OPEN-ACCESS SCHOLARLY PUBLISHING IN ECONOMIC PERSPECTIVE

by

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Open-Access Scholarly Publishing

In Economic Perspective

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Abstract

What is the prospect for migrating scholarly journals from paper to digital formats in a way that lowers university expenditures? Although many journals are published digitally, at least so far, the digital format complements paper, increasing university expenditures. Open-access publications that are free to readers and financed by publication fees paid by authors and their agents may both lower costs and allow scholarship to reach a larger audience. However, gains to universities may depend on open-access being quality-assured and controlled by not-for-profit publishers. Potential savings for a typical US research library might be on the order of $2.3 million per year even as the same level of effort goes to reviewing and editing published articles as at present. To launch the initiative, provosts might adopt policies to support publication fees and not-for-profit publishers might invest in start up funds for editing and marketing open-access journals.

June 11, 2004

Open-Access Scholarly Publishing

In Economic Perspectives[1]

Paper is increasingly unsatisfactory for distributing scholarly publications. Cost has been rising rapidly and the paper format is inconvenient relative to the best quality that digital formats can deliver. Production of journals is increasingly concentrated among a few publishers who exploit their market position by charging high prices. The digital world offers promise of being both more effective for scholars and offering lower cost for universities. The move to digital distribution might also allow reorganizing ownership to limit the perverse consequences of market power. To find a pathway into the digital arena that will achieve these goals is a challenge.

We will describe the cost of conventional modes of journal publication and of digital formats with the goal of evaluating economic prospects for digital publishing regimes. The traditional financial model in academic journal publishing depends primarily on subscription fees from libraries and readers supplemented by submission fees and page charges paid by authors. Some digital publishers use a similar model with subscription fees as the primary method of finance for electronic journals with little or no savings in

[1] I appreciate comments from Ross Atkinson, J. Robert Cooke, Kenneth M. King, Richard E. Quandt, John J. Siegfried, Flo Wilson, and participants at the Cornell/Columbia Workshop on Sustainable Models for University-based Scholarly Publishing. The Cornell University Project on *Creating an Open Access Paradigm for Scholarly Publishing* commissioned this work.

library operation. An alternative is open-access with publication costs borne by authors and their institutions through submission and page charges and distribution by the Internet at no cost to readers.

We conclude that substantial cost savings to universities are possible with open-access distribution of quality-assured journals by not-for-profit publishers whose rates reflect cost rather than each university's ability to pay. Open-access to quality-assured materials via the Internet will increase the use of the materials and expand the influence of scholarship worldwide.

Fundamentals

Thinking about how to reorganize scholarly publishing requires an understanding of three fundamental issues.

Substitutes or Complements

First, digital and paper publishing might be substitutes or complements. If a fall in the price of digital publications causes a decline in the purchase of paper publications, the two are substitutes. Conversely, if a fall in the price of digital publications causes an increase in the purchase of paper publications, the two are complements. Whether the two are substitutes or complements (or unrelated) reflects the behavior of users; that scholarship is distributed digitally is not sufficient to conclude that it substitutes for paper. The National Academy Press posted the full-text of all its books online and saw the sale of print copies increase, a clear indication that its digital and print products were complements. (Tenant, 2001)[2] A number of publishers present digital versions of journals

[2] Whether the effect is permanent is unclear.

as ancillaries to print as though they would only be complements. Obviously, print and digital may interact in many ways. If, however, the growth of digital publication is to lower costs, then the digital publications must act as substitutes for print.

Recipient or Sender Payment

Second, the cost of publication could be charged to either buyers or sellers. The choice will make a difference in the cost and quality of service. In the early days of the Republic, the US Post Office charged recipients for the cost of mail; mail was free to senders. After the introduction of postage stamps in 1847, the Post Office moved in 1855 to require senders to pay. [Reebel, 2003; Fuller, 1972] The "recipient pays" system allowed senders to post many items that recipients rejected. Although the Post Office incurred all the cost of delivery, it received no revenue on unaccepted items. The "sender-pays" system, primarily with pre-purchased stamps, lowered the cost of the mail service and eased the delivery of the mail. An important technical change may allow significant gains by shifting responsibility for transactions costs from recipients to senders (or vice versa).

In the publishing arena, recipients are now the primary source of finance for publication. Readers and their libraries pay subscription fees that carry the cost of preparing and sending the material. By analogy to the change in postal finance of 1855, primary responsibility for the cost of publication could be shifted to senders, that is, to authors and their agents. The marginal cost of digital delivery drops from a considerable amount, about $0.02 per page with print by one estimate, to nil with an open-access digital service. [Bergstrom, 2001] With a shift to digital delivery, readers and authors may be better off with financial responsibility reassigned to authors. The shift, however, involves assigning financial responsibility for editing and quality to authors and their agents and these costs may continue to be substantial.

Packaging and Bundling

A third issue is a concern for the size of the packages. Books, particularly monographs, are generally created and sold as freestanding items such that readers and their libraries may make decisions to purchase title by title. Journals are larger packages of articles, generally purchased on a continuing basis by subscription on the reputation of the editors. In the digital arena, integrators combine the full-text files of the contents from many journals into much larger packages. Readers may search the full-text files to identify articles of interest and scan many items more quickly than with print. The cost of library operations to select and process materials is lower per item when materials come in larger packages. With a digital archive, a reader could select a custom set of items to print and bind for a personal use. There are, however, other implications of packaging.

Here are three motives for larger packages. First, there may be cost savings called economies of scope. [Pindyck and Rubinfeld, 1998 pp. 226-29] There may be fixed costs in creating an integrated database that may be shared more widely the larger the database. There may be advantages in marketing many journal titles in a given broad discipline that give lower marketing costs per title with more titles. Publishers with larger scope may have cost advantages that allow delivering a superior service at lower cost per essay.

Second, larger packages may have advantages for the seller and intermediaries in allowing pricing strategies that extract more revenue from readers and their agents. With a larger suite of products, the seller may offer a bundle of materials at a high fixed price on an all-or-nothing basis. Bundle pricing allows the seller to extract more profit from its customers than could be achieved if each individual journal were individually priced. Bundle pricing may come closer than individual pricing in confronting each customer with the maximum amount he or she is willing to pay. [Pindyck and Rubinfeld, 1998, pp.

397-409] Bundle pricing allows publishers to charge much more for their products than they could earn by selling each individually.

Third, a publisher may flood a market space with titles. If existing journals cover the intellectual universe sparsely, new journals may enter in the interstices. To limit such entry, a publisher might introduce journals focused on narrow segments with the goal of occupying every niche much as Kellogg seeks to cover the spectrum of varieties among breakfast cereals. As journals gain reputation with time, the publisher who enters first gains a long-term advantage, ultimately allowing higher prices and profits.

The discussion here focuses on journals rather than books for reasons associated with the three fundamentals. A) Full-text integrated files of many monographs appear to be complements to print, as with the National Academy Press, leaving little possibility for cost saving from digital distribution. B) Books as paper objects remain a popular method for acquiring book-length ideas. A shift to author-finance for books would make it more difficult to get books into the hands of people who want them because the cost of supplying a printed book to each reader remains significant. C) The cost-pressure on books is much less than with journals because bundle pricing is less effective for books. Buyers of journals, particularly libraries, lock into a journal subscription, giving the publisher power to raise prices once reputations are established.[3]

In some respects, the transition from paper to digital is well along, but how far the transition will go is unclear. Many reference works are more effective in digital format

[3]Because of price pressure from journals, libraries may be buying fewer monographs. With lower library sales, university presses are publishing fewer books. Whether digital distribution of monographs is economically feasible is beyond the scope of this essay.

than paper. Indeed, print formats of a number of reference works have disappeared. Publishers seem to abandon paper when print runs drop below 1,000. On the other hand, paper remains the dominant form for monographs. In between lies the academic journal, the largest category of material expense in large academic libraries. The degree to which digital journals will substitute for print remains an active question. Moreover, whether such a transformation would lower total expenditures for universities is also an open question.

The Publishing Universe

In 2003, there are approximately 21,000 active, refereed, academic and scholarly periodicals published worldwide.[4] Of these, nearly 12,000 (57 percent) are available online.[5] Just over 600 (3 percent of all academic journals) are online but not available in print.[6] [7] Journals that appear only in electronic format began to appear after 1995. About 60 percent of the online-only academic journals are free, some having become free within the last two years.[8] If journals average 93 articles per year, the annual flow of new

[4] [Ulrich's Periodicals Directory], online, listed 21,020 on November 18, 2003.

[5] [Ulrich's Periodicals Directory], online, listed 11,935 active refereed academic and scholarly titles online on November 18, 2003. This understates the total available on line because some journals post their articles online but not as part of a database and some of these are not noted as "online" by Ulrich's. See for example the [*Journal of Political Economy]* and [*The Journal of Economic Education*.]

[6] [Ulrich's Periodicals Directory], online, listed 619 on November 18, 2003 that showed media "online" but not "print" or not "duplicated."

[7] The [Directory of Open-Access Journals] provides links to open-access journals by field.

[8] A random sample of 25 titles selected from Ulrich's list of 619 journals showed 5 with fees, 15 that showed free access, and 5 that did not report information about fees.

articles in the 21,000 academic journals is about two million per year worldwide.[9] Suppose 2,000 libraries subscribe to 10,000 academic journals on average with specialization among libraries so that all journals average 2,000 library subscribers. Let the average price be $240 (the average expenditure per serial title at large libraries as discussed below). Then, the journals involve a total expenditure in excess of $10 billion by libraries annually. If each journal publishes 93 articles, the cost of article publication is about $5,161 per article. The costs of subscriptions to individuals and of the libraries' effort in processing and storing journals are additional costs described below.

The electronic availability of journals grew as an ancillary to print and typically has been a complement rather than a substitute for paper. Electronic access often came for a modest additional price to a print subscription with little, if any, saving offered to libraries that chose an electronic version to replace print. Although a few non-academic publications have abandoned paper in favor of digital distribution, for example, *Byte*, such conversion is rare among academic publications.[10]

Integrators

Electronic access to conventional journals frequently comes through integrators, firms that create full-text databases of many journals, often from many publishers, to allow searching across the full-content space. Ingenta, founded in 1998, offers search of the full-text of the content of 6,000+ journals from 250+ publishers. (Ingenta, 2004)

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[9] The [ISI Web of Knowledge] lists counts of articles in 8,576 journals across many disciplines that published a total of 793,786 articles in a recent year, about 93 articles per journal.

[10] According to [Ulrich's Periodical Directory], *Byte* appeared in print from 1975 to 1999 and digitally as Byte.com since 1999. *Byte.com* is a free digital publication. I have been

Although the search is without charge, access to individual articles themselves may come at a price set by the journal publisher. Some publishers provide free access, some provide access only to subscribers to their print versions, and some set pay-per-look prices at $10 to $20 per article. This latter price is similar to the cost of fulfillment with a non-returnable item by conventional inter-library loan. Access online, however, is instantaneous. [Research Library Group, 1993][11] The full-text search of an integrated database may be a loss leader for fee-based article delivery as well as a complement to library subscriptions. The reader-pays strategy seems well embedded in the financial structure of some integrators.

Another integrator, [OCLC], offers 4,600+ journals through its First Search service. [OCLC] Libraries subscribe to individual journal titles and OCLC makes the full-text available online to subscribing libraries. Johns Hopkins University Press integrates 220 journals from 37 publishers in Project [MUSE]. Elsevier offers its own integration service for the content of its 1,800+ journals through its [Elsevier ScienceDirect]. First Search, MUSE, and ScienceDirect each generate revenues primarily through campus licenses to libraries.

[LexisNexis], now with 3.3 billion documents online, is a special case of an integrator that succeeded in selling access primarily to documents in the public domain, specifically case and statutory law. For Lexis, most of the value is in the online integration and delivery of legal documents. Of course, the database has grown far beyond the public domain legal records. Nevertheless, Lexis does illustrate that online integration has

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unable to identify a refereed academic journal that has dropped paper in favor of digital distribution.

[11] An updated study is in progress.

significant value apart from the copyright of underlying documents. Lexis is a significant substitute for print for many lawyers.

Pre-print Services

The physics, mathematics, and computer science communities developed an on-line self-archive of essays, usually at the preprint or working-paper stage; that is, the archive accepts unreviewed essays. Paul Ginsparg launched the service in 1991 known now as arXiv. [Ginsparg, 2001][12] ArXiv receives about 4,000 submissions by authors per month and sees an average of 120,000 connections per week by readers. The service imposes charges neither on submissions nor readers. It has fixed costs that average about $5 per article because of the high volume of submissions with costs supported by institutions and government. ArXiv dictates a standard format for submission from authors including metadata (tagged author, title, and other key fields) that allow the system to automatically add the article to the database in seconds. The self-archiving pre-print service provides no editorial or review service.[13] Determination of quality occurs outside the distribution process. The service includes an e-mail notification of new postings that goes to registered readers.

Although Ginsparg originally conceived of the service as a method of extending the research community to remote campuses for both authors and readers, its success and low cost have led him and others to advocate it as a substitute for paper distribution. An issue for self-archiving is whether journal publishers will be willing to publish essays that have been made available free to all on the Internet by self-archiving. If digital self-archiving

[12] The [ArXiv] website provides usage statistics.

[13] [ArXiv] requires an author to have a recommendation from another author who has posted to arXiv.

complements refereed journal publication, journal publishers might welcome self-archiving. If digital self-archiving is a substitute for journal publication, then publishers will refuse to publish material that is already self-archived. [Rehmann, 2003][14] Even not-for-profit publishers will protect their revenues so that they can finance their editorial and quality control functions.

Whether the arXiv service has become a substitute for conventional print publication in the disciplines it serves is an open question. A recent survey of journal prices in mathematics suggests that the price differential between non-profit publishers and commercial, especially European publishers in mathematics remains quite high.[15] Publications in premier journals are the trophies of academic research and even free, ubiquitous, well-regarded materials distributed electronically have rarely achieved trophy status. The arXiv service appears to complement traditional publications in the same disciplines even when prices of the conventional journals are quite high and continue to rise. The arXiv program could be decentralized with each university responsible for archiving its faculty's work as with the DSpace initiative discussed below.

The dramatic growth of arXiv spawned a general movement to encourage all pre-prints to be posted in open-access archives in institutional repositories. Common software and modest standards allows the digital archives on participating campuses to be searched in

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[14] For a discussion of the copyright issues, see [Project RoMEO, 2003]

[15] Math Journal Price Survey, based on AMS 2002. High quality domestic non-profit journals are typically priced at under $0.40 per page while many European commercial publishers present journals of lesser quality at over a $1.00 per page. Ulf Rehmann is editor of *Documenta Mathematica*, an open-access journal in mathematics with support for SPARC, a consortium of universities and others who promote open-access publications. http://www.math.uiuc.edu/documenta/

a single Google-like search.[16] Proponents view the Open Archive Initiative as a method for making research more conveniently available than the reader-pay system.[17] The critical issue is whether authors and readers view open archives of unreviewed materials as substitutes for peer-reviewed journal publication. If they are not substitutes, then there is no cost savings.

Casual observation suggests that the widespread availability of journals online may give a 70 percent probability of finding known items online through library subscriptions, open archives, or simply through a Google search of the Internet. A careful estimate of the known item online hit rate by discipline would be useful. Given the convenience of ubiquitous and continuously available online articles, we might wonder whether articles not available online are now less likely to be used and cited, other things equal. This should be a researchable question.

Ultimately, the question as to whether electronic publications substitute for paper is a question of behavior, not of technological possibility. To explore the potential more fully, we explore the cost structures and markets for publishing more carefully.

Paper Publishing

Universities bear three categories of cost in supporting publication by paper.

A) They support the publishers by paying library subscriptions fees.

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[16] The Budapest Open Access Initiative, part of the [Open Society Institute, 2003], advocates each university posting its own intellectual products in a common format that can be searched worldwide. See the [Open Archives Initiative] for technical standards for self-archiving.

[17] [Harnad, 2003] reports the growth of self-archiving with 185 institutions participating as of 2003.

A) They support the cost of the library operations that buy, process, store, and retrieve the paper products.

A) They support the cost of indices, usually through subscriptions, that provide the ability to search a database to find citations to material for a project at hand.

The 100 US members of the [Association of Research Libraries, 2003] (ARL) collectively spent $537 million to purchase serials in 2002 for an average of 21,000 currently purchased serial titles per library. (The 21,000 serials in the average research library include non-periodic series and non-academic periodicals. It is a coincidence that the total count of refereed academic journals published worldwide is approximately the same as the total count of serials at the average research library.) The expenditures on serials at an average US ARL library appear in column 1 of Table 1. We discuss the other columns below. We use the US ARL set because they publish statistics on their expenditures in US dollars that allow convenient analysis. We give an estimated total for all 100 US ARL libraries at the bottom of the table.[18]

The $5,370,000 expenditure on subscription fees in an average large library paid for the publishers' costs of editing, producing, and distributing the journals. As discussed below, perhaps a quarter or more of serial publishing costs may be for printing and distribution with two-thirds or less of costs going to selecting, editing, and designing/typesetting the first copy. Some of the cost is also related to billing and managing subscriber lists.

[18] If there are 21,000 serials published and 2,000 libraries each subscribe to 10,000 of them on average, then there would be 4,200 similar academic libraries worldwide. Given that the distribution of libraries by size is skewed, there are probably a much larger number of smaller libraries.

Table 1:

Annual Cost for An Average US Research Library of 21,381 Current Serials (in $000s, 2002) Showing How Costs Might Adjust Under Reorganization

Cost Element	Conventional Print	Subscription Digital	Open-Access Digital	Non-profit Open-Access
Journals:	(A)	(B)	(C)	(D)
First Copy	$1,840	$1,840	$1,840	$1,840
Distribution	$320	$20	$20	$20
Accounting	$240	$240	$12	$12
Profit	$1,290	$1,290	$1,290	$0
Other Serials	$1,680	$1,680	$1,680	$1,680
Publisher Total	$5,370	$5,070	$4,842	$3,552
Library Process	$790	$790	$420	$420
Library Storage	$320	$170	$170	$170
Grand Total	$6,480	$6,030	$5,432	$4,142
100 US ARL Libraries	$648,000	$603,000	$543,200	$414,200

Source: The $5,370 (thousands) in column A is a statistic computed by the author from the [Association of Research Libraries Statistics, 2003]. The other numbers in the table are heuristics, based on assumptions and calculations described in an appendix. The table assumes an average research library subscribes to 2,400 high price journals, 7,600 other academic journals, and 11,381 other serials.

The average US ARL libraries may have spent $790,000 per year in processing and binding their serials titles assuming expenditure of $37 per title.[19] The total current expenditures for all activities in the average library were $22.76 million in 2002. [Association of Research Libraries, 2003] Of this, $8.68 million purchased materials in all forms of which $5.37 million (62 percent) purchased serials. Spending on binding

alone totaled $236,000 per library. Because current serials attract more interest than back files, libraries keep current serials in prominent open-stack space. Such prime open-stack space might cost $1.50 per year per serial title. [Getz, 1997] Assume the library moves old print journals to compact, remote storage at low cost when they are, say, 14 years old. The present value of the perpetual storage of an annual volume might be $15. The libraries also manage the stacks with reshelving and search for misshelved items, costs not taken into account here. We put the total cost to US ARL libraries of processing and storing 21,000 serials per library at a conservative $1.11 million per year.

A rough estimate of the total cost to the 100 research universities in the US in 2002 of maintaining the academic serial publishing enterprise is likely to be in excess of $537 million in subscriptions plus $111 million in library capital and operations equals $648 million.

Indexing

Journals have two lives. In their first life, they provide news about recent intellectual developments. What questions are asked, evidence presented, conclusions reached? The appearance of each new issue has some of the splash of a *Newsweek* cover. The new articles call attention to themselves and readers want to know what's hot. Although the Internet has made the exchange of pre-prints an important vehicle for following the research frontier, new issues of journals continue to play an important role.

A journal's second life is as a permanent record of findings, available for consultation as needed. Key to the second life is indexing. Indeed, reference to a journal's articles in a leading index is an essential milestone for the success of a new journal title. A significant

[19] Private communication from a middle-sized US Research Library.

amount of use of a journal will arise because scholars search a general subject index to find material relevant to a question at hand.[20]

With traditional paper-based publication, indices are published separately on a subscription basis in paper with costs included in the serials budget described above. Often now, the indices provide electronic access to a cumulative access to the literature of a discipline from a starting date for the electronic file with no print version offered. The cost to produce a conventional index may vary upward from $30 per item depending on the character of the indexing.[21] ECONLit indexes about 35,000 items per year at a cost of about $30 per item, using a limited set of subject headings.[22] A service that indexes a similar number of items but with a changing lexicon of controlled subject headings may have a higher cost. The National Library of Medicine's MEDLINE offers Medline without charge (since 1997) via the Internet with government support.[23]

Table 2 Leading Academic Indices with Count of Journals Indexed

Index	Discipline	Count	Owner	Began

[20] Although some journals may be indexed in more than one of these indices, some of the serials in an index may not be included as academic journals in [Ulrich's Periodical Directory], and in some cases the count of periodicals may include inactive titles. I presume that a modest number of indices provide bibliographic access to the authors, titles, and subjects of most of the academic literature on the planet. *LegalTrac* reported in the table is similar in size to H W. Wilson's *Index to Legal Periodicals*.

[21] Personal communication with the American Economic Association and the OCLC Public Affairs Information Service.

[22] ECONlit indexes over 400 journals. The AEA spends about $1 M per year to index about 35,000 items, about $29 per item. This information is from a personal communication with the AEA.

[23] The [National Library of Medicine, PubMed Central] has grown its PubMed service beyond MEDLINE to include additional life science journals.

Compendex	Engineering	5,000	Elsevier	1970
Medline	Medicine	4,600	Government	1953
MLA International Bibliography	Languages and Literature	4,000	Society	1963
MathSciNet	Mathematics	1,700	Society	1940
PsycINFO	Psychology	1,300	Society	1887
LegalTrac	Law	800	Thomson	1980
ERIC—Current Index to Journals in Education	Education	750	Government	1966
RILM Abstracts of Music Literature	Music	500	Society	1967
Econlit	Economics	400	Society	1969
TOTAL with Double Counting		19,000		

Source: The online indices each provide descriptions of the data and owner. The year "began" notes the starting point of materials indexed in the electronic file.

The scope, ownership, and year the electronic file begins appear in table 2 for a selected set of indices. The total count of journals indexed by these ten indices (with double counting and some non-academic titles included) approached the total count of academic journals worldwide. A modest number of indices dominate indexing activity. Most of the indices are in not-for-profit hands with some important exceptions. The starting year for the electronic index indicates both the importance of back files in a discipline as well as the historic openness of the publisher to digital innovations. The indices may play a larger role in the move to digital publication. Open-access publication may change the nature of indexing.

Digital Subscriptions

Consider a digital alternative to print that might cost $20 per article, once for all on the whole Internet, and therefore $1,860 per journal title (with 93 articles per title) per year. All 21,000 current academic journals would then cost about $40 million if digitally

captured and stored once-for-all with distribution by subscription. Each library might continue to choose 10,000 academic journal titles but the cost of distribution is mostly unrelated to the number of libraries or scholars using a digital title. If 2,000 libraries subscribe to the service worldwide, the cost per library to deliver all 21,000 titles would be about $20,000 per library.

The $20 per article amount is in excess of the $5 per article cost claimed for Paul Ginsparg's digital preprints service in physics. Ginsparg's service requires authors to submit work in a standard digital format and provides full word searching. Somewhat higher costs may be incurred in handling a more heterogeneous set of materials on a larger scale that allows simple use and permanent archiving. The $20 figure is not a specific technical proposal but simply recognition that expansion will add complexity. Low cost per article depends critically on complete (and large scale) automation to spread fixed costs widely.

The American Economic Association pays Ingenta about $10,000 per journal to make its current journals available to members on the Internet. That amounts to more than $100 per article. The Ingenta service provides online Internet access to members without charge. The Association also provides campus licenses for online access to current journals for a fee in addition to print subscription. Ingenta sells access to individual articles from AEA journals for $11 each. Evidently the commercial rate for web-hosting a journal is well above the costs cited by Ginsparg. Web hosting is a competitive market with both for-profit and not-for-profit participants. Ingenta adds automatic links to references in articles and provides searching over many journals as explained below.

The American Economic Association's three print journals embody high selection and production values. About three-fourths of its costs are "first copy" costs, that is the cost of selecting, editing, designing, and typesetting its journals. It would save no more than 20 percent of its costs if paper were eliminated and digital distribution cost nothing. Its first copy costs include about $220,000 per journal for paid editors and reviewers. It has additional costs for copy-editing and typesetting. Its cost of billing and maintaining lists of members and subscribers is about ten percent of its costs. [Siegfried, 2003] The Association holds an annual meeting and provides other services that also use the headquarters accounting and mailing list functions. The ten percent cost is an upper bound.

In contrast to the AEA, some publishers may produce journals for smaller markets with volunteer editors and reviewers and expect authors to present an electronic file in a specific format that will generate the article without editing or typesetting. For such journals, first-copy costs should be low. The cost of distribution in paper might be fifty percent or more of total cost. *Educational Researcher* by the American Educational Research Association is an example with free web access to PDF files of articles, printed copies to Association members with annual membership fee of $45, and library subscription of $61 per year.[24] We do not have detailed cost information from a low budget publisher and therefore stay close to the 20/80 percent split of distribution and first copy costs commonly assumed.

[24] The purpose of the publication with links to the PDF files through an online table of contents is [American Education Research Association]. The prices for print are given in [Ulrich's Periodical Directory] with membership fees given on the AERA member website. I don't have accounting information to identify a cost breakdown. The number in the text is a rough estimate.

Direct comparison of the $40 million for worldwide digital distribution for 21,000 journals with the $537 million total serials expenditure over 100 US ARL libraries is difficult. We break the total of $537 million into five components as shown in table 1. The categories of the breakdown will be useful in thinking about a change to digital. The goal here is to indicate how the structure of cost might change with several possible changes to be discussed below.

The average US ARL library subscribes to about 21,381 serials but many of these are not refereed academic journals. We assume that 11,381 serials are either annuals, not periodic, or are not academic journals (e.g. *Consumer Reports*). Table 1 assigns $1.68 million for an average research library to the purchase of this set and assumes no change in their acquisition or pricing. An analysis of a move to digital format for them is beyond the present inquiry. Of the 10,000 academic journals in an average set found in a large library, we assume that 2,400 are high-priced European commercial journals and assume that these publishers earn $1.29 million in profit over and above the cost of producing and distributing their journals. The total cost of creating the first copy for all the journals might be $1.84 million per research library. The total cost of distribution in print might be $320,000 per library. The cost of accounting and managing mail lists for individual journals may be no more than $240,000 per library.

By shifting all 10,000 current academic journals from paper to digital while leaving the core selection, editing, and first-copy production values, the average US ARL library might save $300,000 annual savings in subscription costs and $150,000 in library storage costs for a total of $450,000 at an average US ARL library.[25] These savings arise from

[25] [Schonfeld, 2004] provides an estimate of the change in library operating costs of a shift from paper to digital subscriptions for four larger ARL libraries: Cornell, NYU,

shifting from paper to digital subscriptions, not from moving to open-access as discussed next. The discussion of market forces below makes clear that universities might not receive the benefit of such cost savings.

Beyond the Research Libraries

We can extrapolate from the US ARL libraries to estimate possible savings for academic libraries worldwide. Economics journals that depend primarily on sales to libraries have about 2,000 library subscriptions worldwide.[26] If universities with research libraries average 1.1 subscriptions to each journal (surely an over-estimate for all titles), then the US Research libraries would account for 6 percent of all library subscriptions. The savings noted above of $45 million per year for replacing all 10,000 library print academic journal subscriptions in 100 US ARL libraries with subscriptions to the digital format, implies savings of worldwide distribution and library savings of $750 million for 2,000 large academic libraries worldwide.

Subscriptions to individuals typically carry a price below that for libraries, reflecting in part the greater elasticity of demand by individuals. The role of individual subscriptions varies widely from broadly based membership societies with many other services associated with membership to journals targeted primarily at libraries as well as near

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Pitt, and Yale. the essay gives (in its table 3) an average per title non-subscription cost of $68.50 with print and $41.25 with electronic subscription. If the saving of $17.02 per title were assigned to the average print title count of 16,500 (inferred from figure 1 of the essay), the average research library would save $400,000 in non-subscription cost annually. Not all of the periodicals are necessarily peer-reviewed academic titles; some may be popular magazines and other non-scholarly titles. The estimate for these four libraries is similar to that assumed here.

newsletters for which libraries are an afterthought. Bergstrom mentions counts of individual subscriptions of 1,000 to 2,000 for good economics journals. For simplicity, we assume that the subscription fees of individual subscribers to academic journals carry the marginal cost of serving them. With a move to digital, the cost of serving them could drop to zero along with revenue from them.

Digital Indexing

Digital publication allows dramatic improvements in indexing. Digital files may be searched by individual words and phrases, allowing readers to find relevant materials by means in addition to standard subject headings and the words that appear in a title or abstract. The power of digital indexing increases when the contents of many journals are combined into a large, cumulative database that allows readers to find material across many journal titles that are relevant to a task at hand.

A search of an index may generate two kinds of errors, missing valuable citations and retrieving irrelevant citations. The conventional index with a controlled list of journals of established quality that uses an official list of subject headings that authors use to label their work should generate relatively few irrelevant citations. However, it may fail to identify many relevant items. In contrast, full-text search is likely to generate many irrelevant citations. In contrast, a powerful index generates a high proportion of all possible relevant citations and few irrelevant ones.

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[26] [Bergstrom, 2001] reports *Econometrica* with 2,400 library and 2,900 individual subscriptions and *Review of Economic Studies* with 2,000 library and 850 individual subscriptions.

To be more powerful, an index must be more comprehensive of works in a given arena. There are economies of scope in electronic journal publishing in building a full-text electronic file that spans many journal titles in a given discipline. At the same time, an index with more refined search tools, the ability to establish relevance in subtle ways, may also have a significant advantage.

The dominance of Google for Internet search illustrates the point. Part of Google's success comes from the method it uses to assign priority to items it returns from its search. It counts how many links extend from one web page to another and assumes that a webpage that is more frequently linked to other sites is more valuable. The analog for a more powerful search tool for an academic literature might take advantage of the references in one document to other documents. If all references were coded uniquely to the sources, a Google-like search engine applied to the full-text database of a large academic literature could count links to references and thereby be more likely to retrieve the most relevant items. For example, the Web of Science takes account of reference links in its search.

Successful digital publishers of academic journals seem likely to want to join indexing structures with comprehensive full-text searching over a discipline with refined Google-like search tools that winnow irrelevant citations from a response to a search request. The transformation of indexing by agglomerating many titles is a significant advantage to digital publishing.

There would be a considerable cost in establishing a system to associate unique identifiers with each reference in every article so that a digital search engine could use them in setting priorities for retrieval. In effect, a scholarly database might need to

require a stable URL or the equivalent for every reference. [University of Waterloo Libraries, 2003][27] If an author's work were much more likely to be cited when linked to references in a more advanced index, then authors might be more likely to publish digitally.

In a number of instances, substantial indices are available online without charge. The National Library of Medicine (NLM) made Medline available without charge in 1997 and saw a seven fold increase in searching with as much as 30 percent of searches by the general public. This case suggests that there can be substantial increases in value in open-access. NLM stopped publication of the print *Cumulative Index Medicus* in 2000 as print sales dropped below 1,000 per year. [National Library of Medicine NLM Newsline 2000] In this case, the digital index was a direct substitute for the print. The AEA also stopped the print distribution of its index in 2000 in favor of its digital product. A number of integrators mentioned above provide access to their index databases without charge as loss leaders to promote sale of subscriptions or pay-per-view article delivery.

Perpetual Archive

The digital format poses a bigger challenge than print as a format for the perpetual archiving of materials. Once a library owns a printed object, it may keep it in perpetuity. With acid free paper, sound binding, and good climate control, paper-based books may last for centuries. In contrast, the digital format raises both technical and ownership issues.

[27] DSpace includes the idea of persistent URLs associated with files posted in the database.

For a digital file to be useful over the centuries, it will have to be periodically refreshed by being copied to new media from time to time because the media for storing digital information is more volatile than paper. More importantly, data may need to be reformatted to migrate to newer software environments. Digital files should be able to survive by being stored many redundant times. Indeed, the mirroring of services at multiple locations used by arXiv suggests a direction for both high reliability and long durability, presuming that each active mirror site maintains recent copies of data in off-site hard storage. Ultimately, mirroring with multiple secure back-ups may be much less expensive than keeping old journals in every library. JSTOR, DSpace, and others have initiatives underway to create permanent archives for digital content. [JSTOR, "The Challenge," 2003; Spedding, 2003] The technical details are not yet sufficiently known to allow an estimate of cost. Presumably, successful development will yield a relatively low-cost production system for maintaining archives. Archiving text and page images may be a relatively simple subset of a much larger problem of archiving other digital documents and software. Archiving digital journals should be possible at modest cost.

Ownership poses a different challenge. Copyright holders of digital files have sometimes licensed universities to use their documents as long as the subscription continues but with all documents reverting to the copyright owner if the subscription is discontinued. The license fee for back files is bundled with the fee for the current subscription, enhancing the market power of the seller. When an integrator bundles many titles together with current files tied to back files in a near all-or-nothing package, publishers or integrators will extract more revenues from universities than if no bundling occurred. Although a one-time fee for perpetual access to back files is a logical possibility, it may not be a pricing strategy that maximizes publisher profit nor would it eliminate risks associated

with bankruptcy of the archive. We consider market forces more carefully after considering open-access.

Open-Access

Open-access would save most of the cost of accounting, billing, and maintaining lists of individual subscribers as well as most of the cost to libraries of managing subscriptions to individual journal titles, adding savings of perhaps $228,000 for a typical US research library. *Economic Bulletin* is an example of such a journal.[28] We assume that accounting costs drop to $12,000 reflecting 93 transactions with authors compared to 2,000 transactions for library subscriptions. If open-access journals were aggregated into large databases by broad discipline, comparable to the major indexes mentioned in table 2, then libraries need incur little or no costs in selecting, processing, and paying for individual journal titles. Table 1 reports the continuing cost of processing the serials other than academic journals, about $420,000 per year. We forecast a savings of $370,000 per year to the average US ARL library if all 10,000 academic journals shift to open-access with the costs as shown by comparing column B and C of table 1.[29]

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[28] [Economics Bulletin] (EB) reviews essays in less than eight weeks, and posts approved essays immediately. Economics Bulletin accepts only essays of seven or fewer pages and is designed to compete directly with Economics Letters, a journal from Elsevier that charges libraries over $1,400 per year. EB reports an average editorial lag of 31.5 days from submission until refereed decision on publication. EB plans to charge a $20 submission fee to authors but to allow all readers access free of charge. EB began in 2001 and won't charge fees until it reaches a critical mass of published work sufficient to attract more authors. See also [Bergstrom, 2001].

[29] Most libraries use subscription agents like EBSCO, Swets, and Harrassowitz as intermediaries in managing journal subscriptions as well as buying directly from publishers. Intermediaries operate on about 5 to 10 percent of the price of journals, sometimes with discounts from publishers. Intermediaries have computer systems that in many cases manage the transactions more economically than libraries could on their own.

Financing journals by publication fees rather than subscription would concentrate the cost on institutions that produce the articles and shift burdens away from institutions with fewer authors and more readers. The major research universities would bear a larger share of the cost. Given the magnitude of the aggregate savings, it seems likely that even universities with the most publications could see cost savings. Moreover, the research universities are substantially philanthropic organizations with the mission of creating and distributing new knowledge. Publication-fees to finance distribution seem to fit their missions easily.

If digital distribution involves essentially zero marginal cost per reader, then the optimal price to the reader is zero. Subscriptions to individual readers and to their surrogates, the libraries, reduce the number of readers and therefore the aggregate value of the new ideas even though there is no extra cost of serving more readers.[30] Authors or publishers could retain copyright of their works and prevent resale, modification, or suppression of their works. Open-access publication need only involve a limited, non-exclusive right to distribute.

Publishing would then need to be financed primarily by authors and their institutions through submission fees and publication charges. The *American Economic Review* (AER) reported spending $1.4 M in 2002 to publish 103 articles, a cost per article of $13,700. (The *Journal of Economic Perspectives* spent $0.7 M to publish 55 articles and features, a cost per article and feature of $13,000. [Siegfried, 2003; Krueger, 2003]) The AER

Private communication from Roberta J. Winjum, Assistant University Librarian, Technical Services, Vanderbilt University Library.

received 990 submissions in 2002 with a $75 submission fee that yielded nearly $75,000. Setting aside 20 percent of the AER budget for paper distribution would save $280,000 gross. Add $2,000 for digital distribution of 100 articles yields a net saving of $278,000 for the title annually.[31] A publication fee in excess of $12,000 per article would be needed to sustain the selection, editing, and production values of the AER, assuming that the flow of articles would be at the same rate. The AER has a circulation in excess of 23,000 and so it achieves substantial economies of scale in paper distribution. For this reason, its prices to readers ($87 for three journals) and libraries ($240 per year for three journals in 2004) are modest relative to other publishers. Digital distribution would have lower publishing cost and would allow the libraries to reduce processing and storage costs.

A high-circulation academic journal like the AER has high paper distribution costs in the aggregate, however, it also has high first copy costs. A low circulation journal, say one sold primarily to libraries, would have lower paper distribution costs in the aggregate but also might have lower first copy costs because it might put less effort to selection, editing, and production. Bergstrom describes the basic cost structure of a not-for-profit journal as involving $100 of first-copy cost per page and $0.02 per page per subscriber distribution costs. [Bergstom, 2001] A typical journal with 2,000 subscriptions and 1,674 pages (93 18-page articles) per year would have $167,000 of first-copy costs and $67,000 of paper distribution cost, putting distribution at 29 percent of the total budget. A library subscription rate of $117 per year would cover the costs of print subscriptions. As an

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[Harnad, 2003], proposes two strategies. (a) Publish in open-access journals or (b) publish in subscription-based journals with deposit in open-access local archive.

[31] The AEA spends considerably more than this amount to make the content of its journals available electronically. It captures little of the economies of scale anticipated here with discipline-wide databases.

alternative, an author publication charge of $1,820 would cover the first copy costs and $20 per article for digital distribution.[32]

The Public Library of Science (PLoS) has announced a new digital journal in biology with open-access, that is, zero price to readers and libraries but a $1,500 publication charge to authors. [PLoS, 2004] It aims to offer important selection, editing, and production values. Presumably, its selection and production values will not be as high as those of the AER but would be relatively close to Bergstrom's typical journal. The PLoS experience should reveal whether the publication fee affects submission patterns and editorial priorities. Will unaffiliated authors or those from less affluent institutions be less likely to publish?

An existing subscription journal could introduce a publication fee that would allow open-access to an article at the author's discretion. The publishers would then make the pre-paid articles available to readers free of fee while charging pay-per-look and subscription fees for those articles not prepaid. This idea for a transition, however, has limited appeal because it adds complexity and therefore cost. Much of the cost advantage of open-access comes from simplicity of operation, a goal made more difficult with a hybrid open/closed journal. Although this scheme might be useful for a transition period, it is unlikely to be an enduring feature of the publishing world.

[32] [SQW, Limited, 2004, p. 3] puts the fixed cost of an article at $1,650 in good-to-high-quality subscription journal with evidence from interviews with Scientific, Technical, and Medical journal publishers. For a medium quality journal, SQW gives a cost of $825. It puts author-pay costs at $1,850 and $925, respectively.

Print-on-Demand

The open-access model could offer printing on demand for an extra fee as an alternative to local printing by readers. Readers who wanted higher quality, bound paper copies could subscribe at an extra fee to a print service that would supply softbound paper copies of journals of good quality in addition to open-access. It is an open question as to how many people would buy current bound issues in print given free contemporaneous digital access with local printing. The alternative of local printing on demand at, say $0.05 per page would put the incremental cost of an unbound, printed copy at $0.95 per article. Printing the 93 articles in a typical annual volume would cost $89. The advantages of personal printing are that a reader need only print articles of significant interest with instant availability. The disadvantages of personal printing include the lack of binding, the necessity of readers organizing their own printing and storage, and the greater cost per page of print.[33]

The economics of printing involve high fixed costs in order to achieve low variable cost. To achieve the high volume needed to spread the fixed costs widely, a publisher packages whole issues of a journal for printing. Suppose that the advantages of high volume cut the cost of printing in half. (The exact proportion depends on the size of the print run.) If a typical reader finds less than half of a journal of sufficient interest to print, personal printing will involve lower outlay than the publisher's high volume printing service. When the size of a print run for a given item drops below 1,000 copies, conventional print services usually become uneconomic. Research on the frequency of personal printing of articles from open-access journals would be relevant. Note as well that

[33] [Xlibris] is an on demand book publisher. For as little as $500, an author may turn a manuscript into an online file for printing on demand at Xlibris. Xlibris sells print on

personal printing gives immediate access to printed copy while print on demand will involve delay and shipping costs. Print on demand does not appear to have great potential for journal distribution given the convenience of personal printing.

Citation Rates

Access to academic literature without charge via the Internet would make the ideas available to all of the wired parts of the planet. This process would increase the value of the literature by allowing more people to use it, provided, of course, that readers can easily find top quality material and avoid unwanted materials. By one estimate, citation rates might double with quality-assured open-access articles compared to those sold by subscription. [Lawrence, 2001][34]

If authors pay for first-copy costs and the fixed costs of distribution, they would make decisions about the value of selection, editing, and production. Presumably, authors and their universities would decide whether to pay high fees for high quality journals or lower fees for lower quality. It seems doubtful that authors' interests would necessarily match those of readers. Authors value winning recognition from the reader's agent, the editors, and ultimately the readers themselves. Publications with finance by authors or their institutions might be viewed with the stigma of vanity publications. The role of widely distributed publications as trophies may derive from reader finance, that is, readers vote with their dollars for the articles top editors view as most important. Perhaps there will be alternate ways of legitimizing trophies. Open-access publications track use and, in large databases, the system can monitor the number and importance of references by weighting

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demand paper titles of about 300 pages for about $20 plus shipping. That comes to $0.067 per page plus shipping. Delivery may take several weeks.

counts of links. Perhaps more commonly referenced essays, particularly those referenced on course reading lists and by more influential scholars, will have trophy value.

Publication fees are separate from submission fees. An open-access journal need impose no submission fee or might use a modest submission fee to discourage frivolous submissions and to offset review costs. Publication fees need only be collected after the editor decides to publish the article. Membership organizations might use membership fees that provide a variety of services to lower publication fees for members, a kind of insurance scheme. A journal might discount publication fees for the best article of an issue, for an author's first publication, for an association's presidential address. If quality-assured open-access publication attracts double the attention of the conventional print publication, publication fees should be readily accepted. Agencies that fund research and the universities seem likely to find methods to support payment of publication fees and view themselves as better off for having reduced payments for journal subscriptions.

A Comparison of Open-Access Costs to Subscriptions

To compare the cost of a publication fee system to the conventional subscription fee regime for the 100 US universities who are members of the Association of Research Libraries, consider first the cost of subscriptions and then the cost of publication fees.

The 10,000 scholarly journals in the typical research library might have an average cost of $4.2 million per library, allowing $3.69 M for subscriptions and $0.52 M for

[34] Lawerence's analysis of 119,924 conference articles in computer science put the offline citation rate at 2.74 and the online citation rate at 7.03.

processing and storage. The total cost to 100 US ARL libraries would be $420 million. (Figures are from Table 1.)

The 100 research universities average 1,460 teaching faculty members for a total of 146,000 overall [Association of Research Libraries, 2003]. If each published 0.65 academic journal articles per year, the total number of new articles would be 95,000, roughly five percent of the world's total. With a publication fee of $1,500, the total cost of the publication fee system would be $1.42 million for a typical research university, a savings of $2.77 million per research university.[35]

This analysis suggests that the cost of the US Association of Research Library universities of a publication fee system would be about 34 percent less than the subscription fee system, assuming a $1,500 publication charge replaced the $240 average subscription charge and library processing and storage costs. If open-access publication

[35] [Goldberger, 19995] Tables K to N. This National Research Council study reports the number of publications per faculty member, 1988 to1992, by field in departments offering PhD programs. The average overall programs in ten large selected fields in science and engineering is 1.31 publications per faculty member per year. (The average is over programs unweighted by number of faculty.) The average number of publications per faculty member in four large selected social science fields is 0.50. The study does not report publications per faculty member in the arts and humanities. It does, however, report 0.14 publications per faculty member per year in history. Using the history rate for all of humanities and weigh science, social science, and humanities at one-third each gives a rate of 0.65 publications per faculty member.

yields double the citation rates, then the publication fee system could cut the cost per citation by two-thirds. Faculty in the most highly ranked quartile of PhD programs in a field generally have publication rates that are about 50 percent higher than the average of a faculty in all PhD programs.[36] Except for top programs in a few fields, for example chemistry, publications per faculty member per year are in ranges where a publication fee system would be lower in financial outlay for universities than the subscription system at rates assumed here. By tying the size of publication fee to the citation impact of the open-access publication, a university can assure itself that payment of publication fees are increasing the exposure of its faculty's work to a wide audience.

Digital Tools for Selection, Editing, and Production

There is a further question as to whether a shift to digital distribution might lower the first copy costs. Might a digital standard for article submission create an on-line database of works in progress that editors and reviewers might access with appropriate security? The database would need to control versions so that revised essays replace each earlier draft. The database might also authenticate authors and establish ownership of intellectual property.

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[36] [Goldberger, 19995] Tables K to N report publication rates by program and by quartile within fields. A technical university with a disproportionate number of science and engineering faculty would have a higher average rate of publications per faculty member but would also likely be paying higher subscription rates for journals. A more detailed analysis would be needed to make an estimate of the change in cost for individual universities.

The standard submission format might feed a copy-editing and production process so that the marginal costs drop. Could the fixed costs of the development of the standards and of the "editor's database" software lower marginal costs? Might there be economies of scope such that a single publisher might produce many journal titles at lower costs for the first-copy for each? We assume that the concept of journals as lists of articles selected in a coherent way by an identifiable editorial group will continue to be useful. Labels are valuable even if the physical distribution of page images for a whole literature comes from a common database.

How would journal editors be compensated? Although some editors are volunteers, many talented potential editors find little reward in editing and turn down offers of editorships even when the positions pay well. Quality editing, the effort to weigh carefully proposed articles and to manage a review process that may involve many referees, has value. Whether readers or authors are the primary source of finance, many capable editors require significant economic incentives.

If the economies of scope from an editor's database were substantial, journal publication would become concentrated among a small number of publishers, each with a significant fixed investment in database production tools that would allow low incremental first-copy costs for each journal in its suite. On the whole, however, a digital submission and production process seems likely to entail modest savings in first-copy costs. Selection of articles, editing them for publication, and designing effective publications takes skill. Higher quality comes at a significant price, regardless of the media. This is an issue needing exploration. We assume no savings in first copy costs in table 1.

Of course, consolidation of publishing has implications for the character of the market for journals.

Market Forces

Market power, the ability to charge a price that exceeds costs, arises in several ways in scholarly publishing. Publishers with significant market power may charge a library according to the library's ability to pay with price bearing no relationship to cost.

Market power arises because each journal is unique, has a reputation that accumulates over time, and has a coherent editorial focus. The consolidation of many journal titles in the hands of a few publishers creates market power that can allow such publishers to earn extraordinary profits. The cost of entry of new publishers may be higher because of the need to incur the expense of the software to address first-copy production. Market power, that is already substantial among large-scale publishers, might then be quite durable. Although some participants believe that universities would be able to retain a non-exclusive right to distribute the copyrighted works of their faculty, the faculty are likely to prefer to assign full copyright to a publisher in order to publish in more prestigious journals. What dean could advise an assistant professor to publish in a less prestigious journal in order for the university to retain a non-exclusive right to distribute the essay in an open-access archive or deny an editor an opportunity to publish in his or her own journal? Journals have market power in direct proportion to the strength of their reputations.

The significant cost savings from a shift from paper to digital might well come from reorganizing publishing under not-for-profit auspices. Bergstrom cites an average annual subscription fee for ten commercial journals in economics of $1,372 in 2000 dollars.

When compared to an estimated cost of $117, the publisher's average profit per title is $1,265. The distribution costs are then about three percent of the total subscription price; first-copy costs are about seven percent; and profits are about 90 percent of total subscription. For many commercial titles, moving to digital distribution and changing the market structure to a non-profit model might lower costs by as must as 93 percent with no change in expenditure on first-copy service. Bergstrom estimates that if an academic library bought all the journals, eighty percent of its expenditure would go to commercial publishers for journals that generate only 30 percent of all citations. [Bergstrom, 2001, p. 188] Most libraries tilt toward lower cost non-commercial titles and so the savings would be less than 93 percent. If open-access publication allowed a not-for-profit sector with prices reflecting costs to replace the high-priced European commercial journals, the shift might save $1.29 million per year for the average US ARL libraries as shown by comparing column C and D in table 1.

So far, the introduction of digital versions of journals has been primarily a complement to print and few of the cost savings envisioned in table 1 have occurred. A shift to open-access publishing of quality-assured journals by non-for-profits might allow universities to capture gains associated with all the changes from column A to column D in table 1. If all 10,000 academic journals found in a typical research library moved to open-access, each library might see expenditures decline by $2.3 million. A first step might be to migrate 1,000 journals, none published by the high price sellers, so as to establish an effective open-access culture. Each library might expect to save about $100,000 per year.[37] Once quality-assured, open-access journals demonstrate their intellectual success and prove to provide trophies comparable to subscription-based journals (perhaps even

[37] Subtract the $5,432 of column A from the $6,480 of column C and divide by ten.

better if citation rates are higher with open-access), then expansion to replace the high priced journals has a chance of success.

A recent essay by Elsevier's Market Intelligence Manager models the financial implications of academic libraries shifting from paper to digital. [Kolloffel and Kaandorp, 2003] The authors conclude that libraries will be able to prune internal operating costs so as to be able to afford to spend more on digital services. The market power of the high-priced European commercial publishers could allow them to raise prices to extract any rents available from their customers' cost savings. The library's ability to pay then determines price rather than any attributes of the costs of operation. In fact, all of the gains shown in table 1 may be contingent on moving to non-profit publishers. Otherwise the advantages of lower cost might accrue to the publishers through higher prices or reductions in their costs that do not lower their prices. The open-access method of finance may be a catalyst for a significant reorganization of academic publishing.

Timing

In recent decades, electronic innovations have defused across higher education in ten to twelve years. Digital innovations in libraries and computing innovations averaged 4.8 years from adoption by the first ten percent to adoption by the median adopter, a rate that indicates 10 to 12 years typically elapse from first adoption until general use. [Getz, Siegfried, and Anderson, 1997] In contrast, curricular innovations took 12.4 years to reach the median and about 25 years to reach full diffusion. The 10 to 12 year period to full adoption of digital innovations seems sufficiently quick to allow reasonable returns on investments in new systems. That nearly 12,000 journals became available in digital format in less than a decade confirms that digital tools are often adopted relatively

quickly in higher education, once they have proven their value. If open-access journals prove their value, they are likely to achieve full-adoption (whatever that might mean) in a decade.

Experiences

Experience to date is mixed. On the negative side, library costs, especially for journals, continue to grow. The ease of electronic exchange of materials appears to have had little effect on the price of journals. Digital publishing seems, so far, to be primarily a complement to print, increasing total expenditures in libraries. Figure 1 shows the growth in serials expenditures by ARL libraries from 1976 to 2002.

Figure 1

On the positive side, a number of initiatives are at play that may lead to a shift to quality-assured, open-access publishing by the non-profit sector. By the estimated values in table 1, current costs total $6.48 M for a typical library to subscribe to, process, and store its serials compared to a potential cost of $4.142 M with quality-assured, open-access journals published by non-profit publishers. The average US research library might save $2.3 million per year with perhaps $230 M saved per year among all US research libraries.

JSTOR, which went live in 1997, has succeeded in producing good quality digital back files of nearly 400 journals.[38] More than 1,100 libraries have subscribed, making JSTOR financially self-sufficient. However, JSTOR does not address first-copy costs because it

[38] [JSTOR, "Currently Available," 2003] For a history of JSTOR, see [Schonfeld, 2003].

offers only back files. Moreover, relatively few libraries have discarded print copies of back files that duplicate JSTOR's holdings and the expected savings in library costs are limited. JSTOR could offset the libraries' cost of archival storage of the back files of journals but so far the effect has been limited. As of 2002, only 23 percent of JSTOR subscribing libraries had moved bound volumes of JSTOR journals to remote storage (another 12 percent plan to do so) and only 13 percent have discarded bound journals found in JSTOR (20 percent plan to do so).[39] JSTOR's technical approach has been to scan paper copies of journals to present to readers with a full-text file created by JSTOR for searching. Presumably, pages created from original digital files can be presented in a more attractive manner and take advantage of improvements in computer display and printing. In 2003, JSTOR announced plans to manage documents from digital sources. [JSTOR, "The Challenge," 2003]

The National Library of Medicine's PubMedCentral began scanning the back files of life science journals in 2003 with a view to making access free. [National Library of Medicine, "Digitizing,"] It will be interesting to learn whether medical libraries will be willing to discard print files when digital page images with full-text searching is available free.

Cornell's Legal Information Institute compiles public domain statutes, court opinions, regulations, and other legal documents and makes them available without charge. [Martin, 2000] It allows ready searching across disparate kinds of documents and promotes interoperability among court and agency electronic services so that users can pursue an issue seamlessly. The service attracts more than a million requests per day and reaches audiences well beyond the fee-based services from Lexis and West. Interestingly,

[39] [JSTOR "Bound Volume," 2002] with 240 libraries responding.

although legal data in the US is not copyrighted, some courts and agencies avoid making their electronic files readily available for free distribution so that they can barter with the for-profit distributors for special services. One might expect the courts, for example, to promote the widest possible dissemination of their rulings. By failing to share documents in convenient formats, they limit access in order to sustain the commercial services on which they depend. It is ironic that access to court records in North Dakota is better than those in New York. One lesson is that authors may avoid free distribution when commercial distribution offers advantages to the author, regardless of copyright. A second is that building interoperability and the use of common standards allows documents from many sources to work together even when not under common control. This sharing is probably practical only in a non-proprietary environment.

As mentioned above, some publishers offer new journal titles only in electronic format.[40] Enough titles have persisted to the point where such offerings seem to be economically viable on a subscription basis in some disciplines. Some digital-only titles offer much faster turn around from submission to appearance. Some offer digital ancillaries that are of little value in print, for example, computer code, statistical datasets, or longer technical appendices. Few digital-only journals have achieved trophy status for quality but that may be because reputations take time to build.

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[40] Here are examples: *African Studies Quarterly* (University of Florida from 1997), *Journal of Religion and Film* (University of Nebraska at Omaha from 1997), *International Journal of Psychopathology, Psychopharmacology, and Psychotherapy* (Psy.com from 1996) and 47 titles published by Internet Scientific Publications LLC, for example, *The Internet Journal of Cardiology*. Ulrich's listed 21,020 active, referred, academic/scholarly periodical titles in all formats, 10,935 of them available electronically of which 619 were available only electronically.

Open-access electronic journals have a limited track record with major initiatives just now occurring. There is doubt about what size fees to be paid by authors will be viable and whether high production values and readership can be sustained in open-access journals. Experimentation is underway.

Stanford University's [HighWire Press] hosts 345 journals in electronic format including 281 on a pay-per-view basis and 20 offered free; 146 offer free back issues. HighWire has contracts with other publishers to host electronic journals and acts as an integrator. Each original publisher defines terms of access. A typical rate for a pay-per-view is $19 per article. For journals in the Highwire service, readers may find articles of interest when searching the whole database. Highwire seeks to achieve a wider scope in electronic indexing, well beyond the titles it publishes itself. Highwire's role as an integrator might readily support the growth of open-access journals but that movement is not essential to Highwire's success.

The [Berkeley Electronic Press] (BEPress) offers electronic journals with four titles in each subject area, each at a different quality level. An author submits to the whole and the editors decide, after review, the specific journal title where the article will appear. This approach allows an author to place an article more quickly because a single review process allows the work to be published appropriately without having a six-month or longer process of evaluation for each added journal approached. BEPress typically makes a publication decision within 60 days. In 2003, BEPress offered its service in 12 broad areas, six of which are in economics. Institutional subscription rates in 2003 range from $140 to $500 per year with a $328 average. The institutional subscription allows unlimited use by anyone on campus, provides access to a perpetual archive, and invites users to use an email alert service. BEPress depends on conventional, third party

indexing, for example, ECONLit for its economics offerings. It is not attempting to achieve the scale needed to be a successful integrator. At least so far, BEPress does not appear to be offering open-access titles.

In 2003, the entire editorial group (more than 40 people) of *Labor History*, published by Taylor and Francis, left the journal, citing irreconcilable differences with the publisher. [Buckholtz , "SPARC Partners," 2003] The Duke University Press welcomed the editorial group, which is launching a new journal, *Labor: Studies in Working Class History* beginning in February 2004. Taylor and Francis is a European commercial publisher that planned to raise the price of the journal. The Duke University Press with the support from the Scholarly Publishing and Academic Resources Coalition—SPARC—will price the new journal at $200 for libraries in print ($180 in electronic only format), compared to the $263 recent price for *Labor History*. All of the Duke University Press journals are available through Project MUSE.

The Public Library of Science, also mentioned above, launched publication of PLoS Biology in October 2003. This journal publishes peer-reviewed articles with high production values and makes them available with open-access. Fees paid by authors finance the publication. The announcement of the launch mentioned several foundations that fund biological and medical research that will include funds to support the authors' publication fees in the grants they award. [Buckholtz , "SPARC and PLoS," 2003] Philanthropic support is critical to the launch of this open-access journal. Whether the venture will win a sufficient audience of authors and readers so as to become self-sufficient is an open question.[41]

[41] Harold [Varmus, 2003], former head of NIH, is a principal figure in the launch of PLoS and of PubMed Central.

At this point, digital distribution whether by subscription or open-access has a beachhead in physics and computer science with new landings in economics, biology, and medicine. Network delivery is sufficiently robust to support good quality digital products. The reduction in cost with significant improvements in the performance of scholarly publishing may be at hand. Indeed the cost of open-access journals by not-for-profit publishers might cut the total cost of publication in half with no change in first copy costs. Digital publications offer more rapid publication cycles and the possibility of better indexing. Open-access also offers the prospect of access to many more readers worldwide with significantly higher citation rates.

Strategy

There appear to be substantial savings on the order of $230M to the 100 US research libraries in substituting quality assured, open-access digital journals published by not-for-profit publishers for the traditional paper. Costs may be borne by authors and their institutions with zero prices to readers. The digital journals have the potential of increasing citation rates dramatically by making journal articles readily available on desktops universally. The expense of editing and other first copy costs could continue at current levels to sustain the quality of the intellectual product. High production values for high quality work will retain their importance. The analysis here is limited to academic journals and does not necessarily apply to publications other than academic journals.

In the extreme, one might contemplate the comprehensive index to a discipline, like those shown in table 2, being tied to a full-text database of all of its articles to allow more sophisticated searches. Indeed, the indices might be redesigned to take account of digital searching. Access to page images and personal printing on demand would be without

charge. Publication fees would be the primary method of finance. Such a service might dramatically increase the influence of scholarship around the world by making our best ideas universally available in well crafted, fully evaluated, and nicely presented essays. An associated database of preprints would allow editors to search for work quickly in unevaluated form in a fashion that would readily feed the editing and production process for publication. Of course, such a service would be a natural monopoly best developed under not-for-profit control with assurances that any surpluses accrue to universities. If well designed and operated within the academic community, this top-of-the-line service might cut the total cost of publishing significantly and dramatically improve its use.

Here are some strategic steps.

Scholars need to be comfortable in having libraries forego print in lieu of digital access. That JSTOR has not proved sufficiently compelling as to cause many libraries to discard quantities of back files is discouraging.

Open-access journals with high selection and production values need to demonstrate that they are more widely read than print counterparts and generate more citations. Trophy status for open-access articles may come as open-access journals become widely read, particularly if the citation rate is much higher than with print.

Universities, granting agencies, and scholars may gain confidence with significant publication charges as a primary method of financing open-access journals. A dean might devise a policy for supporting publication fees for faculty who publish in open-access journals. Perhaps the maximize size fee would be tied to the average citation rate for the open-access journal with bigger fees allowed for more widely cited open-access journals.

Average citation or other impact rate for a journal would play something of the role of Nielson ratings for television advertisers and be the basis of prizes for specific articles. Might institutions and funding agencies limit support for author publication fees to open-access journals published by non-profit publishers?

There may be gains in electronic indexing that would both lower the cost of indexing and improve its quality. Automated indexing with a minimum set of metatags from authors might both lower cost and create superior indices. Unique identifying tags for referencing, essentially permanent URLs for published essays, might play a role.

Perhaps premier scholarly societies will lend their prestige and capital to the launch of brand name journals with high selection and production values with open-access. A society that controls the dominant index to the literature of its discipline might combine with a non-profit integrator so that the environment of the online index would support delivery of page images of documents either free for open-access titles or on a pay-per-view basis for others.

The DSpace initiative begun by MIT and Hewlett Packard provides an infrastructure for open-access to a variety of digital materials. [DSpace Federation] DSpace software allows a university's faculty to post its digital products in an institutional repository, a formal digital archive of essays, datasets, audio and video, and software that is readily searchable. Indeed, at some point a single search might span the DSpace repositories on many campuses. DSpace supports Google searching with persistent URLs. Groups may define communities within DSpace for labeling and management. DSpace aspires to provide a permanent archive of digital products. It may provide some method for managing copyrights and ownership. Open-access publications might grow from DSpace

when publishers use it for distribution and indexing. Publishers would invest in quality editing and might finance their quality assurance efforts with publication fees. Quality-assured publishing is but one possible use of DSpace. [Lynch, 2003] From a publishing point of view, a new open-access journal may well need the services of an integrator or to be digitally integrated with a significant digital index in order to attract readers who are searching to fill a need in hand. At this point, DSpace and the institutional repositories it supports appear to complement other methods of distributing scholarship.

Mathematics may be a good candidate because the mathematicians already use arXiv for some preprints. The commercial publishers retain significant price differentials in math journals. The American Mathematics Society owns the main index, MathSciNet. Economics is a possibility although online preprints are not as well managed as the arXiv service. Psychology might be possible. Medicine is well positioned with NLM leadership and PubMedCentral. Law and Engineering are not promising because the commercial publishers own the indices and already offer extensive full-text services based on subscriptions and pay-per-view. Law reviews, however, may be a possibility because they are well subsidized by their host law schools and depend on unpaid student editors.

A main advantage of the open-source method of distributing scholarly information may well be a significant increase in the use of scholarly materials around the world and outside academia. The dramatic growth in the use of Medline once it became free, the improvements in searching and in the quality of digital display, and the fact that an increasing proportion of adults in the US have college degrees all suggest that use of scholarship may surge when the delivered price to readers drops to zero.

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Appendix

The numbers in table 1 begin with column A. The $5.37 M spent on serials is an average for the 100 US ARL libraries as reported in the ARL statistical survey 2002. The other numbers in the table are heuristics as explained below. The top rows of the table report estimates for an average US research library. The bottom row reports an aggregate for the 100 US ARL libraries. I intend the estimates to be a minimum cost advantage of a shift toward more aggressive use of digital publication, assuming the cost advantages accrue to universities.

1. The high priced European commercial journals expenditures assumes the average library spend $1.4 M for a bundle of 1,800 Elsevier journals, an average of $778 per title. ($1.4 million is an educated guess. Libraries typically subscribe to 1,200 or so of the Elsevier journals and their package price evolves from this history. We assume each gets all 1,800 giving a conservatively low average per title.) Assuming the library subscribes to 2,400 of the 3,000 high priced journals at $778 each, gives a total expenditure of $1.87 million for high priced journals. Assume the cost of each journal is $240 (a figure on the high end of plausible, new journals are introduced at prices under $150 per year). The profit of $778 - $240 for each journal times the 2,400 journals gives the figure in the table. It would be possible with effort to get a better count of journals by publication type for typical libraries.

   The $240 per journal cost exceeds estimates from Bergstrom as mentioned in the text. He assumes $100 per page of first copy cost and $0.02 per page per subscription for distribution. The ISI Web of Knowledge summary of 8,576

journals with 793,786 articles indicates an average of 93 articles per journal. I assume an 18 page average length for articles but have not made a systematic analysis. The American Economic Review has long articles that average about 20 pages and short articles that average about ten pages. Assuming an average of 18 pages, Bergstrom's formula gives an average cost of $117 per journal. The $240 is the average expenditure per serial over all serials, an upper bound on cost absent monopoly rents (profits) for a typical journal.

Most publishers, particularly commercial publishers, do not reveal their costs. There may be little prospect for improving on the heuristics in the table.

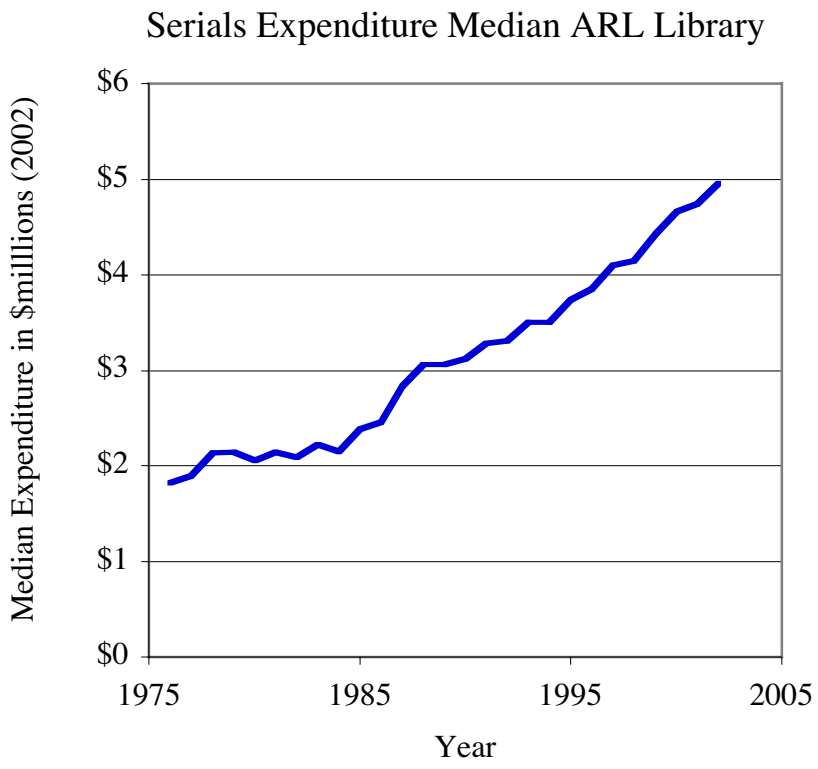
2. Let the remainder of the 21,381 serials be the balance of library expenditure on serials. (The count of serials is an average of the 76 US ARL libraries that report a count of serials in the ARL statistics.) Assume academic journals cost $240 and all other serials (non-academic periodicals, academic annuals, and non-periodic serials) average $75. Assume there are 10,000 academic journals including the high prices ones and 11,381 other serials. It would be possible to get a better estimate of the count of serials that are academic journals at a typical research library.

3. Assume that the cost of each academic journal is $240, assign 10 percent of this cost to accounting, 13 percent to distribution, and 77 percent to first copy costs to get the top three numbers in the column. (The allocation to distribution and first copy is approximately that suggested by Bergstrom.) Because accounting costs likely vary with the number of subscribers, one might think of the distribution and accounting costs varying with the subscriber count.

4. The total of first copy costs, distribution, accounting, and the profits of high priced journals plus the cost of the other serials is the $537 million total serial expenditures by the US ARL libraries.

5. Assume the library spends $37 per title per library in processing and binding expense for each serial title. Put prime open stack storage at $1.50 per title per year per library for each serial. Assume library space costs $200 per square foot to build and $3 per square foot per year to operate. The $200 capital cost implies an annual lease value of about $ 12. The capital and operating cost of space is then about $15 per square foot per year. If a library stores ten volumes per square foot in the current serials area, the cost per volume is $1.50 per year for storage. Suppose, after 13 years a volume shifts to a remote, compact storage facility, costing $0.20 per volume per year. The present value of the cost of perpetual storage of a volume is $15 at a 0.05 interest rate. The table does not include additional library staff costs in maintaining books in stacks with reshelving and other maintenance activities.

Figure 1



Source: Association of Research Libraries Statistics 2002. Values are stated in inflated to 2002 to dollars by the Consumer Price Index.