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Open Access and Academic Journal Quality

Mark J. McCabe and Christopher M. Snyder*

Scholars and librarians have grown increasingly dissatisfied with the market for academic journals. New technologies might be expected to lower journals' production and distribution costs, and for these reduced costs to factor into reduced prices; but library subscription prices remain high (Theodore Bergstrom 2001) and indeed have continued to rise faster than inflation (Mark McCabe 2002). This dissatisfaction has led to the proposal of a new business model for academic journals, open access. In contrast to a traditional journal, which generates most of its revenue with subscription fees, an open-access journal makes its articles freely available on the Internet, generating revenue with author fees. As of October 2004, the Directory of Open Access Journals (www.doaj.org) listed over 1,300 open-access journals across academic fields. Perhaps the most famous of these are published by the Public Library of Science, *PLoS Medicine* and *PLoS Biology*, founded by Nobel-prize-winning biologist Harold Varmus to compete against the top-tier journals in the field. The journals charge substantial author fees, $1,500 per accepted paper.[1]

Much of the previous theoretical work on academic journals (see, e.g., Doh-Shin Jeon and Domenico Menicucci 2003 and McCabe 2004) cannot be used to study open access because it only considers one side of the market, library subscriptions, and does not endogenize author fees on the other side of the market. In an earlier paper (McCabe and Christopher Snyder 2004a), we constructed a two-sided-market model with bilateral externalities (readers obtain benefits from reading and authors obtain benefits from being read). We showed that a commercial journal is more likely to adopt open access the lower its market power, the lower its marginal cost of serving readers, and the greater are author benefits relative to reader benefits.

The last result holds because, if authors have relatively high benefits per reader, the journal will try to recruit more readers by lowering subscription fees, thus increasing the revenue that can be extracted from authors. We proved a series of "anything is possible" results, providing cases in which even a monopoly journal would adopt open access in equilibrium and other examples in which open access is not socially efficient even if the marginal cost of serving readers were zero.

In the present paper, we extend our previous model to allow articles and journals to vary in quality. Good articles provide a reader benefit; bad articles do not. Readers cannot tell the quality of articles prior to reading them, and reading an article requires an effort cost. Journals' quality differences emerge endogenously through the talent of their editors, where more talented editors can distinguish between good and bad articles with more precision. High-quality journals thus publish more good articles.

This extension is useful because it allows for a more realistic depiction of journals. It also allows us to answer new questions of policy relevance about open access. First, should we expect to see open access being more likely to emerge at the high-quality or low-quality end of the journal spectrum? Harold Varmus suggested open access should emerge at the high end: "The most important thing is that we, as publishers of open access journals, want our journals to be high quality. It is the only way we are going to succeed" (House of Commons 2004, p. 80). The House of Commons Science and Technology Committee concluded otherwise: "There is a risk that some parts of the market would be able to produce journals quickly, at high volume and with reduced quality control and still succeed in terms of profit, if not reputation. Such journals would cater for those academics for whom reputation and impact were less important factors than publication itself" (House of Commons 2004, p. 80). Second, should we expect open-access journals to lower their quality standards in order to boost revenue from author fees? Such

is the attack often leveled against open access by commercial publishers, for example the CEO of Elsevier: "If you are receiving potential payment for every article submitted there is an inherent conflict of interest that could threaten the quality of the peer review system" (House of Commons 2004, p. 81).

I. Model

There are three sorts of agents in the model: a unit mass of authors, a unit mass of readers, and a single commercial (i.e., profit-maximizing) journal. Authors submit articles of varying quality to the journal. The journal (more precisely, the journal's editor; the two labels will be used interchangeably here) judges the quality of the submitted articles and accepts a subset. Accepted articles are bundled together in an issue and distributed to readers.

Each author is endowed with a single article. Authors obtain a benefit $b_a \geq 0$ per reader, derived in part from the fact that having more readers increases the article's impact and chances of being cited and thus improves the author's career prospects. The analysis is considerably simplified without much loss of insight with the assumption that all authors have the same benefit b_a. Articles are of random quality. A fraction $\gamma \in [0,1]$ of them are "good" and $1-\gamma$ are "bad". Readers will only obtain a benefit from reading good articles. Since there will be a cost per article of reading, readers will prefer journals that have a high percentage of good articles. To simplify the model, assume authors do not know their own article's quality prior to submission.[2]

The editor can only imperfectly determine an article's quality, depending on his talent, $t \in [0,1]$. The editor can perfectly identify good articles as being good. With probability *t*, he correctly identifies a bad article as being bad. With probability 1-*t*, he mistakenly judges a bad article to be good. Assume *t* is public information.

Readers obtain no benefit from reading bad articles. Reader *k* obtains benefit $b_{rk} \geq 0$ per good article read. Assume b_{rk} is a random variable with cumulative distribution function *F* and density *f*. Reading an article requires effort, which costs the reader $\rho \geq 0$. Hence the reader wishes to avoid reading bad articles, which provide no benefit but are costly to read. The reader cannot determine the quality of an article prior to reading it.

Let $c_s \geq 0$ be the journal's cost of handling a submitted article up through and including the process of judging its quality, reflecting the cost of referees' and editor's time and any administrative costs of processing the author's account. Let $c_a \geq 0$ be the cost of processing an accepted article, reflecting copyediting, typesetting, and administrative expenses. The cost of distributing the articles to a single reader includes a fixed cost $c_r \geq 0$ for the bundle of articles in the journal (reflecting the cost of servicing the reader's account and any fixed shipping and handling costs) plus a variable cost *c* per article (reflecting remaining variable shipping costs, including the cost of bandwidth in the case of Internet distribution).

The journal charges submission fee p_s and, conditional on acceptance, accepted-paper fee p_a. The journal charges readers subscription fee p_r for the bundle of articles in the journal. We will constrain prices p_s, p_a, and p_r to be non-negative.[3] Assume an article's quality cannot be verified ex post, so, in particular, the journal's pricing scheme cannot be conditioned on realized quality (although in equilibrium fees will depend on editorial talent).

The timing of the model is as follows. First, the journal chooses prices. Then authors and readers simultaneously make their submission and subscription decisions. Finally, the journal decides which articles to accept or reject. We will look for a subgame-perfect, rational-

expectations equilibrium in which outcomes on any subgame involving the infinitesimal players (authors and/or readers) is a strong Nash equilibrium (Robert Aumann 1959).[4]

II. Will High-Quality Journals Adopt Open Access?

Taking the case of a monopoly commercial journal, we will perform the comparative-statics exercise of examining the effect of a change in the editor's talent *t* on the equilibrium subscription price with the goal of determining whether a high- or low-quality journal would be more likely to adopt open access.

In this section, we will maintain the assumption that the editor can commit to a policy of only accepting articles believed to be good. Under this editorial policy, the probability of acceptance, denoted α, is $\alpha = \gamma + (1-\gamma)(1-t)$. Journal profit is

$$(1) \qquad p_s n_a + \alpha\, p_a n_a + p_r n_r - TC(n_a, n_r),$$

where $TC(n_a, n_r)$ is the total cost function

$$(2) \qquad TC(n_a, n_r) = n_a c_s + \alpha\, n_a c_a + n_r c_r + \alpha\, n_a n_r c.$$

Aggregate author demand is inelastic because authors are homogeneous. The number of submissions is positive, equal to the unit mass of authors, if and only if net author surplus,

$$(3) \qquad \alpha(n_r b_a - p_a) - p_s$$

is non-negative. Reader *k*'s expected net surplus from subscribing to the journal is

$$(4) \qquad \gamma\, n_a b_{rk} - \alpha\, n_a \rho - p_r.$$

Reader *k* will subscribe to the journal if expression (4) is non-negative, implying that aggregate reader demand is

$$(5) \qquad n_r = 1 - F\left(\frac{p_r + \alpha\, n_a \rho}{\gamma\, n_a}\right).$$

Conditional on the level of the total expected payment from an author to the journal $p_s + \alpha\, p_a$, the particular division into subscription fee p_s and acceptance fee p_a is irrelevant. (This division will become relevant in the next section.) Without loss of generality, we will set the equilibrium submission fee, p_s^*, to 0. Then the equilibrium acceptance fee will be the highest value subject to author demand being positive. From equation (3), the equilibrium acceptance fee and author demand satisfy $p_a^* = n_r^* b_a$ and $n_a^* = 1$. The equilibrium subscription fee maximizes journal profit, which, upon substituting $p_a = n_r b_a$ and $n_a = 1$ as well as equations (2) and (5) into (1), becomes

$$(6) \qquad \Pi(p_r) = (\alpha b_a + p_r - c_r - \alpha c)\left[1 - F\left(\frac{p_r + \alpha\rho}{\gamma}\right)\right] - c_s - \alpha c_a.$$

Applying the implicit function rule to equation (6) yields the following proposition (see McCabe and Snyder 2004b for details).

PROPOSITION 1. Assume $b_a > \rho + c$. Assume the second-order condition from maximization of profit in equation (6) holds. The equilibrium subscription fee p_r^* charged by a commercial journal is weakly increasing in journal quality/editorial talent, *t*.

Proposition 1 states that, under the conditions of the proposition,[5] the subscription fee is increasing in editorial talent, implying that if a high-quality journal adopts open access in equilibrium, a lower-quality journal would as well. Hence, under the conditions of the proposition, a low-quality journal would be more likely to adopt open access.[6] The intuition for the result is that as journal quality (equivalently, editorial talent) increases, authors suffer a direct

loss and readers enjoy a direct benefit. The direct loss to an author is that his article is published with lower probability since his article may be bad, and bad papers are more likely to be rejected. The direct benefit to a reader is that his cost of reading the journal falls because the journal contains fewer bad articles. The journal optimally responds to the relative changes in surpluses by reducing author fees and increasing reader fees.

III. Will Open-Access Journals Cheat on Quality?

As noted in the introduction, critics of open access state that open access will lead to a corruption of the editorial process. Because an open-access journal obtains its revenue from authors rather than readers, it may have to charge high author fees to be viable. Once high author fees are in place, the journal would have an incentive to publish many articles to boost revenue, lowering editorial standards if need be.

To address this issue of possible "overpublishing" by open-access journals, we will examine a model in which the journal cannot commit to abide by the editorial standard of accepting only those articles believed to be good. Rather, the journal makes its editorial after pricing, submission, and subscription decisions have been sunk. A commercial journal would then make the acceptance/rejection decision solely to maximize ex post profit. To make the commitment problem as severe as possible, we maintain a static model, abstracting from any long-run concerns for reputation that might mitigate the commitment problem.

The next proposition states that, even though the model has been designed to make the commitment problem as severe as possible, the commitment problem has no bite in the model: the journal can obtain the same profit if it is not able to commit to an editorial policy as it could if it were able to commit.

PROPOSITION 2. Let p_s^*, p_a^*, and p_r^* be the price scheme for a journal that can commit to an editorial policy of only accepting articles believed to be good, where, without loss of generality, $p_s^* = 0$. Let n_r^* be the equilibrium number of readers, i.e., $n_r^* = 1 - F((p_r^* + \alpha\rho)/\gamma)$. Letting p_s^{**}, p_a^{**}, and p_r^{**} be the optimal prices in the no-commitment case, a journal that cannot commit to an editorial policy can obtain the same profit as the journal that can commit by setting $p_s^{**} = \alpha[n_r^*(b_a - c) - c_a]$, $p_a^{**} = n_r^* c + c_a$, and $p_r^{**} = p_r^*$.

As opposed to the case in the previous section in which the journal could commit to an editorial policy, a case in which there were a whole range of combinations of submission and acceptance fees that could provide an optimum for the journal, when the journal cannot commit to an editorial policy, the division of author fees into submission and acceptance fees is crucial. The acceptance fee must be set to the marginal cost of an additional acceptance $n_r^* c + c_a$. If the acceptance fee is set higher, the journal will "overpublish." If the acceptance fee is set lower, the journal will "underpublish."[7]

The normative lesson from Proposition 2 is that journals should design their author-fee schedule with care. The proposition suggests merits of reducing the acceptance fee to the marginal cost of accepting an article, extracting further author surplus by raising the submission fee. The author-fee schedules of some prominent open-access journals do not appear to conform to this normative lesson. The Public Library of Science journals mentioned in the introduction charge $1,500 acceptance fees and no submission fees. Another prominent set of open-access journals, the BioMed Central journals, have acceptance fees ranging from $500 to $1,000 but, again, no submission fees. It may be the case that these journals are confident that a desire to

maintain a long-run reputation is sufficient to mitigate the "overpublishing" problem. Still, there would appear to be little loss, and the potential gain in the commitment to quality standards, from having more balance between submission and acceptance fees. The Berkeley Electronic Press economics journals (not open access journals, but online journals that charge relatively high author fees) have a fee schedule that is closer to that suggested by Proposition 2. These journals charge a $350 submission fee (or an agreement to referee two papers) and no acceptance fees. Given these journals do little copyediting after accepting articles and have a fairly automated system of posting articles online, it is plausible to suppose the parameters c_a and c are near zero for these journals, so that an acceptance fee near zero is plausibly close to their marginal cost of accepting an article.

IV. Conclusion

In this paper, we constructed a simple model of journal quality. Authors submit articles of unknown quality to a journal. The quality of the journal is related to the talent of the editor in distinguishing bad from good articles. High-quality articles are valuable to readers because they contain fewer bad articles that are costly to read but provide no benefit. The journal can potentially charge fees to both sides of the market, authors and readers, and can further subdivide author fees into submission and acceptance fees.

In Section II, we highlighted some effects that would lead low-quality journals to adopt open access more readily than high-quality journals. In Section III, we evaluated the claim that open access, because it involves author fees, may degrade quality as journals publish more, lower-quality articles to boost revenue. We showed that a judicious division of author fees into submission and acceptance fees would mitigate this problem.

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Footnotes

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[1] In economics, the adoption of open access has been relatively slow, with only nine refereed open-access journals listed on the Directory of Open Access Journals. None of these charges author fees, operating on donated institutional support.

[2] This assumption is consistent with a number of other recent papers involving quality certification by an intermediary (Josh Lerner and Jean Tirole 2004, Alan Morrison and Lucy White 2004). It serves to simplify the analysis by abstracting from complicated signaling behavior by informed authors. Lerner and Tirole show that adding upstream private information does not alter their basic analysis (their Proposition 4).

[3] Journals may subsidize authors and readers, in that prices may be set below marginal cost, but journals are assumed not to make explicit cash transfers to authors or readers. The restriction of cash transfers appears to be nearly universal among scholarly journals.

[4] A strong Nash equilibrium requires the outcome to be immune to profitable deviations by any coalition of the infinitesimal players. See the more detailed theoretical paper on which this article is based, McCabe and Snyder (2004b), for a discussion of the role of this refinement.

[5] A few remarks about the conditions behind Proposition 1 are in order. The condition $b_a > \rho + c$ implies that an author's benefit from having his article read exceeds the generalized

marginal cost of reading it, including the marginal cost of shipping the article to a reader, *c*, and the reader's marginal effort cost ρ. The second-order condition associated with the objective function (6) holds if the slope of *f* is not too negative at an optimum. The condition holds for various distributions including the uniform.

[6] There exist examples in which a profit-maximizing journal adopts open access if it has a low *t* but does not if it has a high *t*. In particular, it can be shown that, assuming *F* is the uniform distribution on [0,1], the journal adopts open access if and only if

$$t \leq \frac{\rho + b_a - c_r - c - \gamma}{(b_a + \rho - c)(1-\gamma)}.$$

[7] In this simple model, a journal that "overpublishes" publishes all articles, those known to be bad as well as those believed to be good; and a journal that "underpublishes" publishes no articles. Of course if one included additional elements in the model such as concern for long-run reputation, one could avoid the stark "all or nothing" results that emerge if p_a^{**} is not set to marginal acceptance cost $n_r^* c + c_a$. Principal-agent frictions between the owners of a commercial journal and its editors may somewhat paradoxically help maintain editorial standards. Assuming the editor obtains at least a small private benefit from the journal's reputation, he can be induced to maintain quality standards and ignore profit considerations by paying him a wage that does not vary with journal profit. Harold Varmus made this point: "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" (House of Commons Science and Technology Committee 2004, p. 80).