Draft Report for the National Academy of Sciences

Online Access and the Scientific Journal Market: An Economist's Perspective

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March, 2013

Introduction

What is a cynic? A man who knows the price of everything and the value of nothing.

Oscar Wilde (*Lady Windermere's Fan* (1892))

Economists have often been likened to Wilde's cynic. But, when I first began to think about the economics of scientific journals in the late 1990s, it occurred to me that there was at least one case where the converse was more accurate: economists knew the value of their journals, but not their prices. Indeed, economists were experts on the quality rankings of their journals; they kept close tabs on which economics faculties published the most articles in top journals, etc. But if I asked them about subscription costs, or the identity of a journal's publisher the average response I received was simply "no idea." Furthermore, it seemed that the same pattern was true in other disciplines like biomedicine or chemistry, i.e. acute awareness of journal quality but little or no knowledge of other seemingly important product characteristics.

What does any of this have to do with online access and scientific journal publishing?

First, most scholars (in OECD countries at least) operate within research institutions that provide them with broad access to the scientific literature. Whether the content is in print or digital format, this has been achieved by maintaining onsite journal collections supplemented by inter-library loans when necessary. Since these *reader* services have traditionally been offered to scholars at no (pecuniary) charge, this fact explains scholars' focus on non-price characteristics, and begs the question of how exactly the transition from print to electronic content distribution

may have affected their use of the research literature. On one hand, online access does not expand what is theoretically available to search and read. On the other hand, it is likely that online access has reduced the cost of search, which may change the quantity *and* type of articles that are downloaded, read, and cited (McCabe and Snyder, 2011). So what is the impact of online access on article downloads, citations, etc.? And why does the answer to this question matter?

Second, although scholars can access their literature at no charge, their institutions often pay millions of dollars on an annual basis for this privilege (journal expenditure data by institution is available from the National Center for Education Statistics at http://nces.ed.gov/). Each institution, in assessing the needs of its faculty, allocates funds to a "journal budget," and then proceeds to purchase access to the print and digital content so that the value of the content is maximized. In practice, this means that libraries at major research institutions, acting as agents for their faculties (the "principals") provide access to the current and archival content of thousands of titles, across multiple disciplines. Starting in at least as far back as the 1980s, and continuing to the present day, prices for these journals have increased at rates far exceeding general inflation rates, and faster than the growth in overall library budgets (see Bergstrom (2001), Edlin and Rubinfeld (2004)). This trend and its negative impact on institutional journal collections are often referred to as the "journals crisis." With the emergence of low-cost internet-based distribution of content in the late 1990s, as well as open access journals, there was some hope in the library community that this crisis might abate, and access prices might even decline. However, prices continued to increase at or above economy-wide rates of inflation. This begs at least two questions: What supply and demand factor(s) have caused these price

increases? And, in particular, what has been the contribution, negative or positive, of the switch to online distribution?

Third, journal quality is important to scholars because of their role as consumers *and* producers of journal articles. Access to quality articles keeps them abreast of the latest development in their respective fields. All else equal, readers prefer journals with many high quality articles. For authors, a published journal article provides a signal of their abilities, and this is the basis for promotion within the academy. Indeed, the number and quality of (1) their published articles and (2) the citations to these articles are perhaps the definitive measure of a researcher's scientific contributions. But the quantity of citations received will depend on the number of readers that the journal has. And the number of readers the journal has depends on the number of articles. And so on. These feedback effects are managed by the journal owner, and influenced by the owner's choice of editorial board, subscription and author fees, etc. as well as competition from other journals. How have the relationships between readers and authors been affected by online access? Is the journal still the important nexus of interaction? How has competition between publishers changed?

Organization of the Report

In the following pages I will address these three sets of issues in reverse order. In **Section 1** of the report I will focus on the most basic unit of analysis – the scientific journal as a communication platform – and then discuss the behavior of publishers, authors, libraries, etc. Once this is accomplished, I can address the questions identified earlier: in **Section 2**, the journals crisis, and in **Section 3**, the impact of online access on citations. Finally, **Section 4**

summarizes the main conclusions of the report, and considers the implications for future research.

Section 1: A Journal as a Platform

Scientific journals as we now define them first emerged in the 17th century (Guédon (2001), Roosendaal & Guert (1998)). In the library and information science literature they are seen as performing a number of important functions, including the: 1. establishment of scientific priority, 2. quality certification, 3. communication of results, and 4. provision of an archival record (see Tenopir & King, 2001, Roosendaal & Guerts 1998.) In modern economics jargon, journals are an example of "two-sided" markets in which an intermediary (or platform owner) sets the terms for participation on each side of the platform (Armstrong (2006), Rochet & Tirole (2006), McCabe & Snyder (2004), (2005), (2007), (2010), Jeon and Rochet (2010), McCabe, Snyder & Fagin (2013)). Here, the platform owner is the publisher, and the participants include authors and reader/subscribers. Each side of the platform benefits from externalities provided by the other: an author benefits from additional readers because this may increase the number of citations to his or her paper; a reader benefits from additional articles because articles contain content which is potentially valuable to them.

From this perspective another function of journals is the management of these externalities when setting author and reader fees. For example, if the reader side of the platform is more valuable (in terms of willingness to pay), there is an incentive to increase the number of authors by subsidizing their participation, even if this implies setting author fees below the corresponding

variable costs. So this can help explain why a journal with a potentially large and valuable set of subscribers (like the *New England Journal of Medicine*) charges no author fees.

Platform objectives also affect pricing. In the case of society and non-profit journals, like the *NEJM,* or *Science*, the objective is normally biased toward maximizing readership, and so lower reader fees are preferred all else equal. Commercial, profit-maximizing journals, like *Nature*, do not favor authors or readers, and this helps explain why *Nature*'s individual subscription rates are higher than those of its direct competitor, *Science*.

Finally, the degree of competition on both sides of the platform is another important determinant of author and reader fees. On the reader side, the fact that content is highly differentiated across journals provides readers with a strong incentive to "multi-home" or subscribe to multiple journals (and this explains why research institutions try to provide access to "everything"). As a consequence, reader demand for individual journals tends to be highly inelastic (See Nevo, Rubinfeld, and McCabe (2005), and McCabe, Nevo, and Rubinfeld (2008)), publishers understand this, and so subscription prices can be set much higher than in a single-homing environment. In contrast, on the author side, the almost universal requirement that authors single-home, i.e. at any point in time, articles can only be under review at a single journal, can create robust competition for articles. As mentioned above, neither Nature nor Science charge author fees, and this is likely related to the fact that these two high-quality general science journals compete for the same set of articles.

This combination of multi-homing on the reader side and single-homing on the author side creates an economic environment which enables journals with different operating objectives to co-exist and thrive. Indeed, *many* journals, whether profit- or readership-oriented, can simultaneously enjoy large "market shares" on the reader side of the market, *and* charge subscription prices that not only cover their overall costs of operation, but also generate healthy profits.

So far I have largely ignored questions related to journal quality and pricing, and only hinted at how market structure and competitive strategies influence outcomes. I now discuss these issues in some detail and then consider the impact of electronic access on publisher behavior.

1. A. Journal Quality

The thousands of peer-reviewed journals published each year vary in many dimensions besides author and reader fees: the frequency of publication, the number of articles and pages, the degree of specialization within a discipline, the speed of the peer review process, the language(s) in which the articles is written, and so on. Although each of these factors do influence the attractiveness of the final product to authors and readers it is fair to say that *the* important distinguishing characteristic for the platform and its participants is the perceived scientific quality of the content. Within each discipline, and each sub-discipline, there is usually a consensus on what constitutes the state of the art in research, and in which journals the articles with the most "impact" are likely to be found, in which journals articles with somewhat less

impact will be found, etc. [1] From the perspective of authors, impact consists of at least two components: the prestige of the journal in which an article is published, and the number of citations that articles which appear in the journal should receive. The prestige of the journal is related to the reputation of the editorial board and the past citation performance of the journal. On the reader side, these same factors guide a scientist's search for new articles, starting with the best and most relevant platforms. To the extent that these expectations are satisfied on both sides of the journal platform determines the nature of author and reader demand, and thus feeds back in to long run pricing and editorial policies of the journal platform.

1. B. Pricing in the Print Era

The vertical differentiation of journal quality has important implications for subscription pricing. Since research libraries care about getting the most value for their budget dollars, they often used a simple decision strategy during the *print* era (that resembles the solution to the knapsack problem in operations research (See Daellenbach and George (1978)):[2]

1. Rank journals on the basis of the ratio of citations to their subscription price.

2. Starting with the highest ranked journal, add journals until the budget is exhausted.

[1] What is usually observed in each discipline is a set of journals which differ in horizontal and vertical dimensions of quality (McCabe and Snyder (2007) discuss vertical differentiation as an equilibrium outcome in a two-sided market setup). The differences in vertical quality translate to reputational advantages that create substantial barriers to entry, in part due to platform coordination issues. See Edlin and Rubinfeld (2004) for a more detailed discussion of entry in the journal market.

[2] Deviations from this strategy can arise if, for example, faculty members intervene and request subscriptions to journals of special relevance to their research, etc.

Given this strategy, as well as knowledge of (A) library budgets, and (B) the relative quality of other journals, publishers can select the optimal prices for their own journals.[3] One implication is that higher quality journals charge higher prices and are purchased by more libraries than lower quality titles. The empirical evidence generally supports these claims (See Dewatripont, et. al (2007) on the quality/price relationship; McCabe (2000) addresses both claims).

Of course, many if not most journals are published by firms who own and/or manage multiple titles, including a few large firms controlling portfolios numbering in the hundreds and even thousands of titles.[4] In the industrial organization literature that addresses multi-product firms, prices for a fixed set of differentiated products may either increase or decrease as ownership grows more concentrated, depending on whether the products are strategic substitutes or complements, respectively. Modeling price equilibria in the print journal case is complicated by library purchasing behavior (they purchase multiple titles, subject to a budget constraint, in comparison to the usual setup where consumers each choose a *single* item from the set of available products). Simulations using price and library holdings data for economics titles suggests that increases in concentration are associated with *lower* subscription prices, i.e. journals are strategic complements (See McCabe, Nevo and Rubinfeld, (2008)). Note, however, that this result does not necessarily contradict other results indicating that journal mergers are associated with *higher* prices, especially for the acquired titles (McCabe, (2002)). As mentioned earlier, publishers with different objectives are likely to have different pricing strategies. So, if a

[3] As discussed earlier, differences in publishers' objectives will influence the "optimal" pricing strategy in this context. All else equal, commercial (non-profit) publishers will set relatively higher (lower) subscription prices.

[4] The two largest commercial publishers, Elsevier and Wiley, publish and/or manage about 2000 and 1500 journals, respectively. Go to http://www.elsevier.com/wps/find/intro.cws_home/ataglance, and http://eu.wiley.com/WileyCDA/Section/id-301695.html

profit-maximizing firm purchases titles that were previously managed by a firm more concerned with maximizing readership, then the net result can be a price increase. That is, the positive price impact of the shift in objectives outweighs the negative impact of the greater strategic complementarities.

1. C. Pricing and Competitive Strategy in the Online Era

The shift to electronic distribution of content that began in earnest in 1995 with the emergence of the first widely used web browsers has induced a variety of changes in the market(s) for scientific journals. Initially, it was understood that the shift from print to digital content would lower distribution costs, but there was no consensus on how this would affect publisher behavior. Institutions weary from facing substantial annual increases in the costs of maintaining their journal collections, hoped that the lower distribution costs would lead to lower subscription prices as well. Meanwhile, publishers experimented with different pricing models – per article charges, subscriptions for unlimited access to a *bundle* of journals, etc. (see, for example, Mackie-Mason, et. al. (1999)). And like their counterparts in other information good markets, publishers discovered that demand existed for electronic access to "current hits *and* old hits," i.e. current content *and* journal backfiles. Meanwhile, open access repositories containing working papers emerged in some fields like physics and economics, including the ad-hoc (personal websites) and the more formal (arXiv and SSRN, founded in 1991 and 1994, respectively).

By 2000 or so, most of the changes wrought by the internet that are visible today were in evidence. They include:

A. Current journal content is sold primarily as part of large publisher-specific journal bundles, or "Big Deals" (Frazier, (2001)), and normally includes access to content back to the 1990s. Print is still available for a surcharge.

B. Bundle prices are institution-specific, and therefore exhibit price discrimination; access is sold on an annual subscription basis.[5] (Contrast this with the absence of price discrimination in the print era, and the lack of bundling.)

C. The emergence of commercial and non-profit open access (OA) journals. OA journals can be accessed online at no charge, and recover their costs through some combination of author fees and grant monies and government funding (Crow (2005)). The Directory of Open Access Journals or DOAJ currently catalogues more than 8500 titles, many of which are peer-reviewed.

D. Publisher sell their electronic journal backfiles for a one-time charge; 3rd parties provide electronic access to backfile content from multiple publishers on an annual subscription basis, e.g. via Ebsco or JSTOR.

E. In addition to the open access working paper repositories mentioned earlier, dozens of major research universities and funding organizations have adopted (open access) self-archiving mandates. (go to http://roarmap.eprints.org/ for a list of the organizations and the repository websites).

F. Google Scholar. This search tool was not introduced until late 2004 but has quickly emerged as a powerful complement to the content available online. According to Google (http://scholar.google.com/intl/en/scholar/about.html):

[5] It is possible to purchase access to individual articles/journals but at a relatively high price; few institutions avail themselves of this alternative.

Google Scholar provides a simple way to broadly search for scholarly literature. From one place, you can search across many disciplines and sources: articles, theses, books, abstracts and court opinions, from academic publishers, professional societies, online repositories, universities and other web sites.

A Google Scholar search provides a list of matching articles, and when available, links to free copies of the corresponding articles. Of interest to users of citation data, each search result article is associated with detailed information about articles that *cite* the searched for article. It thus appear that this free Google tool has the potential to compete with expensive alternatives like Thomson Reuters' Web of Science in providing detailed citation data.

Several of these internet-driven market features -- (1) the Big Deal and price discrimination, (2) Open access journals, and (3) Self-archiving, deserve a closer look.

1. The Big Deal and Price Discrimination

The first two changes – Big Deals and explicit price discrimination – can be explained as a profit maximizing response to the decline in content distribution costs (McCabe (2004)). If distribution costs are equal to zero then each publisher has an incentive to sell access to its entire portfolio to *each* customer at a customer-specific price, even if that customer's willingness to pay is quite modest. This is because higher quality portfolios can claim a greater share of any customer's journal budget, with no cost penalty.

In contrast, during the print era, material and shipping costs were too high to profitably distribute large bundles of journals to all types of customers. Instead, with publisher s setting journal-specific prices that applied to all customers, institutions could self-select their own bundles. Small budget institutions might purchase, for example, only a few dozen Elsevier titles. For

large budget customers, e.g. Harvard or the national libraries, the self-selected bundle more or less consisted of each publisher's full portfolio.[6]

In any case, with the adoption of the internet as a mechanism for distributing digital journal content, the rationale behind the uniformly priced journal subscription model disappeared. After a transition period of a few years during which electronic access was offered as an option for print subscribers, most institutions adopted it as their primary means for providing access to the scientific literature. Each publisher's bundle prices are institution (or consortia) specific. Initially, these prices reflected the "total spend" on each publisher's print titles by a given institution during the transition period.

Several papers in the literature discuss whether this bundling and pricing scheme is efficient or exclusionary, and therefore possibly a violation of antitrust laws (See Edlin & Rubinfeld (2004), McCabe (2004), Jeon & Menicucci (2006)). On one hand, since *individual* publishers now offer their entire journal portfolio to large *and* small institutions via their bundles, this would appear to be an example of how price discrimination can expand output, and therefore increase welfare. However, in the aggregate, and depending on the model, bundling can deter entry of preferred titles (i.e. those offering higher quality than one or more titles contained in the publisher bundles), or force the exit of existing smaller publishers. In either case, welfare declines. However, *in the absence of bundling*, price discrimination appears to be welfare enhancing.

[6] One side benefit of this arrangement for institutions was flexibility in collection management. If any substantial changes in the relative prices of individual titles occurred, they could cancel the corresponding subscriptions and purchase subscription to other journals (in the spirit of the decision process outlined earlier). And although entry by new journals is generally difficult, this flexibility helped to mitigate the existing barriers to entry.

Jeon and Menicucci also consider mergers in their 2006 paper. When price discrimination is allowed but not bundling, there are no adverse effects. If bundling is permitted, then publisher profits increase after a merger (unless the merging firms together already monopolize the market), and journal consumption declines.[7]

2. Open Access Journals

Why did open access journals first appear in large numbers around 2000, and not 1995 or 1996 when traditional publishers were first placing their content online? [8] One possibility is that it took time to understand the implications of internet content delivery. Placing stuff online behind a secure login page to safeguard subscription revenue is one thing, developing a plausible open access business model that generates no such revenue is quite another. Another interpretation is that, compared to the print era, the various Big Deals made it far more difficult for new entrants to grab a share of existing journal budgets. So when institutions finally switched from print to online access, around 2000, new journals and new publishers had little choice but to experiment with OA.

In any case, proponents of the OA business model emphasize the benefits of OA publishing, especially for authors, and society at large: more readers, more citations. I will address the empirical validity of these claims later in the report. However, assuming that these claims are true, let me briefly consider some economics of OA journals, from a two-sided platform perspective. For an OA journal to be successful it will need to attract paying authors and/or

[7] Note that this theoretical claim appears to contradict the empirical results reported in McCabe, Nevo, and Rubinfeld (2008). However, they address mergers in the print era, where no price discrimination was observed. Jeon and Menicucci's (2006) claim cannot be extrapolated to those circumstances.

[8] The first digital-only, free journals appeared before 2000. The Wikipedia entry for "Open Access Journal" (http://en.wikipedia.org/wiki/Open_access_journal) identifies a handful of titles that were first available in the late 1980s.

sponsors (foundations, government agencies, advertisers).[9] As discussed earlier, an author's primary objective is to maximize the impact of his or her scholarship. This requires publishing in prestigious and widely read journals. Here is an excerpt from the PLoS website on what its journals deliver authors in exchange for fees ranging between $1350 and $2900: [10]

What does PLoS deliver for the publication fee?
Above all, PLoS journals deliver OA. For you as an author, that means your work will have maximum impact. Anyone with an interest in your work will be able to find it, read it, download it, redistribute it, translate it, and so on. There is growing evidence…that OA increases the usage and citation of published work. [Source: http://www.plos.org/about/faq.php (downloaded July, 2011; this page can be accessed using the internet archive (web.archive.org))]

So, assuming that OA journals (all else equal) do deliver "maximum impact," is this business strategy competitively viable, and under which conditions? McCabe and Snyder (2010) discuss these questions in a theoretical analysis, and conclude that *commercial* OA is more likely to be observed in situations where the journals' market power is relatively low, author benefits are relatively large compared to reader benefits, and when the marginal cost of serving readers is low.[11] In the case of non-profit OA, the same conclusions hold with one important exception: journal market power is not inconsistent with OA. Increasing a non-profit journal's market power increases the rents it could use to achieve its objective of reader maximization.

[9] Some traditional publishers have experimented with hybrid journals that offer authors a choice between OA/author fees and subscription access/no author fees, on the *same* journal platform. As far as I know no formal analyses of this option's merits have been conducted to date.
[10] The Public Library of Science, founded in 2001, is arguably the best known and highest quality OA publisher. Its first OA journal, PLoS Biology, began publication in 2003. Its current fee schedule is available at http://www.plos.org/publish/pricing-policy/publication-fees/
[11] Market power provides commercial journals with a strong incentive to charge positive reader fees, i,e. they want to extract revenue from all possible sources; in this case, OA will emerge only if author benefits are substantially larger than reader benefits.

In practice, are these several conditions satisfied? Obviously, the marginal costs of serving readers are low. What about market power? In principle this is relatively easy to measure: citation impact. Some OA journals – notably those published by PLoS –have already achieved sufficient prestige and citation impact to attract a large number of submissions from authors despite the high fees.[12] However, some anecdotal evidence based on economics journals suggests that this is not yet generally true. [13] In principle many traditional high impact non-profit journals should be able to at least move towards an OA strategy – increasing author fees, and lowering the reader fees – if their objective was to maximize readership.

Are author benefits relatively large compared to those off readers? Although I am not aware of any studies that have been conducted to assess this situation within and across fields, funding organizations, like the NIH, or the Wellcome trust, *seem to believe*, implicitly at least, that OA is a great idea, but that the current "scientific communications equilibrium" won't transition to OA without subsidies. For the sake of argument, let's assume that these funders share our knowledge of two-sided markets. Their willingness to subsidize author fees at the several

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[12] PloS revenues exceeded expenses for the first time in 2010, largely due to the remarkable growth of PLoS ONE, and this trend continued in 2011. In 2011 publication fees generated more than 90% of PLoS' revenues. Go to http://www.plos.org/about/what-is-plos/progress-updates/ for recent financial results. PLoS ONE's emergence as the largest journal in the world (measured by the number of articles published) is controversial since its editors do not consider scientific contribution as a criterion for acceptance/rejection of an article. Go to http://en.wikipedia.org/wiki/PLOS_ONE for further information on PLoS ONE's business model and the related controversy.

[13] There are two notable OA economics journals, Theoretical Economics, and Economics Bulletin, which compete for authors with the Journal of Economic Theory (Elsevier) and Economics Letters (Elsevier), respectively. The two OA journals have impact factors of 3.209 and 0.62, respectively, while the corresponding Elsevier titles have impact factors of 12.867 and 3.392. Go to http://ideas.repec.org/top/top.journals.simple.html for further information. Note that neither OA journal charges an author fee, though Theoretical Economics does require society membership. Another set of journals that deserve closer examination are the 250+ commercial OA journals published by Biomed Central, a subsidiary of Springer since 2008. Author fees for these journals range between about $685 and $2700, with an average value of $1975. Go to http://www.biomedcentral.com/.

thousand dollar level, in specific disciplines, like biomedicine, can then be interpreted in a number of ways. First, perhaps they believe that author benefits do currently exceed reader benefits in those fields, but that author (and institutional) perceptions have not yet adjusted upwards, ergo the need for a (temporary?) subsidy. A second possibility is that the funders believe that substantial author benefits have not yet appeared, but will at some time in the future, ergo the need for a (temporary?) subsidy. Of course, if we relax the assumption that the funders understand platform economics, then we can't really infer much about author and reader benefits from funder behavior. Instead, as part of a future research agenda, I can offer an excerpt from McCabe and Snyder (2010) which indicates how to begin thinking about this question:

> One could point to cases in which science is considerably advanced by the publication of seminal articles swamping any author benefit. Another effect going in the same direction is that, since the number of readers is invariably higher than the number of authors,..reader benefits should be scaled up in proportion to the relative populations of readers and authors. On the other hand, there are likely a large number of articles that help the career prospects of the author more than they advance the field. Furthermore, there are inherent "business stealing" effects which add to the private benefit of publication but not the social benefit. Intuitively, the marginal social benefit of an article may not be great if another author would have published a similar article in the near future.

Finally, I should note that 3rd party funding of author fees appears to be focused in the life sciences and biomedicine, where journal citation impacts and readership are the highest. There are of course many other disciplines where OA experiments are occurring in the absence of author fee subsidies. These efforts deserve a closer look too.

3. Self-Archiving

The form of OA that involves peer-reviewed journals is sometimes referred to as "Gold" OA. "Green" OA involves self-archiving by authors, on their personal websites, or in institutional and disciplinary repositories, and emerged simultaneously with the internet. [14] In a few disciplines where a pre-print working paper culture was long established – including several sub-disciplines of physics (condensed matter, astrophysics, and high energy physics), business and economics – Green OA has effectively supplanted the role of journals for three of the four functions mentioned earlier; the one exception is quality certification. That is, working papers that are subsequently published are freely available before *and* after the articles are published. For example, Bergstrom and Lavaty (2007) report that a Google search for articles published in economics journals reveals that some 90% of those published in the top 15 journals were Green. This percentage declines as lower impact journals are included, suggesting that the quality of self-archived articles involves some self-selection, a subject I will return to later in the report. More generally, Gargouri, et. al. (2010) report a global baseline rate of self-archiving across all disciplines of about 15%; for four institutions in their study that mandate self-archiving by their faculty this rate jumps to around 60%. The baseline rate is replicated by other studies cited in their paper. Swan and Brown (2005) claim that publisher policies towards self-archiving of *published* articles are generally supportive; nonetheless, researchers do not always have an incentive to self-archive. But there are exceptions. NIH policy regarding self-archiving of NIH-funded research manuscripts is fairly clear about the necessity of this activity:

[14] As mentioned earlier, many of the institutional initiatives involve "soft" mandates to encourage participation. Disciplinary repositories include arXiv.org (physics), SSRN (business and economics), and PubMed Central (life sciences); they are typically funded by universities, government agencies and foundations. In some cases, e.g. the California Digital Library, archiving services are combined with support for OA publishing.

> The Director of the National Institutes of Health shall require that all investigators funded by the NIH submit or have submitted for them to the National Library of Medicine's PubMed Central an electronic version of their final, peer-reviewed manuscripts upon acceptance for publication, to be made publicly available no later than 12 months after the official date of publication: Provided, That the NIH shall implement the public access policy in a manner consistent with copyright law. (http://grants.nih.gov/grants/guide/notice-files/NOT-OD-08-033.html)

What are the economic implications of self-archiving? Because quality certification is still performed almost exclusively by journals, authors in need of prestige, promotion, and tenure will almost certainly continue to submit their papers to these platforms for peer-review. Even if post-publication self-archiving began to approximate 100%, delays in this process, especially due to copyright-related restrictions that constrain the incentives to self-archive (see the above NIH policy), would probably provide institutions with a strong incentive to purchase the major publishers' subscription-based journal bundles. On the other hand, if publishers were not permitted to bundle their journals, self-archiving might dampen subscription prices in those disciplines with high rates of pre-publication self-archiving.[15]

Section 2: On the Journals Crisis

I noted earlier that journal prices over the past few decades increased at rates far in excess of general inflation, or increases in library budgets. Although prices for non-profit journals increased too, the inflation rates for commercial titles were far greater. This helps explain why by 2000 prices for commercial titles were many times more expensive than their non-profit counterparts, even after accounting for quality differences. See Bergstrom (2001), and Edlin and Rubinfeld (2004). Since the introduction of Big Deal contracts, the commercial bundles have

[15] Bergstrom and Rubinfeld (2010) argue that this dampening effect will be strongest for those journals with low quality and/or high prices.

averaged price increases of around 7% per year. Furthermore, the gap between commercial and non-profit bundles, on a per page or citation basis, remains substantial.[16]

What supply and demand factors can best explain these price trends for commercial journals? And, in particular, what has been the contribution, negative or positive, of the switch to online distribution?

With regards to supply factors, the primary argument in the literature is attributed to Noll and Steinmueller (1992).[17] They observed that journal prices and circulation levels were inversely related, and suggested that the proliferation of new titles over time might be an important explanation for the price increases (see Bergstrom (2001) for evidence on journal proliferation). Since journal production, like most information goods, involves a large fixed cost (the "first copy" cost), and low variable costs, the breakeven price for low circulation journals is necessarily higher, due to their higher average costs. So how does an increase in the population of journals lead to lower circulation rates? Noll and Steinmueller argue that the textbook model of monopolistic competition is appropriate (where demand for *all* journals declines as entry occurs). But, given what we now know about how libraries purchase journals (see the earlier discussion in section 1. B.) and the fact that a journal's reputation and impact tend to be inversely related to age, even in the long run (Edlin and Rubinfeld (2004)), journal proliferation will result in low circulation rates, albeit for the new entrants, and not all journals. (See McCabe

[16] See Bergstrom (2011). For example, on an article basis, the Elesevier bundle costs between 6 and 15 times as much as bundles for 9 non-profit publishers, including the IEEE and the American Medical Association.

[17] There is no evidence in the literature that other traditional supply factors, e.g. input cost inflation, played any important role.

(2000) for evidence supporting this view). But even if the addition of new low circulation, high price titles might have contributed to the overall inflation rate, how do we account for the substantial price increases observed for established, high quality journals? Their circulation rates did not significantly decline (see for example Table 3 in McCabe (1999)).

Other "supply" factors, i.e. strategic behavior by publishers and differences in their objectives, combined with inelastic journal demand may offer a better explanation for the price increases. First, as we discussed earlier in the report, journal demand is very inelastic, due in part to the multi-homing behavior of libraries. Using data for biomedicine and economics journals, respectively, McCabe (2000) and McCabe, Nevo, and Rubinfeld (2008) find that estimated journal demand is very inelastic. However, the elasticities are too small in absolute terms to be consistent with profit maximization by commercial publishers. McCabe, Nevo, and Rubinfeld (2008)) offer the following discussion of these results:

> The choice of the profit-maximizing price for a journal is not an easy one….adverse public reaction to high prices by libraries could have led libraries to search for cost-reducing strategies (e.g., cutting down the number of copies of journals, reducing the demand for journals directly, or indirectly as libraries find ways to share with other libraries). Moreover, adverse reaction by faculty could reduce readership and citation rates, both of which would further reduce demand. While we believe that a long-run profit-maximizing strategy can reasonably explain the current phenomena, we have not modeled these possibilities explicitly, and we cannot rule out the possibility that pricing during the 1990s was a profit-maximizing in the long-run.

That is, the price increases may have been a long-term profit maximizing strategy consistent with the peculiar demand conditions observed in the journals market. Annual price increases of 10% or so would be tolerated, but anything much more would have threatened long term profits, and

anything much less would have disappointed shareholders. Since not all firms embraced this strategy – the non-profit publishers in particular, and some commercial publishers as well , e.g. Blackwell (see Bergstrom (2001)) and McCabe, Nevo, and Rubinfeld (2008)) – mergers were another means to exploit this situation, as discussed earlier in the report. The large number of mergers in the 1990s may help explain why inflation during that decade (at >10% per year) exceeded what Bergstrom reports for the most recent decade (~7%).

And is there an impact of online distribution on price trends? Notwithstanding Bergstrom's nascent efforts to collect data on publisher journal bundle contracts (the basis for the annual 7% inflation estimate over the past decade), the dearth of data on prices and institutional bundle collections (due in part to contract confidentiality) has slowed research that might empirically address this question. The conceptual/theoretical analyses of journal bundling discussed earlier suggest that the adoption of Big Deal contracts are likely to deter new entry (and/or encourage exit), and enhance the market power of the largest incumbent firms. In other words, although online distribution did lower distribution costs it obviously did not change the basic demand conditions in this market; if anything this new technology augments their exploitation, since it has facilitated cost effective bundling and price discrimination. The annual 7% price increases should continue until those demand conditions change.

Section 3: The Impact of Online Access on Citations, etc.

Online access has obviously affected the way scientists (and society) search and use the scientific literature. The expectation that online access, including open access, should have expanded the

dissemination and impact of the scientific literature has important implications not only for scientific communication (e.g. are OA journals viable?), but also for society on a broader level (better communication enhances research productivity, which in turn enhances overall economic productivity (see Dosi (1988) and Freeman (1994)).

Understanding the market for academic journals is important to *scholars* because it is the one market in which they function as both producers and consumers.[18] Citations are the currency in this market, the prevailing indicator of the impact of scholars' research, advancing a scholar's prestige as well as salary.[19] If a small change in the convenience of access can cause a quadrupling of citations, then the typical citation may be of marginal value, used to pad the reference section of citing articles rather than providing an essential foundation for subsequent research. According to this view, citations would be at best a devalued currency, subject to access conditions. On the other hand, the finding of little or no citation boost would resuscitate the view of citations as a valuable currency and as a useful indicator of an article's contribution to knowledge.

McCabe and Snyder (2011) examines the impact of *online* access on journal citations using data for economics and business journals (Note: no OA journals were included in the analysis because none fit the data requirements of their study). I rely on their paper to provide an overview of the relevant citation effects literature and to summarize their results. I then briefly consider studies that use other measures of impact, including article downloads, and conclude by discussing some ways of measuring the broader impacts of online access.

[18] See Bergstrom (2001) and Dewatripont et al. (2006) for evaluations of the market for academic journals.

[19] We follow the traditional approach in considering the raw citation count as the "currency." See, e.g., Palacios-Huerta and Volij (2004) and Bollen et al. (2005) for a discussion of alternative impact metrics.

Could a scientist quadruple his or her citation count just by publishing in an online journal rather than one available only in print? Interest in this question has been prompted by the large effects of online access found in various empirical studies. For example, in the study of a cross section of medical journals over the period 1995-2000, Curti et al. (2001) found online journals generated 54% more cites per article than print-only journals. Lawrence (2001) studied a sample of computer-science conference proceedings that exhibited within-proceedings variation in access, with some articles made available online and the rest only in print. In the average proceedings, online articles received 336% more cites than print.

It would not be surprising if convenient online access to the full text of an article boosts its citations.[20] Enhanced access expedites search, allowing citing authors to identify additional relevant articles, and lowers the cost of acquiring, reading, and ultimately citing the articles so identified. But the magnitude of the citation effect in these previous studies beg the question of whether the results are biased upward. A likely source of this bias is that the effect of online or open access is confounded with article quality, which is unobservable to the econometrician and so is an omitted variable. For example, in Lawrence (2001), there is no mention that the proceedings used a random procedure to select articles for online publication. If instead of a random procedure, the best articles were published online, the 336% effect on citations could just be picking up the difference in the citation rates of leading articles versus others.

[20] The use of electronic means to access article information preceded the Internet. Digital bibliographic data became available for libraries in the 1970s, facilitating the searching of and access to academic articles (see Lancaster and Neway 1982). In the mid 1990s, popular Internet browsers such as Mosaic and Netscape Navigator allowed the literature searches previously conducted in libraries for a fee to be conveniently performed on a personal computer for free (Tenopir and Neufang 1995). Around the same time, academic journals began providing Internet access to some articles, allowing scholars instant access to the full text of these articles rather than having to visit the library or to wait for a print copy to arrive via a document-delivery service.

Several recent papers attempt to address the bias due to omitted article quality in estimating the effect on citations of online or open access, but introduce their own specification problems. Two articles in *Science*, Evans (2008) and Evans and Reimer (2009), use the same basic approach as McCabe and Snyder (2011) to control for quality. These two papers use panel data on citations to individual journal volumes and include volume fixed effects in their analysis. Unfortunately their econometric model suffers from a different misspecification problem: the omission of time effects which should be included to account for secular trends in citations. In the absence of such time effects, recent secular increases in citations for certain journals might be picked up by an online or open-access indicator, which generally are turned on in later citation years, leading to an upward bias in the citation effect. McCabe and Snyder (2011) demonstrate this point concretely in their Table 2, where they reproduce a similar estimate to the 26% citation effect for economics and business in Evans and Reimer (2009), but then show that this estimate disappears when appropriate time effects are added.

Two recent papers provide convincing identification strategies in detailed case studies of individual platforms. Davis et al. (2008) conducted an experiment in which articles from American Physiological Society journals were randomly selected to be openly accessible immediately upon publication, the rest receiving the usual treatment of restricted/fee access for the first year. The randomized design solves the problem of separating the open-access effect from unobservable quality. The authors found no differences in citations or in the percentage of articles for the two types of access after one year. Gaule and Maystre (2011) examine the effect of open access on citations to articles in the *Proceedings of the National Academy of Sciences*

(*PNAS*) as did earlier studies (Eysenbach 2006; see also Walker (2004)), but they attempt to control for the endogeneity involved in the author's paying the $1,000 charge for open access by using instruments such as whether the article was published in the last fiscal quarter for the author's affiliated institution (under the presumption that research spending is less elastic then because of "use it or lose it" policies). Instrumenting in this way causes the open access effect to fall by 80% and become statistically insignificant.

Previous research on the effect of *open access* on citations find the same large results as the literature on online access cited above[21] and likely suffer from the same biases,[22] Gargouri, et. al (2010) report that OA has a more modest positive impact on citations, after appearing to control for possible self-selection biases. McCabe and Snyder have obtained the authors' data and will soon post a paper that assesses their results using a more robust econometric specification.

McCabe and Snyder (2011) show that the same huge effects of online access found in the previous literature can be generated if fixed effects capturing the quality level of journal volumes are omitted. Once appropriate fixed effects are included, however, *the aggregate result cannot be distinguished from zero. Thus much of the estimated effect of online access from the previous literature can be attributed to bias due to omitted quality.* They then go on to show that the absence of an estimated effect at the aggregate level masks substantial heterogeneity across

[21] For example, Harnad and Brody (2004) studied the citation rates of published physics articles, some of which were also self-archived by the author on arXiv (a large, online repository offering free downloads of scientific manuscripts). Self-archived articles averaged 298% more cites than the others. Walker (2004) studied an oceanography journal that allowed authors to buy open access for their articles, finding 280% more downloads for open-access articles. See Craig et al. (2007) for a survey of research on the citation boost from open access.

[22] The decision by an author self-archive as studied in Harnad and Brody (2004) or to pay for open access as studied in Walker (2004) study may be plausibly correlated with article quality rather than random. Thus the large boost in citations these studies attribute to open access may be partly or entirely spurious.

platforms. *While the find no effect for, among others, Elsevier's ScienceDirect platform, there is a positive and significant effect associated with JSTOR, boosting citations roughly 10% on average.*

The "non results" reported in Davis (2008) and Gaule and Maystre (2009) are consistent with McCabe and Snyder's (2011) finding of no aggregate effect.[23] However, their finding of heterogeneous effects for individual platforms (positive for JSTOR but not for other platforms) calls into question the generalisability of studies of isolated platforms. JSTOR may provide a citation boost because of its desirable properties: it is well known among academics, it includes a large number of journals, and it includes all past articles for all listed journals. One may expect little citation boost from the more limited American Physiological Society experimental platform, which may not have been well publicized outside of the field, only made a small number of journals available, and offered better access for a scattered sample of articles for just one additional year. *PNAS* may not be the best test case given that most citing scholars have access to the journal through their institutions in any event and that the $1,000 author fee only moves the date of online access up by six months, after which all *PNAS* articles are freely available online.

The lack of online access effects at the aggregate level and the modest effects at the channel level resuscitate the view of citations as a valuable currency and useful indicator of an article's contribution to knowledge. At the same time the modest size of these effects, and the current lack of persuasive evidence that free online access performs better, suggests that the citation

[23] While our aggregate is consistent with these other studies, the domains of our studies differ: we study the effect of online versus print access, whereas they study the effect of open versus fee access for a journal which is already online.

benefits of open-access publishing *may* have been exaggerated by its proponents. Even if publishing in an open-access journal were generally associated with a 10% boost in citations, it is not clear that authors in economics and business would be willing to pay several thousand dollars for this benefit, at least in lieu of subsidies. Author demand may not be sufficiently inelastic with respect to submission fees for two-sided-market models of the journal market (e.g., McCabe and Snyder 2005, 2007, 2010; Jeon and Rochet 2010) to provide a clear-cut case for the equilibrium dominance of open access or for its social efficiency.

Other Measures of Impact

Davis and Walters (2011) provide an overview of the "online impact literature" and include many of the papers discussed above. However, in additions to data-driven analyses of citation impacts they also consider empirical studies of article downloads, surveys of scientists regarding their attitudes towards scholarship in general and online access in particular, use of the medical literature by the general public and its impact on clinical decision-making. They draw the following conclusions:

1. Open Access articles enjoy substantially more full text and pdf downloads than subscription articles, though fewer abstract views. Further investigation is required to determine who is accessing these articles, and for what purpose.

2. The large access-citation effects found in many early studies appear to be artifacts of improper analysis and not the result of a causal relationship.

3. Authors consider factors such as journal reputation and the absence of publication fees when deciding where to submit their work. In contrast, free access is not a significant factor in their submission decisions.

4. Current research reveals no evidence of unmet demand for the primary medical or health science literature among the general public. This does not necessarily reflect the absence of unmet demand; it may simply indicate that the question has not been addressed adequately.

5. Almost no studies have evaluated whether free access to the scientific literature has had an impact on the use of scientific information in non-research contexts such as teaching, medical practice, industry, and government (in fact they can only identify one such study, in the area if clinical decision-making).

Broader Implications of Online Access

Unlike most market analyses where conclusions are narrow in scope, the results of an economic study of scientific communication inevitably raises questions about broader impacts in other knowledge intensive activities or markets. In the current context, easier access to the scientific literature might affect R&D performed by biotech firms, the practice of medicine, or education in a developing nation. Unfortunately, as indicated by the Davis and Walters' article, there is basically no empirical research that examines these potential links.[24] Nonetheless, it is possible to sketch an outline of how researchers might proceed in one particular area, by examining papers that have used data on citations and patents.

McMillan et. al. (2000) examine the role of "public science" in the innovation process. They define public science as "scientific research performed in and supported by governmental, academic and charitable research institutions." Using the non-patent references contained in

[24] There are not many theoretical or conceptual studies either. One exception is a massive engineering process study of alternative publishing models and the potential benefits of OA for R&D in the UK. Houghton, et. al. (2009) assume that the "citation advantage" of OA exists. They then model R&D investment in a growth model and calculate the potential gains from better accessibility to the scientific literature.

patents awarded to biotechnology firms, they show that these firms depend on public science much more heavily than firms in other industries. So, one way to explore how online access affects innovation might be to test whether these science-dependent firms shifted their citation behavior in response to the online availability of different journals. Based on the results in McCabe and Snyder (2011) we might expect content on certain platforms to be cited more often by patents, including articles in the long tail.

Aghion, et. al. (2009 use data from a natural experiment involving genetically engineered mice to explore whether greater "openness" in the upstream intellectual property rights associated with these mice results in more horizontal and vertical exploitation downstream.[25] Since each of the hundreds of genetically engineered mice are associated with a published article ("mouse-articles"), they use difference in differences techniques to compare citations to these mouse-articles before and after the increase in openness, with a control group of mouse-articles. Their results reveal

> …a significant increase in the level of follow-on research. More importantly, the bulk of the new citations arise from articles published by "new" researchers or institutions. In other words, most of the incremental citations to a given mouse-article come from researchers working at institutions that had not cited that mouse-article prior to the NIH agreement. Next, our results offer direct evidence that increased scientific openness is associated with the establishment of entirely new research lines. Specifically, the openness shocks lead to a significant increase in the diversity of the journals in which mouse-articles in the treatment group are cited, and, perhaps even more strikingly, a very significant increase in the number of previously unused "keywords" describing the underlying research contributions of the citing articles.

What is most interesting in their analysis, of course, is not that they identify an aggregate positive impact of greater openness. Rather, most intriguing is the discovery that new institutions *and* new research directions emerge. This use of bibliometric data has not been seen

[25] Here, openness refers to an agreement between the NIH and the patent holder, Dupont, to lift all restrictions on access to and use of the patented mice.

in the online access literature and could easily be implemented to explore similar questions. Of course, since the removal of costly licensing restrictions in the use of patented mice may be a much more important change in research conditions than a shift in the accessibility of research articles, expectations regarding the prospects for this idea should be modest at the outset. Indeed, the focus should be on R&D activity in contexts where access to the scientific literature in the print era was difficult, e.g. in developing countries.

Section 4: Conclusions, Future Research and Policy Implications

Conclusions

Online access to the scientific literature has transformed the distribution of the scientific literature. This literature is now easier to search and read, especially for the producers of new articles: the scientist authors affiliated with research institutions. Unfortunately, the cost of supporting this enterprise has not declined. Ironically, the same technologies that enable immediate access for readers also facilitate bundling and pricing policies by the major commercial publishers that exacerbate rather than alleviate the inflationary pricing trends of the pre-internet era. Although open access journals have begun to proliferate, perhaps in response to publisher bundling, their long-term viability in lieu of subsidized author fees remains uncertain. One of the chief benefits of OA is supposed to be greater readership and impact (and this assumption is important in providing the economic justification for the OA business model). However, the evidence in support of this claim remains uncertain. Although initial studies of this question revealed large positive benefits of online access (including open access), more recent papers on this subject have identified a series of data and econometric problems that when addressed eliminate most but not all of the presumed benefits.

Future Research and Policy Implications

Regarding a future research agenda, Sections 1 and 2 of the describe how online access is likely to have enhanced the market power of the largest publishers of scientific journals. Most of the evidence is conceptual and theoretical in nature; the dearth of data on prices and institutional bundle collections (due in part to contract confidentiality) has slowed empirical research in this area. Evidence on the impact of policies that mandate the deposit of publicly funded research articles in OA repositories is also scarce. Do stricter version of these policies, i.e. those with shorter post-publication delays, reduce the willingness of institutions to pay for journal access in certain disciplines, e.g. the biological sciences? And if so, what are the implications for publisher market power in an environment characterized by comprehensive Big Deals across *many* disciplines?

Competition authorities as well as agencies with specific interest in scientific communication, including the NIH, would have a keen interest in this type of data and any corresponding analyses. For example, faced with evidence of anti-competitive harm, antitrust agencies might not only seek a limit on journal bundling but also demand other changes, such as a further reduction in the post-publication "monopoly" window for publishers. Of course, determining that publishers have violated antitrust laws, and identifying appropriate solutions, requires careful analysis of the empirical evidence. Although antitrust agencies in the United States and Europe can devote considerable resources to such an exercise during the course of an investigation, it is often true that the cumulative effect of *prior* research by independent scholars can have a large impact.[26] Collecting *comprehensive* data and making it available to researchers

[26] The 1996 investigation by the Department of Justice and Security Exchange Commission of price-fixing among Nasdaq market makers is one of the more famous examples of this phenomenon. See Christie and Schultz (1999).

would improve the knowledge base for important decision makers at competition authorities around the world. Such data collection is feasible (see, for example, Bergstrom (2011)) but is neither quick or simple.

Section 3 in the report is dedicated to reviewing the evidence on the impact of online access on various measures of performance, including article citations and downloads. The magnitude of these effects (and of those discussed below) is an important factor in policy questions regarding Open Access publishing (see Section 2): 1. Is OA a sustainable journal business model? 2. If so, for whom, e.g. profit and/or non-profit publishers, the sciences and/or the humanities, and 3. under what market conditions, e.g. in those subject areas already well-served by journals or ones with less intense competition?[27]

Furthermore, the impact of online access, however small, is almost certainly broader than the immediate scientific research community. The absence of any studies that explore the impact of online access in other knowledge-intensive activities may offer a useful opportunity for future research. The challenge here is to identify cases where the transition from print to online access is most likely to have had a substantial impact on access to the scientific literature, e.g. among inventors in developing countries, physicians in small, rural hospitals, etc.

[27] McCabe, Snyder and Fagin (2013) address these and related issues.

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