Opening Access to Research

Armstrong, Mark

Department of Economics, University of Oxford

April 2014

Opening Access to Research

Mark Armstrong*

April 2014

Abstract

Traditionally, the scholarly journal market operates so that research institutions are charged high prices and the wider public is often excluded altogether, while authors can usually publish for free and commercial publishers enjoy high profits. Two forms of open access regulation can mitigate these problems: (i) direct price regulation of the form whereby a journal must charge a price of zero to all readers, or (ii) mandating authors or publishers to make freely available an inferior substitute to the published paper. The former policy is likely to result in authors paying to publish, which may lead to a reduction in the quantity of published papers and may make authors less willing to publish in selective journals. Recent UK policy towards open access is discussed.

Keywords: publishing, journals, open access, two-sided markets, regulation.

"To open a book brings profit" — Chinese proverb

1 Introduction

Two related claims are often made about access to research: (a) many publishers charge research institutions too much to subscribe to their journals, and (b) people should be able to read research for free, especially when it has been publicly funded. The former reflects distributional concerns, in that high subscription charges have a welfare cost if a dollar of library budget is worth more than a dollar of publisher profit, as is plausibly the case when libraries are financed out of public funds.[1] The latter is an efficiency point, since it is

*Department of Economics, University of Oxford. I am very grateful to Doh-Shin Jeon, Alvin Klevorick, Mark McCabe, Richard Price, Alan Sorensen, John Vickers, John Willinsky, and Jidong Zhou for helpful comments. All views and errors are entirely my own.

[1] As House of Commons (2004, page 5) put it: "There is mounting concern that the financial benefits from the Government's substantial investment in research are being diverted to an excessive degree into the pockets of publisher's shareholders."

inefficient to exclude interested readers when it costs nothing extra to serve them. It may also be costly in political terms to exclude readers, if those who ultimately pay for public research are denied access to its final product.

In broad terms, this paper argues that both concerns are valid and judicious policy intervention in the journal market is worthwhile.[2] One form of open access regulation makes a journal's content freely available to all at the time of publication, which is often termed "gold" open access. Another kind of regulation focusses on authors rather than publishers, and requires authors to post online their own version of the paper, a policy often known as "green" open access. Yet another variant has the publisher make its content freely available online but only after an embargo, sometimes known as "delayed" open access.[3] Green and delayed open access share the feature that an inferior version of the published article is made freely available, which limits how much research institutions are willing to pay for the journal itself and indirectly constrains the price that publishers can charge.

Like several other problematic markets, without regulation journal publishers often exploit one group (in this case, their readers) in order to offer a generous deal to another (in this case, authors, who usually can publish their work without charge).[4] The journal market is "two-sided": authors provide content to interested readers, authors gain exposure and citations by being read, and journals traditionally mediate much of the interaction between the two sides.[5] However, there is an important asymmetry between authors and readers,

[2]Scholarly books are different from journals in a number of respects. For instance, authors are paid to publish (royalty rates of between five and fifteen percent are common), and so have more at stake in making readers pay for access. Hard copy distribution is still dominant, and prices for books have not risen nearly as fast as prices for journals. Policy-makers at present do not usually require open access for scholarly books, although this may change as electronic dissemination of books becomes widespread.

[3]Willinsky (2006, Appendix A) lists ten kinds of open access, which includes situations where the print edition of a journal is paid for while its online edition is free, or when the journal is available for free in poorer countries. Another kind of open access policy would be to abolish copyright on scholarly works, a policy discussed in detail by Shavell (2010). If copyright was abolished, authors and others would be free to post the published version of the article online, and the effect would be similar to the "gold" regime.

[4]Other markets with this feature include bank accounts (where a fraction of account holders pay high penalty fees for overdrafts, say, which help to subsidise a free service for other customers), mobile telephony (where subscribers have a subsidised handset, but those who call them are charged high prices), and search engines (where people can search for free, but advertisers pay high prices to appear in their search results).

[5]For an overview of two-sided markets, see Rochet and Tirole (2006). An author who seems to have actively disliked having an audience is Isaac Newton, who did not enjoy publishing in a journal (he did so only once, in the first scientific journal, the *Philosophical Transactions of the Royal Society*) because of tedious follow-up correspondence with readers who disputed his findings. See Willinsky (2006, chapter 13) for more details.

which is that the peer-review process works to ensure that an article is only published in a single journal and is strongly differentiated from other published articles.[6] (The peer-review process also forces authors to cite relevant articles, which drives up demand for access to published work.) Each published article thus constitutes a mini-monopoly, and a journal enjoys a monopoly in providing access by readers to its articles.[7] For this reason, a journal is able to set high prices to readers which bear little relation to the cost of running a journal, and to use some of the resulting profits to fund generous deals to attract authors.[8]

A quirk of the journal market is that publishers do not pay authors for their work. As a result, the most generous deal a publisher can offer is that an author can publish for free, so that authors enjoy "open access" to the journal's subscribers. Since authors cannot be paid, the large revenues from selling subscriptions to institutions are not easily dissipated and commercial publishers can enjoy super-normal profits. High subscription fees and excess publisher profits are due mostly to the monopoly nature of each individual article, not to some more aggregate measure of concentration in the journal market.[9] (However, having a portfolio of many journals may help a publisher obtain yet higher profits, due to its ability to engage in bundling.) A model of the publishing market with these elements is presented in section 5.1.

A gold open access regime, in which journals make their articles freely available at the time of publication, overcomes the bottleneck problem (a) as well as the public access problem (b). Gold open access is a form of price regulation for journals, regulation which forces them to set a price of *zero* to readers. This policy, if widely implemented, would

[6] This asymmetry is masked in theoretical models with just a single journal. In the terminology of two-sided markets, authors "single-home", while readers must "multi-home" (i.e., subscribe to several journals) if they wish to see a range of content.

[7] As it was put in the opening editorial to the open access journal *PLOS Biology* (Brown *et al.* (2003, page 2)): "each journal has a monopoly on a resource vital to scientists–the unique collection of articles it has published. Anyone who depends on the information in a specific article has no choice but to pay whatever price the publisher asks."

[8] This pattern of cross-subsidy would be reversed in an alternative world in which readers each subscribed to a single journal, and authors had to place their work in multiple journals in order to reach a large readership. In that world, readers would be courted by journals, and authors pay high fees for access to the captive readers. This alternative situation is akin to the newspaper market, where most people read a single newspaper, and advertisers have to place adverts in multiple outlets to reach the desired number of eyeballs.

[9] Dewatripont *et al.* (2006, Table 3) reports market shares in terms of citations received for the major publishers. In a few subject areas (chemistry, engineering) there is significant concentration, but otherwise concentration does not seem extreme.

hugely cut library expenditures in research institutions.[10] Journals would then usually have to cover their running costs by charging authors a fee to publish a paper.[11] Like more familiar "one-sided" markets, journals would then compete for custom from authors in terms of publication fee, quality of articles accepted, turnaround time, value-added from the refereeing process, and so on, and there is a greater chance that only normal profits would be observed.[12]

A partial (that is, a green or delayed) open access regime, which instead focusses on making freely available an inferior version of the published article, partly overcomes problems (a) and (b). That an inferior substitute is freely available implies that libraries have a reasonable outside option, and publishers are forced to charge less if they wish to continue selling their subscriptions. The wider public has free access to an inferior variant of the published article, while before they may have been excluded altogether. Nevertheless, publishers may still be able to extract sufficient revenue to cover their costs from libraries willing to pay for the premium published version, albeit with less to spare, and so a partial open access policy may be consistent with authors continuing to publish for free.

While a gold policy fully deals with problems (a) and (b), the fact that authors will likely pay to publish introduces its own problems. First, paying to publish will deter some authors at the margin from publishing at all, as illustrated in the model in section 5.1. Even if many authors have access to funds to cover their publication fees, there will often be

[10] Association of Research Libraries (2006, Table 2) reports that the median library in the association spent about $6 million on journal subscriptions in 2005.

[11] A surprisingly large number of journals currently have neither reader fees nor publication fees. (See www.eigenfactor.org/openaccess for more details.) Presumably, these journals operate with funding from institutions or charities, and/or by editors and reviewers donating their time. An extreme case is the old *Bell Journal of Economics*, which between 1970 and 1981 offered its content for free to anyone who asked (and this was in the days before electronic dissemination, when there was a cost to supply a hard copy to each reader) and paid its authors a substantial fee for publication. The journal's funder, *Bell Labs*, clearly felt it was worthwhile to spend money to attract good papers and to disseminate those papers to the widest audience.

[12] As Brown *et al.* (2003, page 2) put it: "Open access would eliminate monopolies over essential published results, diminishing profit margins and creating a more efficient market for scientific publishing". There remains the danger that network effects may lead to market power. (See the "parable of the anarchists' annual meeting" in Bergstrom, 2001.) For instance, if many readers only look at a few journals because they think all the good articles are published there, an author of a good paper must publish in one of those journals if her article is to be noticed and such journals could charge high publication fees to authors. Open access policy on its own can do little to overcome this coordination problem.

an *opportunity* cost when paying to publish a paper.[13] (Paying to publish an article might mean the author can attend one less conference, say.) Of course, not publishing at all is even more harmful to potential readers than paying a high price for access. Second, more selective journals are likely charge higher author fees in the gold regime, since they follow a more rigorous and costly peer-review process. (By contrast, in the traditional reader-pays model, the extra costs of peer-review are covered by readers.) As such, authors may be less willing to publish in selective journals, and the quality-certifying function of journals may be reduced. A model of the publishing market with this flavour is presented in section 5.2.

In the next section, I discuss the journal market in more detail. I discuss how modern technology has reduced journal costs, and helped to boost revenue, so that publisher profits have risen in recent years. I also discuss how the internet acts to disintermediate the interaction between authors and readers. Authors can post their work online, which can be freely accessed by readers using general search tools. Author reputations are increasingly determined by citations rather than where they publish, and readers can use online metrics (citations, downloads, and so on) to guide them to the most important research. As a result, a journal's traditional roles to disseminate and certify the importance of research are less important now. Section 3 provides a brief history of open access in publishing, including recent policy to widen access to scholarly work in the UK. Section 4 summarises the main arguments concerning the various forms of policy intervention, and suggests that most of the benefits of open access can be obtained with a partial open access policy, without the significant disruption that the gold policy with expensive author fees is likely to cause.

2 Traditional Journals and their Alternatives

2.1 The purpose of a journal

Traditional journals provide a number of benefits to their authors and readers, including: (i) preparing the definitive typeset version of a paper and releasing citation details (e.g., page and volume numbers); (ii) certifying an article's quality via the journal's reputation

[13] I will not be using my limited research funds to pay, say, £1,500 to make this article open access from the publisher. Solomon and Björk (2012a, Tables 5 and 6) report that significant number of authors do pay publication fees out of their own pocket, especially when the fee is below $1000 and when the author comes from a poorer country.

for selectivity; (iii) improving the original manuscript by suggestions from reviewers and editors, and (iv) distributing the published paper to those (and only those) permitted to read it.[14] In the modern era, some of these functions are freely available to all potential readers, even in the traditional reader-pays model. Most importantly, there is "open access" to information about which journal a paper appears in—and the associated quality signal—via an author's CV, journal homepages and the like, even if the reader has no access to the published paper itself.

Task (i) is useful for readers, and necessary for fellow researchers who need to cite the paper accurately. In the era when authors prepared manuscripts on typewriters, typesetting by publishers was a valuable improvement to the appearance of the paper, especially for technical material. Nowadays, though, word processing software allows authors to prepare clean copy on their own computer, including diagrams, tables and figures, and typesetting by publishers provides less value-added. It remains useful, however, for a reader to know she has the very final version of a paper, especially if she wishes to discuss what that paper does in her own writing.

Task (ii) is important to both authors and readers, although less so now than it used to be. Historically, an author attempted to place her article in the most discriminating journal willing to accept it. As a result, a journal provided a signal of the article's quality, which is important for authors, who benefit from being seen to be able to publish in a top journal, and to potential readers who are guided to the work it is most worthwhile to read.

An author's inner circle of fellow researchers in her area will have an idea of her skills, regardless of where her work appears. However, an author cares about her reputation more widely than this. For instance, decisions about salary, tenure and job offers are made by people outside this inner circle, who will rely more on external signals such as where the author has published. Many authors would happily pay a good deal of money to place an article in a prestigious journal.

The journal in which a paper appears is also an important guide to potential readers. Someone looking for useful papers to read cares about both "horizontal" attributes (that is, how relevant the paper is to her interests) and "vertical" attributes (how innovative or

[14] This list is obviously a simplification. See scholarlykitchen.sspnet.org/2012/07/18/a-proposed-list-60-things-journal-publishers-do (accessed 28 March 2014) for 60 things that journals do.

insightful the paper is). A reader cannot judge how useful a paper actually is until she reads it, i.e., a paper is an "experience good". Given that reading a paper involves a sunk cost, a reader benefits from *ex ante* information about both the horizontal and vertical attributes of a paper before deciding what to read. In the pre-internet era, searching for useful papers was a time-consuming, hit-and-miss affair, and as a form of triage it was efficient for a busy researcher to confine her search to a small number of elite and specialist journals. For this reason, being published in a prominent journal helped boost a paper's readership, even among those readers *able* to access most journals at their institution.

However, the internet changes much of this. The internet makes search on the "horizontal" dimension much less costly, and location of relevant work is superbly easy. This makes the traditional role of a specialist journal, to gather together papers of relevance to those working within that specialism for their ease of reference, almost vanish.[15] The internet also makes available additional cues about vertical aspects, that is, about a paper's likely quality. Data about the number of papers which cite a particular article are freely available on scholarly search engines such as *Google scholar*, and these are arguably as good a signal of quality as the host journal's reputation for selectivity once some time has passed.[16] (After all, the decision to publish a paper in a journal is typically made by an editor and couple of referees, while a well-cited paper usually has some kind of approval from many readers.) Casual observation suggests that citation data from *Google scholar* increasingly play a role in hiring and promotion decisions, and a well-cited paper in a mediocre journal nowadays carries much weight in committee decisions.

Readers as well as employers can use citation data on the internet as a guide to likely quality, and download data from subject repositories and other "altmetrics" can provide additional cues. However, this "observational learning"—where an agent chooses what earlier agents have been seen to choose—can easily lead to inefficient herding. Just as people

[15] There may remain a modest supply-side rationale for a specialist journal in terms of having a homogeneous team of editors with similar interests.

[16] There has been citation data available long before *Google scholar*, for instance on *Web of Science*. However, *Google scholar* has a number of advantages, including ease of use, the fact it includes working papers and other non-journal material as well as published articles, and the fact that it is free. (Institutional subscription costs for *Web of Science* are non-trivial. Cornell University reports it pays $155,000 per year for access—see John Bohannon, "Google scholar wins raves–but can it be trusted?", *Science* 343, page 14, January 2014.)

only reading novels on the best-seller list or diners choosing to eat in crowded restaurants may lead to desirable options being ignored, so might easy access to citation and download data lead to undue focus on a few articles lucky enough to gain early prominence.[17]

Of course, journals will continue to play some role in a paper's impact. It may even be that the choice of journal actually makes *more* difference to a paper's eventual success than in the past. For instance, being published in a prestigious journal may generate more early citations, and this early advantage is then amplified via observational learning. (This issue is briefly discussed in the model presented in section 5.2 below.)

A major development in journal publishing is the recent entry of so-called "mega" journals (also known as "repository" journals), mostly in the science area. These journals have very broad scope in terms of subject matter, and have peer-review policies markedly less stringent than the traditional selective journal. The first and most successful of these is *PLOS ONE*, whose editorial policy states: "Too often a journal's decision to publish a paper is dominated by what the editor/s think is interesting and will gain greater readership — both of which are subjective judgements and lead to decisions which are frustrating and delay the publication of your work. *PLOS ONE* will rigorously peer-review your submissions and publish all papers that are judged to be technically sound. Judgements about the importance of any particular paper are then made after publication by the readership (who are the most qualified to determine what is of interest to them)." This journal currently accepts about 70% of submissions, has a very respectable impact factor of 3.73 for 2013, and in 2012 it published 23,464 articles, making it probably the largest journal in the world.[18]

[17] Salganik, Dodds and Watts (2006) report the results of an experiment in the context of music (rather than scholarly) consumption. Subjects arrived sequentially at a music website and were presented with a list of previously unknown songs from unknown bands. Subjects could listen to any number of these songs, and afterwards they could download any of them for later listening. Some subjects did not see download data for songs, and had to decide what to listen to only on the basis of the song title and name of the band. A song's share of downloads among these "neutral" subjects is a natural measure of a song's quality. Other subjects could see each song's download data, which they could use as a cue for likely quality Among these subjects in the "social influence" treatment the distribution of download shares was more concentrated, so that the most popular song was more popular relative to the neutral treatment. On average, song quality was positively correlated with downloads in the "social influence" treatment, although with much noise (e.g., a high-quality song might not do well when downloads were reported).

[18] See *www.plosone.org/static/information* (accessed 26 February 2014). The journal reports download statistics, reader comments, media coverage and social media "shares" for each of its articles, which help to signal likely quality.

Publishing in a mega-journal is a strategy intermediate between publishing in a traditional selective journal and just posting a working paper on the internet. Readers know they have the definitive version of the paper, and with the modest degree of quality control they can be fairly confident that there is nothing "wrong" with the paper before they decide whether to read it. Authors use the journal as a platform to publicise their work, and hope that it gets taken up by the community of researchers. Mega-journals also provide efficiency gains in terms of refereeing effort. Since a reasonable paper is likely to be accepted at such a journal, it will be refereed just once. Traditionally, by contrast, an author would work her way through journals of decreasing prestige until one agreed to publish her paper, generating a new set of referee comments at each stage.[19] The fact that a paper is more likely to be accepted also means that it is published more quickly than when the author submits to several journals, which is obviously of benefit to readers. In practice, mega-journals are open access, though one can imagine a subscription journal having an editorial policy similar to *PLOS ONE*'s. A major reason for this is probably that mega-journals are *new* journals, and most new journals have to be open access to succeed. (Because of the tightness of library budgets, a library's margin is usually to decide which journals to cancel rather than which subscription journals to add.)

Some journals do not supply credible certification services at all. There is a market for "vanity" publishing, and many quasi-fraudulent journals will publish almost anything—including plagiarised or self-plagiarised work—in return for a fee from the author. These journals often market themselves as "open access", although they have minimal readership and could not generate much subscription revenue if they tried. Often these journals have impressive names, perhaps similar to those of established, peer-reviewed, journals. Dishonest, desperate, or inexperienced authors are willing to pay to have a plausible publication on their CV which would not get through a peer-review process.[20] (The model in section

[19] The review process at a mega-journal is also likely to less onerous for referees than at a traditional selective journal, since a referee is asked merely to judge correctness.

[20] See Beall (2012) for more details. (Beall currently maintains a list of dubious journals on his webpage.) Bohannon (2013) reports the outcome of an interesting investigation. He concocted a flawed paper about a new cancer treatment, which he plausibly suggests would not be passed by a credible peer-review process, sent the paper under a variety of assumed names to 304 open access journals. The paper was accepted by 157 (including journals published by Elsevier, Kluwer and Sage), rejected by 98, while the remaining 49 had not responded by the time the investigation went to press.

5.2 describes an unregulated journal market which has reputable subscription journals and worthless author-pays journals coexisting.)

Task (iii) is not unanimously viewed as a benefit by either authors or readers. At least in economics, the traditional revision process has become increasingly costly for authors, both in terms of time and effort—see Ellison (2002). Several decades ago the typical time from submission to acceptance was just a few months, and requests for substantive revisions were rare. In 1999, though, the average time from submission to acceptance in most top journals was two years, plus another wait for publication itself. (If the author has to submit her paper to more than one journal, the overall delay stretches on further still.) Alongside this, published papers have become longer, and now have lengthy introductions and extra sections covering extensions to the basic model. Of course, an unduly lengthy process of revisions is also costly for readers who want timely access to the latest research, even if there is free and immediate access to the work when it is eventually published. While the revision process sometimes improves a paper, especially one submitted from an inexperienced author, a good case can be made that the process has got out of hand. The mega-journals discussed above are a natural vehicle for authors who wish to publish in outlets which allow them to present their work as they see fit and without undue delay.[21]

Task (iv) is most directly relevant to the open access debate. Authors typically put a lot of weight on the size and composition of their readership—to generate career-enhancing citations and generally increase their visibility—and wish to publish in a journal which is read by the desired audience. However, while they care about reaching their peers (who are the only readers likely to generate citations), authors plausibly care less about reaching the "wider public" and would be unwilling to pay a substantial publication fee out of their own pocket to do so.[22]

[21] The observation that authors are dissatisfied by a journal's review policy sits awkwardly with the perspective of the market taken in this paper, which is that journals pander to authors' interests in order to exploit readers. It may be that this slowdown is worst in the top journals, where authors are particularly keen to place their work. Indeed, in economics at least, the pattern seems to be for most of the very top journals to "exploit" authors in terms of forcing an arduous review process and sell cheaply to libraries, while less prestigious journals woo authors in order to exploit libraries. Many journals do attempt to attract authors by reporting their turnaround statistics. For instance, many of Elsevier's journals report submission-to-accept times, as well as accept-to-publication times. (To illustrate, *International Journal of Industrial Organization* reports that its average submission-to-accept time was 13.3 weeks in 2013, far shorter than the delays at most top journals reported by Ellison.)

[22] House of Commons (2004, page 9) quotes the UK's Royal Society of Chemistry as saying "most authors

Nevertheless, there are benefits to the wider public gaining timely access to scholarly material.[23] For example, a provincial lawyer might learn about relevant case law, journalists might write better-informed articles, or history teachers in schools may give better classes. Amateur astronomers benefit from access to journals, and in turn contribute to science themselves. Small-scale innovators find it useful to consult scholarly material but cannot afford to pay much for it.[24] Probably the scholarly topic of widest interest to the public is health and medicine, and millions every day search online for information in this area.[25]

Not surprisingly, putting content behind a pay-wall does appear to make a significant difference to readership (as proxied by the number of downloads), but less so for citations. Davis (2011) secured the agreement of 36 reader-pay journals to select randomly about one-quarter of their articles for open access treatment. He found that during the first year after publication, the open access articles were downloaded more (115% more for HTML downloads and 62% more for pdf downloads) than their pay-to-access counterparts, and accessed by 31% more unique visitors. However, he found no significant difference in citation rates for the three years after publication for the two groups. He interprets these results as consistent with readers of scholarly work falling into two groups: those who work in research universities, who mainly provide citations and have access to most journals in any event, and others who consume but do not contribute to the corpus.[26]

---

care where their work is seen and who it is seen by far more than they care about how many people have seen it." In fact, though, journals are not always available in research libraries, let alone to the wider public. Strieb and Blixrud (2013) report the take up of journals from selected publishers by research-intensive libraries in North America. For example, while in 2012 almost all (96%) of these libraries subscribed to some collection of Wiley journals, only 19% obtained its complete set. (The respective figures for Elsevier are 92% and 23%.)

[23] See Willinsky (2006, chapter 8) and Suber (2012, section 5.5) for a more detailed discussion.

[24] Houghton *et al.* (2011) conducted interviews with 23 smaller research-oriented businesses in Denmark. Some of these businesses subscribe to the most relevant journals, most regularly consult open access material on the internet (in repositories or in open access journals), and some ask contacts in universities to provide them with content. Most report difficulties gaining access to recent research.

[25] Some try to use public interest in heath as an argument *against* open access. House of Commons (2004, page 25) quotes a representative of Wiley as saying "this rather enticing statement that everybody should be able to see everything could lead to chaos. Speak to people in the medical profession, and they will say the last thing they want are people who may have illnesses reading this information, marching into surgeries and asking things."

[26] There is a huge literature now looking at the interaction between ease of access and download/citation rates—see the long footnote 6 in Suber (2012, page 178). A problem throughout is how to isolate the effect of opening access *per se* on subsequent readership. For example, older studies found a huge impact on citations from having an article in an open access journal or repository, but this might be due to authors putting their best work in such journals. In the study cited, it is possible that readers mistakenly took the

As with task (ii), task (iv) can often be bypassed by authors and readers by means of the internet. An author can post (or "self-archive") a version of her work on a public website, such as her own webpage, her institution's or funding body's repository, or a subject-specific repository.[27] Even if these various websites are not prominent themselves, search tools such as *Google scholar* enable easy location of works by specific authors, titles or topics. Different versions of a published paper which might be self-archived are the "pre-submitted" (or "working paper" or "preprint") version, the "accepted" (or "postprint") version which incorporates reviewer comments but which is still the author's own version in terms of formatting, and the final published version as typeset by the journal.

Of course, an author is always permitted to post a working paper on a webpage before she submits to a journal. (Authors have copyright until they assign it to someone else.) However, many prominent medical journals use the so-called Ingelfinger Rule, and will not consider a paper for publication if it has previously been posted ("published") on the internet, which severely deters preliminary circulation of papers.[28] Unless the article is published with open access (either in a full open access journal, or in a "hybrid" journal which allows author to pay to make the paper open access), a publisher will rarely allow an author to post its own version immediately on a public webpage. The intermediate version—the accepted author version—can be self-archived under rules which vary widely from publisher to publisher and over time. If the accepted version can be self-archived at the same time as publication, the benefits of task (iii) are also freely enjoyed by readers and there is *de facto* open access for readers. A reader can check the likely quality of a paper by discovering which journal it appears in and go on to read the near-identical free version online, much as a consumer gets product advice in a bricks-and-mortar store and then goes on to buy the product more cheaply online. In such cases, readers who choose to pay for the published version do so in large part for the limited aesthetic benefits of task

label "open access" as a signal that such papers were particularly good (for instance, because only highly-regarded scholars had research funds to pay for open access). In addition, it is possible that potential readers of the non-open access articles went on to download a self-archived version from elsewhere, so that total downloads from all sources were not so different for the two groups of article.

[27] In fact, some subject repositories do charge readers for access. In economics, this is currently the case with NBER and CEPR working papers.

[28] Franz Ingelfinger was the editor of the *New England Journal of Medicine* who formalised this policy in 1969.

(i) and the peace of mind that one is reading the very final version of the paper.

Self-archiving can be done with or without permission from the journal. Indeed, authors have an incentive to be "careless" about their copyright obligations, since they do not receive the subscription income and illegal distribution may boost their visibility and citations.[29] Traditional subscription journals have an incentive to permit a degree of self-archiving (or alternatively, to make their own content freely available after some delay), partly because this helps to attract authors and partly because wider readership will boost citations and impact factors, which in turn helps publishers market their journals to libraries. Conceivably, the author's version and the publisher's version might even be complements, if a reader "samples" the author's version for free and if she likes it she goes on to buy the published version.[30] Permitting a degree of self-archiving can be viewed as a kind of price discrimination: those readers who particularly value the product pay for the superior version, while other interested readers can obtain an inferior version for free (which brings indirect benefits to the publisher).[31]

2.2 The cost and revenue of a journal

The tasks described in section 2.1 cost money. Indeed, in the past even the most prestigious journals had difficulty making ends meet.[32] Throughout much of the last century, journals in scientific disciplines levied charges on *both* sides of the market to boost their revenues.[33] However, changes in technology mean that important aspects of costs have

[29] Many economists appear to post the published version of recently published papers on their own webpage, in most cases in conflict with the copyright agreement made with the publisher. Morris (2009) reports that many authors do not have an accurate understanding of publisher rules about copyright: authors often think they can post the published version on their webpage when they cannot, and many do not think they can post the accepted version of their paper on a public website when they can.

[30] Finch *et al.* (2012, para. 7.67) reports evidence that "providing access to articles via repositories with high-quality metadata may lead to a marginal increase in downloads from the publisher's site". Suber (2012, section 5.3) discusses the complementarity between electronic and hard-copy book formats.

[31] For similar reasons, suppliers of music, movies or software may be prepared to tolerate a degree of piracy. In markets with network effects, for instance, allowing some piracy to occur causes a firm to expand its base of users, which enables it to charge more to legitimate buyers. See Peitz and Waelbroeck (2006) for a survey of this literature.

[32] Berg (1971, p. 799) writes that in "the 1880s, university subsidies and voluntary labor were essential to the financial viability of the *Quarterly Journal of Economics* and the *Journal of Political Economy*."

[33] In the context of the model in section 5.1, this situation corresponds to the case where expression (2) is not satisfied. Barton (1963) reports how the *Physical Review* had financial difficulties in the 1920s. ("Dues and subscription rates had been increased, but this process could not be continued [...] without risking so

fallen dramatically in recent years, while a journal's ability to generate revenue has grown.

It is now essentially costless to distribute journal articles to additional readers over the internet, while before publishers had to print and send hard copies. (Likewise, a library's storage costs for electronic journals is zero.) Electronic distribution is now the dominant way for readers to access journal articles. Editorial software is nowadays cheaply or freely available, which reduces the costs of managing the submission and peer-review process (perhaps removing the need for a secretary and office premises).[34] Word processing software means that most authors can prepare their own documents in a professional manner, which could greatly reduce a journal's own typesetting costs.

As discussed in section 1, the monopoly nature of each article enables a reader-funded publisher to set high prices to readers which need not be related to underlying costs, and this was true even before the internet. The gradual entry of commercial publishers into the journal market during the second half of the last century has probably led to a greater focus on profits, and less squeamishness in generating those profits.[35] Since it costs nothing to supply electronic journals to additional readers, a commercial publisher's ideal outcome in the internet age is to serve all readers and to fully extract each reader's surplus from its journals, the strategy known as "first degree" price discrimination. Such a strategy not only yields maximum revenue to the publisher from its readers, but achieves the maximum audience for its authors.

While this outcome cannot be perfectly achieved, publishers can often get close. A publisher can condition its subscription charge on the size and nature of the institution it supplies or the wealth of the country.[36] The move to electronic distribution means that a publisher can monitor download activity, which helps it finely tune its prices to institutions

great a decline in members and subscribers that the total income would be reduced rather than raised.") As a result, in 1930 the journal introduced an author per-page charge of $2. In subsequent decades, the practice was followed by several other journals in physics, chemistry and biology.

[34]For instance, the licence for Editorial Express, journal management software used by many journals in the social sciences, costs just $2000 per year. (See *editorialexpress.com*, visited 20 March 2014.)

[35]Dewatripont *et al.* (2006) document how journal prices were rising faster than book prices in the pre-internet era, and argue this may be due to the increased share of journals owned by commercial publishers.

[36]For instance, the University of Chicago Press's price list for its journals and collections of journals conditions price on whether the institution is "very large higher education", "secondary school", "museum", "corporate", and so on, where the highest price is about twice the lowest price for a given package. See *press.uchicago.edu* (visited 20 March 2014).

over time. It is now easier and cheaper for publishers to bundle their journals into a collection which they sell as a package to libraries. For the same reason that a diversified portfolio has a more predictable return to investors, a publisher is better able to predict a library's willingness-to-pay for a large collection of journals than for any individual title. As such, a publisher with many journals is better able to extract a library's surplus from the collection without much risk of the library cancelling its subscription. The result of all this price discrimination is that libraries' budgets are squeezed, but more journals are available in libraries than ever before.[37]

One necessary input for a journal does *not* cost it anything, and that is the paper itself. Since the birth of scientific publishing, the norm is not to pay authors for their articles, although it is not clear from where this norm arises or why it persists. For example, it would be feasible to pay an author each time their article is downloaded from the journal, which is akin to royalty payments in the hard-copy world.[38] (Perhaps if one journal breaks rank and offers to pay authors to publish, it would attract a disproportionate fraction of duplicative work from authors submitting work with much overlap with their previous work?) Because journals do not pay authors for their work, the revenues from selling subscriptions to libraries are not passed back to authors but retained as super-normal profits. Big commercial journal publishers are indeed highly profitable. Reed-Elsevier's *2013 Annual Report* (page 12) shows that its "scientific, technical and medical" division made profit of £826m on revenues of £2126m, a margin of 39%.[39]

However, it is not only commercial publishers which benefit from high prices to libraries, but also learned societies and scholarly associations. Many such associations run journals which are distributed by commercial publishers, and profits from selling subscriptions to these journals are largely passed back to associations. These associations can use these

[37] Association of Research Libraries (2006, Graph 2) shows that in the period 1986-2004, their member libraries' expenditure on journals rose by more than 300%, while the average number of journals available in a library rose by 42%.

[38] Of course, this is not to say that authors are not financially rewarded when they publish, only that the payment does not come from the publisher. Shao and Shen (2011, Table 1) describe an incentive scheme in China which pays authors according to an explicit scheme based on the impact factor of the journal. (For instance, the lead author of a paper in *Nature* or *Science* would receive 200,000 RMB, the current equivalent of about £20,000.) More common is an implicit incentive scheme, where scholars who publish well get promoted or offered better jobs.

[39] Page 14 of the *Annual Report* says there were about 700 million downloads in the year, so that the average revenue per download was around £3.

profits to fund conferences, scholarships, public awareness campaigns, and the like. (In addition, several learned societies in the UK seem to be located in highly prestigious premises in London.) To illustrate, in 2000 the American Astronomical Society obtained around $4.8 million of its overall $8.7 million budget from the revenues of its three journals. Because these associations depend so heavily on journal subscription income, many actively lobby against open access regulations.[40]

A journal's cost per article published will vary substantially, depending on how selective the journal is and how much care it takes in making an article look nice. Some time ago, House of Commons (2004, page 74) reported that Wiley suggested $1500 would be the lowest cost per article, and its more selective journals would have higher costs than this. *Nature* suggested that its cost per article was in the range $10,000 to $30,000 because of its 90% rejection rate.[41] Author fees for gold open access provide some guide to—presumably an upper bound on—the cost of publishing an article. Authors fees at the various PLOS journals currently vary between $1350 for the *PLOS ONE* mega-journal and $2900 for the highly selective *PLOS Biology*. Springer currently offers to make an article open access in its subscription journals for an author fee of $3000. Typically, publication fees for open access in hybrid journals are higher than in full open access journals. The Wellcome Trust released details of the publication fees it paid in the year 2012/13.[42] It paid £3.9 million to make 2126 articles (and one book) open access, which implies an average publication charge of around £1800, and it reports that on average it paid higher fees to hybrid journals than to pure open access journals. It is likely that the costs of running a pure open access journal are lower than a subscription (or hybrid) journal. A publisher incurs "selling costs" when arranging contracts with readers, which it avoids when all its content is freely available. (Publishers have a significant sales force dedicated to negotiating contracts with libraries and other readers, which could be dispensed with under open access.) In addition, when

[40] House of Commons (2004, page 13) quotes the British Pharmacological Society as saying "in 2002-03 we spent over £850,000 on promoting and advancing pharmacology. Nearly £800,000 came from our publishing activities. With this income we should either have to raise funds in a different way or cease to provide most of our current activities." See Willinsky (2006, chapter 4) for further discussion of this topic.

[41] It is a puzzle why more journals do not charge a modest non-refundable submission fee. This would help cover the cost of refereeing, and more importantly discourage speculative submissions which stand little chance of eventual success and which apparently are so costly.

[42] See blog.wellcome.ac.uk/2014/03/28/the-cost-of-open-access-publishing-a-progress-report, accessed 31 March 2014, for details.

published articles are freely available, a publisher need not go to the trouble of checking that authors are complying with their copyright agreements.

While developments in information technology mean that a publisher's costs have fallen and its ability to extract surplus from readers has risen, as we discussed earlier this technology also allows authors to bypass a journal's distribution function. Self-archiving may cannibalise a publisher's revenues from selling subscriptions to readers, and the effect will be greater if more authors do this and if the version they self-archive is a close substitute for the published version. We will see in the next section that few authors seem voluntarily to self-archive, and so the impact on subscriptions is likely to be significant only when self-archiving is mandated. However, since commercial publishers are currently so profitable, a good deal of cannibalisation can occur without causing them financial distress.

3 The Evolution of Open Access

A full account of how access to scholarly knowledge has widened over time would include the invention of the printing press, the adoption of vernacular language (rather than Latin, say) by scholars, the birth of scientific journals in the seventeenth century to document new discoveries, the introduction of public libraries and free museums, and the advent of radio and television.[43] For our purposes, it is convenient to start in the 1990s when researchers first used the internet to distribute their work on a large scale.[44]

In 1991, the physicist Paul Ginsparg launched *arXiv*, a subject-based online repository for physics, and later for mathematics, computer science and statistics. This currently hosts nearly a million papers and has around six million article downloads per month. Three years later was cognitive scientist Stevan Harnad's "subversive proposal" that scholars should make their research freely available on the internet, writing: "For centuries, it was only out of reluctant necessity that authors of esoteric publications made the Faustian bargain to allow a price-tag to be erected as a barrier between their work and its (tiny) intended readership because that was the only way to make their work public in the era when paper publication [was] the only way to do so" (Harnad, 1995).

[43] See Willinsky (2006), especially chapter 13, for an account of these developments.

[44] A much more detailed timeline of developments in open access is provided by Peter Suber at legacy.earlham.edu/~peters/fos/timeline.htm.

Gold open access, in which journal articles themselves are freely available at the time of publication, received a major boost with the launch in 2003 of the Public Library of Science (PLOS) journal *PLOS Biology*, which was free to readers and which originally charged $1,500 to authors. This journal has the highest impact factor in the biology subject area in 2013 according to Thomson Reuters Citation Reports, belying suggestions sometimes made that open access journals must be low quality. BioMed Central is a commercial open access publisher (now a subsidiary of Springer) which started shortly before PLOS, and it now has more than 250 full open access journals in the science and medicine area, with author fees mostly in the range £1000 to £1500.

In 2004, Springer allowed authors of articles in its standard subscription journals to pay $3,000 to make an article fully open access, thus starting a new kind of "hybrid" journal in which some articles are free to authors but readers pay, and other articles have the reverse price pattern. Similar options are now offered by many journals, although it is by no means universal.[45] A number of prominent journals follow a model of delayed open access, so that the published version becomes freely available after an embargo period. The two most cited journals in the world in 2009[46], *Journal of Biological Chemistry* and *Proceedings of the National Academy of Sciences*, both follow this policy (with respective embargoes of twelve months and six months).

A landmark for green open access was Elsevier's decision in 2004 to permit its authors to self-archive the accepted version of published papers (but not the publisher's typeset version) on her own website or home institution's repository without an embargo period. (Depositing the accepted version in a centralised subject repository was generally not permitted.) A representative from BioMed Central, which follows the rival gold route, claimed that "this kind of archiving is in many ways useless to the majority of scientists, mainly because no one will know the copies exist at all or where to find them." However, Stevan Harnad was much warmer, writing "there will be the predictable cavils form the pedants [...]. I, for one, am prepared to stoutly defend Elsevier on all these counts, and to say that one could not have asked for more, and that the full benefits of open access

[45] For instance, at the time of writing none of the "top 5" economics journals (*American Economic Review*, *Econometrica, Journal of Political Economy*, *Quarterly Journal of Economics* and the *Review of Economic Studies*) offer this option.

[46] See archive.sciencewatch.com/dr/sci/09/aug2-09_2.

require not one bit more - from the publisher".[47]

While it is one thing for publishers to permit immediate self-archiving, it is quite another for authors voluntarily to do so. Self-archiving involves a modest cost of time and effort to the author (especially the first time it is done), and if an author believes that her article is disseminated to her desired audience by the journal anyway, it may not be in her interest to self-archive. (Authors have more incentive to self-archive their pre-submitted version, so that their paper becomes known early on.) The model in section 5.1 has the feature that no author self-archives voluntarily.[48]

In the United States, the National Institutes of Health (NIH) is the principal public funder of research in the biomedicine area, and its policies toward research dissemination have played a large role in the open access debate. In 2005, after consultation (and lobbying) in 2004, the NIH announced its new *Policy on Enhancing Public Access to Archived Publications Resulting from NIH-Funded Research*, which stated "NIH-funded investigators are requested to submit an electronic version of the author's final manuscript [...] as soon as possible (and within twelve months of the publisher's official date of final publication)." The relatively lengthy embargo period and the fact that authors were only "requested" meant the policy had relatively little bite, and levels of compliance were low. In 2008, the NIH tightened its policy so that grant-holders were *required* to self-archive their published research (again, with a twelve month embargo), and compliance substantially increased.[49] Many other research funders follow variants of this approach now, although often with a six rather than twelve month embargo period. Note that to monitor author compliance, it

[47] Both this and the previous quote were reported in an article titled "Reed allows academics free web access" in *The Guardian* on 3 June 2004. Somewhat sourly, House of Commons (2004, pp. 57-8) suggested that "We are in little doubt that Elsevier timed the announcement of its new policy on self-archiving to pre-empt the publication of this Report."

[48] The propensity for authors to self-archive varies considerably across subject areas. Bergstrom and Lavaty (2007) investigate a number of economics journals to discover the proportion of published papers which were freely available online in some form. They find that the proportion tends to fall off for less prestigious journals, but for the top 15 journals about 90% of articles were available as working paper versions (though not necessarily the accepted version). They find less propensity to self-archive in political science, where only 30% of published articles at that time were freely available. In the humanities, where books are still an important form of scholarly writing, self-archiving is rarer and authors hardly ever post a pre-published version of a book on the internet, in part because doing so would cannibalise their own royalties.

[49] In Richard Poynder's website *Open and Shut* (visited 24 March 2014), the entry titled "Open access mandates: ensuring compliance" reports that in the voluntary era before 2008, compliance with the NIH request to self-archive was only 19%, while in the compulsory era by 2012 the compliance rate was 75%.

is useful to use a designated repository (or repositories), as it is hard to verify the history of an author's personal webpage. (The NIH uses *PubMed Central* as its repository.)

Universities can also encourage their employees to self-archive. For example, since 2008 Harvard University has tried to ensure that its faculty deposit their work in the university's open access repository. However, the policy appears to be relatively weak, since faculty are not strictly obliged to self-archive in the university's repository, and there are no consequences for failing to comply. As of 2011, half of the Harvard's Faculty of Arts and Sciences had deposited some document to the repository.[50]

In 2004, the UK's House of Commons Science and Technology Committee investigated the market for scientific publications (House of Commons, 2004), and recommended following a green open access approach. Specifically, they suggested (paragraph 115) that universities be funded to establish institutional repositories, and wrote (paragraph 117) that "authors currently lack sufficient motivation to self-archive in institutional repositories. We recommend that the Research Councils and other Government funders mandate their funded researchers to deposit of a copy of all their articles in their institution's repository within [...] a reasonable period to be agreed following publication, as a condition of their research grant." The Government essentially refused to implement any of the main recommendations in this report, and the committee clearly believed that consideration of business interests had "neutralised" the careful analysis from the committee and other government bodies.[51] In retrospect, this was a missed opportunity, since the committee's recommendations were close to current policy in the UK.

In 2012, the UK's Finch group published its report on expanding access to journals, which had been commissioned by government. This report, by contrast with the earlier UK report and with most international policy, suggested following the gold route, and its central recommendation was that "a clear policy direction should be set towards support for publication in open access or hybrid journals, funded by [author publication fees], as the main vehicle for the publication of research, especially when it is publicly funded". Moreover, the report was cautious when it came to any green policies, suggesting that

[50] See Brand (2012) for further details of the Harvard policy. See Suber (2012, chapter 4) for an overview of various mandate policies used by funders and universities.

[51] See paragraph 7 of *Responses to the Committee's Tenth Report, Session 2003-04, Scientific Publications: Free for all?*

"funders' limitations on the length of embargo periods [...] should be considered carefully, to avoid undue risk to valuable journals that are not funded in the main by [author publication charges]" and that "it would be unreasonable to require embargo periods of less than twelve months".[52] In contrast to the previous report in 2004, the Government agreed in 2012 to implement this report.[53]

There followed a period of confusion in UK policy, with the Research Councils changing their stated policy a number of times. A subsequent report, House of Commons (2013, paras. 63, 70) was strongly critical of the Finch Report and its adoption by government, writing that "At a time when the budgets of [universities] are under great pressure, it is unacceptable that the Government has issued, without public consultation, an open access policy that will require considerable subsidy from research budgets in order to maintain journal subscriptions and cover [author publication fees]. Signification public investment has already been made in institutional repositories [...] and they could represent a more cost-effective and sustainable route to full open access", and "We recommend that the Government and [Research Councils] reconsider their preference for Gold open access."

At the time of writing, the policy of the UK's Research Councils is that a grant-funded researcher must either follow the gold route, i.e., publish in a journal which allows immediate free access to the published article, or a green route by publishing in a journal which allows her to self-archive the accepted version of her paper no more than six months after publication (twelve months for humanities and social science subjects).[54] The Research Councils expressed a "preference" for the former, although this preference does not appear to affect a researcher's freedom to choose between the two routes. In addition, the Research Councils will make its contribution towards author publication fees directly to universities (researchers cannot claim for publication fees in the grant itself), who will then distribute

[52] See Finch *et al.* (2012, pp. 7, 8, 10).

[53] See the announcement gov.uk/government/news/government-to-open-up-publicly-funded-research.

[54] The justification for having longer embargoes for humanities and social science subjects is that articles in these subjects often have longer "half-lives" than articles in many science subjects, and hence that readers wish to consult these journals for longer. For instance, Thomson Reuters Citations Reports show that subjects such as history, law or economics have citation half-lives (that is, the median age of a cited article in the reference year) of more than 10 years, while many medical subject areas (such as endocrinology, oncology, geriatrics) have half-lives in the 6-7 year range. A journal with a long half-life will plausibly be commercially hurt more by a green policy with a given embargo period than a journal with a shorter half-life.

these funds to researchers as they see fit.[55] There is also a clause stating that if funds for publication fees are not "available" to the author, the author can self-archive with longer embargo periods (12 months, or 24 months for humanities and social science).[56]

Finally, open access will be required for the next "research excellence framework" in the UK, which covers all important journal publications in the country published after 2016. Similarly to the Research Councils' policy, for a journal publication to be submitted for the next review, the article must either appear without embargo from the publisher itself, or the author's accepted version must be available from a suitable repository no longer than 12 months after publication (24 months for humanities and social sciences).[57] In essence, this will make the great majority of the UK's journal publications open access in some form, albeit with potentially a lengthy delay in many subjects.

4 Conclusions

The first definition of *to publish* in the Oxford English Dictionary is "to make public". However, an unregulated journal market offers limited access to the wider public, alongside high subscription charges for research institutions, free service for most authors and high profits for publishers. The reason for this skewed pattern of prices is that each peer-reviewed article makes a unique contribution, and readers must pay whatever the journal asks to obtain access to this contribution. Since authors care somewhat about the read-

[55] My university will receive £1.1 million from the Research Councils for the year 2013/14 to deliver the Councils' policy on open access. The university plans to devote 80% of this to support publication fees, which it suggests will cover one-third to one-half of the relevant publications. It will prioritise applications for these funds from authors who wish to publish in a fully open access (not hybrid) journal or wish to publish in a hybrid journal which has an embargo period for self-archiving beyond the Councils' stated limits. That is, low priority will be given to authors wishing to pay for open access in a subscription journal when that journal permits adequate self-archiving. See openaccess.ox.ac.uk/applying-for-funding-from-oxfords-rcuk-open-access-block-grant (accessed 26 March 2014) for details.

[56] See www.rcuk.ac.uk/research/outputs (accessed 25 March 2014) for details. It is not clear how the "availability" of funds for author fees will be judged. This is a crucial point, since many journals could not be used with the tighter (six-to-twelve month) embargo. For example, at the time of writing the *Quarterly Journal of Economics* does not offer a gold option and only permits self-archiving of the accepted version after 24 months. Thus, under the strict version of the Research Councils' rules, a grant-funded author would not be permitted to publish in this journal at all. The *Economic Journal* makes an article open access for an author fee of £1500, and again permits self-archiving of the accepted version only after 24 months. Thus, under the strict rules, a grant-funded author would for forced to follow the gold route if they wished to published in this journal.

[57] See hefce.ac.uk/pubs/year/2014/201407/#d.en.86771, accessed 31 March 2014, for further details.

ership for their work, a publisher may not precisely maximize revenue from readers, but temper its prices to ensure the journal is seen by the people the author wants. Nevertheless, most authors do not care enough about being read by the wider public to make it worthwhile for journals to reach that far. The revenue from selling content to institutions makes a publisher keen to attract authors, who usually pay nothing to publish.

This outcome has two main drawbacks: library budgets are siphoned off by commercial publishers, and the wider public and smaller institutions are excluded from research findings. These problems would be mitigated if many authors voluntarily self-archived their papers, by posting the accepted version on their webpage or in a repository. However, the evidence is that many authors do not go to the trouble to do this, especially if their article is anyway being distributed to their desired audience by a journal.

These twin drawbacks are plausibly large enough to make some form of policy intervention worthwhile, costly though that is in itself.[58] Several forms of intervention can be imagined. For instance, copyright on journal articles could be abolished, as suggested by Shavell (2010). Alternatively, there could be some kind of price cap on subscription charges (different from zero, which is the price cap for gold open access), publisher profits above a certain level could have a special high tax rate with the proceeds fed back into the university system, or libraries could form large "consortia" and use their resulting buyer power to mitigate the monopoly power of publishers.

However, the two main kinds of intervention currently under consideration are the "green" and "gold" routes to open access. Green open access (as well as delayed open access) ensures that an inferior version of the published article is made freely available to all readers, while a gold regime makes the published version freely and immediately available. If the inferior version is not too close a substitute to the premium published version—for instance, if the relevant embargo period is not too short—keen readers will still be willing to pay enough to cover the journal's costs and most authors will still publish for free. An open access policy can be implemented with some form of mandate on authors to make their work available in the stipulated manner. This mandate might come from the

[58] Suber (2012, pp. 133-4) discusses some cost-benefit studies of the impact of open access, which claim to find significant gains in a move to open access.

researcher's grant funder, from her university, or at the national level.[59] A funding body can reasonably implement a more stringent policy than, say, a nationwide policy, since a researcher's decision to apply to a particular funder is voluntary, while a strict national policy would unduly restrict a researcher's publishing options.

There are a number of downsides to the green policy, relative to not intervening at all. While not expensive, operating a repository for self-archiving involves some outlay,[60] and it is costly for a regulator to monitor compliance with a self-archiving mandate. Mandated self-archiving imposes some limited costs of effort on authors, and if only a subset of journals comply with the requirements a mandate restricts an author's options to publish. The hope is—and much past experience suggests—that most journals will adapt to a new regime by allowing authors to self-archive the accepted version within the stipulated period.[61] But if the body making policy is small relative to the world market, an international journal may not find it worthwhile to change its policy. It is possible, though not inevitable, that a green policy will result in fewer people reading the publisher's version than before. This could mean that readers do not always know which journal published a paper, and hence do not see the quality signal the journal imparts. However, discovering the paper via *Google scholar* almost always reveals the host journal, and so the loss to readers may not be great.

If a green (or delayed) open access policy has any bite, profits will be affected and we would expect publishers to lobby against the policy (as has already been seen). But from a broader perspective, this is not really a downside as one *aim* of policy should be to transfer surplus from publishers to research institutions. The model in section 5.1 suggests that free version should be a close enough substitute to the published version that all super-normal profits are eliminated. In practice, this outcome is hard to achieve since there is currently

[59] The grant funder potentially has a powerful hold on the author, if its final money is not paid out until there is compliance (or if publishing timescales do not permit this, further grants would not be awarded to an author who had failed to comply in the past). Likewise, a nationwide policy can be a powerful driver of compliance. In the UK, essentially all active researchers can be made to comply if the publications submitted for the "research excellence framework" are required to be open access in the stipulated way.

[60] It currently costs about $800,000 per year to run the *arXiv* repository, and revenue for this comes partly from large donations from Cornell University and the Simons Foundation, and partly from smaller donations from a large number of member institutions. See *arxiv.org* for more information.

[61] A journal might make exceptions to its prevailing copyright policy, for instance by allowing papers funded from a particular source to be self-archived more quickly than its other papers. For example, the *Review of Economic Studies* currently has an embargo period of 24 months for self-archiving, which is reduced to 12 months if the paper has received financial support from a funding body.

only limited empirical data about how subscription revenues are cannibalised with various kinds of self-archiving and delayed open access.[62] However, if policy initially gets it wrong, the journal can make up any revenue shortfall by means of author charges rather than actually going bankrupt.[63]

Scholarly associations often benefit directly from high journal subscription charges, and also actively lobby against open access regulations. However, a principle of competition policy is that exploitative conduct cannot be justified by the use subsequently made of monopoly profits, however benign. In any case, if the activities of the association (such as conferences or scholarships) are valuable, it should be able to obtain funds more directly from funding bodies. It would be a pity if the special interests of associations were an impediment to widening access to research.

A gold policy brings greater benefits, but also greater potential drawbacks. It is surely of some benefit to the reader to read the publisher's version: the format may be somewhat more attractive, the reader has peace of mind knowing she has the final version, and she automatically knows which journal published the paper. As mentioned in section 2.2, a subscription price which is precisely zero (rather than merely cheap) will reduce several costs of a journal. Relatedly, it is far easier for regulators to ensure that authors are complying with their open access obligations relative to a green regime.

Set against these benefits, though, are potential problems caused by authors having to pay to publish. First, there are sound public finance reasons why readers should contribute something to the cost of publishing. Taking a parochial perspective, most readers of journal articles written by authors in a small country will be overseas, and it is not obvious that national taxes should be used to fund free access for these readers. In addition, many readers of scientific research are in the industrial and corporate sector, and it is unclear why all such readers should free ride on a subsidised author-pays regime.[64]

[62] Finch *et al.* (2012, para. 7.67) mentions a survey of librarians asked for their response if journal content became freely available after a six month embargo period. Apparently 10% would then cancel all subscriptions to science, technology and medicine journals and 23% would cancel all subscriptions to humanities and social science journals.

[63] For instance, the journal *Microbiology of the Cell* currently has an extremely short embargo period of two months before its own content is made freely available, and author versions are immediately freely available on its website. The journal supplements its subscription revenue by charging authors as well.

[64] House of Commons (2004, paragraph 175) reports that Elsevier obtains 20% of its journal revenue from this sector, and quotes the Biochemical Society as saying "in the open-access world it would appear

If an author-pays policy is not to have a major impact on the supply of published articles, many authors will need to have their publication fees paid by others. (Recall that the average publication charge for open access paid by the Wellcome Trust in 2012/13 was around £1800.) The details for how to administer these fee subsidies are difficult to formulate, and, in the UK at least, it is far from clear how well current arrangements will work. If authors have publication fees paid automatically, there is a danger of "moral hazard", and authors will choose to publish in expensive, high production-standards journals will little regard for the extra cost in doing so. Perhaps more likely, though, is that many authors *will* incur a personal cost in publishing a paper, either directly out of their own pocket or in terms of having to use research funds which they value for other purposes. Indeed, there is a danger of additional inequities being introduced in the academic world, with established authors with research funds at wealthy institutions having no problem funding expensive publications, while others must place their work in cheaper outlets.

A claim is often made that an author-pays regime gives rise to a conflict of interest for journals, since they make money every time they accept a paper, and this will drive down standards.[65] This argument often reflects special pleading by traditional subscription journals, who in any case also make more money (from their readers) when they publish more articles. Perhaps a better way to think about this issue is that the demand for journal certification by authors may fall when authors pay to publish (as illustrated in the model in section 5.2). In a traditional subscription-funded market, authors of good papers can publish at lower cost (or at least no higher cost) than authors with mediocre papers, and so an author has a clear incentive to place her article in the most discriminating journal willing to accept it. The result is that potential readers obtain a relatively precise signal of quality from the journal in which a paper appears. In an author-pays regime, it becomes *more* expensive to publish a paper in a discriminating journal since peer-review costs are higher. As result, some authors with good papers—particularly younger researchers with less access to research funds or researchers in poorer countries—may not be able to afford the extra

that the only real winners are going to be corporate pharmaceutical companies who would no longer have to pay to access information."

[65] In House of Commons (2004, page 80), Harold Varmus, one of the founders of PLOS, said this argument was "rubbish [...]. We have reviewers who make the determinations about what we are going to accept, who have no direct interest in the fate of our journal, but the most important thing is that we [...] want our journals to be high quality. It is the only way we are going to succeed".

expense, and choose to submit to a less prestigious journal alongside mediocre papers.[66] As a result, readers have a less precise signal of quality than before, and good papers may be lost amongst the mediocre. Nevertheless, it is possible—though not inevitable—that the certification role of journals may be diminishing over time, as potential readers gain easy access to other cues of a paper's quality (such as citations and downloads).

In sum, there are arguments to support of both the green and gold routes to open access. My own view, though, is that for the present a green (or delayed open access) policy which makes a high proportion of research available to the public delivers most of the benefits of full open access, without the significant disruption involved in moving to a high-fee author-pays regime. This is especially the case in a smaller country acting alone. A small country's policy can make little difference to the level of subscriptions its libraries must pay, and the primary impact of an open access policy is to better publicise the country's research around the world.

In the longer term, though, there is the possibility that a journal's role in certifying and improving papers, and the costs they thereby incur, diminishes over time. More journals may adopt editorial policies which focus more on ensuring a paper is "correct" and does not duplicate existing work. Such policies would eliminate much inefficiency and delay in current review procedures. Since less time is spent on writing referee reports and preparing revisions, this would enable authors to devote more of their time to research. And since this research would appear in its final form more quickly, readers would also benefit. The impact of a paper could be gauged more by its citations, downloads and other measures than the name of the journal, and these metrics will come to matter more for an author's reputation and as guides to important work for readers. The current low costs for typesetting articles and administering the submission process, together with the reduced cost of a "light-touch" review process, may mean that publication charges in a gold regime will be easily affordable to the great majority of authors.

[66] For instance, within the PLOS group of open access journals, the highly selective *PLOS Biology* charges authors $2900, while the less selective *PLOS ONE* charges $1350. It could be that all the good biology papers are published in the former journal; however, it is more plausible that some good papers are published in the latter due to financial constraints of some authors.

5 Appendix: Models of Journal Publishing

5.1 A model of journal distribution

The model presented here illustrates three issues: why the traditional "reader-pays" business model is the equilibrium outcome in an unregulated journal market; why the "reader-pays" model leads to prices which might greatly exceed associated costs and to super-normal publishing profits, even in an unconcentrated journal market, and why regulatory intervention to achieve open access can help to overcome the monopoly problem and the public access problem.

There are an unlimited number of identical journals which publish papers submitted by authors and distribute them to readers. Each journal incurs a cost f for reviewing and typesetting each article, but there is no cost for distributing an article to readers. The peer-review process ensures that a published article is strongly differentiated from every other article, and so a reader's willingness-to-pay for one article does not depend on whether the reader has access to other articles. We assume that a reader values each article equally, and a type-v reader is willing to pay up to v for each article they read.[67] (In the next model we discuss a scenario where articles have differing quality.) There are two kinds of reader: "libraries", of which there are n in number and which are each prepared to pay up to v_H for any published article, and "the wider public", who are m in number and who are each prepared to pay v_L per published article.[68] We suppose that information or arbitrage constraints mean that a publisher must charge all readers the same price.[69]

A number of authors each have a paper. Authors care that their article reaches the libraries. For instance, an author cares that fellow researchers can read her article, and researchers have access to journals via their libraries. However, we assume authors gain

[67] The simplifying assumption that a reader has the same willingness-to-pay for every article implies there is no incentive for publishers to bundle articles or journals. Relatedly, it implies we can consider policy towards each article separately. For example, open access policy might apply only to particular articles (those which are publicly funded, say), while other articles might be distributed using the traditional reader-pays business model.

[68] Note that libraries do not have exogenous "budget constraints" in this model. See Jeon and Menicucci (2006) for a model of the journal market where libraries cannot afford to subscribe to all the journals they would like to.

[69] If a publisher could set different prices to the two kinds of reader, first degree price discrimination would be possible, and all readers would be served (although all their surplus would be extracted).

no further benefit from reaching the wider public. Given that journals are available in libraries, authors view journals as perfect substitutes as vehicles to disseminate their work and will choose the journal with the lowest publication fee. For exogenous reasons, we suppose that a journal cannot pay an author when it publishes her article, and it charges the publication fee $p \geq 0$ to its authors. If authors have to pay p to publish their paper in equilibrium, suppose that $N(p)$ authors will choose to publish. In general, $N(\cdot)$ is a decreasing function, reflecting that authors may have heterogeneous access to funds or obtain different benefits from publishing. Suppose that $V(p)$ is the associated net surplus of authors when the publication fee is p, which satisfies $V'(p) \equiv -N(p)$.

An author can bypass the dissemination function of journals by self-archiving a version of their paper. However, suppose that authors incur a small private cost when self-archiving their work, and so will not voluntarily do so if their journal is available in libraries and they can publish for free.

Suppose that

$$nv_H > (n+m)v_L \ , \tag{1}$$

which ensures that a journal obtains more revenue from selling only to libraries than it does from selling to all readers. Suppose also that

$$nv_H > f \ , \tag{2}$$

so that the revenue from selling to libraries covers the cost of running a journal.

The unique equilibrium in an unregulated market is easily derived. Given assumption (1), a journal makes the most revenue from readers by selling only to libraries. Moreover, an author obtains no benefit from reaching the wider public, nor does she care intrinsically about the price a library pays, and so a journal obtains no competitive advantage from offering to supply the wider public or from offering to set a low price to libraries. We deduce that each journal will choose a subscription charge $P = v_H$ to extract all library surplus. Since each article then generates profit $nv_H - f$, a journal has a strong incentive to attract authors. Since an author will choose the journal with the lowest publication fee, it is clear that the only equilibrium publication fee is zero. (If not, then a publisher has an incentive to undercut the prevailing positive fee a little, and attract all authors.)

The outcome in the unregulated market favours authors at the expense of readers: authors can publish for free, while readers either have all surplus extracted or are not served at all. Journals make profit $nv_H - f > 0$ per article published.[70] Suppose that publisher profit is worth nothing in the welfare calculation, and we are only interested in the sum of author and reader surplus. In this case, welfare in this unregulated market is

$$W_1 = V(0) \ , \tag{3}$$

since readers obtain no surplus in equilibrium.

Note that an open access journal cannot succeed in this unregulated market. If it does not charge readers, it must cover its costs by charging authors instead, and no author would prefer to pay a positive price instead of publishing for free.[71] A journal would not wish its authors to self-archive their paper since that would reduce a library's willingness-to-pay for access (see below). But since authors incur a small cost to self-archive and enjoy no extra benefit from doing so, there is no need for a journal to prohibit self-archiving.

Consider a "partial" open access regime in which an inferior version of the published paper is required to be made available, either by the publisher in the form of delayed open access, or by the author who self-archives her own version of the article. (In the latter case, since we assumed there is a small cost involved in self-archiving, authors need to be mandated to do this.) If a reader has valuation v for the published version of a paper, suppose that this reader has valuation γv for reading the inferior version instead, where $\gamma < 1$ is the same for all readers and represents the substitutability of the two versions.[72] If the reader charge is P, a reader with valuation v will pay for the published version rather than read the free version if $v - P \geq \gamma v$, i.e., if $P \leq (1 - \gamma)v$. Under the same condition

[70] If there were not the exogenous constraint that authors cannot be paid when they publish, the equilibrium would instead be that publisher profits are passed back to authors, who are paid $nv_H - f$ for their article. The outcome for readers is unchanged. In the model presented, the equilibrium appears to be somewhat "knife-edge", in that authors are precisely indifferent between all journals, and if a journal could somehow slightly improve its offer to authors it could attract much profitable business. (For instance, a journal might compete on its turnaround time, or attractive layout, or by giving a mug to an author.) This drawback could be overcome in a slightly extended model where authors viewed journals as being slightly differentiated, say. The fact remains that many commercial publishers are highly profitable, suggesting that there is some barrier to profit dissipation in this market.

[71] If some authors did intrinsically care sufficiently about reaching the wider public, some journals would voluntarily set a low enough reader price to induce all readers to subscribe.

[72] As discussed in section 2.1, it may on occasion be that the refereeing process actually makes a paper worse. In such cases, we would have $\gamma > 1$.

(1), a journal prefers to sell only to libraries, but its subscription charge can now be no higher than $(1-\gamma)v_H$. The parameter γ captures the extent to which the free version cannibalises a journal's revenue from libraries.

If γ is small enough so that

$$n(1-\gamma)v_H \geq f \ , \tag{4}$$

then this reduced revenue from libraries is still sufficient to cover the journal's cost. The equilibrium with this form of regulation is that authors are again charged nothing to publish, libraries pay the reduced price $(1-\gamma)v_H$ to have access to the premium published version, while the wider public can access the inferior version for free. Putting this together implies that total welfare in this regime is[73]

$$W_2 = V(0) + N(0)\gamma[nv_H + mv_L] \tag{5}$$

Thus, since the extra term in (5) is positive, a requirement to make an inferior version freely available boosts total welfare in this model. The gain comes from two sources. First, the wider public is able to read the inferior version, while before they were excluded altogether. Second, libraries are charged $(1-\gamma)v_H$ to access the published version, and so a library has net surplus γv_H in this regime. The policy has no significant impact on authors, who can publish for free and reach their desired audience in any case. In sum, this partial open access policy both expands readership and transfers a fraction γ of profits from publishers to libraries.

Consider next the "gold" open access regime, when journals must offer readers access to their published articles for free. Here, the equilibrium involves authors paying the cost of the journal, so that $p = f$, and journals obtain no profit. We suppose that journals are needed for certification and reputation, in the sense that an author will have no readers and/or obtain no reputational benefit if she merely self-archives her paper without also publishing in a journal. The welfare of readers and authors is now

$$W_3 = V(f) + N(f)[nv_H + mv_L] \ . \tag{6}$$

The impact of the policy is that all readers have free access to published research, publisher profits are eradicated, but the number of published articles may fall. If the supply of articles

[73] We suppose that with a green policy, the author's cost of self-archiving is small enough that it can be ignored when calculating welfare.

is inelastic, so that $N(f) \approx N(0)$, then $V(f) \approx V(0) - N(0)f$, and (6) implies

$$W_3 \approx V(0) + N(0)\left[nv_H + mv_L - f\right] \ .$$

Given (4), welfare with the gold policy is then higher than in both the unregulated market (3) and the green regime (5). Publisher profits obtained in the unregulated market are fully transferred to the academic sector of authors and libraries (although within this sector there is a transfer from authors to libraries), and the wider public have free access to the published version of research.

However, this welfare ranking is changed if the supply of articles is sufficiently elastic. Since authors are worse-off in the gold regime relative to the partial regime, a sufficient condition for welfare to be lower in the gold regime than the partial regime is that readers are worse off. However, readers are worse off in the gold regime if and only if

$$N(f)[nv_H + mv_L] < N(0)\gamma[nv_H + mv_L] \ ,$$

i.e., if the "quality adjusted" number of published articles is higher in the partial regime so that $N(f)/N(0) < \gamma$. This condition is satisfied if the supply of articles contracts sufficiently when author fees are introduced.

In practice, in a partial open access regime, the policy-maker can *choose* how inferior the free version is, so that γ is endogenous. For example, the length of embargo period determines how close a substitute the free version is to the published paper. As γ varies from 0 to 1, the partial policy nests the unregulated market ($\gamma = 0$) and the gold policy ($\gamma = 1$) as polar cases. This analysis shows that policy should at least choose γ high enough that (4) just binds and authors can continue to publish for free. So long as there is no impact on the supply of published articles, welfare is improved when the wider public can enjoy a better version of the research and when more profit is transferred to libraries. It is possible that welfare can be improved further by choosing γ even higher, so that authors are required to contribute to journal costs, but that calculation requires a more delicate analysis of the elasticity of supply of articles.

5.2 A model of quality certification

The previous model focussed on the dissemination task performed by journals. Another important task is to certify the quality of papers they publish. Journals have earned a

reputation for being selective, and the fact that a paper is published in a particular journal is informative about its likely quality. As discussed in section 2.1, *ex ante* information about an article's quality is valuable to readers because that helps them better target their reading efforts. Likewise, certification is valuable to authors of good papers, as being published in a discriminating journal enhances this author's reputation among those who do not already know the author's work directly and also makes people more likely to read their paper.

The model presented here illustrates how a gold open access policy might adversely effect the equilibrium amount of certification performed in the market. Suppose that there are two kinds of article, "good" ones with quality q_H and "mediocre" ones with quality q_L. An author knows the quality of her article *ex ante*, but has no control over whether her article is good or mediocre.

By incurring cost $c > 0$, which might be interpreted as the cost of a peer review process, a journal can accurately determine an article's quality. A journal can be one of two types: a "discriminating" journal publishes only good articles and incurs the evaluation cost c per submission and cost f per publication, while a "non-discriminating" journal publishes any article submitted, and so incurs only the cost f per publication. Readers and authors are assumed to be able to observe which journals are discriminating and which are not, perhaps because they have consulted journals in the past or because they know a journal's impact factor or similar. We assume that an author of a mediocre paper will not submit to a discriminating journal, so that a discriminating journal's cost per article published is $f + c$. (This can be ensured by supposing that a discriminating journal charges a non-refundable submission fee in addition to a publication fee. Since authors know the quality of their paper they will then only submit if they have a good paper.) There is an unlimited supply of both types of journal.

Suppose that an author obtains reputational benefit $b(q)$ if she publishes an article which is perceived to have (average) quality q, and authors do not care directly about the readership of their article.[74] Suppose that a journal can extract revenue $r(q)$ from

[74]This simple framework abstracts away from the likelihood that an author of a good paper will gain reputational benefits from being read, in addition to being able to put a good publication on her CV, since those who read the paper will discover that the paper is indeed good, even if it appears in a non-discriminating journal.

the population of readers for an article with perceived average quality q. Naturally, both $b(\cdot)$ and $r(\cdot)$ increase with q. All articles published in a discriminating journal are known to have quality q_H, while an article in a non-discriminating journal has expected quality which depends on the proportion of good and mediocre articles submitted in the relevant equilibrium. We focus on the case where

$$r(q_H) \geq f + c \ , \tag{7}$$

so that an article known to be good generates sufficient revenue from readers to cover its cost of publication and peer review.

The equilibrium outcome in an unregulated market is for all good papers to appear in discriminating journals. Given assumption (7), competition for authors with good papers by discriminating journals implies that the author fee is driven down to zero and such an author obtains payoff $b(q_H)$. Such an author could instead choose to publish in a non-discriminating journal. In this candidate equilibrium, readers believe that a paper in a non-discriminating journal is surely mediocre, and so publishing in a non-discriminating journal yields the author reputational benefit $b(q_L)$. As a result, the payoff to the author is at most $b(q_L)$ since she may also have to pay a publication fee. Therefore, in this candidate equilibrium the author of a good paper has no incentive to deviate and to publish in a non-discriminating journal. (The author of a mediocre article cannot publish in a discriminating journal since her article will be rejected, and that deviation need not be considered.) It is thus an equilibrium for all good papers to appear in discriminating journals. A related argument shows there can be no equilibrium in which some good papers appear in non-discriminating journals, and so this is the unique equilibrium.

What happens to authors of mediocre papers in this equilibrium depends on how much revenue such a paper generates. If $r(q_L) \geq f$, then even a mediocre article generates reader revenue sufficient to cover a non-discriminating journal's cost. In this case, all authors can publish for free. However, if $r(q_L) < f$, then authors of mediocre papers will have to contribute to the cost of publication, and in equilibrium they are each charged $p = f - r(q_L)$. In the extreme case where an article known to be mediocre goes entirely unread, so that $r(q_L) = 0$, these authors must cover the full cost of publishing. A non-discriminating journal can then style itself as "open access" without losing reader revenue.

In an unregulated market, the equilibrium then involves good articles being published in discriminating reader-pays journals for free, while authors of mediocre articles engage in "vanity" publishing and pay for their work to appear in non-discriminating open access journals. (In section 2.1 we discussed how something similar to this can be seen currently in the journal market.)

As in section 5.1, suppose that a partial open access policy requires an inferior version of the published paper to be made freely available, where this inferior version is viewed by a reader who values the published article at v as having value γv. (In particular, in the case of a green policy where the author makes her own version of the published paper available, we assume that a reader who is considering whether to read the self-archived paper knows the journal in which it is published, either by checking directly or because the author is required to state the journal when she self-archives.) As a result, the revenue function is shifted down from $r(q)$ to $(1-\gamma)r(q)$. In this case, a similar equilibrium to that in the unregulated market is seen, provided that γ is small enough that

$$(1-\gamma)r(q_H) \geq f + c \ ,$$

so that a discriminating journal can cover its costs without charging authors. In particular, all good papers appear in discriminating journals, and potential readers have an accurate signal of quality from the journal in which the article appears. Provided that it allows discriminating journals to cover their costs from subscriptions alone, a partial policy has no adverse impact on the "certification" services provided in the market. As before, the policy enables all potential readers to access the research and transfers profit from publishers to those readers who choose to pay for the published version.

With gold open access regulation, an author bears the cost of publishing. Competition between journals implies that the author publication fee at a discriminating journal is $f+c$, while at a non-discriminating journal the fee is f.[75] Thus, a crucial difference between a reader-pays and an author-pays regime is that in the former case publication fees tend to be lower at discriminating journals, while the latter has the opposite pattern.

[75] There indeed appears to be an imperfect correlation between the "quality" of an open access journal and its publication charge. See the discussion of the PLOS collection of open access journals in section 4, as well as Solomon and Björk (2012b, Figure 5).

With the gold policy, an author with a good paper will choose to publish in a discriminating journal only if the additional reputational benefit of publishing in a discriminating outlet outweighs the disutility of paying the extra publication fee. Such an author may choose to publish in a non-discriminating journal if her marginal utility of research (or private) funds is sufficiently high.[76] Since now some good articles are published in non-discriminating journals, readers have a less precise signal about articles quality than they did in the unregulated market. For instance, if mediocre articles are worthless, no one would ever read a non-discriminating journal in the unregulated market. In the gold open access regime, though, a reader will either have to sift through these journals to find the fraction of good papers they contain, or ignore these journals altogether, which means the good articles in them go unnoticed.

Example: To make this analysis a little more concrete, consider the following special case. Suppose that all readers are identical and each article is an experience good, in the sense that a reader does not know its quality until she has invested effort in reading it. Specifically, suppose that a reader incurs a private reading cost $s > 0$ for reading any paper, in addition to the payment P required by the journal. If an article has expected quality q and access price P, suppose that a reader is willing to read the article if and only if $q \geq s + P$. Thus, if there are N readers, the revenue function is $r(q) = N(q - s)$ if $q \geq s$. If $q < s$, then no one will read the article even if it is free. Provided that condition (7) holds, in the unregulated market, when $q_L < s < q_H$ no one will read a non-discriminating journal, while discriminating journals will charge $P = q_H - s$ for access.[77] In a gold open access regime, suppose that the equilibrium proportion of mediocre articles in a non-discrirminating journal is α, so that average quality in such a journal is $q = \alpha q_L + (1-\alpha)q_H$. If α is large enough that $q < s$, then no one will consult a non-discriminating journal and so miss out on the good articles they contain. If $q > s$ then a reader will read these journals, but incur a loss $s - q_L$ for each mediocre article they have to read in the process.

This model assumes that the journal's name is the only signal of quality available to

[76] Alternatively, different authors may place different weight on reputation, so that the function $b(q)$ may be less steep for some authors, who then are not prepared to pay the extra for a better reputation.

[77] If $q_H < s$ then a reader will not read even a known good paper, while if $q_L > s$ a reader will read even a known mediocre paper. In either case, having *ex ante* information about an article's quality is not useful to readers.

readers. As discussed in section 2.1, though, nowadays readers have additional cues for quality, including the number of citations or downloads an article receives. As a result, the certification function of journals may be less important, and the danger of moving to the gold regime in this regard may not be so severe. Nevertheless, *early* readers have only the journal name to use as a signal. If non-discriminating journals are not read by early readers since they do not contain a sufficient proportion of good articles, good articles in these journals do not pick up citations and downloads, and so go unread by later readers as well. In this situation, the journal's reputation for selectivity continues to play an important role in determining a paper's eventual impact.

5.3 Related theoretical literature

The perspective of the publishing market taken in the model presented in section 5.1 is that it is a "competitive bottleneck" (Armstrong, (2002, section 3.1) and Armstrong (2006, section 5)). In particular, there is a close connection between this view of the publishing market and "call termination" on telephone networks as discussed in Armstrong (2002, section 3.1). There, people subscribe to a single telephone network (just as an author publishes her article in one journal), and anyone who wishes to call a particular subscriber has to pay whatever "termination charge" is demanded by that subscriber's network (just as anyone who wishes to read a published article has to pay what that journal demands). Telephone subscribers may care about the volume of calls they receive (just as authors care about the size of their readership), which will induce their network to temper high prices for call termination somewhat. Without regulation, revenues from call termination in a competitive market are passed back to subscribers in the form of a subsidized or free handset (just as profits from readers fund free publishing for authors). If the number of subscribers is inelastic, however, it is optimal to regulate the price of call termination to be equal to marginal cost (just as it is then optimal to have gold open access in the publishing context). If the supply of subscribers is elastic it is optimal to set the price for termination above cost, and use the resulting profits to fund better deals for subscribers (just as it may be optimal to make readers contribute to the cost of journals when the supply of articles

is elastic).[78]

Turning to related studies of the journal publishing market, Shavell (2010) presents a model of the academic market which is similar to that in section 5.1. In particular, he also focussed on the case where the journal market is competitive, and where potentially high revenues from selling the journal to readers are passed onto authors in the form of a subsidised charge for publishing. Shavell supposes that all authors write articles of equal quality (that is, readers have the same demand function for each article) but differ in how much they value readership. Authors who value having many readers will choose a contract with a low reader price (and so relatively large publication fee), while authors who care little for readers opt for a contract with a revenue-maximising reader price and are paid for their work. In contrast to the model in section 5.1, Shavell does not impose the constraint that authors cannot be paid to publish, and so his publishers make zero profits in equilibrium.

McCabe and Snyder (2005) present a model of a monopoly profit-maximizing journal that chooses which articles to publish and how much to charge the two sides of the interaction. (They assume that a paper is either "good" or "worthless", and authors do not know the quality of their article at the time of submission.) They find that the better the journal is at picking out the good articles the higher is its charge to readers (and the lower its charge to authors). They interpret this as implying that a less expert journal is more likely to offer open access.

Jeon and Rochet (2010) also consider a market with a single journal, which chooses the quality threshold for the papers it accepts. In their model, they find that the socially optimal way to price to the two sides is to have open access (see their Proposition 2). One reason for this unambiguous result, however, is that they do not require the journal to break even; if revenues from the two sides must cover the journal's cost, it may be optimal to charge readers for access so that authors are not unduly discouraged from publishing by high publication fees. The rest of their paper mostly studies the case where the journal aims to maximizes its readers' welfare. However, closer to the focus in the current paper,

[78] One major difference between the two markets, however, is that any super-normal profits enjoyed by telephone networks in an unregulated market can be siphoned off when government auctions the rights to use the spectrum needed to provide mobile telephony. In the publishing market, there is no such essential resource which can be used to extract publisher profits.

in their appendix they also study a for-profit monopoly journal. (The framework I study in section 5.2 is quite similar to Jeon and Rochet's model. Articles are either good or bad—where a "bad" paper has benefit to the reader which is below her reading cost—and they assume that an author knows her quality in advance.) They find that a reader-pays journal will never accept bad papers, since that diminishes a reader's willingness-to-pay for the journal. However, in an author-pays regime the journal may accept a portion of bad papers, as it cares less about pandering to reader interests. As a result, open access may be associated with a fall in standards, just as the competitive market studied in section 5.2 exhibited a noisier signal of quality in an author-pays than a reader-pays regime.[79]

McCabe, Snyder and Fagin (2013) study a model with two authors and two readers. One author cares about reaching readers (valuing each reader at a) while the other does not; one reader has a value r from seeing any article, while the other does not and can be reached only with open access. Suppose it costs f to process each paper and disseminate it to any number of readers.[80] When there is a single profit-maximizing journal, there are five strategies that the journal might follow: (i) publish one article and sell to one reader, which yields profit $a + r - f$; (ii) publish one article but with open access to both readers, which yields profit $2a - f$, (iii) publish two articles and sell both to one reader, which yields profit $2r - 2f$, (iv) publish two articles with open access, which yields negative profit, or (v) follow a "hybrid" strategy, and offer the author who does not care about readers free publication to one paying reader, and offer the author who does care about readership open access in return for a publication fee, which yields profit $a + r - 2f$.[81] Thus, the journal has no incentive to follow the hybrid strategy, which is dominated by strategy (i).[82] (However, if policy forced the journal to offer some form of open access, the journal may prefer the hybrid option to the full open access policy.)

[79] Jeon and Rochet do not investigate whether an author-pays or reader-pays regime (or a mixture of the two) is observed in an unregulated monopoly market, but rather they derive the price to one side given an exogenous constraint that the other side has free access.

[80] In fact, McCabe *et al.* suppose there is a constant cost of distributing the paper to each reader.

[81] Since the author who cares about readership could mimic the other author (who has access to a single reader for free), the journal can only charge a publication fee of a to this author.

[82] In richer frameworks it would be optimal to offer a different readership to different authors, i.e., to follow a "hybrid" strategy. A general version of this situation would have authors differing in their "demand" for readers and readers differing in their demand for papers, and a monopoly journal solves a two-sided screening problem in which the total volume of demands on the two sides must coincide. For a model with this flavour, see Gomes and Pavan (2014).

References

Armstrong, Mark (2002), "The theory of access pricing and interconnection", in *Handbook of Telecommunications Economics* Vol. 1 (eds. Cave, Majumdar and Vogelsang), pp. 295–384. Amsterdam: North-Holland.

Armstrong, Mark (2006), "Competition in two-sided markets", *RAND Journal of Economics* 37: 668–691.

Association of Research Libraries (2006), *ARL Statistics 2004-05*, Washington DC.

Barton, Henry (1963), "The publication charge plan in physics journals", *Physics Today* 16: 45–57.

Beall, Jeffrey (2012), "Predatory publishers are corrupting open access", *Nature* 489: 179.

Berg, Sanford (1971), "Increasing the efficiency of the economics journal market", *Journal of Economic Literature* 9: 798–813.

Bergstrom, Theodore (2001), "Free labor for costly journals?", *Journal of Economic Perspectives* 15: 183–198.

Bergstrom, Theodore and Rosemarie Lavaty (2007), "How often do economists self-archive?", mimeo.

Bohannon, John (2013), "Who's afraid of peer review?", *Science* 342: 60-65.

Brand, Amy (2012), "Beyond mandate and repository, toward sustainable faculty self-archiving", *Learned Publishing* 25: 29–34.

Brown, Patrick, Michael Eisen and Harold Varmus (2003), "Why PLoS became a publisher", *PLoS Biology* 1: 1–2.

Davis, Philip (2011), "Open access, readership, citations: a randomised controlled trial of scientific journal publishing", *The FASEB Journal* 25, 2129–2134.

Dewatripont *et al.* (2006), *Study on the Economic and Technical Evolution of the Scientific Publication Markets in Europe*, Brussels: European Commission.

Ellison, Glenn (2002), "The slowdown of the economics publishing process", *Journal of Political Economy* 110: 947–993.

Finch, Janet, *et al.* (2012), *Accessibility, sustainability, excellence: how to expand access to research publications*, Report of the Working Group on Expanding Access to Published Research Findings.

Gomes, Renato and Alessandro Pavan (2014), "Many-to-many matching and price discrimination", mimeo.

Harnad, Stevan (1995), "Universal FTP archives for esoteric science and scholarship: a subversive proposal", in *Scholarly Journals at the Crossroads: A Subversive Proposal for Electronic Publishing* (Okerson and O'Donnell, eds.), Washington DC, Association of Research Libraries.

Houghton, John, Alma Swan and Sheridan Brown (2011), *Access to Research and Technical Information in Denmark*, Report to the Danish Agency for Science, Technology and Innovation.

House of Commons (2004), *Scientific Publications: Free for all? A report of the Science and Technology Committee*, London: The Stationary Office.

House of Commons (2013), *Open Access: A Report of the Business, Innovation and Skills Committee*, London: The Stationary Office.

Jeon, Doh-Shin and Domenico Menicucci (2006), "Bundling electronic journals and competition among publishers", *Journal of European Economic Association* 4: 1038–1083.

Jeon, Doh-Shin and Jean-Charles Rochet, (2010), "The pricing of academic journals: a two-sided market perspective", *American Economic Journal: Microeconomics* 2: 222–255.

McCabe, Mark and Christopher Snyder (2005), "Open access and academic journal quality", *American Economic Review* 95: 453–458.

McCabe, Mark, Christopher Snyder and Anna Fagin (2013), "Open access versus traditional journal pricing: using a simple 'platform market' model to understand which will win (and which should)", *Journal of Academic Librarianship* 39: 11–19.

Morris, Sally (2009), "Journal authors' rights: perception and reality", *Summary paper 5,* Publishing Research Consortium.

Peitz, Martin and Patrick Waelbroech (2006), "Piracy of digital products: a critical review of the theoretical literature", *Information Economics and Policy* 18: 449–476.

Rochet, Jean-Charles and Jean Tirole (2006), "Two-sided markets: a progress report", *RAND Journal of Economics* 37: 645–667.

Salganik, Matthew, Peter Sheridan Dodds and Duncan Watts (2006), "Experimental study of inequality and unpredictability in an artificial cultural market", *Science* 311: 854–856.

Shavell, Steven (2010), "Should copyright of academic works be abolished?", *Journal of Legal Analysis* 2: 301–358.

Shao, Jufang and Huiyun Shen (2011), "The outflow of academic papers from China: why is it happening and can it be stemmed?", *Learned Publishing* 24: 95–97.

Solomon, David and Bo-Christer Björk (2012a), "Publication fees in open access publishing: sources of funding and factors influencing choice of journal", *Journal of the American Society for Information Science and Technology* 63: 98–107.

Solomon, David and Bo-Christer Björk (2012b), "A study of open access journals using article processing charges", *Journal of the American Society for Information Science and Technology* 63: 1485–1495.

Strieb, Karla and Julia Blixrud (2013), "The state of large-publisher bundles in 2012", *Research Library Issues* 282: 13–20.

Suber, Peter (2012), *Open Access*, MIT Press.

Willinsky, John (2006), *The Access Principle: The Case for Open Access to Research and Scholarship*, MIT Press.