Assessing Open Archiving Mandates

A Risk Assessment Model for Society Publishers

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Note on the Risk Assessment Model & Disclaimer

The risk assessment model described in this document is intended to assist society journal publishers in evaluating the potential financial implications of open-access mandates and in responding constructively to such mandates. The model provides a basis for exploring various financial outcomes, but should not be construed as guaranteeing any particular outcome or result. Some of the market assumptions, journal attributes, and/or mandate requirements are likely to change. The risk assessment model is intended to help society publishers estimate the extent to which their journal publishing operations might be affected by such changes.

The example values used in this guide are for illustrative purposes only. Any reliance upon the model described in this document or any other use of the information or data contained in this document shall be at the sole risk of the user. Neither BioOne nor Chain Bridge Group will be liable for any damage, loss, cost or expense of any kind arising from the interpretation, use or adaptation of the data or other information contained in this document.

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PART ONE

1—REPORT CONTEXT, PURPOSE & STRUCTURE

1.1 Context & Purpose

Increasingly, nonprofit publishers, in all disciplines, must accommodate funder and institutional mandates requiring the deposit of sponsored research publications in open archives. Societies, including those sympathetic to the spirit of open archiving policies, are often apprehensive about the potential implications of such mandates for the revenue streams that support the publications and that (often) subsidize other mission-oriented activities. Multiple factors affect the impact of mandates on journal revenue, and sorting out the potential effect of mandates on existing business models is a complex undertaking. Relatively few society publishers have the organizational resources necessary to assess accurately the implications of mandates on the financial sustainability of their publishing programs.

To guide strategic and practical responses to mandate policies, society publishers require a realistic assessment of the implications of mandates on their publishing operations. To that end, BioOne commissioned this report to provide society publishers with a practical perspective on open-access mandates and an analytic framework for assessing the potential effect of mandates on their journals. The report is intended primarily for society and other nonprofit publishers affected by existing or proposed open archiving mandates, including STM, social science, and humanities publishers.

Absent a reliable model for estimating the potential effect of open-access mandates, society publishers may rely on intuitive assessments, driven by one or two indicators, such as the proportion of funded research or embargo length. Such casual assessments often articulate the risk perceived in terms of a tipping point—the notion being that once a sufficient (but unspecified) proportion of a journal's content becomes openly available, a critical (but unspecified) number of institutions will cancel their subscriptions. The notion of a tipping point thus implies a specific risk threshold, but does not define what that threshold might actually be.

Cognitive studies have demonstrated that such intuitive risk assessments often result in poor management decisions. Further, given the risk aversion of many societies, reliance on a casual assessment may lead a society to overstate the risk posed by open archiving. Even when other factors are considered, a society publisher may simply rank risk along a notional scale from low to high, without attempting to quantify the probability of the risk or to estimate the severity of its impact. This can lead a society to expend disproportionate effort avoiding an exaggerated risk, rather than pursuing more productive responses.

As the ability of academic libraries to pay for the value added by publishers erodes, society publishers fear that libraries might cancel journal subscriptions were the same content openly accessible. However, openly archived articles that comply with mandates are rarely perfect substitutes for the full published journal. The probability model described in this document intends to provide society publishers with a better assessment of the financial implications of a given set of open archiving policies than would otherwise be available. The structured open archiving assessment process allows a society to:

- Estimate the extent to which openly archived articles might serve as substitutes for a published journal;
- Calculate the effect of the potential substitution on journal subscriptions and revenue; and
- Determine the likelihood that any forgone revenue would exceed the society's capacity to absorb the loss.

1.2 Purpose of the Risk Assessment

This report provides society publishers with a structured process and probability model for assessing the implications of various types of mandates and for responding constructively with policies and funding models that serve both mission and business requirements. The open archiving assessment model described here uses probability ranges to express uncertainty about the potential effects of mandate requirements given a particular set of journal attributes. The model then applies a simple Monte Carlo simulation—a computer-enabled method for generating random scenarios—to test the likelihood that potential lost revenue would exceed the society's stated tolerance.

Some might object to the assumption, inherent in the model, that open archiving will affect the perceived value of a journal. However, such an assumption is dictated by economic axiom: the availability of a substitute—even an imperfect substitute—affects the demand for any good, including peer-reviewed journals. The *extent* of the substitution effect is the issue, and the model presented here provides a systematic, if necessarily approximate, method for predicting what that effect might be.

At the same time, the model's development was motivated by a concern that society publishers often perceive greater risk from open archiving policies than such policies actually pose, and that an exaggerated perception of risk could lead societies to respond in ways more appropriate to a for-profit than a nonprofit entity. For-profit publishers seek to maximize revenue and return for their shareholders, and typically fight to avoid any diminution of revenue. Society publishers, however—while not indifferent to revenue concerns—typically seek to balance financial sustainability with increased reach and access. The model is intended to help societies refine that balance, rather than to protect existing revenue models.

Either under- or overestimating the financial risk posed by open-access mandates could have negative consequences for a society:

- Underestimating the risk could starve a society of the capital required to respond effectively to a changing market environment and undermine the society's ability to support its publications program or provide key member services.
- Overestimating the risk from mandates might lead a society to misallocate financial and organizational resources to avoid an overstated threat. It could also drive a society to adopt a reactionary strategy that does not align with the needs or expectations of its members, or to alienate key constituencies, including academic libraries.

While the open archiving assessment model described here attempts to quantify the substitution effect of funder mandate requirements given specific journal attributes, each society will need to determine for itself the level of risk—both financial and political—that it is able and willing to accept.

1.3 Report Structure

The report is structured as follows:

Part One (Sections 2 – 3) reviews the various types of open-access mandates—including funder mandates, institutional mandates, and popular (member-driven) mandates—and discusses the practical implications of each. It also describes key mandate characteristics, such as repository deposit requirements, embargoes, and compliance mechanisms.

Part Two (Sections 4 – 7) provides a framework for assessing the financial implications of mandates for subscription journals, focusing on how specific mandate requirements might affect a journal's revenue given specific journal characteristics.

Part Three (Sections 8 – 9) provides a practical guide to applying the open archiving assessment model, including detailed instructions and examples.

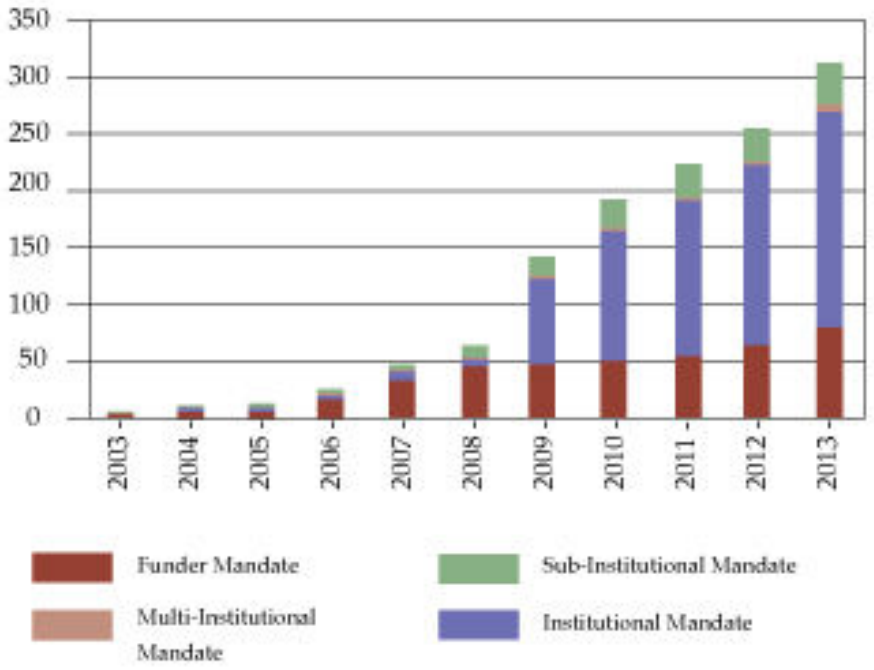
2.1 Growth & Coverage of Funder & Institutional Mandates

2.1.1 Growth of Mandates

Open-access mandates—policies that require or encourage authors to make their published research more widely accessible—have proliferated in recent years. Public and private research funders have begun to issue mandates that stipulate minimum access requirements for publications by grant recipients, while faculty at some universities and research institutions have voted to comply voluntarily with publishing guidelines designed to increase access to the research they publish. The logic behind most funder mandates is maximizing the return on the funder's social investment by increasing access to, and use of, the published research results. Institutional mandates serve a similar function by increasing the visibility and impact of the research generated by an institution's researchers.

Besides funder and institutional mandates, a society publisher might face a popular mandate, driven by member expectations of expanded access. As such member expectations do not entail specific compliance requirements, we have not addressed them in detail here. However, some of the metrics and analytical tools described in this document will be relevant to a society attempting to assess the implications of responding to a member mandate for increased open access.

Exhibit 2-1: Growth in Funder & Institutional Mandates, 2003 – 2013



Data Source: ROARMAP. http://roarmap.eprints.org/

The number and scope of both funder and institutional mandates continue to increase (see Exhibit 2-1). There are now scores of funding organizations mandating some form of open-access dissemination as a condition of a grant award, with additional funders considering new mandates.[1] These funders include

[1] For lists of funder and institutional open access publishing and archiving requirements, see the Registry of Open Access Repositories Mandatory Archiving Policies (ROARMAP; http://roarmap.eprints.org/) and the SHERPA/JULIET database (http://www.sherpa.ac.uk/juliet/).

large research foundations (e.g., Howard Hughes Medical Institute, the Wellcome Trust, etc.), government agencies (e.g., the National Institutes of Health), national research councils (in Australia, Canada, the UK, and Europe), and disease research and patient-advocacy organizations (e.g., Autism Speaks, British Heart Federation, Canadian Cancer Society, etc.). According to the SHERPA/JULIET database—which provides a registry of funder open-access policies—60% of funder mandates require (rather than simply encourage) open-access archiving or publication.[2]

The approval of an open-access policy by the Harvard University faculty in 2008 provided the impetus for a number of institutions to adopt similar policies, and almost 200 institutions worldwide have now adopted open-access mandates. Although the rate of growth has slowed somewhat, colleges and universities continue to announce new open-access policies. According to ROARMAP[3]—a database of institutional repository mandatory archiving policies—the majority of institutional open-access mandates are found in the US, Australia, the UK, and Europe, although such mandates have also been adopted by institutions in Asia, Africa, and South America.[4]

In the US, institutions adopting open-access mandates range from large research-intensive institutions to small colleges, and include Harvard, MIT, the University of California system, Princeton, Duke, Rice, Amherst, and Oberlin. Besides mandates that cover entire institutions, a number of mandates apply to a specific school or department within an institution. For reasons discussed below, many institutional mandates are hortatory, rather than compulsory.

2.1.2 Coverage of Mandates

2.1.2.1 Funder Mandates

The overall number of research articles covered by funder mandates also continues to grow. Government agencies represent the largest source of research funding, especially in the sciences. The Research Councils UK (RCUK), which fund about £3 billion of scientific research per year, announced in 2012 that papers resulting from wholly or partially funded research must be compliant with its open-access policy. That policy allows an embargo period of from six to 24 months, depending on whether an article is self-archived or published in a fee-based open-access journal.[5]

Also in 2012, the Higher Education Funding Council for England (HEFCE), which funds approximately £1.6 billion in research per year, indicated that it would be developing open-access policies to make its sponsored research as broadly accessible as possible.[6] With UK authors representing 4% - 6% of global research article output annually, and about 60% - 70% of UK articles receiving some level of public funding, articles covered under UK-based mandates would represent approximately 2.5% - 3.5% of global article production.[7]

The European Commission has identified the open dissemination of publicly funded research results to be critical to the effectiveness of research investment and has signaled its intention to implement a mandate governing research funded by the EU Research Framework Programs (e.g., Horizon 2020 and FP7). Starting in 2014, all articles from research funded under Horizon 2020 must be openly accessible,

[2] SHERPA/JULIET is maintained by the University of Nottingham and funded by JISC and the Research Libraries UK; http://www.sherpa.ac.uk/juliet/.
[3] ROARMAP was developed and is maintained by the School of Electronics and Computer Science at the University of Southampton; http://roarmap.eprints.org/.
[4] In Latin America, legislation requiring publicly funded research to be available in open access digital repositories was approved in Argentina and Perú in 2013. See http://www.mincyt.gob.ar/noticias/es-ley-el-acceso-libre-a-la-informacion-cientifica-9521
[5] For the RCUK policy, see www.rcuk.ac.uk/media/news/2012news/pages/aspx.
[6] www.hefce.ac.uk/news/newsarchive/2012/statementonimpkementing openaccess/.
[7] Aspesi, September 2012, 11.

either immediately via the publisher (with the potential for article fees to be reimbursed under the funding program), or through deposit in an open repository within six months of publication (12 months for the humanities and social sciences). The EC is advising individual member states to adopt open-access mandates with the same general provisions, with the goal of 60% of European publicly funded research to be available open access by 2016.[8] According to one estimate, if the EC members, especially Germany and France, mandate open access, then such policies could affect approximately 25% of total global research output.[9]

In the US, public access to federally funded research is being promoted by both legislation and the executive branch. The Fair Access to Scientific and Technical Research Act (FASTR),[10] which succeeds the previously proposed Federal Research Public Access Act (FRPAA) legislation, was introduced into both houses of Congress in February 2013. As with the earlier bill, FASTR would require federal agencies funding more than $100 million in research to provide public access within six months of publication, either through agency-hosting or through institutional or subject-based repositories. The new bill also calls for common deposit procedures across agencies and for deposit formats and license policies that facilitate computational analysis and constructive reuse. FASTR would extend open access to (non-classified) research funded by over 100 federal agencies, including the Departments of Defense, Energy, Health and Human Services, and Transportation; the National Aeronautics and Space Administration; the National Endowment for the Humanities; and the National Science Foundation.

Complementing the legislative action, the White House Office of Science and Technology Policy (OSTP) issued a directive, in February 2013, requiring federal agencies funding more than $100 million in research to develop plans to make publications resulting from funded research publicly accessible within one year of publication.[11] Although FASTR and the OSTP directive share many elements, the latter is already in effect. At the same time, a future president could rescind the executive directive, while the FASTR legislation would provide a more certain future for a federal public access policy. If the US government adopts an open-archiving policy along the lines proposed by FASTR and/or the OSTP directive, approximately 18% of global research output would be affected.[12]

In the meantime, an omnibus appropriations bill, passed in January 2014, included language that effectively codified the OSTP Directive requirements into law for the Departments of Education, Labor, and Health and Human Services, and their related agencies (including the Agency for Healthcare Research and Quality and the Centers for Disease Control).

Together, the UK, EU, and US research output potentially subject to open archiving mandates represents almost half of annual scientific research articles worldwide. Although the timelines for these government mandates vary—the RCUK policy took effect in 2013; the EC intends to implement its policies starting in 2014; and a US policy has yet to be implemented—society publishers need to be aware of the implications for their particular disciplines. In some well-funded disciplines, particularly biomedicine, the percentage of articles potentially affected could be significant, while in under-funded disciplines the proportion of articles under funder mandates may remain low.

[8] See RIN 2009 and http://ec.europa.eu/research/science-society/index.cfm?fuseaction=public.topic&id=1294&lang=1. Several prominent European research funders—including Inserm in France and Deutsche Forschungsgemeinschaft in Germany—have already established open-access policies.

[9] Aspesi September 2012, 12.

[10] For text of the bill, see http://beta.congress.gov/bill/113th-congress/senate-bill/350?q=s350.

[11] http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf

[12] Aspesi September 2012, 12.

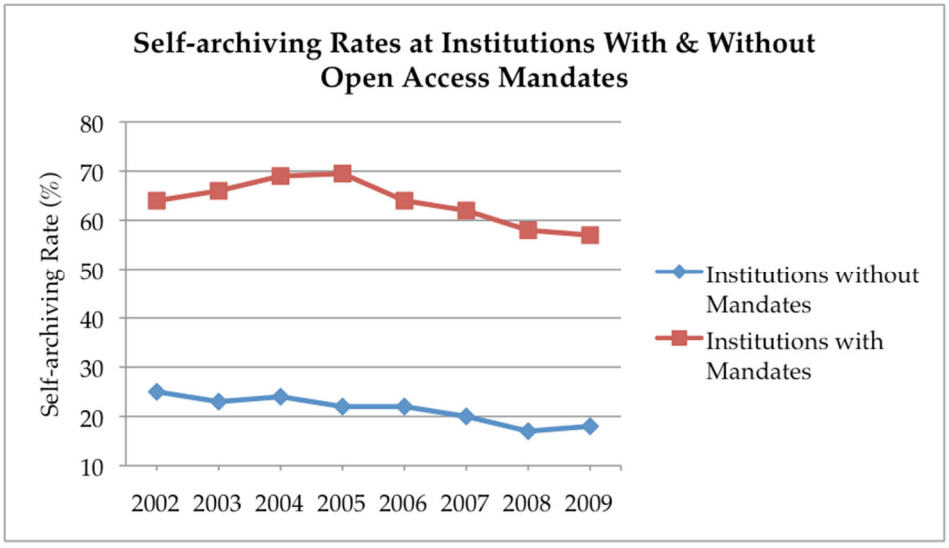
In addition to the potential for additional federal mandates, several US states—including California,[13] Illinois,[14] and New York[15]—have passed, or are actively considering, open-access legislation that targets state-funded research. This state legislation could have significant implications for journals that have a high percentage of state-funded research.[16]

Private nonprofit agencies, foundations, and patient-advocacy groups—such as HHMI, the Wellcome Trust, and the Health Research Alliance—which fund hundreds of millions of dollars of research annually, will have a particular impact on biomedical journals.[17]

2.1.2.2 Institutional Mandates

The number of articles published by authors at institutions with open-access mandates is more difficult to estimate. Institutional mandates have a broad, positive effect on self-archiving deposit rates, with one analysis indicating that self-archiving at institutions with mandates is triple the deposit rate of institutions without mandates (see Exhibit 2-2).[18] The ROAR website provides data on the self-archiving activity for individual institutional repositories, including those at institutions with mandates.[19]

Exhibit 2-2: Self-Archiving Rates at Institutions With & Without Open Access Mandates



Data Source: Poynder 2011. http://poynder.blogspot.com/2011/06/open-access-by-numbers.html

[13] California Taxpayer Access to Publicly Funded Research Act (AB 609). See http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_609&sess=CUR.

[14] The Illinois Open Access to Articles Act (SB 1900). See http://www.ilga.gov/legislation/fulltext.asp?DocName=09800SB1900&GA=98&SessionId=85&DocTypeId=SB&LegID=&DocNum=1900&GAID=12&Session=.

[15] NY State Taxpayer Access to Publicly Funded Research Act (A 180 / S 4050). See http://open.nysenate.gov/legislation/api/1.0/lrs-print/bill/S4050-2013.

[16] California currently funds approximately $200 million per year in scientific research—down from $350 million before the 2008 recession (see http://www.ccst.us/publications/2008/2008RandD.php) and the sponsors of the New York legislation claim that the state funds scores of millions of dollars in research.

[17] The Wellcome Trust awards an average of £800 million per year for biomedical research. The Health Research Alliance (HRA), http://www.healthra.org/, which represents about 50 of the largest private funders of biomedical research in North America, provides about $16 billion per year in research funding. Although none of the HRA organizations has yet issued an open-access mandate, the member organizations are beginning to coordinate mandate policies.

[18] Gargouri *et al*. 2012.

[19] See ROAR, http://roar.eprints.org/.

Individual research institutions can account for a significant number of peer-reviewed articles per year. The faculty at the ten campuses of the University of California, for example, publish upwards of 40,000 articles per year, which represents about 2.5% of global research article output.[20] However, the articles covered by institutional mandates are less likely to be concentrated by discipline than those under funder mandates, and the effect of a particular institution's mandate on a given journal will need to be evaluated individually.

2.2 Mandate Policy Attributes

Several mandate policy attributes have implications for subscription-based journals, as they affect the extent to which openly archived content serves as a substitute for the published journal. These requirements include the version of the article to be archived, the allowable timeframes for deposit and access, and where the paper must be deposited. We discuss below the principal attributes of funder and institutional mandates as context for understanding their implications for substitution and for journal revenue models.

2.2.1 Version Archived

Most funder mandates stipulate deposit of the author's "Accepted Manuscript;"[21] that is, after peer review comments have been incorporated, but before copyediting and publisher formatting have been applied. Few, if any, funder mandates accept the "Author's Original" version as submitted to a journal, but before review comments have been included. Similarly, few mandates require deposit of the "Version of Record," the final published version of an article, unless access to the article is provided via the publisher's website or results from payment of an open-access publication fee.[22]

Although researchers prefer the Version of Record, especially when preparing formal research publications of their own, the author's Accepted Manuscript is perceived to be an adequate substitute for the published version by many researchers and librarians.[23] We discuss the substitution implications of the deposited version in §5.5.

2.2.2 Embargo & Deposit Timeframe

Although there is no empirical evidence documenting their effectiveness, content embargoes remain the prevalent strategy for reducing the risk of substitution. As we discuss in §5.4, an embargo's stated duration is just one dimension of determining the substitution effect of an embargo, and other factors—including actual use of the journal within the embargo period—must be taken into account.[24]

Embargoes established by publishers vary considerably in length, both within and across disciplines.[25] One recent study indicates that the most common embargo period is 12 months (48% of journals), followed by 24 months (28%), and then six months (17%), with a small percentage of journals having

[20] "Academic Senate approves open access policy," University of California Press Release, August 2, 2013, http://www.universityofcalifornia.edu/news/article/29858.

[21] We use here the terms proposed by the NISO/ALPSP Technical Working Group on Journal Article Versions (http://www.niso.org/publications/rp/RP-8-2008.pdf).

[22] For example, to comply with the RCUK policy, a journal must either provide immediate access through the publisher's website or allow self-archiving of the author's accepted manuscript. See http://www.rcuk.ac.uk/documents/documents/RCUK%20_Policy_on_Access_to_Research_Outputs.pdf.

[23] Beckett and Inger 2005.

[24] Although the model includes average online use within an embargo period as one input for the risk assessment, it does not test the effectiveness of relative embargo lengths.

[25] See, for example, Jones 2013.

embargo periods of less than six months or more than two years.[26] Further, some embargoes carry additional restrictions, such as the payment of a fee or requiring formal permission to self-archive.

The policies of the largest research funders vary in terms of acceptable mandate length. The NIH public access policy requires deposit within 12 months, the Wellcome Trust within six months, and RCUK within six months (with provision for longer embargoes in the humanities and social sciences). The pending EC policy and FASTR legislation propose six-month embargoes.

Institutional mandate policies do not always stipulate a specific deposit timeframe, although some call for immediate deposit upon publication, with access opened in compliance with the publisher's mandate terms.

2.2.3 Deposit Channel(s)

The ease and reliability with which openly archived content can be discovered and used is largely a function of the repository in which it is deposited.

Institutional mandates typically call for authors to deposit articles in the institution's online repository, while funder mandates vary in their deposit requirements. Some funders stipulate a specific repository where grantees must deposit to be in compliance. For example, the mandates of major biomedical funders, including NIH and the Wellcome Trust, require deposit in the National Library of Medicine's PubMed Central (PMC) or in Europe PubMed Central. In other fields, mandates call for an author to deposit in an appropriate institutional or subject-based repository and/or for access to be available via the publisher's website.

We discuss the substitution implications of mandated deposit channels in §5.6.

2.2.4 Compliance Provisions

The rate at which authors comply with a mandate affects the amount of content available for potential substitution for the published journal. A 2005 survey of researchers indicated that a significant majority of researchers (> 80%) would comply willingly with a funder or institutional open-access mandate.[27] Still, in practice, compulsory funder mandates tend to enjoy higher compliance rates than voluntary self-archiving policies.

2.2.4.1 Institutional Mandate Compliance

Institutional open-access policies are typically self-imposed mandates, approved by an institution's faculty. In order to get enough support to pass an open-access policy in the faculty senate, most institutional mandates include liberal waiver policies that allow faculty to publish without complying with the mandate. As a result, many institutional self-archiving policies might be better characterized as pledges than mandates. Fewer European institutions have such opt-out clauses, resulting in higher compliance rates.[28] Further, in the UK and some European countries, a faculty member's research publications must be deposited in the institution's repository to be considered for review in professional assessment exercises.

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[26] The SHERPA Services Blog (November 2, 2011) reporting on the 19,000 journals tracked by the SHERPA service. See http://romeo.jiscinvolve.org/wp/2011/11/24/60-of-journals-allow-immediate-archiving-of-peer-reviewed-articles-but-it-gets-much-much-better/.

[27] Swan and Brown 2005, Table 29. Another 13% indicated that they would comply reluctantly, and 5% indicated that they would not comply.

[28] For example, the University of Liège, which has a mandatory policy (http://roarmap.eprints.org/56/) is reported to have a deposit rate of over 80%.

Deposit rates have been shown to climb significantly at institutions that adopt open-access mandates—even relatively weak ones—with much of that growth facilitated by libraries that utilize staff to promote compliance. A recent study based on ROARMAP data demonstrated a significant correlation between deposit rate and institutional mandate strength, with the strongest mandates realizing compliance rates of over 70% within two years, compared to a self-archiving rate of 20% for institutions without mandates.[29]

Irrespective of an institution's policy, mandate compliance is likely to be highest in disciplines with a culture of information sharing and a predisposition to open access. Thus, authors in fields such as computer science, economics, mathematics, and physics may be expected to comply with mandate policies at a higher rate than authors in the social sciences and humanities.[30] Although compliance rates vary by institution, as the number of institutions adopting open-access mandates grows, the number of openly archived articles available to serve as substitutes increases.

2.2.4.2 Funder Mandate Compliance

Funders typically have enforcement leverage and strong mandate compliance provisions, and compliance rates have climbed for the major funders that have implemented stricter controls. Initially, for example, compliance with the NIH public access mandate was voluntary and grantee compliance rate was reported to be under 5%. A policy introduced in 2008 made deposit mandatory, and compliance rose significantly thereafter, increasing to its current rate of approximately 75%.[31] The relatively high compliance rate is supported, in part, by large publishers managing PMC deposit requirements for their authors.[32]

Similarly, the Wellcome Trust's mandate compliance policy hardened in 2009, with non-compliant papers resulting in a portion of the grant budget being withheld. The Wellcome Trust now reports a 60% compliance rate, but has announced plans to increase compliance further by shifting responsibility to the researcher's host institution and ensuring that all publications from previous grants are in compliance with the policy before any funding renewals or new grant awards.[33]

The FundRef registry, recently developed by CrossRef,[34] provides a standard taxonomy with which editorial workflow systems can capture article funding information from authors. This information will allow publishers to analyze the funded articles in their journals and help funders track and increase compliance with their policies.

We discuss the implications of mandate compliance rates for estimating the percentage of a journal's content exposed to substitution in §5.3.

2.2.5 Focus on Funder Mandates

As described above, both funder and institutional mandates will have an impact on the amount of openly archived content available to serve as a substitute for the published journal. However, for practical

[29] Gargouri *et al*. 2012. See also Nicholas *et al*. 2012 and Xia *et al*. 2012.
[30] See Kim 2010.
[31] Aspesi 2012, 20.
[32] For a list of publishers supporting author deposit in satisfaction of the NIH policy, see http://publicaccess.nih.gov/select_deposit_publishers.htm and http://publicaccess.nih.gov/submit process_journals.htm.
[33] See Wellcome Trust Authors' FAQs http://www.wellcome.au.uk/About-us/Policy/Spotlight-issues/Open-access/Guides/WTDo18855.htm#ten and *Times Higher Education*, March 29, 2012 (http://www.timeshighereducation.co.uk/story.asp?storycode=419475).
[34] http://www.crossref.org/fundref/

purposes, the open archiving assessment model we describe in the following sections focuses on funder mandates.

Although open-access mandates are in effect at some of the world's leading research institutions, they cover a relatively small fraction of the annual global output of research articles. Moreover, in the majority of cases, it would be difficult to estimate the percentage of content affected by institutional mandates for any given journal.[35]

The relatively rare journal that derives a significant percentage of its research content from authors at a well-defined set of universities can apply the methods described in the rest of this document to assess the risk of substitution posed by the mandates at those institutions. For the majority of journals, however, focusing on funder mandates will provide the most effective approach to assessing and responding to the risk of substitution.

Exhibit 2-3 summarizes the key attributes of major funder mandates. Additional information on funder mandates is available via the ROARMAP service.[36]

Exhibit 2-3: Summary of Major Funder Mandate Attributes

Funder	National Institutes of Health (NIH)	Wellcome Trust	Research Councils United Kingdom (RCUK)	European Research Council	License	FASTR	Howard Hughes Medical Institute (HHMI)
Application	In effect since April 7, 2008 Covers all research wholly or partially funded	Updated policy in effect since April 1, 2013 Covers all research wholly or partially funded	In effect since April 1, 2013 Covers all research wholly or partially funded	In effect since 2008	Author grants NIH a non-exclusive right to copyright to the original paper in PMC	Pending legislation	In effect since January 1, 2008. Applies to all work conducted using HHMI Does not apply to HHMI grantees
Version	Author's accepted manuscript	Author's accepted manuscript, if self-archived; Version of record, if article fee paid	Author's accepted manuscript, if self-archived; Version of record, if article fee paid	Author's accepted manuscript, if self-archived; Version of record, if article fee paid	CC-BY, if article fee paid	Version of record &/or Author's accepted manuscript	Version of record &/or Author's accepted manuscript
Embargo/ Deposit Timeframe	Within 12 months	Within 6 months	Immediate for paid OA, otherwise within 6 months (12 months for social sciences & humanities)	Immediate for paid OA, otherwise within 6 months (12 months for social sciences & humanities)	CC-BY, if article fee paid	Within 6 months	Within 6 months
Deposit Location	PubMed Central	Europe PMC	Institutional or subject repository	Europe PMC, arXiv & other specified repositories	Not stipulated	Suitable depository to be designated by each agency	PubMed Central
Enforcement	Delayed or withdrawn funding. Compliance rate ~75%	Delayed or withdrawn funding. Compliance rate ~60%	Linked to Research Assessment Exercise; block grants to fund article fees	Condition of funding	Not stipulated	Presumably, similar to NIH policy	Condition of employment

[35] Additionally, although it is not recommended, a publisher could control whether its content is covered by institutional mandates through retrograde licensing terms (for example, by introducing inordinately long embargo periods or license transfer policies designed to defeat the effects of institutional mandates). As explained in §3.2, factors under a publisher's control should be excluded from the risk assessment.

[36] http://roarmap.eprints.org/

PART TWO

3—FRAMEWORK FOR ASSESSING THE FINANCIAL IMPLICATIONS OF MANDATES

3.1 Risk Assessment Issues

3.1.1 Probability & Impact

Risk is typically described as having two dimensions: probability and impact. Probability relates to uncertainty, as risk refers to the possibility of a future state, which may or may not occur. Impact relates to what would happen were the event to occur. Thus, risk is often defined as the potential loss multiplied by the probability that the loss will occur. In the case of a society publisher assessing the implications of funder mandates, quantifying risk entails assessing the probability that various mandate requirements might result in subscription cancellations and determining the financial impact were the cancellations to occur.

In most cases, it will be relatively simple to estimate the impact of the cancellation risk in terms of forgone revenue. However, assessing the probability of risk is more problematic, as:

- testing the probability of subscription cancellations can be difficult without actually putting subscriptions at risk or without incurring significant market research costs;
- risk inherently involves uncertainty; and
- probability estimates can be influenced by subjective and unconscious biases.

Reviewing each of these issues in turn will provide context for a description of a structured framework for assessing and responding to mandate requirements.

3.1.2 Need for a Market Surrogate

For most journals, there is no cost-effective way for a publisher to test the potential effects of available substitutes on cancellations without exposing itself to an unacceptable risk. Journal-specific market research might provide better information about potential library responses to the availability of substitutes, and thus reduce uncertainty in assessing the risk for a given journal. However, properly conducted in a manner designed to yield reliable results, such market research would likely prove too expensive for many society publishers. Further, simply waiting to see the market response to the availability of substitutes might limit a society's response options. Therefore, a risk assessment model is needed to provide a market surrogate.

The open archiving assessment model described here provides a publisher with a tool to assess potential market responses to substitution actively and before the fact. Moreover, the time and effort required to apply the risk assessment tool should be far less intensive than performing the journal-specific market research and environmental analyses that would otherwise be necessary.

3.1.3 Measuring Uncertainty

It is impossible to determine probability precisely in a complex decision such as subscription cancellations. Although assembling accurate data and controlling for perception biases will improve the accuracy and utility of substitution estimates, there will always be some degree of uncertainty and imprecision. Fortunately, precision is not necessary in order to provide a useful estimate of the probabilities of various substitution scenarios.

Reducing uncertainty is useful, even if does not eliminate uncertainty entirely. Although it may not always be possible to achieve a high degree of precision—and some of the measurements proposed for

assessing substitution risk retain a significant amount of potential error—the model nevertheless represents an improvement over casual assumptions.[37]

The open archiving assessment model takes into account the lack of complete or accurate journal and market information by using probability ranges that measure the relative likelihood of a given outcome, using values that lie on a continuum between impossibility and certainty. These ranges are defined with scales that provide a publisher with a meaningful frame of reference for estimating the probability of a given risk.

The model measures this uncertainty by assigning a probability range to the likelihood of substitution for each critical journal attribute based on the best evidence available. Using probability ranges allows a publisher to assess risk without making assumptions that go beyond what it knows to be factually correct. An upper and lower bound of probability is identified for each of the substitution factors, with the goal of establishing a 90% confidence interval. Given the nature of the data available, and the element of subjectivity inherent in some of the factors, broad probability ranges are sometimes required to achieve a high confidence that the true value lies within the range.

Research indicates that explicitly documenting the validity of probability estimates significantly improves the calibration of the estimates.[38] Although the specific values for the substitution risk variables (see §3.2) will vary for each journal, we have proposed general ranges for the variables and documented the rationale behind the range assumptions. Suggesting ranges for the substitution variables in this way risks anchoring or priming the values for a publisher that wishes to modify the proposed ranges. Therefore, we repeat reminders of these risks wherever we propose default confidence ranges in Part 3 of this report.

Naturally, the accuracy of the probability assessment will be affected by the quality of the data underlying it. Lack of accurate data on relevant journal attributes (such as a journal's use curve or the proportion of articles resulting from funded research), and an incomplete understanding of market demand, complicate an assessment of the implications of various mandate requirements on substitution. However, improving the accuracy of data, even where possible, will not always prove cost effective. The benefit of refining the estimated range of any given risk factor must be weighed against the cost of collecting the additional data required.

3.1.4 Credibility & Legitimacy

The results of the risk assessment must be understood, and considered legitimate, by decision-makers within a society. Often, decision-makers will prefer a quantitative assessment of risk, assuming that the measurement methodology is sound. Where an empirical basis for establishing the substitution probability ranges is weak or absent, a pragmatic approach, that marshals available data, may be required. In any event, the data used to justify a probability assumption must be documented and synthesized in a logical and transparent manner.

Estimating probability can be influenced by subjective and unconscious biases. Cognitive studies[39] suggest that a variety of perceptual factors can influence the way a society perceives uncertainty and risk. Factors that merit special attention for society publishers include:

[37] See Slovic 1987 and Hammond *et al*. 1998.
[38] See Hubbard 2010, 64 – 65.
[39] See, for example, Hammond *et al*. 1998; Hillson and Hulett 2004; Kahneman 2012; and Slovic 1987.

- Familiarity—

  The extent to which a society has experience analyzing subscription risk factors can affect whether it will perceive the risk probability as high or low. A society with little or no previous experience with such analyses will often perceive a higher degree of uncertainty (and therefore risk) than one with extensive experience.

- Timeframe and scale—

  A society will perceive the risk of cancellations to be higher if the risk is closer in time, rather than further into the future. This can lead a society to perceive the risk of cancellations resulting from mandate policies to be great, while it underestimates the incremental threat of cancellations that cumulate over time. Similarly, a society may perceive the risk of a sudden drop in subscriptions to be greater than a gradual, but equally harmful, decline.

- Control—

  The extent to which a society perceives that it can exercise some control over an outcome will affect its perception of the risk. This is true even where the perception of control is illusory. This may help explain why publishers appear to be more apprehensive of externally imposed embargo periods than those they implement—without apparent empirical evidence—themselves.

- Motivation—

  Motivational bias can occur when the assessing individual(s) or organization has an interest in influencing the results. In the case of a society publisher, this bias could run either way: assessors with a predisposition to increased access might reflect a bias toward lessening the perceived risk, while more conservative assessors might be biased towards an increased perception of risk. Involving a variety of stakeholders (including members, staff, and independent stakeholders) in the risk assessment exercise can help counter such motivational bias.

As these perceptual factors operate subconsciously in individuals and groups assessing probability, a structured approach that helps manage potential bias will provide a more realistic and useful assessment of probability.

3.2 Substitution Assessment Model Overview

3.2.1 Substitution Risk Factors

An overview of the logic behind the risk model will provide useful context for discussing the substitution risk factors and Monte Carlo simulation in detail. As already noted, the open archiving assessment model has been designed to:

1) assess the probability that openly archived articles might serve as a substitute for a subscription to a published journal; and

2) estimate the extent to which this substitution might translate into lost revenue.

The substitutability of openly archived content for a subscription to a published journal will be affected by several factors. Three of the factors quantify the amount of content that will be openly available and two additional factors qualify the extent to which the open content might serve as a substitute. The three quantitative factors are:

- The proportion of a journal's research content affected by funder mandates—

  The first step is to determine the percentage of a journal's content that would be subject to one or more funder mandates. Not all of a journal's research content is covered by a mandate (the proportion covered is typically less than 50%), and research articles do not necessarily represent all of a journal's content (for example, reviews, letters, editorials, and other communications can comprise a significant portion of some journals).

- The percentage of authors complying with funder requirements—

  Not all of the content covered by mandates necessarily gets deposited per the funder's policies. The compliance rate for funder mandates depends on funder enforcement policies and other factors and, as a result, may change over time. Sometimes the compliance rate for a funder's mandate is documented and published, while in other instances the extent of actual compliance is unknown.

- Use of a journal's content within the embargo timeframe—

  Embargo lengths vary from six months to 24 months, and the percentage of online use that occurs within the embargo period varies by type of journal (e.g., fast-cycling scientific journals receive a higher proportion of use upfront than social science and humanities journals). Use within the embargo timeframe provides a better metric for evaluating the effect of an embargo than the nominal embargo period.

Together, these quantitative factors define the amount of content that would be available as a substitute (however imperfect) for the published journal. As a simplified example, were 40% of a journal's content covered by a funder mandate with an 80% compliance rate, and were 75% of the use of that content estimated to occur after the embargo period, then 24% (i.e., 40% * 80% * 75%) of the published journal's content would be available to serve as a substitute.

If the openly available content were exactly the same in all other respects as the content in the published journal, then the journal's value, *relative to its current price*, could be said to be reduced by 24% as a result of the open archiving. However, in most cases, the openly archived content is not the same as the published version in several significant respects, and these differentiating factors mitigate the substitution effect of the openly archived content.

While the quantitative factors measure the *amount* of content available for substitution, the differentiating factors represent qualitative considerations that reduce the extent to which the available content might serve as a substitute for the published journal. There are two principal differentiating factors:

- The version of the article that is openly archived—

  Surveys of academic libraries indicate that an author's post-peer review manuscript is a better—although still imperfect—substitute for the published article than the author's manuscript before any revisions. Most mandates require the deposit of the author's manuscript after referee comments have been incorporated, but before copyediting and the publisher's formatting has been applied. However, mandate policies can vary.

- Reliability of access, functionality, and extent of content integration—

  Some mandates require that content be deposited in a subject-specific repository, while other mandates allow content to be deposited in any online repository. Content archived in centralized, well-indexed repositories is easier to discover, and provides a more effective substitute for the published journal, than scattered content for which discovery is less reliable.

The risk assessment model measures each differentiating factor by the probability that the factor would be considered an effective substitute for the published version, thus reducing the value of the journal to a subscriber relative to the journal's current price. For example, for the "archived version" variable, an 80% substitutability value would indicate that 80% of subscribing institutions would consider the openly archived version to be a sufficient substitute for the published version. As a result, the 80% substitutability of the archived version would reduce the value of the published content by 20%. (In practice, this probability will be treated as a range to achieve a 90% confidence interval, as described below.)

Again, the overall value of the substitute content—that is, the exposed content adjusted by the qualifying factors—is treated as functionally equivalent to a reduction in the published journal's value relative to the journal's current price. As subscribers will have various intensities of demand (that is, varying consumer surplus) for a journal, a given decrease in relative value will not typically translate into a commensurate reduction in the number of subscriptions. To estimate the effect of the substitution on subscriptions, the model uses a journal's price elasticity of demand (see §6.1).

3.2.2 Critical Modeling Assumptions

Each of the quantitative and qualitative substitution risk factors are logically independent of one another, and the substitution probability ranges reflect the effect of each factor individually, all other things equal.[40] However, in making a decision whether to cancel a journal and rely on openly archived content as a substitute, librarians often consider the contributing factors together.

Strictly speaking, determining the extent to which funder mandate requirements might increase substitution for a published journal would require an analysis of historical price and circulation data, controlling for all relevant variables—including journal quality, price, version archived, and reliability of access. Theoretically, such an analysis of revealed preferences would be possible for those journals that have been operating under mandates for some time. However, such an analysis would be time-consuming, expensive, and—by definition—*post hoc*.

As rigorous econometric modeling is beyond the resources of most society publishers—and a *post hoc* analysis typically irrelevant in any event—we have designed the model to allow journal publishers to estimate—with a reasonable degree of accuracy—the potential impact of funder mandate policies on the revenue streams for their journals. The model makes the following critical assumptions:

1) To measure the extent to which openly archived content would serve as a substitute for published content, we have multiplied the probabilities of the individual risk factors.

   As described above, calculating the amount of content that might serve as a substitute is relatively straightforward: For example, were 40% of a journal's research content covered by a mandate with an 80% compliance rate, then (*ceteris paribus*)[41] the substitution risk would be 32%. And were 75% of the use to occur outside the embargo period, then the substitution risk for that factor would be 75%. Again, considering only the three quantitative factors, the probability of substitution would be: 40% * 80% * 75% = 24%.

[40] If articles based on funded research were to receive consistently more use within a journal than other original research articles, then the usage attribute would not be independent of the percentage of funded research. However, an analysis of article usage for a sample of BioOne journals does not suggest a correlation between funding and use. Therefore, we assume such situations would be rare or nonexistent.

[41] That is, assuming immediate access to the final published manuscript via the publisher's web site.

Establishing a 90% confidence interval for the three quantitative factors presents a straightforward sampling issue for each factor. (Establishing the bounds for a 90% confidence interval is important for the Monte Carlo simulation, described in §7.)

2) For each of the qualitative factors, there are criteria that can be assessed to allow the potential extent of the substitution to be expressed quantitatively.

   For example, content known to be archived in a well-indexed, centralized repository—as mandated by some research funders—would pose a greater risk of substitution than content archived in unspecified repositories with limited or non-existent indexing practices. Similarly, content archived with robust metadata and indexed by leading search engines and library discovery tools would typically be more susceptible to substitution than content scattered across multiple digital repositories of unknown discovery standards. Absent survey or revealed preference data documenting librarian perceptions of these factors, we can assign—arbitrarily, but pragmatically—substitution probabilities for the factors along a broad scale, as described in §5.

   Although these probability ranges reflect a lower standard of certainty than might be possible were better empirical data available, they serve a legitimate purpose by helping to reduce uncertainty. The bounds for a 90% confidence interval for substitutability based on such criteria will tend to be broad. Running thousands of scenarios under a Monte Carlo simulation allows us to model the effects of the substitution assumptions, despite the necessarily broad ranges.

   Further, although the ranges for these values are broad, they should be sufficient for the purposes of most scholarly and scientific societies. In most cases, the value of additional measurement to refine the probability ranges (and reduce uncertainty) would not justify the additional cost.

3) Conceptually, the qualitative factors can be thought of as reducing the substitution effect of the openly archived content. (Practically, the order of the probabilities being multiplied does not matter.) For example, assuming a journal with:

   - 24% of its content openly available based on the three quantitative factors (as calculated in the example above);
   - a 75% probability of substitution given the version archived; and
   - a level of access with a 60% probability of substitution,

   the overall substitution effect would be as follows:

   Substitution = 24% * 75% * 60%; that is, Substitution = 10.8%

4) The model posits that the overall calculated substitutability equates to a commensurate reduction in the journal's value to a subscriber *at the journal's current price*. In other words, if the openly archived content available given a set of mandate requirements represented a 10.8% substitute for the published journal, this would be the effective equivalent of a reduction in the journal's value, relative to its current price, of 10.8%.

5) The model further assumes that a reduction in a journal's value via substitution is functionally equivalent to an inferred increase in the journal's price. This equivalence is important, because we use this change in value in combination with a journal's price elasticity of demand to predict the number of subscriptions that might be at risk given such a change in value (see §6).

Not all subscribers value a journal equally. Some institutions will be at the limit of what they are willing to pay for a journal, while others would be willing to pay more than the journal's current price. As determining the consumer surplus for each individual subscriber—that is, the difference between what an institution is currently paying and what the institution would be willing to pay—would be practically impossible, the model uses a journal's price elasticity of demand to translate a marginal loss in value/demand into a loss of subscriptions.

For example, a journal with archived content available that represents a substitutability of 10.8% (and therefore an inferred price increase of the same percentage) and an arc price elasticity of demand (see §6) of 0.41, would be expected to have a 4.4% decline in the quantity of subscriptions demanded (0.108 * 0.41 = 0.0442). Applying this predicted change in quantity demanded to the institutional subscription base, and multiplying by the average subscription price, would thus yield the lost revenue predicted for each scenario. (The model allows for the elasticity to be adjusted for journals that have already been affected by archiving mandates.)

The model uses a Monte Carlo simulation to generate random values, within the established probability ranges, for each of the substitution variables. The results of each scenario are compared against the publisher's revenue risk tolerance (see §4) which reflects the publisher's perception of the revenue loss that it would be able to accept for the journal. The simulated probability of exceeding a specified lost revenue threshold (over 10,000 scenarios) represents the financial risk to a journal's publisher. (As described below, a publisher may use the model to test multiple revenue loss thresholds.) The publisher then needs to consider this financial risk, along with any non-financial risks, in the context of compensatory benefits such as mission fulfillment.

Sections 4 – 7 below describe each component of the model in greater detail.

4.1 Purpose of a Risk Threshold

A society's risk tolerance—stated as a dollar amount—provides a basis against which to test the potential financial impact of funder mandate requirements. As explained above, the risk model uses a Monte Carlo simulation to generate random values for a set of substitution factor probability ranges. The model compares the outcome of thousands of scenarios against a financial risk threshold established by the publisher, and calculates the probability of exceeding that threshold. Obviously, the lower the financial risk tolerance, the greater the probability—all things equal—that the substitution effects of a mandate will exceed the publisher's tolerance. Therefore, determining how much financial risk a publisher is willing and able to accept represents a critical component of the analysis.

Societies have different perceptions of risk, and each society will need to determine its own capacity for absorbing it. In setting a financial threshold, a publisher will need to be especially careful to avoid introducing motivational bias. For example, a society may be tempted to set the financial risk threshold to increase the probability that the substitution effects of a mandate will fall above or below the society's risk threshold. The model assumes that a publisher has successfully controlled for such bias according to the principles outlined in §3.1.4. In other words, the open archiving assessment exercise assumes that a publisher is seeking as objective an assessment as possible. A publisher that does not consider the logic behind the model's risk assessment variables to be compelling should adjust those variables, rather than manipulating the risk threshold.

After running the Monte Carlo simulation based on the financial threshold(s) identified, a society should evaluate the financial risk in combination with non-financial considerations, such as mission alignment and member demand. This will allow the society to account for any significant non-financial risks and any compensating benefits in evaluating the implications of the financial risk assessment.

The revenue risk threshold should take into account the incremental loss a society is able and willing to tolerate excluding any losses that would be incurred independently of the mandate's implications (for example, from current cancellation trends). At a later stage, the society will need to take any revenue losses unrelated to mandates into account in determining the type of response that might be warranted based on the totality of the journal's revenue position. Additional detail on establishing a risk threshold for modeling purposes is provided in §8.2.

4.2 Effect of Substitution on Non-Subscription Revenue

In calculating the change in subscription revenue that a journal could absorb in order to break even or lower its operating margin to a specific percentage, the publisher must take into account both the variable costs of fulfilling journal subscriptions and the contribution of non-subscription revenue streams.

For most peer-reviewed journals, institutional subscription revenue represents over 75% of a journal's total revenue, and for small journals institutional subscriptions can account for over 90% of revenue. Although subscriptions represent the largest source of revenue, most journals generate some revenue from other sources, including rights and permissions, print advertising, aggregator license royalties, single issue sales, pay-per-view fees, and (in some instances) page charges.[42]

To calculate a journal's risk threshold, a society needs to identify whether non-subscription revenue streams might be affected by an increase in the availability of openly archived content. While the revenue

[42] Although some societies allocate individual member dues to offset the cost of providing member copies, this discussion focuses on external revenue sources.

of each journal will need to be assessed individually, we comment in general below on the potential effect of substitution on each type of revenue.

4.2.1 Aggregator License Royalties

In addition to subscriptions to the primary journal, many journals are also distributed via online journal databases offered by aggregators (including EBSCO, JSTOR, ProQuest, etc.), either with or without a content embargo, and license royalties from these databases can represent a significant portion of a journal's non-subscription revenue. For the purposes of this model, royalties received for distribution of the primary journal—for example, via Project MUSE or BioOne—should be treated as subscription revenue.

A high percentage of openly archived content might marginally reduce the value of a journal's content in aggregated databases. However, academic libraries typically subscribe to such journal aggregations to provide convenient research resources for students and faculty (especially when conducting interdisciplinary research), and this convenience value should not be significantly diminished by the availability of openly archived content. Indeed, it is not uncommon for content in aggregated databases to duplicate journal content that a library holds in other formats. Further, individual journals bundled in an aggregation cannot be readily deselected by subscribing institutions. Taken together, these factors suggest that the availability of openly archived content should not have a significant impact on a journal's royalty revenues from journal aggregations.

4.2.2 Rights & Permissions

Revenue for reprint and electronic reserves permissions typically represents less than 5% of a journal's total revenue, and for many journals such revenue has been declining with the rise of online distribution. (Medical journals, for which reprint sales for clinical trials can be substantial, are an exception.) Logically, where a funder mandate requires a CC-BY license,[43] one might expect the demand for permissions to decrease in proportion to the number of articles covered by the mandate. In practice, however, the manner in which permissions are processed tends to dampen the substitution effect of openly archived content.

Most permissions revenue is processed by reproduction rights organizations—such as the Copyright Clearance Center (CCC) in the US, the Copyright Licensing Agency (CLA) in the UK, and Access Copyright in Canada—that offer comprehensive annual licenses to institutions on behalf of rights holders, including journal publishers. These blanket licenses effectively bundle the rights to articles, reducing the substitutability of an openly archived version of any given article. Although the rights management agencies also offer transactional licenses and online services (such as RightsLink) for course packs and electronic reserves, the onus for determining whether an open-access substitute is available lies with the permission seeker. Given the practical hurdles to substitution, and the relatively low percentage of revenue represented, the model does not assume any material loss of permissions revenue due to mandated open archiving.

4.2.3 Advertising & Sponsorships

Advertising also represents less than 5% of total revenue for most peer-reviewed journals. Although most advertising revenue is driven by subscription circulation, the correlation is not necessarily linear. A significant decline in circulation would lower the value of a journal as an advertising venue. However, a 5% drop in subscriptions would not translate into a commensurate drop in advertising revenue. If the risk model indicates a drop in the number of subscriptions greater than 20%, a society might adjust the

[43] For an explanation of the CC-BY license, and other Creative Commons licenses, see http://creativecommons.org/licenses/.

revenue threshold to account for an anticipated loss of advertising revenue. However, a loss of subscriptions on such a scale would likely require a major revision to the journal's income model in any event.

4.2.4 Pay-per-View Fees

Pay-per-view (PPV) revenue often represents less than 1% of a journal's overall revenue. PPV transactions might be expected to decrease for openly archived articles, although the substitution would be inhibited by the same imperfect market information affecting rights and permissions revenue. At the same time, PPV transactions might be expected to grow in the event of substitution-driven journal cancellations, as former subscribers seek access to the non-open content. Given the potential for the effects of open archiving on PPV demand to offset each other, coupled with the immaterial amount of revenue typically at stake, the model does not assume any incremental loss in PPV revenue due to open archiving.

5.1 Journal Attributes & Substitution Risk

As already discussed, the openly archived version of an article will rarely afford a perfect substitute for the published version. The journal attributes described below affect the perceived value of openly archived content as a substitute for a subscription to the published journal. Subscribers on the margin—that is, with low demand relative to price[44]—will be more open to imperfect substitutes for a journal. Therefore, to estimate the potential effect of mandate policies on a journal's value to subscribers (and, ultimately on a journal's revenue) requires that we determine the extent to which openly archived content provides a substitute for the journal itself, taking into account all the principal factors that affect such substitution.

For any given institutional subscriber, the decision to acquire or retain a subscription involves a number of evaluative criteria that determine a journal's relative value to the institution. These factors typically include:

- relevance to an institution's core academic programs and curriculum (including maintaining a balance between disciplines at an institution, supporting new programs, etc.);
- level of local use (as measured by online use, re-shelving statistics, etc.) relative to other resources serving the same programs;
- faculty feedback on a title, including local faculty involvement with a journal as authors and editors;
- cost relative to local importance and use, and relative to other titles in a subject area;
- the availability of substitutes in other formats (for example, via aggregated databases, pay-per-view, consortia sharing, inter-library loan, etc.);[45]
- the currency of the content, including how frequently it is updated; and
- journal quality and publisher authority, with publications from professional associations and journals with high Impact Factors, sometimes favored over other journals.

Cancellation decisions are also affected by local budget exigencies and other environmental factors. Further, substitution risk can vary by market segment, requiring a journal with a significant proportion of non-academic subscribers (such as corporate or special libraries) to assess the demand of those segments independently.

Libraries vary in how carefully and empirically they weigh the above criteria, including local usage and the percentage of content available openly. Necessarily, the substitution assessment described here assumes that libraries analyze the amount of content openly available and make cancellation decisions accordingly. However, in practice, such analyses can prove difficult and resource intensive.[46] As a result, the substitution model may overstate the risk of substitution.

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[44] Technically speaking, subscribers with a low consumer surplus for a journal at the subscribed price.

[45] In some disciplines—for example, visually oriented disciplines—there may still be demand for a print edition that would prevent a library from cancelling in favor of an online-only substitute. In reality, however, the journals most likely to experience a continuing demand for a print edition are unlikely to be significantly affected by mandates. Therefore, the risk model does not include demand for a print edition as a substitution risk factor.

[46] For several perspectives on library behavior in the face of openly archived alternatives, see the discussion on the GOAL listserv on September 16, 2013 and digested in Lib-License on September 17, 2013, especially the contributions by Rick Anderson of the University of Utah Library and Ellen Duranceau of the MIT Libraries.

Although a journal's relevance to an institution's research and teaching focus represents the preeminent subscription acquisition/retention criterion, it is not practicable to take into account institution-specific criteria in assessing the potential substitution risk across all subscribers. However, the risk model uses the following factors to determine the likelihood that, on average, mandate-compliant content would provide an effective substitute for the published journal and result in a marginal reduction in a journal's value:

- percentage of a journal's overall content that funded research articles represent;
- rates of author compliance with mandate deposit requirements;
- online usage relative to the timeframe of the embargo;
- the version of the content archived; and
- ease of discoverability and access to the archived content.

The first three attributes are quantitative and can be said to describe the extent of a journal's content exposed to substitution. The remaining attributes are qualitative and serve to mitigate the substitution effect of the exposed content. The substitution risk factors are independent of one another. That is, the occurrence of one factor does not influence the occurrence of another.

In estimating the substitution risk, the model does not consider journal attributes over which a society could exercise control. These include attributes that the publisher could modify to minimize or eliminate risk, such as the journal's subscription price or the price of a pay-per-view option. Additionally, although a journal's price and value represent important preference factors in acquisition/cancellation decisions, the model takes these factors into account by using a journal's price elasticity of demand (see §6) to estimate the impact of a marginal reduction in value on a journal's subscriptions and revenue.

The risk model takes each of the factors above into account to determine the probability that mandate-compliant openly archived content would substitute for a published journal, potentially resulting in journal cancellations and reduced revenue. Because the journal attributes are independent of each other, the substitution risk can be calculated by multiplying the probability of each of the factors.

The model requires that a publisher define a range of values for each factor that represents a 90% confidence interval. To facilitate this assessment, we have described each of the principal risk factors in more detail below. Section 8 provides sample value ranges for each variable, along with the rationale behind the assumptions. These probability assumptions can be modified to reflect the particular situation of any given journal.

5.2 Percentage of Research Content Affected

The percentage of a journal's content that results from research funded under an open-access mandate is an obvious factor in assessing the potential risk of substitution for the published journal. Indeed, along with embargo length, it is often one of the only factors a publisher might consider in a casual assessment of risk. At the same time, a 2006 library survey indicated that librarians place less weight on the amount of freely archived content than other factors (such as quality, cost, article version, access, etc.) when weighing substitution alternatives, with only 12% of librarians considering it the principal consideration.[47]

For some journals, non-research content represents an important element of the journal's value. Therefore, in assessing the percentage of content that funded research represents, a publisher should

[47] Beckett and Inger 2006.

measure the funded content against all of a journal's content—including editorials, letters, reviews, and other non-research content—not only relative to other research content.[48]

Additional detail on determining the percentage of research content is provided in §8.4.

5.3 Deposit Compliance Rate

The compliance rate for a relevant mandate represents another quantitative factor that affects the amount of content available to serve as a substitute for the journal. Compliance rates for funder mandates will tend to be higher when the publisher manages the content deposit. Although responsibility for compliance typically resides with the author, some large publishers provide mandate compliance support as a service for authors. Presumably, where a publisher deposits on behalf of its authors, the compliance rate will be near 100%.

Additional detail on determining the deposit compliance rate for modeling purposes is provided in §8.5.

5.4 Use Outside Embargo Period

The length of the embargo period allowed by a funder mandate often plays a disproportionate role in casual assessments of substitution risk. However, as discussed above, embargo length is just one element of a complex cancellation decision for institutional subscribers. One-dimensional assessments that artificially isolate embargo length as a risk factor are likely to under- or overstate risk.[49]

Although an embargo ostensibly precludes access to content for a specified period, not all of the use occurs within the embargo timeframe. In reality, therefore, there are two components to the perception of content currency: 1) the nominal length of the embargo itself, and 2) the actual amount of use that the content receives within the embargo period. The nominal length of the embargo affects a subscriber's perception of the currency of a journal's content, while the proportion of use that the content receives within the embargo period more accurately reflects the actual value that a subscriber derives from the journal during the embargo period.

For example, a subscriber might perceive a 12-month embargo as being too long for self-archived articles to serve as effective substitutes for a subscription. However, if most of the use of the content actually occurs after the embargo period ends, then the extent to which an embargo decreases substitutability may be less than the nominal length of the embargo might imply. Therefore, the journal's use *outside* the embargo period represents the extent to which the content might substitute for the content in the published journal. For example, if a journal's content receives, on average, 35% of its use within the embargo window, then the value of the content given the embargo would be 65% of the value of the published journal.

This discrepancy between the stated embargo length and its actual effect complicates an effort to estimate an embargo's substitution impact, as some subscribers will act based on the nominal embargo duration, while others will base their decisions on an analysis of a journal's local use patterns. Given the increasing reliance of institutional libraries on local usage data in making acquisition and renewal decisions, the

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[48] Further, the risk assessment model projects the change in the number of subscriptions based on the price elasticity of demand for the journal, and that elasticity is predicated on all of the journal's current content.

[49] Such as the survey sponsored by ALPSP and the Publishers' Association (Bennett 2012), which asked "Would you continue to subscribe were most of a journal's content freely available within six months of publication?" See also Davis 2012. The PEER project (www.peerproject.eu) also found that embargoes of 6, 12, and 18 months had little effect on demand for the published journal. However, the design of the PEER study makes it difficult to generalize from that study's findings. See http://www.peerproject.eu/fileadmin/media/reports/20120618_PEER_Final_public_report_D9-13.pdf and http://www.peerproject.eu/reports/#c20.

conservative approach is to assume that libraries will evaluate substitution based on actual use, and a journal's average use across all institutions should provide a serviceable proxy for local use.

The content's use within the embargo timeframe might seem to be a dependent variable. That is, use of the journal might seem correlated to the other substitution factors (such as accessibility) in that a readily accessible journal might be expected to receive more use than a less accessible journal. While that would be true for the overall volume of use of the journal, the use of the journal *within the embargo timeframe* measures the *distribution* of the journal's use, irrespective of the overall volume of use. That distribution of use is an independent variable.

Additional detail on determining a journal's use relative to the stated embargo period is provided in §8.6.

5.5 Deposited Version

The universal use of web-based discovery and retrieval tools tends to obscure the provenance of content, which can increase the extent to which preprints of an article may serve as substitutes for the published version of record. The major funder mandates require deposit of the author's submitted version of an article, incorporating any peer review changes, but prior to final copyediting and publisher formatting. Few mandates appear to consider the author's original submitted manuscript to be adequate or, at the other extreme, to require the publisher's final version.

Studies of the manner and extent to which the final published version of an article differs from the author's corrected manuscript indicate that there are real differences between the author's refereed, but not copy edited, manuscript and the publisher's final version.[50] The integrity of references appears to be the principal improvement added to the published version,[51] and copyediting now appears to have as much to do with the accuracy of XML tagging as with sense and consistency of style. However, these improvements are not always sufficient to affect the value perception of end users.

Additional information on determining the substitution probability range for various article version is provided in §8.7.

5.6 Discoverability & Access

Another factor affecting the extent to which an openly archived article might serve as a substitute for the published version is the ease with which an article can be discovered, retrieved, and used. The reliability with which self-archived content can be discovered and retrieved depends on the quality of the metadata associated with the content and the repository in which it is deposited. As discussed in §2, funder mandates differ on where articles are to be archived. Some require deposit in a specific digital repository—such as the NIH's public access policy, stipulating deposit in PubMed Central—while others allow deposit in any complying institutional repository.

The quality of the metadata associated with the content archived in these repositories can vary considerably. Some repositories have specific requirements for metadata, while others simply allow for voluntary, author-assigned metadata. Further, some repositories allow full-text indexing by Google/Google Scholar and web-scale library discovery services (such as Serials Solutions Summon and XLibris Primo), while others do not. As a result, self-archived content known to reside in a repository with policies that promote reliable access will provide a better substitute for the organization and coherence afforded by the published journal than content for which the reliability of discovery and access are uncertain.

[50] Wates and Campbell 2007; Goodman *et al*. 2007.

[51] Representing approximately 43% of copy editing changes according to Wates and Campbell 2007.

Additional detail on determining the substitution probability range based on reliability of access is provided in §8.8.

5.7 Other Journal Attributes

There are several other journal attributes that might seem relevant in assessing the potential for openly archived content to substitute for a published journal. As described below, some of these factors are already subsumed under one of the attributes described above, while others are within a publisher's control, and have therefore been excluded from the risk model.

5.7.1 Content Quality & Value

Not surprisingly, librarians report that content quality is the most important preference factor in acquisition/cancellation decisions.[52] However, the intellectual quality of the content in an article is essentially the same whether the content is openly archived or available through the published journal. Therefore, quality does not affect the substitution of an archived article for a published journal. To the extent that the content does differ—for example, an author's manuscript prior to peer review versus the published article—that difference is covered by the Deposited Version attribute (see §5.5).

Of course, cancellation decisions are made relative to other journals (and other priorities), and journal quality plays a critical consideration in such decisions. Subscribers with low demand relative to price (that is, with a lower consumer surplus) will typically be more open to imperfect substitutes for a low-quality journal than for a high-quality title. However, the risk model takes relative consumer surplus into account by using a journal's price elasticity of demand (see §6) as a mechanism for translating a relative drop in demand into a quantifiable decrease in subscriptions. Therefore, the risk model does not treat a journal's quality and value as independent variables.

5.7.2 Functionality

Dissimilarities in platform functionality can also differentiate the published content from self-archived versions. Access via the publisher's platform often provides CrossRef-enabled reference linking, advanced search functionality, dynamic content alerting, multimedia and interactive article elements, and support for mobile devices. The absence of this functionality could reduce the extent to which the archived version would provide an acceptable substitute for the published journal. At the same time, the value subscribers perceive in the publisher platforms appears to be decreasing with time. In some cases, this has been accelerated by the use of web-scale library discovery services, which allow users to download content PDFs without interacting with a publisher's platform, thus discounting the value of publisher-provided tools and platform features. As a result, the model does not treat platform functionality as a discrete variable.

5.7.3 Cited Half Life

Cited half-life is a measure of how long a journal article continues to be cited after publication. Cited half-life is calculated as the median age of the articles in a journal that were cited in a given year of the *Journal Citation Report*.[53] In other words, half of the journal's cited articles were published more recently than the cited half-life.

An exceptionally short cited half-life may reflect a journal that focuses on the rapid communication of current information and for which content currency is especially valued. However, a long cited half-life does not necessarily mean that the currency of a journal's content is not valued; rather, that the content's

[52] Beckett and Inger 2005.

[53] See http://admin-apps.webofknowledge.com/JCR/help/h_ctdhl.htm.

usefulness or popularity remains steady over time. Therefore, we have used online usage within the embargo period (see §5.4) as a more accurate indicator of the value placed on currency.

5.7.4 Pay-per-View Access

The availability of a journal's content on a pay-per-view (PPV) basis provides a substitute for the journal for institutions that cannot justify or afford a subscription to the journal itself. However, because a publisher can control the per-view pricing for its journals—for example, by increasing the PPV price for its content to a level that effectively precludes substitution—PPV does not constitute a relevant factor for assessing the potential for subscription substitution.

Exhibit 5-5: Hypothetical Risk Register

Percentage of Content Covered by Mandate(s), §8.3	
Lower Bound	*Upper Bound*
35%	40%
Compliance Rate of Mandate(s), §8.4	
Lower Bound	*Upper Bound*
60%	80%
Percentage of Use Outside Embargo Timeframe, §8.5	
Lower Bound	*Upper Bound*
40%	50%
Archived Version Substitutability, §8.6	
Lower Bound	*Upper Bound*
45%	95%
Access Substitutability, §8.7	
Lower Bound	*Upper Bound*
30%	80%

Mandate Risk Model/Risk Register

5.8 Risk Factor Summary

Taken together, the substitution variables described above help predict the likelihood that funder mandated openly archived content would substitute for a published journal. The results for the individual variables can be summarized in a risk register, as illustrated in Exhibit 5-5 for a hypothetical journal.

The following sections describe how the substitution probability ranges summarized in a risk register can be translated into a quantifiable impact on the number of institutional subscriptions and a probability distribution established using a Monte Carlo simulation.

6.1 Translating Substitution Risk into Financial Impact

The substitution risk equation—based on the five journal attributes described in §5—measures the extent to which the journal's marginal utility or value declines for the average subscriber. In practice, however, a subscriber would not have the option of paying a lower subscription price for a journal were the value to decrease. Typically, a subscriber's only option would be to either retain the subscription at the current price, despite the relative reduction in value, or cancel the subscription entirely and forgo all the non-funded content.[54]

Assessing the financial impact of partial substitution requires that a publisher: 1) quantify any decline in value in terms of the number of potential subscription cancellations, and 2) estimate the average value of a cancelled subscription. The first, translating a decline in value into subscription cancellations, needs to take into account that subscribers will have different levels of consumer surplus for a journal; that is, some subscribers will place a higher value on a journal relative to its price than others. The model uses a journal's price elasticity of demand to translate a decrease in value into a decline in subscription units. The decline in subscription units is then multiplied by the average price of a cancelled subscription.

6.2 Price Elasticity of Demand

The risk model allows a publisher to assess the extent to which self-archived content might substitute for the published journal, thus marginally reducing the value of the journal relative to the price paid by subscribers. However, this marginal reduction in value would not invariably translate into subscription cancellations, as some or all of the institutions subscribing to a journal would be willing to pay more than they are currently paying.[55]

The market price of a journal is different from the journal's economic value to subscribers: a journal's price only reflects the minimum amount that an institution is willing to pay, while a journal's value is the highest price an institution would be willing to pay. Institutions for which a journal's value exceeds the price actually paid—that is, in economic terms, institutions that enjoy a "consumer surplus"—would retain their subscriptions despite a relative drop in value.

Determining the extent of this consumer surplus for each of the subscribers to a journal—in order to estimate how much value could be reduced relative to price before triggering cancellations—would be difficult to determine cost effectively. Therefore, the model requires a means by which to measure the potential effect a marginal decrease in value might have on a journal's revenue. For this purpose, the model uses a journal's price elasticity of demand.[56]

Elasticity measures how responsive quantity demanded is to a change in price. Specifically, elasticity measures the change in quantity demanded, in percentage terms, relative to the size of a price change, also in percentage terms. Demand for a journal is said to be elastic when the change in quantity demanded is greater than the percentage change in price that caused it, and inelastic when the percentage change in quantity demanded is less than the percentage change in price.

If demand for a journal is elastic—that is, if the market is sensitive to a decline in value relative to price—then the decrease in value due to substitution would result in a higher number of subscription

[54] Although institutions would likely seek access to the cancelled content via other routes (including PPV and ILL), that substitution lies beyond the specific substitution effects and revenue impact of funder mandates.
[55] That is, absent perfect price discrimination, whereby a journal's pricing would reflect the actual value for each subscribing institution, some subscribers would be willing to pay more than the journal's current price.
[56] For convenience, we sometimes refer to the price elasticity of demand as price elasticity, demand elasticity, or elasticity.

cancellations. If the demand for the journal is relatively inelastic, then the effect of substitution on subscription cancellations would be lower.

Elasticity is typically used to predict the effect on revenue given a potential change in price. For the purposes of our model, we can consider the change in a journal's perceived value, due to the availability of openly archived content as a substitute, to be functionally equivalent to an increase in price. That is, from a subscriber's perspective, a reduction in a journal's value of 10% would be effectively the same as an increase in price of 10%. Thus, the model uses a journal's price elasticity to predict the change in demand for subscriptions given a probable change in value. This can be expressed simply as:

Substitution % * Elasticity = % Change in Quantity

We describe below (see §8.8) how a journal's price elasticity of demand is calculated. However, it is important to recognize that factors other than price affect demand for a journal. The law of demand states that, *other things equal*, an increase in price results in a decrease in quantity demanded and a decrease in price results in an increase in quantity demanded. Here, "other things equal" means that determinants of demand *other than price*—including the size of library budgets, institutional preferences, significant changes in the scale or scope of the journal itself, a change in the importance of a field or discipline, and the availability and prices of substitutes (including aggregated journal databases and self-archived content)—remain the same along the demand curve. A shift in demand can occur when one or more of the non-price factors changes.

For simplicity and practical necessity, the model assumes that subscription cancellations precipitated by the availability of openly archived content can be isolated from cancellations for other reasons.[57] In reality, the factors cannot be easily separated. Although the resulting measurement is imperfect, it represents a significant improvement over an intuitive approach.

6.3 Subscription Units Exposed

The model uses the substitution probabilities and price elasticity of demand to estimate the percentage of exposed subscriptions that would be liable to substitution. This substitution percentage is then applied against the number of institutional subscriptions to a journal. This requires that a publisher determine the number of subscriptions actually exposed to potential substitution.

The model assumes that, in most cases, only individual institutional subscriptions to a journal will be affected by substitution. Subscriptions included as part of a subscription bundle (including so-called "Big Deals"), or included in an online aggregation (either the publisher's own or a third-party's), are not as readily susceptible to substitution as primary subscriptions. Although a library could cancel a subscription bundle in order to subscribe only to selected high-use titles, the cumulative price of the individual titles can often exceed the price of the bundle (such discounts being the appeal of such aggregations in the first place). Similarly, the model assumes that individual society membership would not typically be affected as a journal only represents element of the benefits being delivered to a member. Moreover, any substitution that might have taken place would have already occurred when members gained online access to the journal via institutional site licenses.

[57] Although the model uses a journal's current price elasticity of demand to predict the effect that a change in value would have on demand for subscriptions to the journal, in reality, the availability of openly archived articles would reduce demand for the journal overall, independent of price. In the case of journals that have been publishing articles affected by funder mandates for some time, the current elasticity should already reflect this shift in demand. For journals that have yet to publish articles under mandates, we have had to ignore the potential effect of a future demand shift, as controlling for such a shift would require an impractical data collection and analysis exercise.

6.4 Average Revenue per Subscription

To determine the revenue impact of the substitution risk, the model multiplies the estimated number of units that would be subject to substitution by the average amount of revenue that would be at risk for each cancelled subscription. The simplest approach to determining average revenue at risk from cancellation will typically be to calculate the weighted average subscription price across all subscribers.

This approach would also be conservative—that is, it would likely overstate the risk—as most of the cancellations would come at the margins of the journal's subscription base, from institutions that place less value on the journal. Often, these subscribers will have access to the journal via a consortia offering or tiered pricing that discounts a journal's price in order to reach a larger audience. As a result, these institutions at the margin will typically pay a lower average price than other subscribers.

7 — MONTE CARLO SIMULATION MODEL

7.1 Simulation Model Overview

As described in §3, the open archiving assessment model described here measures uncertainty by assigning probability ranges to the critical risk variables based on the mandate requirements a journal faces. To achieve a high degree of confidence that the true value for a given risk factor lies within the range,[58] a broad probability spread may sometimes be required. Fortunately, a computer-based Monte Carlo simulation allows us to use a spreadsheet model to generate thousands of scenarios using the probability ranges as inputs.

Each scenario in the simulation generates a random value within the probability range for each of the substitution risk factors to determine a specific value for that variable. These specific values are then used to calculate the potential impact on revenue for each scenario. The Monte Carlo simulation allows a publisher to model the potential revenue impact under thousands of scenarios to determine the probability that the financial effects of the mandate requirements will exceed the publisher's risk tolerance; that is, the publisher's perception of the revenue loss that it would be able to accept for the journal (see §4).

Each scenario generated by the model is based on a set of randomly generated values for each of the substitution risk factors; that is, the percentage of research content covered by a mandate, the mandate compliance rate, the use of the content within the embargo timeframe, the version of the content archived, and the accessibility and functionality of the archived version.

The substitution percentage generated by the randomly selected values is then used to calculate, in conjunction with the arc elasticity calculation and the average price per subscription, the revenue that would be lost at the randomly generated values. For some of the scenarios, the lost revenue will exceed the publisher's financial tolerance threshold and for others the lost revenue will fall below the threshold. By generating thousands of scenarios, a publisher can determine the probability distribution for the results.

The simulated probability of exceeding a specified lost revenue threshold, over the 10,000 scenarios, represents the financial risk to a journal's publisher. A publisher may use the model to test multiple revenue loss thresholds. The publisher then needs to consider this financial risk, along with any non-financial risks, in the context of compensatory benefits, such as mission fulfillment.

7.2 Monte Carlo Simulation Description

Exhibit 7-1 illustrates the simulation model's data table for the substitution risk variables.[59] (The example uses the hypothetical substitution risk values shown in the Risk Register; see Exhibit 5-2.)

Exhibit 7-1: Monte Carlo Simulation, Sample Ranges & Values

	Ranges					Elasticity, Units & Price		
Ranges	Substitutable Content %	Compliance Rate %	Use Substitution %	Version Substitution %	Access Substitution %	PEoD	Units, Current Year	Price, Current Year
Upper Bound	45%	80%	50%	95%	80%			
Mean	40%	70%	45%	70%	55%	1.2727	500	$ 375.00
Lower Bound	35%	60%	40%	45%	30%			

[58] A 90% confidence interval means that the range has a 90% probability of containing the true value. To achieve a 90% confidence interval means ensuring that the publisher is 95% certain in the upper and lower bounds for the range.

[59] The Monte Carlo simulation spreadsheet is based on that described in Hubbard 2010, 79 – 97.

The exhibit summarizes the upper and lower bounds for the substitution risk variables in the simulation. The mean is used in calculating the standard deviation for the normal distribution assumed for the analysis. The elasticity (PEoD), as well as the subscription units and average revenue per primary subscription for the current year (that is, the last full year) are used for calculating the revenue impact for each of the generated substitution scenarios. As noted in §6.4, the number of subscription units should only reflect direct subscriptions to a journal, excluding subscriptions in aggregations or subscription bundles.

A publisher could estimate the logical extremes for the substitution risk by calculating the product of the lower bounds for all of the variables and the product of the upper bounds for all of the variables. However, this approach will typically yield too broad a range to allow a publisher to determine how best to respond to the substitution risk.

7.2.1 Risk Variables

Exhibit 7-2 illustrates the first six (of 10,000) randomly generated scenarios based on the hypothetical substitution risk variables. (The following descriptions apply to the "Monte Carlo" tab of the companion Substitution Model workbook.)

Exhibit 7-2: Substitution Risk Scenario Examples, Monte Carlo Simulation

Scenarios											
1	2	3	4	5	6	7	8	9	10	11	12
Scenario #	Content %	Compliance %	Use %	Version %	Access %	**Substitution %**	Adjusted Substitution % ("Price Increase")	% Δ in Quantity	Unit Δ in Quantity	Revenue Decrease, Year 1	Threshold Exceeded
1	34%	73%	47%	88%	68%	6.89%	6.66%	8.47%	42.36	$ 15,885	1
2	42%	75%	46%	86%	81%	9.95%	9.47%	12.06%	60.29	$ 22,610	1
3	31%	71%	46%	84%	51%	4.39%	4.30%	5.47%	27.36	$ 10,262	-
4	44%	58%	42%	78%	18%	1.47%	1.46%	1.86%	9.29	$ 3,484	-
5	38%	62%	42%	66%	40%	2.55%	2.52%	3.21%	16.05	$ 6,020	-
6	39%	63%	45%	61%	39%	2.60%	2.57%	3.27%	16.35	$ 6,132	-

Exhibit 7-3 shows detail on the substitution risk columns (columns 2 – 6). These columns represent the randomly generated values for each of the risk variables.

Exhibit 7-3: Substitution Risk, Monte Carlo Simulation

1	2	3	4	5	6
Scenario #	Content %	Compliance %	Use %	Version %	Access %
1	34%	73%	47%	88%	68%
2	42%	75%	46%	86%	81%
3	31%	71%	46%	84%	51%
4	44%	58%	42%	78%	18%
5	38%	62%	42%	66%	40%
6	39%	63%	45%	61%	39%

The random value for each variable is calculated by using the normal cumulative distribution for the mean (i.e., the 90% Confidence Interval (CI) upper bound plus the 90% CI lower bound divided by two)

and standard distribution (i.e., the 90% CI upper bound less the 90% CI lower bound) divided by the 3.29 (the standard deviation in one 90% CI).[60]

Exhibit 7-4 shows detail on the calculated values (columns 7 – 12). The calculated values are described below:

- **Substitution percentage** (column 7)—

  The substitution percentage represents the product of each of the risk variables (columns 2 – 6). That is:

  Compliance % * Content % * Use % * Version % * Access % = Substitution %

Exhibit 7-4: Substitution Risk, Monte Carlo Simulation

7	8	9	10	11	12
Substitution %	Adjusted Substitution % ("Price Increase")	% Δ in Quantity	Unit Δ in Quantity	Revenue Decrease, Year 1	Threshold Exceeded
6.89%	6.66%	8.47%	42.36	$ 15,885	1
9.95%	9.47%	12.06%	60.29	$ 22,610	1
4.39%	4.30%	5.47%	27.36	$ 10,262	-
1.47%	1.46%	1.86%	9.29	$ 3,484	-
2.55%	2.52%	3.21%	16.05	$ 6,020	-
2.60%	2.57%	3.27%	16.35	$ 6,132	-

- **Adjusted substitution percentage** (column 8)—

  The model uses the arc price elasticity of demand, taking into account the average elasticity for the part of the demand curve represented by the data (see §6), as the basis for calculating a change in units demanded. As a result, the Substitution Percentage needs to be adjusted to reflect the arc price for the journal. Appendix F explains this adjustment.

- **Percentage change in quantity** (column 9)—

  The percentage change in quantity is calculated by multiplying the journal's price elasticity of demand by the adjusted substitution percentage. For example, an adjusted substitution percentage of 6.66% and an elasticity of 1.2727 would yield a percentage change in subscription quantity of 8.47%.

- **Unit change in quantity** (column 10)—

  The unit change in quantity is calculated by multiplying the current subscription base (in units) by the percentage change in quantity. For example, 500 units and a percentage change in quantity of 8.47% would result in a change in quantity of 42.36 units.

- **Decrease in revenue, Year 1**[61] (column 11)—

  The decrease in revenue due to mandate-driven substitution is calculated by multiplying the current subscription price by the unit change in quantity. For example, in the first scenario, 42.36 units and an average revenue per primary subscription of $375 would result in a decrease in Year 1 revenue of

[60] The Excel formula is: =NORMINV(RAND(), ("90% CI Upper Bound" + "90% CI Lower Bound" / 2), ("90% CI Upper Bound" – "90% CI Lower Bound" / 3.29).

[61] Year 1 refers to the first year to which the analysis applies. Typically, the year following the current year.

approximately $15,885. The model indicates the average decrease in revenue across all of the scenarios; for example, the average decrease under the example variables would be approximately $11,250 per year.

- **Threshold Exceeded** (column 12)—

  The model compares the decrease in revenue for each scenario and compares it against the publisher's financial tolerance threshold. If the threshold is exceeded, the model returns a "1."

The model uses the results of column 12 to calculate the percentage of scenarios that exceed the threshold, as shown in the hypothetical example illustrated in Exhibit 7-5. In the example, the probability of exceeding the publisher's stated risk threshold, given the variable values, is 41%. (The model also indicates the average forgone subscription revenue given a particular set of assumptions.) We provide case studies, based on anonymized data provided by three society publishers, in §9.

Exhibit 7-5: Substitution Simulation, Example Summary Results

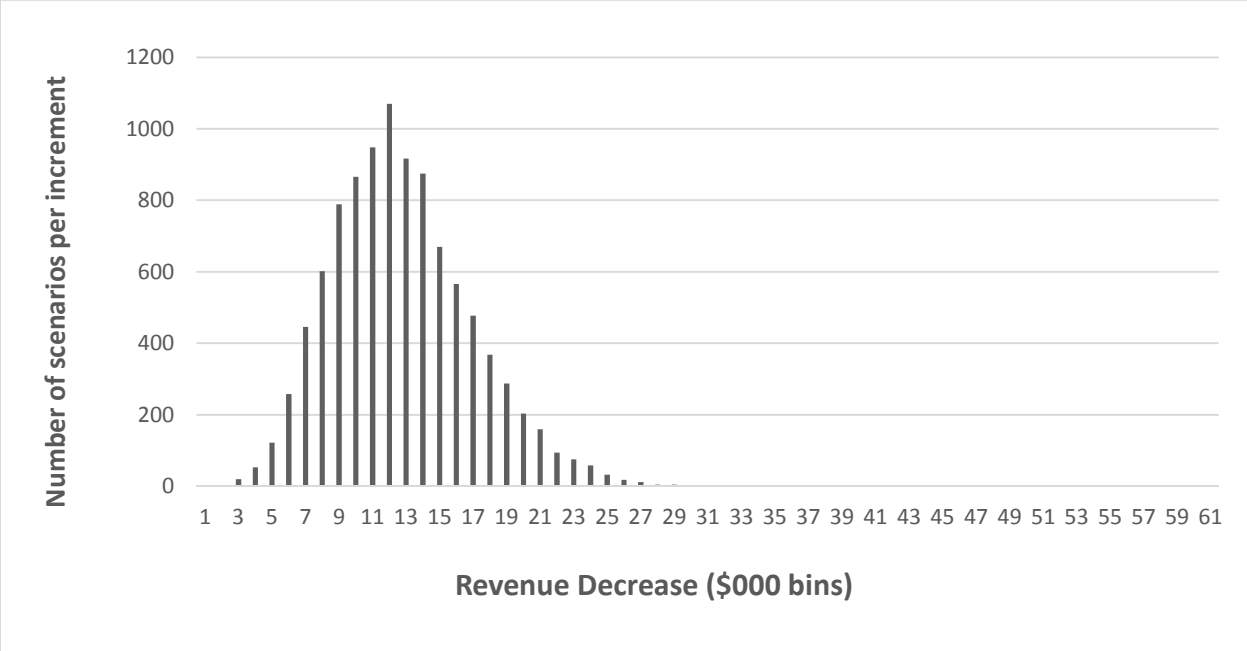
Publisher's average annual risk threshold for the journal. Model assesses probability that revenue risk will exceed the threshold.	$11,719
The probability that the revenue loss will exceed the annual revenue threshold.	41%
The chance that the revenue loss will not exceed the risk threshold.	59%

7.2.2 Probability Distribution

The model calculates the percentage of scenarios that exceed the threshold, which represents the probability of exceeding the publisher's stated risk threshold given the variable values. Besides the average across all of the scenarios, another way of looking at the probability of a journal exceeding the publisher's risk threshold is to create a histogram that that counts the number of scenarios that fall within specified increments. Appendix G provides an example of such a histogram, and the simulation tool in the companion worksheet automatically generates one. A histogram provides a more nuanced perspective of the risk probability and can be useful in presenting the potential outcomes to stakeholders within a society.

The histogram sorts scenarios into thousand dollar increments or bins. The histogram data can then be used to generate a chart, such as the one in Exhibit 7-6. A histogram provides a more nuanced perspective of the risk probability and can be useful in presenting the potential outcomes to stakeholders within a society.

Exhibit 7-6: Example Histogram



PART THREE

8—GUIDE TO USING THE SUBSTITUTION ASSESSMENT MODEL

8.1 Guide Introduction

This section provides a step-by-step guide to applying the mandate substitution risk assessment model, including suggestions on assembling and preparing the journal data required. The descriptions below refer back to the relevant sections in the report that provide background and context for the data or analysis being described, and to the relevant models and templates in the companion Excel-based simulation model.

8.2 Establishing a Risk Threshold

A society's tolerance of risk—stated as a dollar amount—provides the basis against which the open archiving assessment model tests the financial impact of funder mandate requirements. (See §4.1.) The risk model compares the outcome of thousands of scenarios against the financial risk threshold established by the publisher, and calculates the probability of exceeding that threshold. Therefore, determining how much financial risk a publisher is willing and able to accept represents a critical component of the analysis.

There are two principal steps to establishing a society's risk threshold: 1) calculating a baseline for a journal's current financial performance (for example, based on net income or net revenue contribution), and 2) determining the extent of a change in the journal's current financial performance that the society could realistically accommodate, taking into account the society's overall financial position. The second step may result in the society identifying several alternative financial risk tolerance scenarios that it wants to test.

For modeling purposes, the revenue risk threshold should take into account the incremental loss a society is able and willing to tolerate excluding any losses that would be incurred independently of the mandate's implications (for example, from current cancellation trends).

8.2.1 Defining a Performance Baseline

For modeling purposes, the revenue risk threshold should take into account the incremental loss a society is able and willing to tolerate excluding any losses that would be incurred independently of the mandate's implications (for example, from current cancellation trends). As described in §4.2, the effect on non-subscription revenue will typically be limited. Therefore, the description here focuses on the net change in subscription revenue. The process also requires that the revenue be adjusted to reflect variable costs, as failing to do so would overstate the net financial impact of revenue lost to substitution.

We describe below how to calculate a risk threshold based on a journal breaking even in terms of net income (that is, gross revenue less all direct and indirect expenses). This approach requires a caution: Allocating indirect costs (including overhead and other shared costs) across a society's journal(s) and other programs invariably relies on some logic extraneous to the activities of the individual programs themselves.[62] As a result, overhead allocations are inherently arbitrary. At the same time, such allocations reflect a society's current financial expectations of a journal vis-à-vis other society programs. Therefore,

[62] For example, general operating and overhead cost allocations are often allocated based on the revenue an activity generates (e.g., an activity that produces 25% of the organization's revenue is allocated a quarter of the general operating costs) or proportional to the direct costs that the activity incurs. Although these allocation approaches are appropriate from a financial accounting perspective, they are less useful for establishing a society's risk threshold for a journal. For societies, balancing both revenue-generating and subsidized programs, overhead cost allocations typically reflect political or policy decisions as well.

calculating the change in a journal's net income provides a logical starting point in assessing financial tolerance. A society might subsequently consider shifting resources and/or rebalancing program costs and resources.

Alternatively, a society could calculate the net revenue a journal contributes to shared operating costs—that is, the revenue a journal contributes to a society's finances before indirect costs are taken into account—to provide a financial baseline. Some societies will consider this approach preferable, as it effectively isolates the financial performance of the journal. For a description of net revenue contribution and related concepts, see Appendix A.

8.2.2 Establishing a Risk Threshold

As the first step in establishing a risk threshold, the society needs to determine how much of a change in net income it would be able to absorb. This calculation will depend on a variety of factors, typically including how much net income the journal currently contributes, the amount of surplus revenue (if any) generated by other journals or programs, and the availability of cross-subsidies from other society income streams (including member dues, endowments, dedicated publication funds, etc.).

After determining the annual change in net income that it would be able and willing to absorb, a society needs to translate this change in net income into a change in top-line (gross) subscription revenue. Translating a society's tolerance for a change in net income into gross revenue is simply a matter of dividing the net income amount by the journal's contribution margin for subscription revenue.[63] For example, if a society determined that it could absorb a loss to net income of $10,000 a year for a journal with a contribution margin of 80%, the revenue risk threshold would be $12,500 (i.e., $10,000/0.80). Appendix B illustrates a worksheet (see the "Threshold" tab in the Substitution Model workbook) that a publisher can use to determine the revenue threshold for modeling purposes.

> In Tab 1, "Risk Threshold," of the *Substitution Model* workbook, a publisher should enter the revenue amount for the journal's primary subscriptions in Line a), the variable costs for those subscriptions in Line b, and the total net income the publisher is able and willing to risk in Line d). The values entered will yield the publisher's revenue risk threshold for the journal and this value will automatically populate Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

The model assesses the probability of exceeding the risk threshold in a single year. In reality, however, it may take several years for the market to adjust to the availability of openly archived content as a potential substitute. As a result, the revenue risk may not be as great in the years immediately following the imposition of a mandate.

A society that publishes multiple journals will want to assess the substitution effect on each journal individually, which will require setting separate financial thresholds. The society can then analyze the combined financial implications across all the journals analyzed.

A society might conclude that it cannot tolerate any change in the net revenue generated by its publishing program. In such a case, of course, the model will indicate a 100% probability of the journal's risk tolerance threshold being exceeded. Even so, it would still make sense for a society to run its journal attributes through the open archiving assessment model to test the potential extent of a decrease in

[63] Contribution margin as a percentage = (revenue – variable costs) / revenue. For example, a journal with $100,000 in revenue and $20,000 in variable costs would have a contribution margin of 80% (100,000 – 20,000)/ 100,000. See also Appendix A.

revenue. This would provide the society with better information with which to plan a response to the changing market situation.

8.3 Journal Attributes

The journal attributes described in §5 affect the perceived value of openly archived content as a substitute for a subscription to the published journal. The risk model uses the following factors to determine the likelihood that mandate-compliant content would provide an effective substitute for the published journal and result in a marginal reduction in a journal's value:

- percentage of a journal's overall content that funded research articles represent;
- rates of author compliance with mandate deposit requirements;
- online usage relative to the timeframe of the embargo;
- the version of the content archived; and
- ease of discoverability and access to the archived content.

The first three attributes describe the extent of a journal's content exposed to substitution. The remaining attributes mitigate the substitution effect of the exposed content.

The risk model takes each of the above factors into account to determine the probability that mandate-compliant openly archived content would substitute for a published journal, potentially resulting in journal cancellations and reduced revenue. Because the journal attributes are independent of each other, the substitution risk is calculated by multiplying the probability of each of the factors.

The model requires that a publisher define a range of values for each factor that represents a 90% confidence interval. To facilitate this assessment, we have provided below sample value ranges for each variable, along with the rationale behind the assumptions. These probability assumptions can be modified to reflect the particular situation of any given journal.

8.4 Percentage of Funded Research Content

Determining the percentage of a journal's content published under a funder mandate should be relatively straightforward. For journals that only publish original research articles, the proportion of funded-research articles can be determined based on the average number of items that cite a relevant research funder (typically, in the article's acknowledgements). Given the potential for growth in federal, state, and private funder mandates, it makes sense to track all funded research, even if not all of the funded research is currently under a mandate, so that the potential implications of any future mandates can be evaluated. For journals that include non-research content—which can differ in length from research articles—the proportion of funded research content can be calculated based on average page counts.

To determine a 90% confidence interval for the percentage of a journal's content represented by funded articles—whatever the basis of comparison used—the publisher can analyze five issues of the journal picked at random over a time period that reflects the current funding trends in the discipline. If the sample is truly random, there is a 93.75% chance that the median value for the results for all the issues is between the highest and lowest values in the sample. For example, were the five random issues to have funded article percentages of 43%, 35%, 45%, 40%, and 37%, there is a 93.75% chance that the median percentage for all of the journal's issues would be between 35% and 45%.[64]

[64] That is, the chance of selecting five issues that are either all above or all below the median is 3.125%, the equivalent of getting heads five times in a row in a random coin flip. See Hubbard 2010, 30. Alternatively, a publisher might use the small sample

In Tab 2, "Content Under Mandate," of the *Substitution Model* workbook, a publisher should enter the low and high bounds for the percentage of funded research content. The values entered will automatically populate Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

Although non-research content needs to be taken into account, subscribers will often value original research articles more highly than some other journal content. Therefore, journals that have a significant proportion of non-research content—and have surveyed their readers as to the relative perceived value of the content—may want to weight the content accordingly.

8.5 Deposit Compliance Rate

A publisher depositing on behalf of its authors should have empirical data regarding its author compliance rate. Uncertainty in such circumstances should be low, and the 90% confidence range for the compliance variable should thus be relatively narrow. Similarly, the compliance rate for a mandate of a major research funder—especially if it requires deposit in a centralized repository—is more likely to be published and readily available than the compliance rates when deposit in any conforming institutional repository is acceptable.[65] Access to published compliance rates will reduce (though not eliminate) uncertainty on the part of a publisher, so that the range of values for the variable should be narrower than for mandates with unpublished compliance rates.

Exhibit 8-1: Default Substitution Probability Ranges, Deposit Compliance

Low Substitutability Low or unknown compliance	**Medium Substitutability** Moderate compliance/ Moderate confidence	**High Substitutability** High compliance/ High confidence
5 - 40%	30% - 75%	60% - 95%

Mandate Risk Model/Compliance Rate

Exhibit 8-1 illustrates the substitution probability ranges for the compliance rate variable under several sets of circumstances:

- A high compliance rate and high confidence in the quality of the compliance data—for example, given publisher-managed deposit and journal-specific data;
- A moderate compliance rate and a moderate confidence in the compliance data—for example, author-managed deposit and the availability of funder data on compliance across all authors, but not specific to a given journal; and
- A low or unknown compliance rate—for example, deposit is scattered across multiple repositories with undocumented compliance rates.

Some journals will be solely or predominantly affected by a mandate from a single funder. Others may publish content covered under multiple mandates. In the latter case, to make the probability model as accurate as possible, it may be necessary to adjust the amount of content covered by each mandate by the compliance rate for that mandate. For example, a journal with 20% of its content subject to a mandate

technique described in §8.5 and Appendix D, in the context of determining the percentage of a journal's use within an embargo timeframe.

[65] While deposit in a centralized repository (e.g., PMC) affects both accessibility and the compliance rate, the substitution effects are logically independent of one another.

with a reported compliance rate of 75% and another 15% of its content covered by a mandate with 60% compliance, would have 24% of its content exposed to substitution ((20% * 70%) + (15% * 60%) = 24%).[66]

> In Tab 3, "Mandate Compliance Rate," of the *Substitution Model* workbook, a publisher should enter the low and high bounds for the percentage of funded authors complying with funder mandates. The values entered will automatically populate Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

8.6 Use Outside Embargo Period

Most journals continue to receive use, albeit at a reduced level, for years after initial publication. To estimate the average use within an embargo period requires the publisher to set an artificial timeframe (for example, the first four years after publication) as the basis for the estimation. One justification for this approach is that institutional libraries may be expected to place relatively greater value on near-term use when making subscription retention decisions. Although imposing such an artificial timeframe reduces the accuracy of usage as a variable in estimating the effect of an embargo, even an imperfect adjustment is preferable to taking the nominal embargo length at face value.

Alternatively, a publisher can make an assumption about the proportion of lifetime use that occurs within a given period after publication. For example, by assuming that 80% of a journal's lifetime use occurs within the first four years after publication, a publisher could adjust the proportion of use that occurs within the embargo period to reflect the estimated lifetime usage. An example of such a calculation is shown in Appendix C.

As the substitution risk is represented by the content's use *outside* the embargo timeframe, the substitution percentage equals the inverse of the use percentage. For example, if, on average, a journal receives 35% of its first four years' use within the embargo window, then the substitution risk would be 65%. That is, the value of the embargoed content would be 65% of the value of the same content available immediately upon publication.

The greater the depth of usage data available, the higher a publisher's confidence in the average use calculation for a journal. In any event, many journals will be limited in terms of the usage data available for such an analysis. For example, for a quarterly journal, a publisher would require at least four years' worth of use data to get four samples (each issue would provide one sample), and less frequently published journals would require five or more years' of data to get at least four samples. The usage data should be available from a society's primary publishing partner or, in the case of self-published journals, the journal's platform or website host.

To compute a 90% confidence index for a small sample set, the publisher can use the t-statistic, which assumes a broader distribution than the normal distribution for larger sample sizes. For example, using this approach—which is described in Appendix C—four usage samples of 45%, 42%, 30%, and 37% would yield a range of use within the embargo timeframe of 31% - 46% for a 90% confidence interval. This would translate into a range of use outside the embargo timeframe of 54% - 69%.

[66] Unless online use of the content differed—significantly and consistently—depending on the funder sponsoring the research, the same usage percentage (see §5.4) would apply across the funded content.

In Line a) of Tab 4, "Use Outside Embargo," of the *Substitution Model* workbook, a publisher should enter the percentage of a journal's estimated use within the first four years after publication to provide a basis for estimating the percentage of use within an embargo timeframe. In Line b) of Tab 4, a publisher should **e**nter the low and high bounds for the percentage of a journal's use *within* the embargo timeframe based on the average use data for the journal. The values entered will automatically populate Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

8.7 Deposited Version

Institutional libraries state a strong preference for the peer-reviewed version of research articles over unrefereed author manuscripts.[67] However, as long as a paper has been through the peer review process, additional refinements in the archived version of the article appear to have little effect on subscription retention/cancellation decisions.[68] Likewise, most individual researchers in the sciences and social sciences consider pre-prints as important for their research, although pre-prints appear to be far less important for research in the humanities.[69] Publishers of journals in the humanities may expect the substitutability of pre-prints for the published journal to be lower than for science and social science journals.

Exhibit 8-2: Default Substitution Probability Ranges, Archived Version

Low Substitutability Unrefereed Manuscript	Medium Substitutability Refereed Author Manuscript	High Substitutability Published Version
5 - 50%	40% - 80%	65% - 95%

Mandate Risk Model/Version

The substitution risk probability boundaries shown in Exhibit 8-4 reflect this subscriber survey data. The three substitutability levels reflect the logical range of article versions, although, as noted above, few funder mandates would accept the unrefereed manuscript or require the final published version. As a result, the medium range will be appropriate for most journals.

Although necessarily subjective, this scale aligns with article version preferences identified in researcher and librarian surveys. One survey reports that respondents considered the final published version only slightly more critical in subscription decisions—all other factors held equal—than the author's refereed and copyedited manuscript or the author's refereed manuscript prior to copy editing. Only a small percentage of respondents indicated that an author's unrefereed manuscript would be acceptable.[70]

The probability ranges in the exhibit reflect this finding that a post-peer review version of an article will frequently provide an acceptable substitute for the published version. The lower bounds are more difficult to determine. As a result, in the absence of empirical evidence—for example, the availability of a journal-specific survey—the proposed bounds for a 90% confidence interval have been set broadly. A publisher may elect to modify these ranges based on journal-specific situations. For example, a journal for which either copyediting or formatting is *perceived by subscribers* as especially important.

[67] Beckett-Inger 2006, especially Figures 1 and 8.
[68] This complements research that suggests that researchers prefer the published version when preparing a formal paper, but are satisfied with the pre-publication version for general research purposes. See RIN 2009.
[69] Housewright, Schonfeld, and Wulfson 2013, 14 – 15, Figure 1.
[70] Beckett and Inger 2006, Figure 4.

In Tab 5, "Archived Version," of the *Substitution Model* workbook, a publisher should enter the low and high bounds for the estimated percentage of users for whom the version archived is anticipated to provide a substitute for the published article. The values entered will automatically populate Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

8.8 Discoverability & Access

Journals operating under a funder mandate specifying a centralized repository with high discoverability will confront a greater risk of substitution than journals for which archived material is distributed across multiple repositories with unknown discoverability standards. Content that is covered by more than one mandate—or that is known to be deposited, by common practice, in a subject- or discipline-specific repository with high discovery standards—would have a substitutability risk somewhere in between.

Exhibit 8-3: Default Substitution Probability Ranges, Reliability of Access

Low Substitutability Uncertain Discoverability Standards	Medium Substitutability Mixed Discoverability Standards	High Substitutability High Discoverability Standards
5 - 50%	40% - 80%	50% - 95%

Mandate Risk Model/Access

The substitution risk probability boundaries shown in Exhibit 8-3 take into account the relative uncertainty regarding the accessibility of archived articles.

In Tab 6, "Access," of the *Substitution Model* workbook, a publisher should enter the low and high bounds for the estimated percentage of users for whom discovery and access for the archived version is anticipated to provide a substitute for the published article. The values entered will automatically populate Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

8.9 Price Elasticity of Demand

The model uses a journal's price elasticity over the most recent four to five year period to predict the effect of the substitution probability on the number of subscriptions. The acquisitions budgets for many academic libraries underwent structural changes in 2008 and 2009 (concurrent with the global economic downturn) and these changes will have shifted the demand curve for journals at many institutions. Therefore, calculating elasticity based on data that post-dates 2008 may provide a better indicator than a deeper data set.

For practical reasons, the model assumes that the elasticity calculation will be based on primary subscriptions to the journal; that is, subscriptions to the journal as an individual title, excluding subscriptions to the journal bundled in a multiple-title aggregation (such as BioOne). This assumption is necessary as aggregations exhibit different demand characteristics and elasticities than individual journals.

Elasticities vary over the length of the demand curve, even for the same journal. Elasticity tends to be higher as one moves up the demand curve (the part of the curve reflecting higher prices and lower quantities) and lower as one moves down the curve (the part of the curve associated with lower prices and higher quantities). As a result, calculating a journal's arc elasticity—that is, based on two points along a journal's demand curve—will more accurately represent the journal's elasticity than would a

single point on the curve. Practically speaking, arc elasticity can be calculated by using an average of the change in price and the quantity demanded.[71]

A journal's elasticity of demand can be summarized by the following equation:

$$\frac{\%\ \text{Change in Quantity}}{\%\ \text{Change in Price}}$$

The formula for calculating the arc price elasticity of demand (PEoD) is:

PEoD = % Change in Quantity Demanded (QD) / % Change in Price (P), where:

the % Change in Quantity Demanded = $(QD_2 - QD_1) / ((QD_1 + QD_2) / 2)$

and the % Change in Price = $(P_2 - P_1) / ((P_1 + P_2) / 2)$

For example, if a journal price increase from $400 to $485 were to result in a drop from 800 to 700 subscriptions, the price elasticity of demand for the journal would be 0.6941. Exhibit 8-4 shows the detail behind this example calculation.

Exhibit 8-4: Example Arc PEoD Calculation

P_1	$	325.00	QD_1	600
P_2	$	375.00	QD_2	500
Difference	$	(50.00)	Difference	100
Average P_1 & P_2	$	350.00	Average QD_1 & QD_2	550
% Change Price		-14.29%	% Change Demand	18.18%
PEoD =		-15.38%/10.53%		
PEoD* =		1.2727		

*Dropping the negative sign. Mandate Risk Model/Elasticity

The "Elasticity" tab of the companion Substitution Model workbook provides a template for calculating a journal's arc elasticity of demand.

To translate a change in value resulting from substitution into a change in the number of subscriptions demanded, the model multiplies the substitution probability by the price elasticity. For example, a journal with a risk profile indicating a substitution probability of 5.47% and an elasticity of 1.2727 would be projected to have a decrease in subscriptions of 6.96% (i.e., 0.0547 * 1.2727).

Adjusting a Journal's Price Elasticity of Demand

There are situations in which a publisher may need to adjust the elasticity calculation for a journal. These include:

1) When a journal's content has already been subject to funder mandates, but for a relatively short period of time;

[71] In the equations that follow, QD_1 = the starting quantity demanded; QD_2 = the new quantity demanded; P_1 = the starting price; and P_2 = the new price.

2) When extraneous market factors are known to have affected the quantity demanded for the journal during the timeframe assessed; and

3) When the available price and subscription data for the journal yield an implausible result (that is, there is not an inverse relationship between price and quantity demanded).

Appendix E describes how a publisher can adjust for the above contingencies.

A publisher can use the price elasticity template, provided in the "Elasticity" tab of the *Substitution Model* workbook, to adjust a journal's price elasticity. The resulting adjusted price elasticity calculation is linked to the Data Input table (*Substitution Model* workbook, "Data Input" tab).

In Tab 7, "Elasticity," of the *Substitution Model* workbook, enter the journal's starting price in Line a) and the journal's ending price in Line b); enter the journal's starting quantity of primary subscriptions in Line c) and the journal's ending quantity of such subscriptions in Line d); and enter the estimated percentage change in the quantity due to factors other than a price increase in Line e). The adjusted elasticity will automatically populate Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

8.10 Exposed Subscription Units

The model uses the substitution probabilities and price elasticity of demand to estimate the percentage of exposed subscriptions that would be liable to substitution. This substitution percentage is then applied against the number of institutional subscriptions to a journal. This requires that the publisher determine the number of subscriptions actually exposed to potential substitution.

As subscriptions included in irreducible bundles behave differently than other types of subscriptions—for example, institutions cannot easily cancel an individual journal included in a bundle—for most journals, only individual "primary" institutional subscriptions will be affected by substitution. Therefore, subscriptions included as part of a multiple-journal bundle (including so-called "Big Deals"), or included in an online aggregation (either the publisher's own or a third-party's) should not be counted in determining the number of exposed subscriptions.

Although counting the actual number of subscriptions might sometimes be complicated by consortia sales, most societies should be able to estimate the subscription base reasonably accurately.

The number of exposed primary subscriptions is pulled from Line b) of Tab 7, "Elasticity," and automatically populates Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

8.11 Average Revenue per Subscription

To determine the impact of substitution on revenue requires that a publisher estimate the average amount of revenue that would be at risk for each cancelled subscription. The simplest approach to determining average revenue at risk from cancellation will typically be to calculate the average subscription price across all primary subscribers (that is, excluding subscriptions to the journal in multiple-title bundles and online aggregations).

Calculating the average subscription price is simply a matter of dividing the net primary subscription revenue (after subscription agent discounts and commissions, etc.) by the number of primary subscriptions. In practice, however, isolating primary subscriptions and revenue can be complicated. Societies relying on revenue reports from publishing partners will need to ensure that primary

subscription revenue is distinguished from aggregation revenue and ancillary income (e.g., from permissions, PPV, etc.).

> The average revenue per primary subscription is pulled from Line d) of Tab 7, "Elasticity," and automatically populates Tab 8, "Data Input Summary" of the *Substitution Model* workbook.

8.12 Example Results

Exhibit 8-5 provides an example of a completed "Data Input Summary" tab from the *Substitution Model* workbook, and Exhibit 8-6 shows an example "Simulation Results" tab based on the example variables.

Exhibit 8-5: Example "Data Input Summary"

Revenue threshold:	$ 11,719

Percentage of Content Covered by Mandate(s)	
Lower Bound:	35%
Upper Bound:	45%

Deposit Compliance Rate of Mandate(s)	
Lower Bound:	60%
Upper Bound:	80%

Percentage of Use Outside Embargo Timeframe	
Lower Bound:	38%
Upper Bound:	50%

Archived Version Substitutability	
Lower Bound:	45%
Upper Bound:	95%

Access Substitutability	
Lower Bound:	30%
Upper Bound:	80%

(Adjusted) Price Elasticity of Demand	1.2727

Exposed institutional subscriptions	500

Average subscription revenue	$ 375.00

Substitution Simulation/Data Input Summary

Exhibit 8-6: Example "Simulation Results"

Publisher's average annual risk threshold for the journal:	$11,719
The probability that the revenue loss will exceed the annual revenue threshold:	39%
The chance that the revenue loss will not exceed the risk threshold:	61%
Average revenue decrease:	$10,951

Substitution Simulation/Substitution Results

Section 9 provides some example substitution risk calculations based on data provided by BioOne publishers.

9—BIOONE EXAMPLES

9.1 Introduction

Exhibit 9-1 (next page) summarizes actual data for several (anonymized) BioOne journals and provides a substitution risk assessment for each under various revenue risk tolerance assumptions.

The percentage of content covered by funder mandates and the percentage of use outside the embargo timeframe for each of the journals are based on tracking data for a single issue over a four-year period. In practice, a publisher would likely base these criteria on a larger sample. For our purposes here, the modeling assumes upper and lower bounds that represent a 10% spread relative to the sample; a larger sample might result in a narrower range for the upper and lower bounds.

Not surprisingly, as the BioOne journals have a number of characteristics in common, the results for the three journals are substantially similar. We have described the substitution analysis for one journal (Journal A) in detail below.

9.2 "Journal A" Substitution Modeling

The risk factor variables assumed for Journal A are described below. The analysis assesses the substitution risk assuming the passage of the FASTR legislation, the implementation of the OSTP public access directive, and the ratification of the pending EC public access policies. In other words, it assumes all proposed government funding mandates are put into effect.[72]

Percentage of content covered by a funder mandate—

Nineteen percent of the content in the issue of the journal sampled was funded by a US federal agency that would be covered by either the FASTR legislation and/or the OSTP public access directive or by a public access policy of an EC member state. As noted above, the modeling assumes 5% above and below the sample data point, yielding a range of between 14% - 24%.

Compliance with mandate—

A quarter of the journal's covered content is funded by NIH, which has a relatively high compliance rate due to mature enforcement policies. The compliance rate for the remainder of the funded content—largely funded by NSF grants—will depend on future implementation policies. We have assumed that, over time, these mandates would have approximately the same compliance rate as NIH. Therefore, we have used a compliance rate range of 60% to 80%.

Percentage of use outside the embargo period—

For the sample, the journal received 51% of its use outside an assumed one-year embargo period. (The analysis would need to be modified to reflect a longer or shorter embargo period.) The modeling assumes a range of from between 46% - 56%.

Version substitutability—

The modeling assumes deposit of the author's accepted manuscript, and assumes a high degree of acceptance for that version for research purposes, but a lower acceptance of the author's version when citing an article for formal publication purposes. Given these assumptions, we have assumed a version substitutability range of 65% to 95%.

[72] None of the journals sampled published research funded by one of the US states with a pending public access mandate.

Exhibit 9-1: Substitution Profiles, Selected BioOne Journals

Journal	Journal A		Journal B		Journal C	
% Content Covered by Mandate	Includes content that may be covered by future US federal & EC public policy mandates. Bounds represent a 10% spread relative to current year data.		Includes content that may be covered by future US federal & EC public policy mandates. Bounds represent a 10% spread relative to current year data.		Includes content that may be covered by future US federal & EC public policy mandates. Bounds represent a 10% spread relative to current year data.	
Substitution Range	Low	High	Low	High	Low	High
	14%	24%	22%	32%	23%	33%
Compliance Rate	Most of the content under mandates with high average compliance.		Most of the content under mandates with high average compliance.		Most of the content under mandates with high average compliance.	
Substitution Range	Low	High	Low	High	Low	High
	60%	80%	60%	80%	60%	80%
Use Outside Embargo	Bounds represent a 10% spread relative to an analysis of four years of usage data.		Bounds represent a 10% spread relative to an analysis of four years of usage data.		Bounds represent a 10% spread relative to an analysis of four years of usage data.	
Substitution Range	Low	High	Low	High	Low	High
	46%	56%	43%	53%	56%	66%
Version Substitutability	Author's Accepted Manuscript. High disciplinary acceptance of preprints.		Author's Accepted Manuscript. High disciplinary acceptance of preprints.		Author's Accepted Manuscript. High disciplinary acceptance of preprints.	
Substitution Range	Low	High	Low	High	Low	High
	65%	95%	65%	95%	65%	95%
Access Substitutability	Most of the covered content deposited in a centralized repository, with the remainder accessible via agency-specific repositories.		Most of the covered content deposited in a centralized repository, with the remainder accessible via agency-specific repositories.		Most of the covered content deposited in a centralized repository, with the remainder accessible via agency-specific repositories.	
Substitution Range	Low	High	Low	High	Low	High
	40%	90%	40%	90%	40%	90%
Price Elasticity of Demand	1.626		1.440		2.062	
Average Weighted Revenue per Subscription	$375		$341		$285	
Number of Primary Institutional Subscriptions	177		320		177	
Average Substitution %	3.5%		4.7%		7.1%	
Average revenue decrease	~$3,700		~$7,200		~$7,000	
Revenue Threshold %	5% of revenue	10% of revenue	5% of revenue	10% of revenue	5% of revenue	20% of revenue
Revenue Threshold $	$3,320	$6,640	$5,465	$10,925	$2,525	$10,100
Probability of Exceeding Threshold	~60%	~2%	~35%	~6%	~98%	~13%

Mandate Risk Model/B1 Examples

Discovery & access substitutability—

As with mandate compliance, the extent to which ease of discovery and access affects substitutability will depend on policies that may be implemented as part of the FASTR legislation or OSTP directive. For

modeling purposes, we have assumed that some sort of centralized repository—or coordinated network of repositories—will be implemented to facilitate discovery and access. Therefore, we have assumed an upper bound of 90% substitutability (for mature, centralized repositories) and a lower bound of 40% (given potential uncertainty and inconsistency of discovery).

Elasticity—

Based on the price and primary subscription data provided by the journal's publisher, Journal A has a price elasticity of demand of 1.626, which is relatively elastic. Although other factors may have affected demand for the journal, we do not have sufficient information with which to adjust the elasticity.

Revenue risk threshold—

For modeling purposes, we have tested two risk tolerance thresholds: 5% of primary institutional subscription revenue and 10% of primary institutional subscription revenue, yielding risk thresholds of $3,320 and $6,640, respectively.

Probability of exceeding revenue threshold—

Running the model over 10,000 scenarios, there would be about a 60% chance of exceeding the 5% revenue threshold and about a 2% chance of exceeding the 10% threshold.

The results for the other two BioOne journals summarized are similar, although in the case of "Journal C," the chances of exceeding the revenue threshold remain relatively high until the threshold reaches about 20% of revenue.

Appendix A: Example Risk Threshold Calculation

Net Revenue Contribution & Contribution to Overhead & Surplus

A journal's net revenue contribution is the journal's gross revenue less the direct variable costs of producing and fulfilling the journal. The journal's contribution margin (indicated as a percentage) is the net revenue contribution divided by the top-line revenue. Thus, a journal with $100,000 in revenue and variable costs of $20,000 would have a net revenue contribution of $80,000 and a contribution margin of 80%. Deducting the direct fixed costs of producing the journal from the net revenue contribution reveals the revenue remaining to contribute to covering the society's overhead costs and contributing to any operating surplus.

Example/Illustration of Calculating Net Revenue Contribution to Shared Operating Costs

Step 1) Establish a baseline for the journal's Contribution to Shared Costs & Surplus (CSC&S):

Example Summary Income Statement

Line	Description		201X	Logic/Source
(a)	Journal Revenue	$	100,000	Publisher-supplied data.*
(b)	Variable Costs	$	20,000	Publisher-supplied data.*
(c)	Net Revenue Contribution	$	80,000	= (a) - (b)
(d)	Contribution Margin		80%	= (c) / (a)
(e)	Direct Fixed Costs	$	50,000	Publisher-supplied data.*
(f)	Contribution to Shared Costs & Surplus	$	30,000	= (c) - (e)

*Journal data for the current year or the average of 3 most recent years. Whichever provides the most representative data.

Step 2) Convert the adjusted change in Contribution to Shared Costs & Surplus to revenue:

Example conversion of Contribution to Shared Costs & Surplus to top-line revenue:

Line	Description		201X	Logic/Source
(g)	Change in CSC&S to breakeven	$	30,000	As calculated above; Line (f).
(h)	Plus adjustment to CSC&S	$	5,000	As determined by publisher.
(i)	Adjusted CSC&S	$	35,000	= (g) + (h)
(j)	Contribution Margin		80%	As calculated above; Line (d).
(k)	Top-line Revenue Change Threshold	$	43,750	= (i) / (j)

Step 3) Multiply acceptable annual revenue change by 3 to get Revenue Risk Threshold:

(l)	**(3-Year) Revenue Risk Threshold**	**$**	**131,250**	= (k) * 3

Mandate Risk Model/Rev Threshold Example

Appendix B: Revenue Risk Tolerance Threshold Example

Financial Threshold, Example

Line	Description		Value	Source/Logic	Relevant Report Section	Comments
a)	Contribution margin %):		80%		See §4, §8.2 & Appendix A	Contribution margin = (subscnription revenue - variable costs) / revenue
b)	Tolerance for decrease in net income ($):	$	9,375	Determined by publisher.		
c)	**Risk threshold for modeling purposes:**	**$**	**11,719**	= b / a		Net income translated into subscription revenue.

Financial Threshold, Worksheet

Instructions:

Line a)

Enter a journal's contribution margin (i.e., net revenue contribution divided by revenue), stated as a percentage.

Line b)

Enter the society's tolerance (in $) for decreased annual net income.

Line	Description		Value	
a)	Contribution margin %):		0%	
b)	Tolerance for decrease in net income ($):	$	-	
c)	**Risk threshold for modeling purposes:**		**Calculated Field**	Enter the results of this field in Line 1 of the Data Input tab.

Appendix C: Calculating Use Inside/Outside Embargo Period

Estimating the percentage of a journal's use that occurs within the first four or five years after publication provides a basis for estimating the percentage of a journal's use within a given embargo timeframe. Ideally, this parameter will be based on historical data.

The percentage of a journal's use within the embargo timeframe should be based on the average use data for the journal.

(A worksheet version is provided in the "Use Outside Embargo" tab of the companion Substitution Simulation Model workbook. A publisher can enter the variables in the worksheet)

Example Calculation of Use Inside/Outside Embargo Period

Description		Value		Source/Logic	Comments
a)	% of content lifetime use within first 4 years after publication:	80%		As estimated by publisher	
		Low	High		
b)	% of current content use within embargo timeframe:	40%	50%	Based on journal usage data	See §8.5 for description of appropriate sampling methods.
c)	Use within embargo timeframe, adjusted for lifetime use:	32.00%	40.0%	= a * b	
		Lower Bound	Upper Bound		
d)	Substitution risk % (i.e., use outside embargo timeframe):	60%	68%	= 1 - c	Substitution risk equals the use outside the embargo timeframe.

Substitution Simulation/Embargo-Use

Appendix D: Calculating 90% Confidence Interval for a Small Sample of Usage Data

Example data points (four-year timeframe)

Timeframe	% of use within embargo timeframe
2007 - 2010:	45%
2008 - 2011:	42%
2009 - 2012:	30%
2010 - 2013:	37%
Number of samples:	4

Step 1

Calculate the sample variance:

a) Determine the mean of the sample: 0.385

b) Subtract the average of the sample from each of the samples and square the result for each sample:

0.004225
0.001225
0.007225
0.000225

c) Add the squares and divide by one less than the number of samples to get the sample variance: 0.0043

Step 2

Divide the sample variance by the number of samples and determine the square root of the result: 0.032787

Step 3

Look up the appropriate t-stat for the sample size using the simplified t-statistic table shown to the right: 2.353

Step 4

Multiply the t-statistic (Step 3) by the result of Step 2 to get the sample error: 7.71%

Step 5

Add the sample error to the mean of the sample (Step 1a) to get the upper bound and subtract the sample error from the mean of the sample to get the lower bound:

Upper:	46.21%
Lower:	30.79%

Simplified t-statistic Table

90% confidence interval (2 sided)

Sample Size	**t-stat**
2	6.314
3	2.920
4	2.353
5	2.132
6	2.015
7	1.943
8	1.895
9	1.860

Source: Wikipedia, Student's *t*-distribution

http://en.wikipedia.org/wiki/Student%27s_t-distribution

For a fuller explanation of the simplified calculation, see Hubbard 2010, pp. 142 - 144.

Appendix E: Adjusting Elasticity

As described in §6.2.3, there are situations in which a publisher may need to adjust the elasticity calculation for a journal. Some of these situations are described below, along with a description of how a journal's price elasticity of demand can be adjusted.

Pre-existing Substitution

If a new substitution channel for the journal was introduced within the period covered by the elasticity data, the effect of that substitution on the number of subscriptions should be taken into account. For example, were a publisher to have offered a pay-per-view option or licensed content through an additional online aggregator during the period covered by the elasticity data, then the effect of that offering on institutional subscriptions should be estimated and the elasticity adjusted accordingly.

Pre-existing Mandate Effects

Presumably, the elasticity for a journal that has been operating under an existing funder mandate for a number of years already reflects the effects of the mandate on demand for the journal. However, in other circumstances, a journal's content may have been affected by funder mandates for a relatively short period. In such cases, it will be difficult to assess the extent to which the mandate has already affected demand for the journal.

Adjusting for Market Factors

A variety of market and environmental factors can affect the price elasticity for a journal. These include library budget constraints and other local exigencies, a change in the importance of a field or discipline, and the availability of other substitutes (for example, database aggregations with embargoed content).

The cost and effort of applying more rigorous data analysis methods to bracket out the effects of such environmental and market issues will typically outweigh the potential increase in accuracy. Therefore, the model provides a simple method for adjusting a journal's price elasticity (see below) to reflect the effects of known extraneous factors. Although the adjustment may lack precision, it should result in a more accurate elasticity measure than would otherwise be available.

Adjusting a Journal's Price Elasticity of Demand for Non-Price Factors

We described how to calculate a journal's arc elasticity in §8.9. If demand for a journal has changed substantially for reasons other than price—such as the circumstances described above—the computed elasticity can be easily adjusted. A publisher can make the adjustment by multiplying the calculated elasticity by the inverse of the change in demand due to non-price factors. For example, if a publisher calculates a journal's elasticity to be 1.2727 (using the example described in §8.9), but estimates that non-price market factors accounted for 5% of the change in unit count, the journal's elasticity would be adjusted as follows:

Adjusted Elasticity = 1.2727 * (1.0 - 0.05); or

Adjusted Elasticity = 1.209

The companion Sustainability Model workbook provides a table for adjusting a journal's elasticity (see the "Elasticity" tab).[73]

[73] The adjustment calculation described assumes that quantity demanded and the non-price factors being adjusted for are all moving in the same direction. For example, that the subscription base for the journal has decreased due to a price increase and the

Appendix F: Description of the Adjusted Substitution Percentage

The simulation model, described in §7.2, uses the arc price elasticity of demand for projecting the effect of substitution on the quantity of subscriptions demanded. As a result, the substitution percentage needs to be adjusted to reflect the arc price for the journal.

The arc price for the journal can be summarized by the following equation:

Arc Price = $(P_3 - P_2) / ((P_3 + P_2) / 2)$

Where P_2 is the current year's price and P_3 is the first projected year's price. The first projected year's price (P_3) is calculated by increasing the current year's price (P_2) by the Substitution Percentage, which (recall) is the functional equivalent of a price increase (see §3.2.2).[74]

adjustment factor(s) also reduce the number of subscriptions due to decreased demand (e.g., due to a new substitute, etc.) or that the subscription base for the journal has increased due to a price decrease and the adjustment factor(s) also increased units due to an increase in demand (e.g., due to an extraordinary marketing campaign, etc.). A different adjustment method is required when demand and any adjustment factors move in opposite directions. Given the anticipated rarity of such situations, the method has not been described here.

[74] We cannot adjust the unit quantity to reflect the demand arc because the simulation is solving for the unit quantity.

Appendix G: Dynamic Histogram Example

The histogram in the companion substitution simulation model worksheet ("Monte Carlo" tab) sorts scenarios into thousand dollar increments or bins. The histogram data can then be used to generate a chart.

Dynamic Histogram		
Bin	*Cumulative Frequency*	*Bin Frequency*
0	5	5
1,000	7	2
2,000	24	17
3,000	68	44
4,000	192	124
5,000	454	262
6,000	843	389
7,000	1452	609
8,000	2301	849
9,000	3210	909
10,000	4206	996
11,000	5177	971
12,000	6103	926
13,000	6939	836
14,000	7679	740
15,000	8259	580
16,000	8723	464
17,000	9094	371
18,000	9355	261
19,000	9550	195
20,000	9702	152
21,000	9814	112
22,000	9876	62
23,000	9924	48
24,000	9944	20
25,000	9967	23
26,000	9981	14
27,000	9993	12
28,000	9995	2
29,000	9999	4
30,000	9999	0
31,000	9999	0
32,000	10000	1
33,000	10000	0
34,000	10001	1
35,000	10001	0
36,000	10001	0
37,000	10002	1
38,000	10002	0
39,000	10002	0
40,000	10002	0

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