leads to wealth maximization: in this case, increasing or improving scientific discovery and maximizing public investment dollars. Globally, scientific discovery is responsible for a variety of different economic engines including: health care (medical care, medical equipment, and pharmaceuticals), consumer goods (improvements to consumables), and engineering (improvements to increase efficiency in use). While availability of scientific information on its own does not drive allocative efficiency, improvement of discovery through access to information advances public benefit. Similarly, return on investment is a common and critical aspect to any investment decisions, private or public. If governments can collect some benefit from what has already been spent in the form of royalties or reinvestment, the original investment breathes new life. In order to weigh the degree to which publishing models advance scientific invention and maximize invested capital, the author analyzes the existing system in its respective market, positive analysis, and then examines an alternative legal result in the same market, normative analysis.71 In the scientific publishing system, the active agents include researchers (PIs) who produce scientific articles, scientists who consume scientific articles, general public consumers, and publishers as distributors.

67 See, eg, RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW (1973); RICHARD A. POSNER, THE ECONOMICS OF JUSTICE (1981); RICHARD A. POSNER, THE PROBLEMS OF JURISPRUDENCE (1990); RICHARD A. POSNER & WILLIAM M. LANDES, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW (2003); RICHARD A. POSNER, THE CRISIS OF CAPITALISTIC DEMOCRACY (2010).

68 Stephen Palmer & David J. Torgerson, Definitions of Efficiency, 318 BMJ 1136, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1115526/

69 Richard A. Posner, A Reply to Some Recent Criticisms of the Efficiency Theory of the Common Law, 9 HOFSTRA L. REV. 775 (1981), http://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=2821&context=journal_articles. The weaker conception of law and economics is embraced more often by mainstream legal scholars.

70 Courts often use law and economics not only in contract ‘waste’ analysis under common law breach of contract claims, but also employ its use in tort litigation to establish whether duty exists (the ‘Hand’ formula.). Stronger forms of law and economics analyze market systems, including law as policy.

71 Thomas J. Miceli, The Use of Economics for Understanding Law: An Economist’s View of the Cathedral, University of Connecticut Department of Economics Working Paper Series, at 7, http://ideas.repec.org/p/uct/uconnp/2011-25.html (last accessed Sep 12, 2014). Typically positive and normative analyses are paired, first to analyze the current state’s facts and itemize, then make a value judgment based on this analysis. The author positively analyzes both non-enforcement of the OA publishing term or condition and the enforcement of the publishing term or condition, then identifies the better model using normative analysis.
Economic analysis of OA knowledge dissemination

While much empirical research has analyzed citation dynamics and bibliometrics for OA journals and repositories in contrast to traditional publishers, less recent empirical evidence to date examines the direct effects of OA publishing on knowledge dissemination. The most persuasive and applicable to the NIH publishing controversy is Houghton, Rasmussen, and Sheehan’s 2010 report to SPARC on economic and social returns of the compulsory deposit requirement. According to Houghton et al.’s research, governments employing green OA repositories for publicly funded research can expect significant gains: 72 expected return on investment for governments could net accessibility and efficiency gains of 1 to 10 per cent on spend, with social returns of 20 to 60 per cent over 10 to 30 years. 73 If no embargo period existed for deposit in these repositories, expected gains could nearly double. 74

With regard to soft OA benefits, Hamad has identified an ‘OA Advantage’, a set of factors illustrating the factors calculating greater efficiency for articles published in OA repositories and journals. 75 The applicable positive economic factors include: research can be reported earlier, improving faster ‘uptake’ of research data, methods, and results; individual freedom from handicaps and biases, because articles are deposited in the same open repository, rather than selection by a journal; availability versus non-availability, when research is available though others’ research is behind a paywall; and pure impact, in that OA articles are downloaded roughly three times more. 76 Based on these studies, OA activities seem to net greater economic benefit overall, though who benefits requires deeper analysis of the agents in this economic system.

Positive analysis: NIH-funded publishing today

In positive analysis, categorization of the facts known today enables an accurate economic analysis of the current state, absent any value judgment. The list of facts (see Table 1 and Figure 2) itemizes transactions, showing which agents pay more or receive more, and the overall benefit balance within this system. Figure 3 illustrates the relationship between agents and the flow of benefits conferred.

Producers

Producers in today’s economic scenario are PIs and other researchers conducting funded research and publishing results. Despite the obvious benefits of publishing in an OA repository due to worldwide accessibility and dissemination and an NIH contractual requirement to deposit, researchers rank their preferences, seeking to maximize their own benefit and ‘dedicate resources’ to achieve their own objectives. The primary

72 John Houghton, Bruce Rasmussen & Peter Sheehan, Economic and Social Returns on Investment in Open Archiving Publicly Funded Research Outputs, Report to SPARC (July 2010) at 4, 8, http://sparc.arl.org/sites/default/files/vufrpa.pdf
73 Id.
74 Id.
75 See generally, S. Harnad, OA Impact Advantage = EA + (AA) + (QB) + QA + (CA) + UA, Eprints Website (2005), http://eprints.ecs.soton.ac.uk/12085/ (describing the advantages for OA articles against non-OA versions).
76 Id.
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Table 1: Positive analysis, non-enforcement model

| United States Model   | Academic Producer | University Libraries | Academic and Public Consumers | Distributor Publisher |
|-----------------------|-------------------|----------------------|-------------------------------|------------------------|
| Science Funding       | $0                | $0                   | ($54 Billion)                 | $0                     |
| Periodical Funding    | $0                | ($2.7 Billion)       | $2.7 Billion                  | $2.7 Billion (from libraries) |
| Pay-per-download Income | $0               | $0                   | (Recurring Downloads)         |                        |
| Article Copyright     | (Recurring income)| $0                   | $0                            | Recurring income       |
| Balance               | (Recurring copyright income) | ($2.7 Billion) | ($51.3 Billion+) | $2.7 Billion+          |

*Id.* This model combines US spend for funding and library spend, against publishing revenue.

Figure 2: Financial Model for the Publishing Oligopoly (See R&D Magazine, *supra* note 8; Sahadi, *supra* note 4; Cope & Kalantzis, *supra* note 7; Bergstrom & McAfee, *supra* note 28; The Royal Society, *supra* note 78 and *infra* note 78; and American Library Association, *supra* note 81 and *infra* note 81. R&D Funding tops $205 billion globally. This flow chart illustrates the flow of money between institutions in the existing R&D and publishing environment.)
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objective includes publishing in a handful of prestigious journals to receive academic credit through high-impact publication, the march towards tenure.  

Researchers who publish in these journals receive no payment for the articles and often lose publication, reproduction, and derivative rights, typically for the life of the copyright, to the publisher, unless the researcher pays an additional fee or has reputational bargaining power. Because only 10 per cent of journals are OA, a large majority of journals will not provide immediate access to research publication, and even with OA, many authors retain few rights with respect to self-archiving, derivative works, or distribution, activities that could enhance broad knowledge transfer. The paywall-dominated and use-restricting nature of scientific knowledge dissemination is a direct result of both a failure to enforce OA publishing where it is required and a failure of university committees to incentivize sharing behavior.

In some cases, researchers may not even receive what they bargained for: citations and notoriety. Studies have illustrated that a journal’s impact factor is not a strong predictor for citation volume of an individual work, and in many cases, publishing in a traditional or hybrid journal and not in an OA repository minimizes citation volume.

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77 Zoë Corbyn, A Threat to Scientific Communication, TIMES HIGHER EDUCATION, Aug. 13, 2009, http://www.timeshighereducation.co.uk/407705.article

78 The Royal Society, Science as an Open Enterprise, Royal Society Website (2012), http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/projects/sape/2012-06-20-SAOE.pdf

79 See Kravitz & Baker, infra note 84.

80 See Gargouri et al., infra note 115.
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Consumers

Academic consumers access subscriptions chosen by their university libraries, an approximate spend of $2.7 billion in the United States.\(^8\) Scientific consumers who do not have a library with the subscriptions they need and consumers without means to afford $50 pay-per-download articles may access non-peer reviewed OA or pre-published articles. This is especially dangerous as scientific peer review includes duplication of research results, essential for results validation. Other scientific consumers wait lengthy periods of time to access OA versions of publishers’ previously published articles, delaying or causing duplication of research. Other scientific consumers work with limited OA articles available, providing only partial information about the current state of active or recent research in their respective fields. Researchers further only have part of the information when they can access it because many publishers do not house or publish complete research data.\(^8\) Research data combined with journal articles is often critical for those furthering previously conducted research and necessary for broad testing of scientific hypotheses within a researcher’s scholarly community.\(^8\) Finally, the existing scientific publishing process seems to value selection over timely release, with few articles accepted in a first round of review, and an average publication time frame of around eight months.\(^8\) For hybrid journals with an embargo period, some scholarship may not be available to the public for nearly two years from the time a researcher drafted the article.

Alternatively, some academic consumers may benefit today from a limited selection of scientific works, assuming that selection locates the most novel scholarship. With an ever-increasing volume of published articles, including self-archiving sources, it has become difficult for even the most erudite academic to read all relevant scholarship, even in a narrow scientific field. Some consumers may benefit by accessing journals that effectively present novel work in their areas of scholarship, paid-for through institutional library subscriptions.

General public consumers essentially pay for scientific research twice: first when tax payers fund science through taxes and second when they download the scholarship.\(^8\) Public consumers who may learn from research or write about research online have

\(^8\) American Library Association, *Number of Libraries in the United States*, ALA Website, http://www.ala.org/tools/libfactsheets/alalibraryfactsheet01. The total number of academic libraries in the United States has reached 3689. See also U.S. Department of Commerce, *Profile America Facts for Features—Back to School: 2011-2012*, Census.gov website (2012), http://www.census.gov/newsroom/releases/archives/facts_for_features_special_editions/cb11-ff15.html. Today, 4409 degree-granting universities exist in the United States.

\(^8\) Elsevier, *Database Linking*, Elsevier Website (2014), http://www.elsevier.com/about/content-innovation/database-linking#about-database-linking. Some publishers are beginning to house research data as well as publications. For example, Elsevier has recently created a data repository.

\(^8\) Dwight J. Kravitz & Chris I. Baker, *Toward a New Model of Scientific Publishing: Discussion and a Proposal*, *FRONT. COMPUT. NEUROSCI.* (Dec. 5, 2011), http://journal.frontiersin.org/Journal/10.3389/fncom.2011.00055/full. Kravitz and Baker found that only 3.6 per cent of articles were accepted on first review, only 33.6 per cent of papers were accepted to the first journal submitted, and the time between first submission and acceptance (including revisions) averaged 221 days, around eight months.

\(^8\) Michael Eisen, *Research Bought, Then Paid For*, *The New York Times*, Jan. 11, 2012, http://www.nytimes.com/2012/01/11/opinion/research-bought-then-paid-for.html
limited information to consume, except what is profiled in popular news sources, and the public is demanding more value for the money they pay.\textsuperscript{86} Pay-per-download pricing of $50 per article is largely unreasonable pricing for unsponsored academics, academics in developing countries, or the general public, who already pays for funding, yet receives no direct benefit, right, or option with respect to the output.

**Distributors**

The distributor in this process, the publisher, benefits significantly with nominal cost. The least share of the overall effort comes at the end of the publishing process, as scientific peers have already reviewed and rewritten articles. The publisher at this time implements layout and design choices, engages in copyediting and proof reading, arranges print production and distribution of copies, and then determines market strategy in order to sell subscriptions. These activities advance the user experience and improve profitability, but do not add a great deal to core scientific knowledge production. Publishers net a 37 to 40 per cent profit margin per year,\textsuperscript{87} and continue to benefit from the ongoing copyright assignments, often lasting the life of the copyright.

Hybrid and OA publishing companies expend less time in the publishing process, engaging in editor production tasks, yet spending less time printing, managing distribution, and engaging in sales, because the revenue stream comes from author fees or external funding. Furthermore, many OA journals operate similarly to traditional journals, limiting licenses and prohibiting deposit in some green OA repositories. Publishing in an OA journal does not necessarily ensure that a PI can deposit the article in PubMed or otherwise use aspects of the article in other research publications. Access to and licensing of articles often are subject to different rules, and while OA journals signal the increase in availability to consumers, publishers can still retain rights to dissemination, derivation, and publication.

**Model Outcome**

In the current model, publishers enjoy the largest benefit, while producers and consumers suffer the highest cost, as publishers leverage producers for uncompensated labor and then subsequently charge high prices to access publicly funded scholarly work, delay access for significant periods of time, or limit subsequent use, distribution, publishing, and derivative rights. All other agents in the publishing system are disadvantaged, while one agent, the distributor, receives most of the benefit.\textsuperscript{88} While this system may maximize financial utility for one agent, almost every other agent in the system is minimally allocated any benefit. The main benefit for other agents includes a selection and display value, a curation of specific scientific articles. Assuming that these articles represent the most innovative in a field and do not only reflect the biggest names in science, guaranteed to drive up impact factor,\textsuperscript{89} the relative usability for a small subset

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\textsuperscript{86} David C. Prosser, *Public Policy and the Politics of Open Access*. 17 LIBER, \url{http://liber.library.uu.nl/index.php/lq/article/view/7877/8084}

\textsuperscript{87} The Economist Website, *The Price of Information*, \textit{The Economist}, Feb. 4, 2012, \url{http://www.economist.com/node/21545974}

\textsuperscript{88} Karen M. Albert, *Open Access: Implications for Scholarly Publishing and Medical Libraries*, 94 \textit{J. Med. Libr. Ass’n} 253, 263 (2006), \url{http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1525322/}

\textsuperscript{89} See Wellen, \textit{supra} note 34, House of Commons Science and Technology Committee in Wellen.
of consumers may prove beneficial. However, the vast majority of consumers are still disadvantaged.

With few competitors, the big four scientific publishers have determined a range of journal and individual article prices significantly higher than an elastic system would produce.\textsuperscript{90} Print and online subscription journals cost an average of nearly $2600 more than an OA equivalent.\textsuperscript{91} Despite higher prices, the largest four scientific publishing companies continue to make record profits each year from individuals and libraries,\textsuperscript{92} even during a global recession,\textsuperscript{93} and the grassroots OA movement simply cannot compete with the largest publishers.

\textbf{Normative Analysis: Improving efficiency for the system}

When PIs deposit published work in PubMed, the current publishing model attains greater efficiency. First, anyone can access PubMed for free, so competitive pricing can influence existing pricing of $30 to $50 per article and high journal subscription prices. Additionally, overall reuse of data and results for scientific consumers would lead to more availability, more research, and additional publications, advancing knowledge and increasing the long-range value associated with initial funding investment.

\textbf{Producers}

Scientific producers depositing in PubMed would dramatically improve convenience, accessibility, and timely availability of information for use by subsequent producers. Making information accessible sooner drives higher quality scholarship, more accurate attribution, higher citation count,\textsuperscript{94} and provides access to research conducted much more broadly, including access to fewer big name journals and exposure for smaller publishing houses and university presses, which today constitute 5 per cent of total published articles.\textsuperscript{95} Tenure committees may also relax requirements of publishing in traditional journals, if grant funding requires depositing in a government-mandated repository and citation increases by using PubMed.\textsuperscript{96}

\textsuperscript{90} See Werden \textit{infra} note 132. As the number of market players in an oligopoly increases, the effect of a duopoly in fixing a price (limited members of the market) trends towards zero effect. As such, the influence of the oligopoly on the rest of the market is determined by the number of players and the amount of market share.

\textsuperscript{91} John Houghton, Bruce Rasmussen & Peter Sheehan, \textit{Economic Implications of Alternative Scholarly Publishing Models}, JOINT INFO. SYS. COMM. (2009), \texttt{http://go.nature.com/uqrqw}. As previously mentioned, the margin for the big four publishers is markedly higher than average for print and online subscription journals.

\textsuperscript{92} Aaron S. Edlin & Daniel L. Rubinfeld, \textit{Exclusion or Efficient Pricing? The 'Big Deal' Bunding of Academic journals}, 72 \textit{ANTITRUST L.J.}, 121 (2004), \texttt{https://www.law.berkeley.edu/faculty/rubinfeld/Profile/publications/Edlin-Rubinfeld%20ALJ%20Paper.pdf}

\textsuperscript{93} Roberta Cuel, Diego Ponte & Alessandro Rossi, \textit{Towards an Open/Web 2.0 Scientific Publishing Industry? Preliminary Findings and Open Issues}, Liquid Publications Project, \texttt{https://www.academia.edu/1074663/Towards_an_Open/Web_2.0_Scientific_Publishing_Industry_Preliminary_Findings_and_Open_Issues_} (last accessed Sep 13, 2014).

\textsuperscript{94} Steve Hitchcock, \textit{The Effect of Open Access and Downloads ('Hits') on Citation Impact: A Bibliography of Studies}, University of Southampton (2013), \texttt{http://opcit.eprints.org/oacitation-biblio.html}. Citation increases between 5:1 and 7:1.

\textsuperscript{95} James A. Evans, \textit{Electronic Publication and the Narrowing of Science and Scholarship}, 321 \textit{SCIENCE} 395 (2008), DOI: 10.1126/science.1150547.

\textsuperscript{96} Diane Harley et al., \textit{The Influence of Academic Values on Scholarly Publishing and Communication Practices}, 10 \textit{J. ELEC. PUBL.} 2 (2007), \texttt{http://dx.doi.org/10.3998/3336451.0010.204}. Harley et al. interviewed scholars in a variety of fields, and the overwhelming majority stated that there is no reward for changing the status quo,
Overall, the optimally efficient practice of science requires collaboration, knowledge sharing, and extensive peer review, and the OA model produces a nearly ‘frictionless’ exchange with low transaction cost, as long as peer review occurs. This model also produces more overall producer output, all without requiring producers to license away their respective copyright. According to Piwowar, Vision, and Whitlock, for every $400,000, a typical funding and publishing model could result in 16 papers, while a green OA data repository model may produce 1150 papers with the same funding dollars through information reuse (see Figure 4), assuming producers deposit both published work and supporting data, as required by NIH funding terms and conditions. Of course, the projected additional spend could also be evaluated as potential savings, for example saving around 24,000 dollars for an equivalent amount of research resulting in a paper. While these exact multipliers should be investigated further, the underlying rationale holds true: when researchers deposit articles in OA repositories, other

and concerns about peer review and quality review dominated perceptions about traditional publishing versus electronic publishing. Of course, this study was done in 2007, and some attitudes may have evolved since that time. Overall, this illustrates the entrenchment of traditional publishing models and the need to enforce mandates that may otherwise not evolve alone.

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97 Francis Heylighen, Why is Open Access Development so Successful? Stigmergic Organization and the Economics of Information, Open Source Jahrbuch (Bernd Lutterbeck, Matthias Bärwolff & Robert A. Gehring eds., 2007), http://arxiv.org/ftp/cs/papers/0612/0612071.pdf. In addition to interactions to gain information requiring very little effort on the part of a consumer, information does not diminish in value as it is accessed more often (non-rival good); often, it increases in value the more individuals cite to it. However, peer review is a critical and foundational element for scientific publishing. While OA models have tremendous potential, OA must employ the same stringent requirements in peer review to minimize damaging and less efficient outcomes as others rely on these publications.

98 Heather A. Piwowar, Todd J. Vision & Michael C. Whitlock, Data Archiving is a Good Investment, 473 NATURE 285 (2011), DOI: 10.1038/473285a. Piwowar et al. draw on a study by Savanna Reyes with Alan Tessier and Susan Mazer, which evaluated NSF funding and papers published based on funding dollars. For every $400,000 of funding dollars, approximately 16 papers were produced. This study proposed that the reuse of datasets and publication information, that 1150 papers could be produced within four years, given the same amount of funding dollars.
researchers can reuse and repurpose these findings, resulting in higher overall efficiency of government research funding.

Consumers

Academic consumers in this model have the most to gain. Not only will university libraries have additional leverage to negotiate prices with publishing companies, they have the option to stop paying for duplicate articles already in PubMed. Academic consumers without university library access only require an Internet connection to connect to timely research. Overall, costs for libraries would dramatically reduce, and individual consumers would no longer pay 30 to 50 dollars per article for pay access.

On the other hand, assuming that publishers do play a role in identifying key scientific contributions, the overall usability of available resources may reduce. If libraries begin forgoing subscriptions because of PubMed duplicates, a limited number of academic consumers who previously had a cultivated collection of information may now need to put forth substantial effort to find valuable resources.

Depositing in PubMed also dramatically improves utility for public consumers. While the public may not seem like a primary consumer, the public does consume scientific research. Studies have shown that when information is openly available, public consumers do access articles for learning purposes, and often these consumers cite work to share with the broader public, sharing on websites and blogs, maximizing awareness of scientific work for the public benefit. The more scientific producers publish in OA, the more public consumers read and link to scientific articles, even advancing public participation in scientific research (PPSR).

Distributors

Publishers may lose some monetary utility if NIH-funded researchers all publish in OA repositories, but it does not necessarily follow that publishers will stop publishing science articles. The NIH deposit requirement does not prohibit PIs from publishing in traditional journals, though they may not assign exclusive rights licensing. Publishers will likely experience reduced earnings due to fewer library subscriptions and

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99 John Holdren, Increasing Public Access to the Results of Scientific Research Petition, The White House, https://petitions.whitehouse.gov/response/increasing-public-access-results-scientific-research. This petition has already garnered 65,704 signatures. See also Konstantin Kakaes, Scientists’ Victory over the Research Works Act Is Like the SOPA Defeat, SLATE, Feb. 28, 2012 http://www.slate.com/blogs/future_tense/2012/02/28/research_works_act_elsevier_and_politicians_back_down_from_open_access_threat.html. Scientists have similarly signed an Elsevier boycott, originally in response to the now-defunct Research Works Act.

100 John Houghton & Peter Sheehan, Estimating the Potential Impacts of OA to Research Findings, 39 Econ. Analysis Pol’y127, 142 (2009).

101 Charlotte Tschider, Investigating the ‘Public’ in the Public Library of Science, 11 First Monday (2006), http://firstmonday.org/ojs/index.php/fm/article/view/1340/1260. When information is technically accessible to the public and readable, the public tends to comment more often in public forums.

102 Jonathan D. Wren, OA and Openly Accessible: A Study of Scientific Publications Shared via the Internet, 330 Brit. Med. J. 1128 (2005), doi: http://dx.doi.org/10.1136/bmj.38422.611736.E0 (last accessed Sep 13, 2014).

103 See generally, Jennifer L. Shirk et al., Public Participation in Scientific Research: a Framework for Deliberate Design, 17 Ecology and Soc’y 29 (2012), [describing the way public participates in science (PPSR), for example contracting or signaling to researchers a need for investigation in a particular area, contributing by providing data, collaborating to develop a study and gather results, co-create by working with scientists to develop a study, and independently conduct research for a discipline]. Ultimately, the power of broader involvement in science, a sort of ‘crowd-sourced’ science, is not possible without broad sharing of research results with the public.
individual paper costs. In a new model, publishers will need to change their existing operating model and focus on marketable curation rather than control.

**PubMed deposit outcome**

**Economic incentives**

The PubMed model significantly maximizes the gains of most agents. Under Kaldor–Hicks efficiency analysis, a less stringent variation of Pareto efficiency, an agent can be worse off in a model if other agents could, at least in theory, reimburse the losses of the worse-off agent.\(^{104}\) In the PubMed model, producers retain copyrights and still maintain tenure benefits, academic consumers have access to exponentially more data and articles, and public consumers can access scientific literature without charge, balancing scientific funding value. The improved efficiency in this model for pure availability (rather than quality of access) could more than cover losses for publishers; it could completely remove the big four publishers and still be considered Kaldor–Hicks efficient (cf. Tables 1, 2 and 3) based on availability alone. Without scientific producers, no content exists, but without scientific publishers, publishing can still continue through existing university, independent and OA publishers. Overall, the economic model not only increases utility for almost all parties, the utility is more evenly distributed, driving allocative efficiency (see Figure 5).

Enforcing the PubMed deposit requirement also maximizes financial investment. A recent economic estimate for Australia showed that federally funded OA publishing could conservatively earn back 20 per cent of overall budget previously spent, while Houghton et al. have projected even higher percentages over a longer timespan (see Figure 6).\(^{105}\) Assuming that these research findings could transfer to additional countries, the USA could net a return due to greater availability of around 6 billion dollars per year simply by enforcing current NIH publication requirements. This future benefit illustrates that the economics of the future are productivity and innovation, or ‘knowledge put to work’, and our greatest economic asset is scientific and technical research.\(^{106}\)

**Other incentives**

While actual dollar values have not yet been assigned to Hamad’s OA Advantage, OA advances societal ‘goods’ and likely maximizes allocative efficiency.\(^{107}\) For example,

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\(^{104}\) Richard Craswell, *Efficiency and Rational Bargaining in Contractual Settings*, 15 Harv. J. L. Pub. Pol'y 805, 807 (1992). This model adapts Pareto analysis, which requires that all agents at least be the same, and at least one agent is better off. Unfortunately, in most models that dramatically improve overall efficiency, one agent may be worse off. Kaldor–Hicks balances this by requiring enough benefit from other actors to offset the change—this means the entire system itself is better off (if you are able to offset any loss, overall gain is greater than the previous model). The secondary criterion asks whether the losing agent could prevent the change by bribing the other players. Here, given the significant gain both in the government’s ROI and article volume increase, this is unlikely. However, the publishing industry did try. In December 2011, the Research Works Act was introduced to the House of Representatives, backed both by Elsevier and the American Publishers Association, which, if passed, would have made illegal the NIH publishing requirement. Researchers and the public pushed back aggressively, resulting in the bill’s removal two months later.

\(^{105}\) See Wren, supra note 102.

\(^{106}\) See generally, Richard A. Lanham, *The Economics of Attention* (2006) (describing motivating factors for knowledge sharing, especially broadening attribution as a kind of currency).

\(^{107}\) See Harnad, supra note 75.
Table 2: Normative analysis, enforcement model

| United States Model          | Academic Producer | University Libraries | Academic and Public Consumers | Distributor Publisher |
|-----------------------------|-------------------|-----------------------|-------------------------------|-----------------------|
| Science Funding             | $0                | $0                    | $54 Billion                   | $0                    |
| Periodical Funding          | $0                | <$2.7 Billion (Non-scientific periodicals still funded, fewer scientific periodicals) | <$2.7 Billion |
| Pay-per-downloads           | $0                | $0                    | $0                            | $0                    |
| Article Copyright           | $0                | $0                    | $0                            | $0                    |
| **Balance**                 | $0                | <$2.7 Billion         | $56.7 Billion                 | <$2.7 Billion (minus revenue loss) |
| **Multipliers**             | 72X more articles per $400K investment, increased citation | 20% ROI, goodwill, global advancement |
| **Adjusted Balance**        | 153MM more articles/yr | <$2.7 Billion | $68.04 Billion | <$2.7 Billion (minus revenue loss) |

See R&D Magazine, supra note 8; Sahadi, supra note 4; Cope & Kalantzis, supra note 7; Bergstrom & McAfee, supra note 28; The Royal Society, supra note 78; Wellen, supra note 34; Edlin & Rubinfeld, supra note 92; Piwowar et al., supra note 98; and Wren, supra note 102. This model tabulates spend, ROI, article volume, periodical spend, and publishing revenue to see the normative economic status of enforcing the deposit contractual provision.

Table 3: Normative enforcement model, global OA

| United States Model          | Academic Producer | University Libraries | Academic and Public Consumers | Distributor Publisher |
|-----------------------------|-------------------|-----------------------|-------------------------------|-----------------------|
| Science Funding             | $0                | $0                    | $205 Billion                  | $0                    |
| Periodical Funding          | $0                | <$9.2 Billion         | <$4.9 Billion                 | $<4.9 Billion         |
| Pay-per-downloads           | $0                | $0                    | $0                            | $0                    |
| Article Copyright           | $0                | $0                    | $0                            | $0                    |
| **Balance**                 | $0                | <$9.2 Billion         | $205 Billion                  | $<4.9 Billion (minus loss of business) |
| **Multipliers**             | 72X more articles per $400K investment | <$9.2 Billion | 20% uptick ROI for spend | $<4.9 Billion |
| **Adjusted Balance**        | 700MM more articles/yr | <$9.2 Billion | $246 Billion | $<4.9 Billion (minus loss of business) |

See R&D Magazine, supra note 8; Sahadi, supra note 4; and Piwowar et al., supra note 98. This model combines all global data to illustrate the normative global model for funding deposit requirements.
earlier availability of findings could enable researchers in the same area of research to limit research objectives, forego repetitive research, or adjust hypotheses and methods, making research more relevant and timely. Individual freedom from handicaps and biases based on impact factor could enable funded researchers without the same level of publishing notoriety to provide research findings to a broader peer group. The consumption of OA articles is larger as well: scholars without significant library subscriptions use OA articles more because of their availability, increasing overall (potential) influence of researchers on the public and peers. Furthermore, the quality of

Figure 5: Normative analysis, enforcement model.

Figure 6: United states productive capital, 20 per cent ROI (See Sahadi, supra note 4 and Wren, supra note 102. This graph combines US spend with the 20 per cent predicted ROI by depositing in an OA repository.)
research findings can increase with broader peer review. Because data sets, publication, field notes, and citations can reside together, more peers will access and assess results, likely reducing fraud and misconduct.\textsuperscript{108}

Consequences of deposit requirements
While OA may increase available scholarship, improve speed to market, and enable greater scientific transparency, scholars may need a more efficient method for viewing the most important scholarship for their field. Publishers may not be the only distributor of scholarship, but they could effectively combine and present the most important scholarship, as long as publishers are able to adapt to changing circumstances and continue profitable operation by maximizing usability through effective navigation, accessibility, readability, variable presentation styles and formats, and novel delivery methods.

Large quantities of information can create more problems than solutions, and in some cases may minimize adoption when use requires high effort. As data volume increases, the US government will need to define its role in relation to article deposit and decide its overall aim for publishing, for example, if it intends to supplant publishing altogether or simply provide a searchable database.

Furthermore, the increase in low-quality OA journals may reduce effective peer review before depositing in PubMed. PubMed today allows journals to deposit articles in PubMed directly, and in some cases funded PIs may submit articles to lower quality OA journals, and then deposit on their own.\textsuperscript{109} While some OA journals have rigorous peer review processes, others may adhere to less rigorous evaluation, have difficulty locating qualified reviewers, or short-cut review processes to increase funds for the journal. A recent OA controversy has brought some of these issues to light, showing that publication does not necessarily equal research honesty, accuracy, or diligence.\textsuperscript{110}

Without consistent threshold review before a PI deposits in PubMed, low-quality articles could be presented as equivalent to high-quality articles, potentially causing economic waste for researchers who depend on them. While these issues do not necessarily occur only in OA journals, author-pays models may tempt OA editors to accept lower quality scholarship out of financial necessity,\textsuperscript{111} cascading impacts to PubMed, unless PubMed processes, people, or tool functionality can independently verify either the journal’s or contribution’s scientific accuracy.

In order to effectively provide a solution for knowledge dissemination that provides a highly usable, simple interface, the NIH will need to continue to invest in highly intuitive search features and dynamic keyword indexing, which will enable the user to find articles similar to the previous article viewed, explicit linkage between publication

\textsuperscript{108} See Houghton et al., \textit{supra} note 91, at 127.

\textsuperscript{109} National Institutes of Health, \textit{PMC Policies}, PubMed Central Website (2014), \url{http://www.ncbi.nlm.nih.gov/pmc/about/guidelines/}

\textsuperscript{110} John Bohannon, \textit{Who’s Afraid of Peer Review?} 342 \textit{Science} 60, 65 (2013), \url{http://www.sciencemag.org/content/342/6154/60.full} Over 50 per cent of OA scientific journals to which Bohannon submitted a fictitious and scientifically flawed article accepted his article. Titles owned by Wolters Kluwer, Sage, and Elsevier also accepted the article, illustrating the peer-review issue. Alternatively, OA journals like PLoS ONE pointed out many of the paper’s flaws. Some journals subsisting on an author-pays model derive the funds to operate from author fees, some of which are paid by the author’s institution, others directly by the author.

\textsuperscript{111} Id. See also David Malakoff, \textit{Open-Access Group Sanctions Three Publishers After Science ‘Sting’}, AAAS.org (Nov. 11, 2013), \url{http://news.sciencemag.org/people-events/2013/11/open-access-group-sanctions-three-publishers-after-science-sting} (describing the outcome of Bohannon’s OA sting).
and data to enable deeper review of the research results, and active linkage between publications to facilitate ease of navigating additional research without searching independently. 112 The NIH should also consider crowd-sourced quality control features, such as ratings mechanisms, reviews, recommendations, and comments, or implement an institutional light scientific review process. Scientific review could include a spot check of publications for scientific accuracy or provide routine review upon conclusion of the grant agreement and article deposit, in order to reduce inaccurate or misleading results. Until this time, presumably a role still exists for publishing houses as curators, assuming that enough institutions would pay for this service. 113

If the USA can maximize availability, usability, and quality of published, publicly funded work, it can dramatically advance innovation and investment return. 114 While complying with the NIH publication requirement will not solve every publishing challenge the USA faces, it will significantly improve access to information. Complying with the NIH publication requirement will exponentially increase knowledge availability both in the United States 115 and support the United States’ global development agenda. 116

PART IV: RECOMMENDED DIRECTION
Absent legal intervention or legislation, the publishing oligopoly’s intransigent market dynamic may never change. Traditional modern publishing has existed for 300 years and universities have leveraged impact factor for 40 years, so it is unlikely that tenure committees and researchers will change behavior independently. In order to change this behavior, four options exist: unilateral remedies, improvement to the funding contract, contract litigation, and antitrust protection.

Unilateral action
First, the NIH should continue exercising their rights to stop multiyear funding to PIs who do not comply with all terms and conditions of their agreement. According to the NIH contract signed by each PI, the NIH may unilaterally stop performing when grant officers become aware of non-compliance. Additionally, any issues may be transferred

112 PubMedHelp FAQs, PubMed Website (2014), http://www.ncbi.nlm.nih.gov/books/NBK3827/#pubmedhelp.FAQs. Today, PubMed Central does include search criteria, key words, and it highlights recent articles published, 51 search options in the drop-down in the search builder.

113 While curation appears to be a reasonable role for the scientific publishing industry, it may also cut into profits significantly, resulting in bankruptcy if scientific publishers do not evolve to hybrid or OA models. In this case, with fewer viable alternatives available, the United States does risk a lack of traditional curating functions, making knowledge discovery more difficult for those who previously relied on this model to reduce individual effort of finding the most critical articles. At the same time, the increase of OA journals with peer-review and strong editing staff may effectively provide an alternative solution.

114 Jennifer C. Molloy, The Open Knowledge Foundation: Open Data Means Better Science, 9 PLoS Biol. 1 (2011), DOI: 10.1371/journal.pbio.1001195.

115 Yassine Gargouri et al., Self-Selected or Mandated, Open Access Increases Citation Impact for Higher Quality Research, 5 PLoS ONE (2010), DOI: 10.1371/journal.pone.0013636.

116 John Willinsky, The Access Principle: The Case for Open Access to Research and Scholarship (2006), http://arizona.openrepository.com/arizona/handle/10150/106529. Researchers in developing countries use OA resources more than any other group.
to the NIH administrative arbitral panel for review of borderline cases. Of course, this arbitral panel consists of NIH designees, highly likely to find in the NIH’s favor.\textsuperscript{117}

Unfortunately, the NIH likely could not legitimately hold back funding for subsequent grant agreements that have commenced, unrelated to the initial contract. This becomes problematic when PIs do not need to deposit published articles until one year following publication, and some publications may record overall final results of research (and no funding remains). In these cases, the NIH may not convince PIs to deposit articles when the NIH cannot cut off subsequent funding. The NIH could, however, decide not to award subsequent grants to PIs who did not meet the obligations of their previous grant. In this case, both parties are free not to contact for any reason, and the NIH makes no commitment as to grant eligibility: the process is entirely one-sided.

Even if the NIH could not legally stop funding, a communicated enforcement process could help the Court of Federal Claims find in the NIH’s favor. Because the NIH may stop funding if PIs do not perform their contractual responsibilities, the NIH can establish a pattern of behavior illustrating the materiality of the deposit term, for example communicating non-compliance. If the NIH consistently communicates in written form that the NIH intend to stop funding unless the article is deposited (as the NIH do today) or that they plan to treat non-deposit as a breach of contract, this enforcement behavior may help to establish the materiality of the deposit term, making it far easier for the NIH to establish material breach in a subsequent lawsuit.

Cutting off existing future funding or failing to select PIs for future funding opportunities could also create strong enforcement for the PubMed deposit requirement and establish more complete grounds for future litigation. However, in some cases, unilateral action may not be enough.

**Improvements to the funding contract**

The NIH can also improve the odds of courts later finding for material breach by directly expressing that the deposit requirement is material. Expressly drafting the requirement as a ‘material term’, while not dispositive in a court of law, might help the PI understand the significance of the term and, thus, the court’s interpretation of contractual meaning. The NIH should also explicitly list some verbiage about publishing requirements in the actual grant proposal and agreement or directly incorporate rather than generally referencing various circulars and web site postings.

The NIH should also reduce complexity in grant agreements. The complexity of existing grant terms buried in pages with references to external links and policies may encourage the Court of Federal Claims to find that the term is not material or worse, that

\textsuperscript{117} See generally, 2A AM. JUR. Legal Forms 2d § 23:58 (updated Nov. 2013) (providing an example arbitration provision for government contracts); Kirby Behre, *Arbitration: A Permissible or Desirable Method for Resolving Disputes Involving Federal Acquisition and Assistance Contracts?* 16 PUB. CONT. L.J. 66 (1986) (describing implicit prohibitions for some federal contract arbitration provisions). NIH arbitration is more of an administrative proceeding rather than typical arbitration. If the NIH was able to effectively draft an arbitration provision that provided neutral proceedings, reasonable cost sharing, and flexible location, it could reduce cost and effort for legal disputes. However, the US government has not yet embraced neutral arbitration for government contract disputes fully. Otherwise, arbitration could be a beneficial alternative to litigation for parties both within and outside the United States, given the federal government’s deference to the Federal Arbitration Act and the broad list of signatories to the New York Convention on the Recognition and Enforcement of Foreign Arbitral Awards.
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the PI has substantially met the deposit requirement by conducting the research. Further, the contract’s adhesive nature combined with buried terms could cause the court to question whether a PI could reasonably have agreed to its terms. The NIH would do well to simplify the agreement in order to clearly communicate terms and conditions to PIs.118

Additionally, the NIH should help PIs navigate the publishing requirement with subsequent parties. The NIH can draft standard licensing provisions and language to be added to any publisher contracts, preventing future legal issues for PIs. The NIH could also work directly with publishers to draft uniform language in contracts and otherwise arrange more flexible licensing terms to benefit PIs.119

Litigation in the court of federal claims

To maximize the NIH’s ability to take action in breach in a timely manner,120 as well as actually receive the published work, it is in the best interest of the NIH for courts to categorize the publishing requirement as a material term, rather than a typical term or condition.121 Some evidence does support this position. The language on the NIH website, for example, explains the importance of the requirement:

Results of NIH-funded research become more prominent, integrated and accessible, making it easier for all scientists to pursue NIH’s research priority areas competitively. Clinicians, patients, educators, and students can better reap the benefits of papers arising from NIH funding by accessing them on PubMed Central at no charge. Finally, the Policy allows NIH to monitor, mine, and develop its portfolio of taxpayer funded research more effectively, and archive its results in perpetuity.122

118 James A. Harley, Economic Duress and Unconscionability: How Fair Must the Government Be? 18 PUB. CONT. L.J. 76, 149–153 (1988). A government contract contracting for service and intellectual property licensing rights would not fall under the auspices of the Uniform Commercial Code (U.C.C.). Even the U.C.C., as interpreted through federal contracts is complicated, as plaintiffs have not prevailed based on a theory of unconscionability, let alone the common law. The common law in most states typically, though not exclusively requires a finding of both procedural and substantive unconscionability, and if a PI could effectively argue that a provision in the NIH grant agreement is so one-sided and unfair as to reach a level of substantive unconscionability, the PI could likewise argue effectively that the large, complex, and nebulous nature of the grant agreement process procedurally led the PI to sign an agreement where she did not know the contents of the agreement. See generally 8 Williston on Contracts § 18:10 (4th ed., updated May 2013) (listing substantive and procedural unconscionability requirements); William F. Ferreira, Academic–Industry Collaboration under Federal Grants and Cooperative Agreements: Financial, Administrative, and Regulatory Compliance, 18 RES. MGMT REV. 73 (2011) (describing foundational compliance issues and complexities in working between government, industry, and universities). Government grant agreements constitute one of the most difficult, confusing, and enormously tedious efforts most PIs will experience. As a result, it may prove more difficult to argue that the publishing requirement is a material term, when the term is buried on a website, when the PI just filled out a grant proposal with hundreds of pages.

119 Birgit Schmidt & Kathleen Shreerar, Licensing Revisited: Open Access Clauses in Practice, 22 LIBER (2012).

120 Time is of the essence in this kind of dispute. Because science moves so quickly, published work for science has a very low shelf life. This means that by the time the NIH could effectively commence administrative proceedings and then proceed to a court, the value of the published work in dispute will have reduced.

121 Material breach does not necessarily mean that the other party cannot cure, in this case, depositing the published work or works.

122 National Institutes of Health, Public Access Policy, NIH Website (2013), http://publicaccess.nih.gov/faq.htm (last accessed Sep 9, 2014).
Multiple facts could substantiate the NIH’s intent to designate rights transfer a material term. For example, in comparison to other government appropriations contracts, the NIH receive no direct benefit from this funding, other than for funding recipients to engage in research and to receive royalty-free, shared rights to research products, including documentation, data, and inventions. Further, the NIH give each PI, on average, $450,000 per year in return for research results. It is unlikely that the NIH would contract for scientific development with no corresponding data or synthesized results to actually explain research outcomes for broad use.

External factors also illustrate the importance of this requirement. In 2013, the White House, through the Office of Science Technology Policy, mandated that every government office conducting research over $100 million must develop a plan for offering data and research results to the public for free, and the 2014 Consolidated Appropriations Act codifies this requirement.

If the NIH can show breach of contract, the Court of Federal Claims should strongly consider a specific performance remedy for cases involving non-deposit of research articles. Although specific performance remedies are generally rare, courts should consider specific performance because replacing the published article would require double-funding and duplicating research, which would be protected through the original PI’s intellectual property. By its very definition, the Institute cannot receive what it bargained for: money could not substitute equivalent service and intellectual property. Unlike most breach of contract cases, research results cannot be substituted: as a copyright-protected document, courts should presume that the federal government cannot find an alternative on the open market or effectively estimate the

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123 National Institutes of Health, Research Project Grants: Average Size, NIH.Gov (2013), http://report.nih.gov/nihdatabase/charts/Default.aspx?chartId=155&catId=2
124 See Thermalon Indus., Ltd. v. United States, supra note 57, at 415. In Thermalon, the Court of Federal Claims found that the government’s grant agreement did not evidence a gift, but rather evidenced mutual obligation.
125 John P. Holder, Increasing Access to the Results of Federally Funded Scientific Research, White House Website (Feb. 22, 2013), http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf
126 H.R.3547—113th Cong. (2013-2014), Jan. 17, 2014.
127 Specific performance is comparatively rare for a variety of reasons, typically because it forms a coercive action that may require a great deal of court time to enforce, at least when an alternative remedy would be adequate. For contracts for the sale of goods, specific performance remedies may be possible in situations where finding a market replacement is inefficient and inconvenient, typically in situations where the good is highly unique (like fine art) or limited numbers exist (an antique car). For services contracts, courts find specific performance highly suspect and tantamount to involuntary servitude. Intellectual property transfer does not enjoy a specific presumption, and courts use specific performance remedies more frequently in patent licensing disputes. Like patents, research publication is dependent on years and likely millions of dollars of research, making replacement through duplication highly inefficient. Further, once published, a similar publication cannot be created to replace the original, or it would likely infringe the original work. By its very nature, the patentable results and its subsequent communication are protectable, and even the original copyright holder would not be able to reproduce the results without the publisher alleging a form of infringement through derivation.
128 The SCO Group, Inc. v. Novell, Inc., 578 F.3d 1201 (10th Cir. 2009). Unfortunately, the highly original and specific nature of a research agenda precludes market replacements. Since the result of this research is intellectual property, by its very nature original and singular if non-public information, the NIH presumably contracted for this specific service and resulting product licensing (both for inventions under Bayh–Dole and expression under the NIH policy), not just any service or intellectual property.
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Furthermore, the NIH could not accept just any research results; the NIH specifically contract for the PI’s research results, the party who merited NIH funding.  

Antitrust

Unlike typical market scenarios, the big four scientific publishing companies nearly dominate their market. If the United States begins to recognize the threat of oligopolies generally and advocate for stronger international agreements prohibiting oligopolic activity, antitrust law could solve publishing challenges by introducing competition and driving down prices to acceptable levels.

Oligopolies exist in part because of a limited number of market players. In competitive (non-oligopoly) markets, players can reduce price elastically within an acceptable production cost, netting more purchasers and gaining market share. Comparatively, oligopolies exhibit interdependent pricing, meaning oligopolists can identify and respond to competitor price cuts quickly, minimizing the positive effects of price reduction. Oligopolists rationally calculate that the most productive move in this scenario is not to move by reducing prices. This enables oligopolists to retain existing market share and price without tacit collusion. The effect of an oligopoly market is that most competitors cannot afford to compete, and many consumers cannot afford to enter the market.

The USA does protect the US market and consumers from monopolistic and anticompetitive practices. However, existing law does not dissolve non-collusive oligopolies and does not prohibit market domination and non-collusive price fixing. In U.S. v. International Harvester Co. and Theatre Enterprises, Inc. v. Paramount Film

[129 71 AM. JUR. 2d Specific Performance § 171 (updated Feb. 2014). Typically, the uncertainty of market value differentiates the need for specific performance from the availability of a suitable market alternative. However, many unique goods can be estimated in value, yet would be subject to specific performance, for example fine art.

[130 Any parties can legally contract for intellectual property rights, but when a party no longer holds rights they contract to transfer to a third party, courts should find the original party in breach of the second contract and find reasonable remedy, as breach of the second contract can be reduced to market value, for example how many individual journal articles or journals would have sold through an exclusive licensing agreement.

[131 Richard A. Posner, Oligopoly and the Antitrust Laws: A Suggested Approach, 21 STAN. L. REV. 1562, 1564 (1969).

[132 Gregory J. Werden, Economic Evidence on the Existence of Collusion: Reconciling Antitrust Law with Oligopoly Theory, 71 ANTITRUST L.J. 719, 721 (2004). This concept is considered non-cooperative equilibrium in game theory (the Nash Equilibrium), the concept that no player has incentive to alter its action, assuming that competitors would take the same action, advanced by John Nash. In this example, because a small group dominates a market, they can respond quickly to changes in it. In a typical competitive model, a member of the group would drop prices and reap the rewards of additional sales—dropping prices to a point where marginal benefit = marginal return) would maximize overall return. However, when a small group dominates and one member drops prices, the price-dropping member does not see the overall return because another member will drop prices immediately. As a result, members of an oligopoly or cartel typically remain the same and resort to other methods to increase market share.

[133 Many oligopolies do not operate through collusive practices, such as price fixing. Instead, companies generally keep prices relatively constant, regardless of supply or demand. For the publishing industry, instead of adjusting price, oligopolists acquire smaller players, reduce non-performing titles, bundle journals to maximize subscription size and spend, charge similar prices for online and paper subscriptions despite reduced production cost, and work to increase title impact factor to gain market share.

[134 See generally Thomas A. Pirano, Jr., Regulating Oligopoly Conduct under the Antitrust Laws, 89 MINN. L. Rev. 9 (2004) (proposing interpretation of antitrust law to include oligopolical behavior).
Distributing, the US Supreme Court established that consciously acting in parallel with another company for your own advantage could not be deemed collusive under the Sherman Act. However, where conscious behavior is interdependent, collusion can be inferred.

Oligopolies, however, by their nature, do not require any formal agreement to set a monopolistic price, so it becomes almost impossible to prove collusion. The Federal Trade Commission (FTC) has brought several cases in the USA on the basis of anticompetitive, oligopolic practices, but no successful case has succeeded solely based on conscious parallel action in regard to price, or simply being aware of competitor pricing and adjusting price at the same time. The FTC must prove some level of collusion, whether tacit or inferred. Still, courts have established strict requirements for successfully litigating under the Sherman Act, often requiring more than just parallel action, usually a corporation acting against its own self-interest. In the publishing industry, only recently did the Department of Justice successfully sue six major publishers for price fixing of electronic book sales, and this price fixing was deemed collusive, illustrating the rarity of antitrust litigation for collusive oligopolies.

Global antitrust law has not expanded beyond US conceptions of tacit and inferred oligopolic collusion. While global antitrust law is growing at the country level, and future trade agreements barring anticompetitive behavior across countries are more possible than in previous years, it seems unlikely that oligopolic practices would be subject to international antitrust law, at least for the foreseeable future. The first international effort to establish antitrust started with the USA attempting to enforce an international extraterritorial effects-based test, which was regarded with ‘great hostility’ in targeted countries. Perhaps due to residual international sensitivity, the founders of multilateral trade agreements like the General Agreement on Tariffs and Trade have specifically avoided antitrust language.

Starting in 1967, members of the Organization for Economic Co-operation and Development (OECD) did develop antitrust cooperation recommendations and have subsequently conducted investigations, working through the international law principle of comity in order to change behavior in relation to antitrust. The OECD discussed the effect of oligopolies on global competition in 1999, but the topic focused

135 U.S. v. International Harvester Co., 275 U.S. 693 (1927); Theatre Enterprises, Inc. v. Paramount Film Distributing, 346 U.S. 537 (1954).
136 U.S. v. Container Corp. of America, 393 U.S. 333 (1969).
137 E.I. DuPont de Nemours & Co. v. FTC, 729 F.2d 128 (2nd Cir. 1984).
138 Michael K. Vaska, Conscious Parallelism and Price Fixing: Defining the Boundary, 52 U. Chi. L. Rev. 508, 521–523.
139 United States v. Apple, Inc., 12 Civ. 2826 (S.D.N.Y. 2013). In United States v. Apple, Inc., the District Court found that Apple facilitated collusive behavior for price fixing electronic books to edge out Amazon competition. However, this finding specifically found collusive behavior, rather than non-collusive Nash-style oligopolic behavior. This behavior has not been effectively litigated in the United States.
140 Edward T. Swaine, The Local Law of Global Antitrust, 43 W. & M. L. Rev. 627, 630 (2001). The broad proliferation of trade codes has improved the chances of broader international antitrust.
141 Id. at 643.
142 Id. at 147 [citing Spencer W. Waller, The Internationalization of Antitrust Enforcement, 77 B.U. L. Rev. 343, 355–56 (1997)].
143 Id. at 726, 727. Of course, comity does not provide the hardened standard of international law, but is something more than a guideline, so recognition of antitrust concerns would be at least very persuasive.
on prohibiting collusion and explicitly dismissed parallel conduct (non-collusive) as a means for establishing anticompetitive behavior.\(^\text{144}\)

Given the reliance on comity rather than more explicit trade agreements, the significant differences between countries’ antitrust law,\(^\text{145}\) and the focus (when countries can agree) on solely collusive oligopolies, it is unlikely that antitrust law will change dramatically in coming years to disturb the scientific publishing oligopoly. Until then, courts have an opportunity to manage damaging market conditions through the application of law and economics analyses.

### International publishing

The global community is also struggling with a similar publishing crisis. Similar to the US mandate, the European Union (EU)’s Horizon 2020 initiative requires OA publication and research data for government investment, though in many cases, the EU has largely resisted compulsory deposit requirements.\(^\text{146}\) The United Kingdom, in particular, has mandated the same requirement as the United States with limited success to date, as have many individual member countries.\(^\text{147}\) Many researchers now conduct scientific research across geographical boundaries, intermingling data sets, resulting in cross-funding and cross-attribution, increasing overall impact.\(^\text{148}\) As global research efforts continue to multiply, a consistent international deposit requirement becomes increasingly crucial. While this article does not analyze the impact of international law on collaborative science, the United States, EU member states, and other interested states should consider creating a global commission on scientific research and development for further investigation.

### Towards an efficient system for the biosciences

The invention of the OA journal and OA repository has forever changed the way researchers disseminate research results, yet an optimal system is not yet obvious. While traditional embargo, hybrid, and OA journals provide broad access to scientific work, verifiability issues for some and delayed access for others lessen potential economic improvements. Megajournals, while scientifically accurate, may provide an alternate

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\(^\text{144}\) Organisation for Economic Co-Operation and Development, *OECD Policy Roundtables: Oligopoly*, OECD Website (1999), at 7, [http://www.oecd.org/daf/competition/1920526.pdf](http://www.oecd.org/daf/competition/1920526.pdf)

\(^\text{145}\) Brett Kraabel, *WTO, Free Trade, and Oligopolies* (2004), [http://bkraabel.free.fr/publications/white_papers/WTO_Banana_Wars.pdf](http://bkraabel.free.fr/publications/white_papers/WTO_Banana_Wars.pdf). While the FTC can bring charges for holding a 65 per cent monopoly interest, the United Kingdom requires 40 per cent, and the entity must abuse its power to warrant legal action.

\(^\text{146}\) European Commission Research & Innovation, *Report of the European Commission—Public Consultation on Open Research Data*, European Commission Website (Oct. 2013), [http://ec.europa.eu/research/science-society/document_library/pdf_06/report_2013-07-open_research_data-consultation.pdf](http://ec.europa.eu/research/science-society/document_library/pdf_06/report_2013-07-open_research_data-consultation.pdf). After presenting a working version of this paper to the Association of European Research Libraries, a Spanish colleague at the Ligue des Bibliothèques Européennes de Recherche (LIBER) shared that Spain would not consider a mandatory requirement, and that culturally, a legal remedy would not be appropriate, despite limited compliance with existing OA requirements.

\(^\text{147}\) Richard Van Noorden, *Open-Access of U.K.-funded Science Papers Will Start in 2013*, *Scientific American*, July 16, 2012 [http://www.scientificamerican.com/article/open-access-uk-funded-science-papers-start-2013/](http://www.scientificamerican.com/article/open-access-uk-funded-science-papers-start-2013/). RCUK is setting a goal of 75 per cent over a number of years. Wellcome Trust, a private UK funding group, has remained around 50 per cent compliance since the mid-2000s.

\(^\text{148}\) Organisation for Economic Co-operation and Development, *Science, Technology, and Industry Scoreboard: Innovation Growth and Knowledge Economies*, OECD Website (2011), at 9, 10, [http://www.oecd.org/sti/sci-tech/48712591.pdf](http://www.oecd.org/sti/sci-tech/48712591.pdf)
option for managing peer review, but may also dramatically increase available publications, flooding the scientific market with volume when the scientific community also needs to effectively identify critical scholarship.

Enforcing the PubMed deposit requirement improves the overall outlook for the biological sciences by improving access to articles, providing search criteria for accessing articles, safeguarding article access, cross-linking articles and data, and establishing non-exclusive licensing terms. Enforcing these requirements can improve access to critical research results, leading to an improved economic position for the United States.

However, enforcing the public deposit requirement does not maximize economic results on its own. The PubMed deposit requirement still honors an embargo period, decreasing speed to knowledge dissemination. PubMed also does not complete any independent peer review, relying instead on publishers that may not conduct substantial review. Enforcing the PubMed requirement may also cause more journals to convert to hybrid or OA in order to recoup subscription fees previously collected from libraries after publication by collecting fees from authors, institutions, or funding sources upon article acceptance. As a result, megajournals could become the dominant model for hybrid and OA commercial journals, as they aim to offset previous subscription revenue by maximizing the volume of articles published and author-side fees. As a result, academic institutions and the NIH may experience rising prices for author fees as a greater number of articles are published.

The most economically beneficial future option may include the NIH operating PubMed as a green–gold repository for all PIs to deposit the original, funded article with some level of NIH peer review. If NIH researchers or other PIs can effectively provide basic scientific validity review on a timely basis, similar to the megajournal model, articles and associated data could be available immediately, at a nominal cost to the author, institution, or the NIH, with the exception of basic operating costs. Further, if the NIH can support additional services and build additional features, all consumers would have open access to scientifically accurate, reliable, user-friendly, and curated information as soon as possible, and unspent subscription funds could be spent on critical research needs, such as open data repositories, big data management solutions, and data sharing mechanisms, to build or expand major databases like NIH’s GenBank.

Future research
While existing research seems to point to green OA repositories as the most efficient model for the sciences, more research is still needed to investigate whether a repository, with limited additional processes, would prove more economically efficient for total publishing investment, or if an alternate optimal balance of journals and repositories would advance accessibility, verifiability, and usability of knowledge resources. To date, the full scale of models including megajournals, OA, hybrid, traditional, and traditional-embargo have not been evaluated together to determine which access method or

149 Damien Besancenot & Radu Vranceana, A Model of Scholarly Publishing with Hybrid Academic Journals, ESSEC Working Paper (2014), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2419849 (last accessed Sep 13, 2014).

150 Id. If journals begin to have competition by way of a free option to research, it is unlikely that publishers will continue on the same path as prices continue to fall and libraries stop paying for access. Instead, publishers will seek to recoup costs on the front end, maximizing volume to offset a reduced upfront cost.
combination of methods actually transfers the most knowledge, in particular for the lowest cost with the highest usability and scientific accuracy.

CONCLUSION
The United States has an exceptional opportunity to advance innovation and receive return on its investment while disseminating knowledge for the collective benefit of its citizens and of science practitioners around the world. PubMed, with some usability and process improvements, can facilitate knowledge transfer both within the United States and globally. By legally enforcing the NIH deposit requirement, the United States can dramatically improve the utility of scientific knowledge and reduce longstanding exploitive practices.

As scientists determined long ago, knowledge availability has an incredible ability to spur knowledge production and, following, innovation. Unilateral action by government agencies and more diligent legal enforcement of contractual funding provisions will increase compliance and remove cultural academic barriers to open science publishing. It is within both the United States’ economic responsibility and legal ability to drive efficiencies for global consumers of scientific research and concurrently protect academic copyright interests, even if this action provides just one step towards a more efficient system for scientific publishing.

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