Economic Inquiry

COST EFFECTIVENESS OF OPEN ACCESS PUBLICATIONS

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Open access publishing has been proposed as one possible solution to the serials crisis—the rapidly growing subscription prices in scholarly journal publishing. However, open access publishing can present economic pitfalls as well, such as excessive article processing charges. We discuss the decision that an author faces when choosing to submit to an open access journal. We develop an interactive tool to help authors compare among alternative open access venues and thereby get the most for their article processing charges. (*JEL* I2, C1, A1)

I. INTRODUCTION

Institutional subscription prices of academic journals continue to increase more rapidly than library budgets (Kyrillidou 2012). Journals produced by for-profit publishers typically cost libraries about three times as much as comparable journals produced by nonprofit publishers (Bergstrom and Bergstrom 2004a, 2006; Bergstrom and McAfee 2013). As a result, library budgets are badly strained while for-profit publishers are able to extract large profits from the university community. Open access publishing has been widely heralded as a potential solution to this so-called "serials crisis" (Willinsky 2009; Young 2009; Suber 2014).

But open access publishing is no panacea. Firstly, while author-pay open access continues to grow (Björk et al. 2010; Laakso et al. 2011), it is unclear that open access publishing will quickly—or ever—come to dominate the market for scholarly publishing (McCabe and Snyder 2010; Shieber 2009). Second, the author-pay model is not without its own pricing perils. Some commercial publishers levy article processing charges as high as $3,000 for publishing a single article. A number of "predatory" open access publishers operate like vanity presses, charging authors substantial fees in exchange for the thinnest veneer of editorial oversight (Beall 2012; 2014).

On the positive side, the structure of the market for open access publications offers the potential for a more competitive marketplace than that for subscription-based publication (Bergstrom and Bergstrom 2004b). The reason is straightforward: authors, when deciding where to publish, can substitute one journal for another in order to get the best deal. This is not the case for libraries deciding what journals to subscribe to. Because open access publications are substitutes, authors can afford to comparison shop, seeking out only the very best deals and patronizing these exclusively. Should authors do so, publishers would be forced to compete aggressively on price, much as they have already started to compete on other factors such as time-to-publication. The result would be better deals for the academic community. Our aim of this article is to describe and deploy an online tool that makes it easy for scholarly authors to engage in this kind of comparison shopping.

ABBREVIATIONS

DOAJ: Directory of Open Access Journals
JCR: Thomson-Reuters Journal Citation Reports

*The authors are the founders of the Eigenfactor Project. The open access cost effectiveness tools described here are freely available at http://www.eigenfactor.org/openaccess/. This work was supported in part by National Science Foundation Grant SBE-0915005 to C.T.B.
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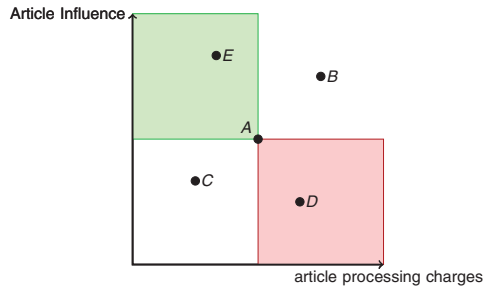
II. THE AUTHOR'S PERSPECTIVE

Academic journals require one or more revenue streams to cover their costs. There are three basic sources of revenue to which a publisher can turn: (1) authors, (2) readers, and (3) sponsors. Publishers regularly employ each of these sources, sometimes in combination. For example, *Proceedings of the National Academy of Sciences of the United States of America* requires authors to pay page charges, and also charges subscription fees to university libraries. The PLoS family of journals imposes article processing charges, and has received grant funding from agencies including the Sloan foundation and the MacArthur foundation. Authors may be charged upon publication of their work, upon article submission, or some combination of these. Here we examine authors' motivations for paying such fees.

The competitive peer review system used by the majority of scholarly periodicals serves to certify the novelty, interest, and quality of academic publications. Publication in a leading journal confers substantial prestige upon a scholarly author, and authors are strongly motivated by this incentive (Attema, Brouwer, and Van Exel 2014). A record of publication in the top tiers of the journal hierarchy has a critical impact on hiring, promotion, tenure, merit, salary, and funding decisions. Moreover, to have a significant influence on scholarly thought, one needs to be read widely by one's peers. Journals vary considerably in readership; researchers often conscientiously follow the publications in top journals, while turning to lower-tier journals only in pursuit of specific references. Of course prestige and readership are not independent of one another. Journals become prestigious in part because they are highly read, and prestigious journals are highly read in part because their prestige allows them to attract the top papers in a field.

When an author (or more commonly, her funders or home institution [Dallmeier-Tiessen et al. 2011]) pays open access article processing charges, she is not only paying for the broad accessibility to readers that results from open access publishing. She is also paying for the prestige and the readership that she will gain by publishing in that particular journal. When choosing among alternative venues, a sensible author would like to get as much as possible for her money. In order to quantify what an author receives in exchange for her article processing charges, we note that both prestige and readership translate into the number of scholarly citations that a article receives. With all of the usual caveats (Seglen 1997), we estimate this quantity using journal-level citation data. We use the Article Influence® score[1]—a measure of per-article citations weighted by influence (West, Bergstrom, and Bergstrom 2010)—to estimate the prestige and readership obtained from publishing in a given venue.[2]

FIGURE 1
Comparing Journals



Notes: With all else equal, authors will prefer journals with higher Article Influence scores to lower, and they will prefer journals with lower article processing charges to higher. Thus an author will prefer journal A to the more expensive and less prestigious journal D and likewise to any journal in the red quadrant. Similarly, the author would prefer the less expensive and more prestigious journal E and likewise any journal in the green quadrant to journal A. How journal A compares with journals B and C depend on the author's willingness to pay extra article processing charges in exchange for extra prestige.

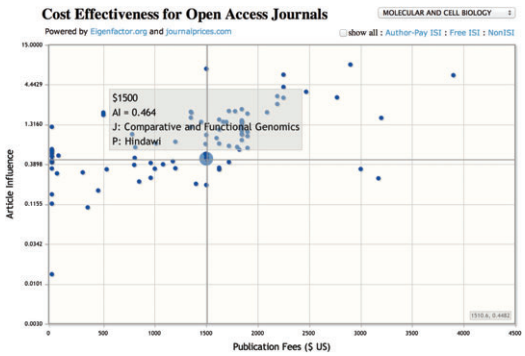
Figure 1 compares the deals offered by five different hypothetical journals. All else equal, authors will prefer to publish in journals with higher Article Influence scores, and with lower article processing charges.

To facilitate comparisons of this sort, we have deployed an interactive visualization that shows

1. A journal's Article Influence score is a measure of journal prestige analogous to the Impact Factor. A journal's Article Influence is calculated as a journal's Eigenfactor score, divided by the number of papers published. The journal's Eigenfactor score, described in detail by West et al. (2010), is a type of eigenvector centrality measure for the citation network in which journals represent nodes and citations represent directed links.

2. Journals provide a different type of value to authors than they do to institutional subscribers. In exchange for article processing charges, an author buys the right to publish a single article in a journal, whereas in exchange for subscription fees, a librarian buys the right to carry all articles published in the journal. Thus we use a per-article measure (Article Influence score) to quantify value to an author, whereas elsewhere (http://www.eigenfactor.org/costeffectiveness.php) we have used a per volume measure (Eigenfactor score) to quantify value to a subscriber.

FIGURE 2
A Screenshot of the Interactive Visualization, which Can Be Found at http://www.eigenfactor.org/openaccess/



Notes: The Article Influence scores are log (base 10) transformed. The selected journal is highlighted with a larger blue circle. The "crosshairs" indicate the four quadrants noted in Figure 1.

how each open access journal compares with its competitors with regard to (1) article processing charges and (2) Article Influence score. The visualization, available at http://www.eigenfactor.org/openaccess/, is shown in Figure 2.

The visualization allows users to examine articles from one discipline at a time. Disciplines are determined using the Eigenfactor Categories provided at Eigenfactor.org. These categories are derived from the community structure of the journal-level citation network, using the map equation approach (Rosvall and Bergstrom 2008). This divides the set of open access journals into 50 distinct disciplines of science and social science such that each journal belongs to a single discipline. Since these disciplinary categories are relatively wide, not all journals in a given discipline would be an appropriate venue for the same article. Journals on cardiovascular disease, epidemiology, pediatrics, and nutrition are all classified under Medicine, for example. Furthermore, many regional journals may be appropriate for only certain authors and articles. Nonetheless, the categories tend to group similarly situated journals together and as such provide a good indication of where a given journal stands relative to other open access journals on related subject matter.

Our focus here is on journals that are truly open access in that all of their content is open access. Many other journals offer hybrid open access programs in which individual articles can be made open access for a fee, often in the range of $ (Pinfield 2010). It is more difficult to quantify the value of making one's article open access in a hybrid journal. On one hand, the prestige conferred by the journal is approximately the same whether one chooses to make one's article open, or not. On the other, open access articles in hybrid journals will probably attract more readers and possibly additional citations (see Wagner 2010 for an overview of the controversy around open access citation advantage).

We should note that publishing in an open access journal is not the only way to make an article freely available. Most academic journals allow immediate posting of a final refereed copy of an author's article where search engines can find them on the author's own website or in a freely available institutional archive. Harnad (2007, 2010) presents a compelling case for open access self-archiving as a means of transition to open access publishing. Harnad argues that as self-archiving becomes more widely practiced, competitive pressure will force open access publishers to realize potential cost-savings of open access publication and to pass these savings on in the form of lower article processing charges. The website Sherpa/Romeo (http://www.sherpa.ac.uk/romeo/) has a nearly complete list of the policies of publishers with respect to copyright and self-archiving.[3] Since this option is available for a very large number of journals, authors and institutions may prefer to self-archive at zero cost rather than pay high article processing charges to publishers for open access publication.

III. DATA AND RESULTS

To get an overall view of well-established open access journals, we examined 1,357 open journals included in the 2011 Thomson-Reuters Journal Citation Reports (JCR). Of these, 1,024 are listed by the Directory of Open Access Journals (DOAJ) and the rest are listed by journalprices.com as freely available. By this count, approximately 13% of the journals in the JCR are freely available. These journals account for 8% of the articles and 5% of the citations received in the JCR (Table 1). Of the publishers with the

3. Sherpa distinguishes two policies, each of which allows posting of a final copy of one's articles. These are Green–Can archive pre-print and post-print or publisher's version/PDF and Blue–Can archive post-print (i.e., final draft post-refereeing) or publisher's version/PDF.

TABLE 1
Open Access Journals, Articles, and Citations Received in the Thomson-Reuters Journal Citation Reports 2011

	Journals	Articles	Citations
Open access	1,357	91,937	142,338
All journals	10,796	1,116,613	2,778,668
Fraction open	12.6%	8.2%	5.1%

TABLE 2
Contribution of Five Major Publishers to JCR 2011-Listed Open Access Publishing

	Journals	Articles	Citations
Biomed Central	8%	9%	18%
PLoS	1%	5%	17%
Hindawi	2%	2%	1%
Springer	2%	3%	2%
Elsevier	1%	1%	1%

TABLE 3
Open Access Journals, Articles, and Citations Received by Country of Publication

	Journals	Articles	Citations
United States	164	14,718	41, 581
Brazil	103	7,814	6,073
Poland	58	3,158	2,552
United Kingdom	55	15,672	31,888
Japan	48	4,730	5,774
India	45	3,623	3,173
Spain	45	3,485	9,313
Turkey	44	2,012	1,130
Germany	43	3,352	5,747
Chile	34	962	420
Korea	33	2,691	1,954
Croatia	31	1,531	1,312
Mexico	31	1,386	610
Iran	28	1,013	710
Italy	26	1,351	2,422
Switzerland	25	1,907	3,593
Romania	22	1,059	527
Canada	21	772	1,476
Czech Republic	20	1,103	762
Argentina	19	622	650
Egypt	19	966	1,307
Serbia	19	1,061	786
South Africa	17	576	311
Colombia	16	496	155
China	15	1,792	762
Australia	13	447	678
France	8	395	459

largest open access portfolios—Biomed Central, PLoS, Hindawi, Springer, and Elsevier—PLoS and Biomed Central account for the vast majority of citations received (Table 2). Rather than being concentrated in one or a few countries, open access publishing is well-represented on an international scale, with 26 nations publishing more than 10 JCR-listed open access journals (Table 3).

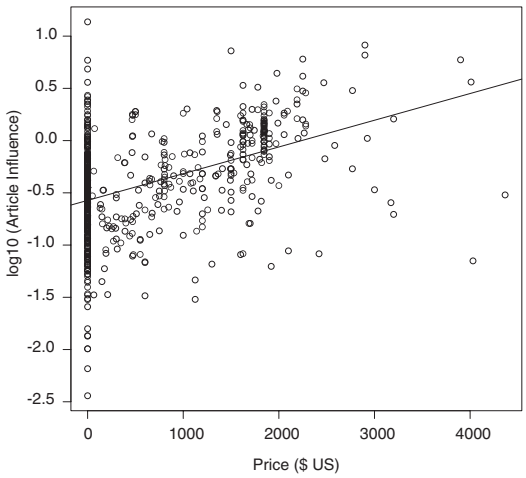
Of the open access journals in our study, 71% request no article processing charges whatsoever. These journals account for about 1/3 of the citations received by open access journals. Journals without processing charges are able to cover their costs in a number of different ways. It is important to realize that an efficiently run access journal can operate with very low costs. Founders and editors of three open access journals, Stuart Shieber, of the *Journal of Machine Learning Research* (see http://blogs.law.harvard.edu/pamphlet/2012/03/06/an-efficient-journal), Conley and Wooders (2009) of *Economics Bulletin*, and Caveleri et al. (2009) of the *European Journal of Comparative Economics* supply detailed explanations of how an open access journal can be published cheaply. From the time of its founding in 2006 until its takeover by the Econometric Society in 2010, the open access journal *Theoretical Economics* was able to cover all of its costs with a $75 submission fee and no author processing charge. (See http://econtheory.org/history.php for a brief history of this journal.) Many open access journals benefit from subsidies paid by government agencies (*Emerging Infectious Diseases*), nonprofit foundations (*eLife*), or scholarly societies (*Journal of Economic Perspectives*). Some journals may initially be free or inexpensive, in hopes of building up a reputation and later raising prices.

To investigate the relationship between article processing charges and journal prestige, we collected pricing information on 985 open access journals from 422 different publishers as of January 2012. To provide an overview of these data, Figure 3 shows the 2010 Article Influence scores and 2012 article processing charges for the JCR-listed open access journals.

Figure 4 compares the distribution of Article Influence scores for the open access journals with the distribution for non-open-access journals. The mean Article Influence score for all open access journals in 2010 is 0.737. The mean Article Influence score in 2010 for non-open access journals is 0.776. These means are not significantly different (Mann-Whitney p value = .2198).

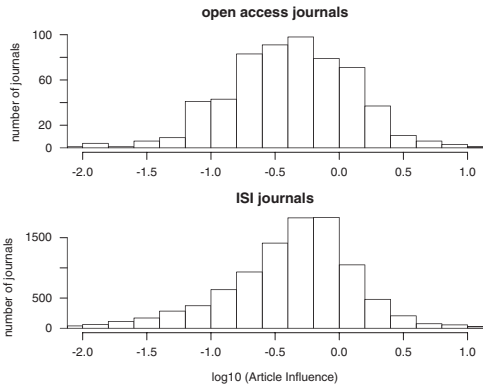
Figure 5 shows a histogram of the article processing charges levied by open access journals. The modal cost is zero, highlighting the large number of free open access journals in the data

FIGURE 3
Article Influence Score Versus Article Processing Charges



Notes: Only JCR-listed journals are included in this graph. The Article Influence scores are log transformed. The linear regression line indicates that more prestigious journals tend to have higher article processing charges.

FIGURE 4
Article Influence Distributions for Open Access Journals (top) and Non-Open-Access Journals (bottom)

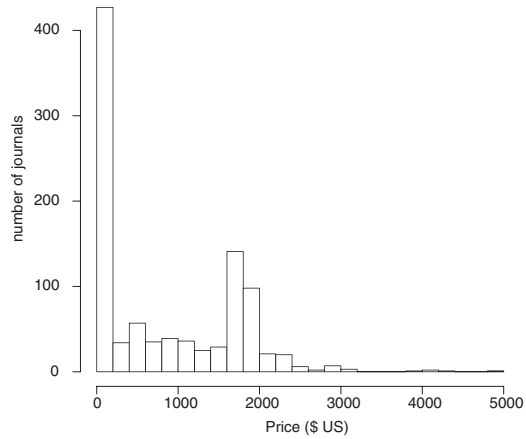


Note: The Article Influence scores are log (base 10) transformed.

set. Another prominent peak just below $2,000 indicates a common price point for many journals that require article processing charges.

For some applications it may be desirable to quantify the cost effectiveness of open access venues using one single number. We do this

FIGURE 5
Article Processing Charges for Open Access Journals in 2012



by looking at the ratio of Article Influence to article processing charges. We define the *cost effectiveness* of a journal as (1000 * Article Influence/article processing charges). We provide cost effectiveness values for the major open access journals, and within each discipline we list open access publications ranked from the most to the least cost effective. We are able to compute Article Influence scores only for those journals listed in Thomson-Reuters' JCR. While the JCR includes over 10,000 total publications and more than 1,000 open access publications in 2011,[4] some newer open access journals and many lesser-known ones are not included in this list. We provide partial information for these journals, including ISSN number and article processing charges where possible, at http://www.eigenfactor.org/openaccess/nonISI.php. Some of these journals may represent good value as well, though potential authors should think carefully about the prestige and readership to be gained from publishing in journals not included in the JCR.

Open access journals offer several different pricing models. In our data set, there were 480 journals that charge a fixed fee per article. Table 4 lists the top 10 of these ranked by cost effectiveness. An additional 357 journals charge no article processing charges whatsoever; we refer to these

4. Early on, Wouter Gerritsma compiled a useful list of the open access journals indexed in the Thomson-Reuters Journal Citation Reports (Gerritsma 2011).

TABLE 4
Top 10 Author-Pay Open Access Journals Ordered by Cost Effectiveness (CE), i.e., 1,000*Article Influence Score Divided by Price

Journal	AI	Price	CE
1. *Publication of the Astronomical Society of Japan*	1.302	$73	17.841
2. *Journal of Physiology and Pharmacology*	0.510	$64	7.976
3. *Asian Pacific Journal of Cancer Prevention*	0.296	$50	5.918
4. *Oceanography*	1.898	$500	3.795
5. *DNA Research*	1.897	$500	3.793
6. *Molecular Medicine*	1.769	$500	3.538
7. *PLoS Biology*	8.211	$2,900	2.831
8. *PLoS Genetics*	6.027	$2,250	2.679
9. *PLoS Medicine*	6.580	$2,900	2.269
10. *Evolutionary Bioinformatics*	4.408	$1,980	2.226

Notes: AI is the Article Influence score. This list includes only JCR-listed open access journals that charge by the article, rather than by the page.

TABLE 5
Top 10 Free Open Access Journals Ordered by Article Influence (AI) Score

Journal	Category	AI
1. *Living Reviews in Relativity*	High Energy Physics	13.691
2. *Journal of Economic Perspectives*	Economics	5.880
3. *Aldrichimica Acta*	Physics	4.840
4. *Bulletin of the American Mathematical Society*	Mathematics	3.611
5. *Bulletin of the American Museum of Natural History*	Ecology & Evolution	2.716
6. *European Cells & Materials*	Pharmacology	2.638
7. *Journal of Machine Learning Research*	Information Theory	2.448
8. *Bulletin of the World Health Organization*	Medicine	2.375
9. *Emerging Infectious Diseases*	Infectious Diseases	2.240
10. *Bayesian Analysis*	Prob & Stats	2.237

as free journals. Table 5 lists the top 10 free journals ranked by Article Influence score. Finally, 148 journals charge by the page rather than by the article. For these journals, we multiplied the price per page by an article length of 15 pages to determine the article processing charges used in our analysis.

IV. CODA

In this article, we develop a tool to help authors comparison shop among alternative open access venues. In general, authors should prefer journals with higher article influence scores and lower article processing charges. A separate question which we have not treated in detail here is that of how universities or funding agencies should subsidize open access publishing. In discussion of subscription-based publishing, Shieber (2009) draws the analogy between academic publishing and medical care. In both cases, consumers do not pay directly for what they consume and thus do not respond to price incentives (Shieber 2009). Shieber acknowledges, but largely dismisses, the potential for a similar problem with subsidized article processing charges. Our view is that full subsidies of article processing charges will create the same problems that arise under subscription-based publishing. We believe that it would be wiser for funders to support open access in ways that encourage price competition among open access publishers. A way to ensure that authors remain sensitive to price differences would be for funders to bear only a fraction of the cost beyond some low threshold (e.g., $500). In economic terms, we want the price elasticity of demand to remain high. Of course, university administrators should be attentive to quality as well as price. Subsidizing publication in low-quality, low-prestige venues is not likely to be in a university's best interest.

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