A Model of Academic Journal Quality with Applications to Open-Access Journals

Mark J. McCabe
Georgia Institute of Technology

Christopher M. Snyder
George Washington University

March 7, 2005

Abstract: Previous research modeled academic journals as platforms connecting authors with readers in a two-sided market. This research used the same basic framework also used to study telephony, credit cards, video game consoles, etc. In this paper, we focus on a key difference between the market for academic journals and these other markets: journals vary in terms of quality, where a journal's quality determined by the quality of the papers it publishes. We provide a simple model of journal quality. As an illustration of the value of the model, we use it to address issues that have arisen in the recent debate concerning whether, in the Internet age, journals should become "open access" (freely available to readers, financed by author rather than subscriber fees). Among other issues, we examine (a) whether open-access journals would tend to publish more articles than traditional journals, moving further down the quality spectrum in order to boost revenue; (b) whether journal quality affects the profitability of adopting open access; and (c) whether submission fees or acceptance fees are better instruments to extract surplus from authors.

Keywords: Open access, academic journal, two-sided market, quality

Journal of Economic Literature Codes: L14, L82, D40, L31

Contact Information: Mark McCabe, School of Economics, Georgia Institute of Technology, 781 Marietta Street, N.W., Atlanta, GA 30318, email mark.mccabe@econ.gatech.edu, tel. (404) 385–0512. Christopher M. Snyder, Department of Economics, George Washington University, 1922 F Street N.W., Washington DC 20052, email csnyder@gwu.edu, tel. (202) 994-6581.

Acknowledgments: We are grateful for funding provided by grants from the Open Society Institute and the NET Institute.

1 Introduction

There has been growing dissatisfaction among some scholars and librarians with the academic journals market. While one might expect increased use of the Internet to lower journals' distribution costs, and for these reduced costs to factor into reduced prices, in fact library subscription prices have continued to increase faster than the rate of inflation (McCabe 2002, Wellcome Trust 2003). 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, library subscription fees in particular, an open-access journal makes its articles freely available on the Internet, generating its revenue with author fees. As of October, 2004, the Directory of Open Access Journals listed over 1,300 open access journals across scholarly fields.[1] Perhaps the most famous open-access journals are those published by the Public Library of Science, *PLoS Medicine* and *PLoS Biology*, founded by Nobel Prize winning biologist, Harold Varmus, with the stated goal of competing with the top-tier journals in biomedicine. The PLoS journals charge $1,500 author fees. 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 open-access economics journals charges author fees, operating on donated institutional support.

In this paper, we build on two strands of the previous economics literature on the market for academic journals. One strand (Jeon and Menicucci 2003, McCabe 2004) posits journals of different quality, but only considers one side of the market, library subscriptions. To analyze open access requires a two-sided-market model, with author fees as well as subscription fees. A second strand of the literature (McCabe and Snyder 2004) considers such a two-sided-market model. However, McCabe and Snyder (2004) abstracts from a potentially important aspect of the journals market, quality. The present paper builds a two-sided-market model in which articles

[1] Data downloaded on October 31, 2004, from the Directory of Open Access Journals' website, www.doaj.org.

may differ 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.

The paper is structured as follows. Section 2 sets up the model. For simplicity we focus on a monopoly journal with inelastic author demand and elastic reader demand.

Section 3 analyzes the interaction between a journal's quality and its propensity to adopt open access. We show that the answer depends on the journal's objective function, with different answers emerging for a profit-maximizing journal than for a non-profit journal that maximizes social welfare subject to a break-even constraint. Our motive for studying this interaction is to add some formal analysis to the ongoing debate concerning which end of the journal market open access will flourish. Public Library of Science founder Harold Varmus suggests open access will flourish 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 Science and Technology Committee 2004, p. 80). The House of Commons Science and Technology Committee suggested the opposite outcome might be possible: "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 to those academics for whom reputation and impact were less important factors than publication itself" (House of Commons Science and Technology Committee 2004, p. 80).

Section 4 addresses another issue that arises with open access, namely whether charging author fees would lead open-access journals to publish more papers to boost revenue, with the marginal papers being lower on the quality ladder. Attacking the open-access model, the Chief Executive Officer of Elsevier, Crispin Davis, stated, "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," sentiment supported by a representative of Blackwell Publishing, "The subscription based model favours rejection, which is especially important, for example, in clinical medicine, where the risks associated with publishing substandard material are higher," an argument Harold Varmus dismissed as "rubbish" (House of Commons Science and Technology Committee 2004, pp. 81). To address the issue, we modify the model by having the editor move last in making the acceptance/rejection decision for articles, after prices have been set and submission and subscription decisions made. We analyze the consequences for assuming the editor cannot commit to an editorial policy such as accepting only articles believed to be good. Even in a static model without dynamic reputation concerns in which one might expect the lack-of-commitment problem to be most severe, we show that the commitment outcome can be recovered by carefully choosing the menu of submission and acceptance fees.

As mentioned above, the present paper is related to two strands of the literature on the market for academic journals. We build on the first strand of the literature not only by providing a two-sided-market model, as mentioned, but also by endogenizing journal quality. In Jeon and Menicucci (2003) and McCabe (2004), journal quality is an exogenous parameter. The present paper builds on the second strand of the literature by adding a quality dimension for articles and journals. The quality model in the present paper represents a three-fold contribution. First, it provides a more realistic model of the journal market. Second, it allows us to answer a new set of questions about the relationship between quality and open access. Third, and most fundamental, it provides a better justification for the existence of journals. While McCabe and Snyder (2004) forced authors to distribute articles through journals for exogenous reasons, here journals provide a screening function, saving readers time wasted reading bad articles. More broadly, the present paper is related to some recent research on quality screening by intermediaries in two-sided markets. Lerner and Tirole (2004) construct a model in which standard-setting organizations are intermediaries between technology sponsors and end users. Intermediaries obtain perfect signals of the value to end users of submitted technologies and choose whether or not to certify the technologies as being good or bad for end users. Intermediaries are benevolent, differing in the weights they put on the surpluses of the two sides of the market in their objective functions. Our model differs from Lerner and Tirole's (2004) in that our intermediaries (journals) obtain imperfect signals of article quality. Journal editors differ in the precision of their signals of article quality. Another difference is that, in addition to considering benevolent intermediaries (we analyze non-profit journals that place an equal weight on surpluses of the two sides of the market), we also consider profit-maximizing intermediaries. Our model is perhaps closest to Morrison and White's (2004). In Morrison and White (2004), the intermediaries are regulators that license banks as being sound or unsound. Regulators in different countries differ in the prior probability that they have a viable screening technology. Their model differs from ours in that their intermediaries are benevolent and in addition do not charge licensing fees, so the central question in our analysis, the level of access prices on the two sides of the market, is not an issue in their paper.

2 Model

There are three sorts of agents in the model: authors, readers, and a journal. There will be an identity between the journal and the journal's editor—we will not investigate the possible agency relationship within the journal in this paper—so we will use the terms synonymously. Authors submit articles of varying quality to the journal. The editor 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.[2] Authors obtain a benefit $b_a \geq 0$ per reader. This term embodies a number of potential benefits. It embodies the pure enjoyment of being read by an additional reader. It embodies the benefit of being published and thus certified by

[2] As we will see, the benefit per article is linear in the number of readers, so it would be straightforward to handle the case of multiple articles per author by treating the articles as being written by different authors.

a scholarly journal. Certification in this way is beneficial because it enhances the author's curriculum vitae and thus improves the author's career prospects (i.e., for tenure, promotion, outside offers, etc.). This certification benefit can be thought of as increasing with the number of readers since publication in a widely-read journal carries with it greater impact. The term b_a also embodies the benefit from the expected number of citations by an additional reader. Citations benefit authors because they are used as a measure of impact that again affects 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. Normalize the mass of authors to unity.

Articles are of random quality. A fraction $\gamma \in [0, 1]$ of them are "good" and $1 - \gamma$ are "bad". As we will see, 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. This assumption is consistent with a number of other recent papers involving quality certification by an intermediary (Lerner and Tirole 2004, Morrison and White 2004). It serves to simplify the analysis by abstracting from complicated signaling behavior by informed authors. Lerner and Tirole (2004, Proposition 4) show that adding upstream private information does not alter their basic analysis.

The editor can only imperfectly determine an article's quality, depending on his talent, $t \in [0, 1]$, in the following way. 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. We will make various assumptions about the editor's ability to commit to an editorial policy. We will first assume in Section 3 that the editor can commit to accepting a paper if and only if he believes it to be good. In Section 4, we will investigate the alternative assumption that the editor cannot commit to an editorial policy, raising the possibility that he may accept some bad articles in order to increase the journal's revenues from acceptance fees.

Readers obtain no benefit from reading bad articles. Reader k obtains benefit $b_{rk} \geq 0$ per good article read. This term embodies the benefit the reader obtains from the information contained in a good article. Assume b_{rk} is a random variable with cumulative distribution function F and density f. Normalize the mass of readers to unity. 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. He cannot determine the quality of an article prior to reading it.[3]

The benefits that readers provide authors and vice versa are externalities. That is, we assume there is no way for an author to pay readers for the benefit their reading confers to him. Similarly, there is no way for a reader to pay authors directly for the benefit of their articles. It may be possible for a reader to pay authors indirectly by passing subscription fees back to authors, but as will be seen we will impose an exogenous limit on these payments by assuming, as is consistent with industry practice, that journals cannot make positive payments to authors. Given that there are externalities flowing both ways in this market, it is a classic example of what the economic literature refers to as a two-sided market. See Rochet and Tirole (2004) for a discussion and review of the literature. In ordinary markets, as is taught in introductory microeconomics courses, the incidence of a tax is the same regardless of the side on which it is assessed (i.e., the seller or the buyer side). Because of the externalities, in two-sided markets, the side of the market on which a tax is assessed does have real economic effects. More to the point in our application, economic outcomes will depend on the level of author and reader fees individually, not just some aggregation of them such as the sum.

Let c_s be the editor's/journal's cost of handling a submitted article up through and including the process of judging its quality. Thus c_s includes 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

[3] Though the reader obtains a differential benefit from good and bad articles, we are not necessarily assuming that the reader can perfectly determine the quality of an article upon reading it. The reader may not make a conscious determination, or the determination may only be made a considerable time after reading it. Thus, readers may not be a substitute for editors in judging article quality.

an accepted article up through and including the "first copy" cost of the published article. Thus c_a includes copyediting, typesetting, and administrative expenses. The cost of distributing the articles to a single reader includes a fixed cost c_r for the bundle of articles in the journal plus a variable cost c per article. The fixed cost c_r includes the cost of servicing the reader's account and any fixed shipping and handling costs. The remaining (variable) shipping costs are embodied in c. Shipping costs can include 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. Following general market conventions, we will take p_r to be a fee for the bundle of articles in a journal, independent of the number of articles the journal contains. Also following general market conventions, we will constrain prices p_s, p_a, and p_r to be non-negative. Journals may subsidize authors and readers, in that prices may be set below marginal cost, but journals cannot make explicit cash transfers to authors or readers. The restriction of cash transfers appears to be nearly universal among scholarly journals. We suspect journals' strong motivation for this restriction is to avoid the appearance of corruption. It would be interesting to develop a broader model in which this restriction arises endogenously, but in this paper it is imposed exogenously. 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 p_s, p_a, and p_r. Then authors and readers simultaneously make their submission and subscription decisions. Finally, the editor decides which articles to accept or reject.

We will look for a subgame-perfect, rational-expectations equilibrium. The existence of the infinitesimal players (authors and readers) generates a multiplicity of such equilibria, supported in many cases by anomalous coordination behavior. For example, there will exist a subgame-perfect, rational-expectations equilibrium with marginal-cost pricing. The equilibrium is supported by author and reader strategies of refusing to deal with the journal unless the journal prices at marginal cost. The journal cannot make positive profit; so it may as well price at cost. There is no incentive for an author (respectively, a reader) to deviate unilaterally if the journal charges higher prices since it obtains no surplus from dealing with a journal with no readers (respectively, authors). We say that such equilibria are supported by "anomalous" coordination behavior because the infinitesimal players are coordinating on an outcome that is Pareto dominated by another. We thus will strengthen our subgame-perfect, rational-expectations equilibrium concept to require the outcome on any proper subgame played by the infinitesimal players to be a strong Nash equilibrium (Aumann 1959). A strong Nash equilibrium requires the outcome to be immune to profitable deviations by any coalition of the infinitesimal players. An immediate consequence of the definition is that a strong Nash equilibrium is a Pareto optimum for the infinitesimal players within the feasible payoff space of the subgame.[4]

3 Commitment to Editorial Policy

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 $\alpha = \gamma + (1-\gamma)(1-t)$.

We begin by analyzing author demand. Suppose n_a authors submit an article to the journal and n^r readers subscribe. The journal's profit is

$$p_s n_a + p_a \alpha n_a + p_r n_r - TC(n_a, n_r), \tag{1}$$

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

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

[4]The existence problem that often arises with strong Nash equilibrium (Bernheim, Peleg, and Whinston 1987) does not arise in our setting because infinitesimal players play a coordination game in which they have common interests.

If an author submits his paper to the journal, he obtains expected net surplus

$$\alpha(n_r b_a - p_a) - p_s. \tag{3}$$

With probability α, the author's article is accepted, yielding him net surplus $n_r b_a - p_a$. The author must pay the submission fee p_s up front. Aggregate author demand is inelastic because authors are homogeneous. Aggregate author demand is positive, equal to the mass of authors (normalized to 1), if and only if expression (3) is positive:

$$n_a = \begin{cases} 1 & \text{if } \alpha n_r b_a \geq p_s + \alpha p_a \\ 0 & \text{if } \alpha n_r b_a < p_s + \alpha p_a. \end{cases} \tag{4}$$

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 when the journal cannot commit to an editorial policy in Section 4.) Without loss of generality, we will set the equilibrium submission fee, p_s^*, to 0.

We next turn to reader demand. If reader k subscribes to the journal, he obtains expected net surplus

$$\gamma n_a b_{rk} - \alpha n_a \rho - p_r. \tag{5}$$

To understand expression (5), note reader k obtains benefit b_{rk} per good article, times the number of good articles published, γn_a. Reader k's cost of reading the journal is ρ per article times the αn_a number of published articles. The reader must also pay subscription fee p_r. Reader k will subscribe to the journal if his surplus given in expression (5) is non-negative, or upon rewriting, if $b_{rk} \geq (p_r + \alpha n_a \rho)/(\gamma n_a)$. Reader demand is thus

$$n_r = 1 - F\left(\frac{p_r + \alpha n_a \rho}{\gamma n_a}\right). \tag{6}$$

3.1 Profit-Maximizing Journal

A profit-maximizing journal will choose p_a to be the highest value possible subject to author demand being positive. From equation (4), the equilibrium acceptance fee and author demand will 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 (6) into (1), becomes

$$\Pi(p_r) = (\alpha b_a + p_r - c_r - \alpha c)\left[1 - F\left(\frac{p_r + \alpha\rho}{\gamma}\right)\right] - c_s - \alpha c_a. \tag{7}$$

The main result of this section regards whether a high- or low-quality journal would be more likely to adopt open access. Taken together, Propositions 1 and 2 imply that a low-quality journal would be more likely to adopt open access. Proposition 1 states that 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. Proposition 2 provides an example in which a low-quality journal adopts open access but a high-quality journal does not. 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.

Proposition 1. *Assume $b_a > \rho + c$. Assume the second-order condition for profit maximization in equation (7) holds. The equilibrium subscription fee p_r^* charged by a profit-maximizing journal is weakly increasing in journal quality/editorial talent, t.*

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 (7) holds if the slope of f is not too negative at an optimum. The condition holds for various distributions including the uniform.

Proposition 2. *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, assume F is the uniform distribution on $[0, 1]$. Then the journal adopts open access if and only if*

$$t \leq \frac{\rho + b_a - c_r - c - \gamma}{(b_a + \rho - c)(1 - \gamma)}. \tag{8}$$

Other comparative statics are straightforward as well. A profit-maximizing journal will charge lower prices, and thus be more likely to adopt open access, the lower are costs c_r and c and the higher are author benefits, b_a.

3.2 Non-Profit Journal

A related set of questions regards the conditions under which a non-profit journal would adopt open access. Suppose that a non-profit journal maximizes social welfare subject to a break-even constraint. In other words, suppose a non-profit journal implements the second best. Since author demand is inelastic, without loss of generality the second-best author fee is the highest value subject to authors having positive demand. As in the previous subsection, $p_a = n_r b_a$, and $n_a = 1$. The following proposition characterizes the optimal subscription fee for a non-profit journal.

Proposition 3. *Social welfare in the second best is weakly decreasing in p_r. Therefore, without loss of generality, the second-best submission fee (equivalently, the non-profit journal's optimal price), p_r^{**}, p_r^{**}, can be taken to be*

$$p_r^{**} = \min\{p_r \geq 0 | \Pi(p_r) \geq 0\}. \tag{9}$$

Monotone comparative statics results along the lines of Milgrom and Roberts (1994) can be applied to the expression for p_r^{**} in equation (9) to derive the comparative-static effect of an increase in journal quality t on p_r^{**}.

Proposition 4. *Consider the following expression:*

$$b_a(1-F) - c_a - c(1-F) - (\alpha b_a + p_r - c_r - \alpha c)\left(\frac{f}{\gamma}\right). \tag{10}$$

If (10) is positive, then p_r^{**} is weakly increasing in t. If (10) is negative then p_r^{**} is weakly decreasing in t.

Note that the arguments on F and f in expression (10) have been dropped for brevity.

There are four separate effects of an increase in journal quality on the second-best submission fee, corresponding to the four terms in (10). The first effect is that authors have a lower probability of publishing with a higher-quality journal, reducing their willingness to pay for publication, in turn reducing revenue from authors. The loss in revenue is proportional to the author benefit from being published, b_a per reader, times the mass of readers $1-F$. To make up for this revenue shortfall, subscription fees need to be raised. The second and third terms reflect the fact that higher-quality journals reject more (bad) articles, reducing acceptance costs, proportional to c_a, and distribution costs, proportional to the cost c per reader times the mass of readers $1-F$. These lower acceptance and distribution costs factor into lower subscription fees. The last term reflects the fact that higher-quality journals require less reader effort and induce more readers to subscribe. The mass of additional readers is proportional to f/γ, and the margin earned on these additional readers is $\alpha b_a + p_r - c_r - \alpha c$.[5] This gain in revenue allows a non-profit journal to lower the subscription fee required to break even.

The terms in (10) do not all have the same signs, suggesting that the sign of dp_r^{**}/dt is ambiguous, in turn suggesting that journal quality has an ambiguous effect on the propensity to adopt open access. The numerical examples in Table 1 bear this suggestion out formally. In Example 1, the low-quality journal adopts open access—note its subscription fee in column (1) is zero—but not the high-quality journal—note the subscription fee in column (2) is 0.058.

[5]The term αb_a is added to this margin because increasing the number of readers increases author surplus and thus raises the maximum fees authors would be willing to pay.

Table 1: Numerical Examples for Non-Profit Journal

	Example 1		Example 2	
	Low-quality journal $t = 0$	High-quality journal $t = 1$	Low-quality journal $t = 0$	High-quality journal $t = 1$
	(1)	(2)	(3)	(4)
Expected author fees	0.195	0.099	0.099	0.059
Subscription fee	0.000	0.058	0.018	0.000
Number authors	1.000	1.000	1.000	1.000
Number readers	0.980	0.874	0.743	0.890
Journal profit	0.085	0.000	0.000	0.006
Consumer surplus	0.400	0.460	0.278	0.344
Social welfare	0.485	0.460	0.278	0.349

Notes: Reader benefits uniformly distributed on $[0, 1]$ in both examples. Example 1 parameters are $c_s = 0.16$, $c_a = c_r = c = 0$, $b_a = 0.25$, $\gamma = 0.5$, and $\rho = 0.01$. Example 2 parameters are $c_s = c_r = c = 0$, $c_a = 0.14$, $b_a = 0.17$, $\gamma = 0.5$, and $\rho = 0.11$.

In Example 2, the reverse is true. In Example 1, author benefits are high, and the low-quality journal's promise of a higher likelihood of publication allows the journal to extract a higher author fee than the high-quality journal. The low-quality journal can therefore afford to charge a lower subscription fee and still break even. The fact that it makes positive profit of 0.085 implies that it could afford to charge a negative submission price, but the constraint $p_r \geq 0$ prevents it from doing so.[6] In Example 2, author benefits, b_a, are lower and the cost of processing an accepted paper, c_a, has been raised relative to Example 1. With a higher c_a, the low-quality journal's costs are substantially higher than the high-quality journal's since the former accepts more papers. The low-quality journal has to raise subscription fees to cover these higher costs,

[6]The non-profit journal could "burn" this profit by reducing author fees, by paying its editorial staff more, or by pursuing additional activities such as sponsoring conferences.

and so cannot adopt open access as does the high-quality journal.

Another feature of the journals market that we have not yet modeled would increase the relative propensity of lower-quality journals to adopt open access. Suppose the opportunity cost of the editor's time is increasing in t. This could be modeled by having a fixed cost of operating the journal that increases with t assuming that operating the journal requires a fixed amount of the editor's time regardless of the number of articles process. It could also be modeled by having the cost of processing a submitted article increase with t (i.e., $c_s = c_s(t)$, with $c_s'(t) > 0$) assuming that more editor time is required when more articles are submitted for review. In either event, this new feature would add another positive term to expression (10), increasing the relative propensity of lower-quality journals to adopt open access. Intuitively, lower-quality journals would be less expensive to run, requiring lower subscription fees to recoup the costs of operation. Of course the correlation between editorial talent and opportunity wage is not perfect in practice. In practice, talented editors may be motivated by public spirit or the prestige of editing a particular journal, and thus might edit the journal for low or no pay.

4 No Commitment to Editorial Policy

As noted in the Introduction, critics of open access, most notably representatives of commercial publishers, 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 "over-publishing" 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 acceptance/rejection decision for articles after pricing, submission, and subscription decisions have been sunk. A profit-maximizing 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 reputational concerns 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 5. *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 $p_r^{***} = p_r^*$, $p_a^{***} = n_r^* c + c_a$, and $p_s^{***} = \alpha[n_r^*(b_a - c) - c_a]$.*

As opposed to the case 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 "over-publish." In this simple model, a journal that "over-publishes" publishes all articles, those known to be bad as well as those believed to be good. If the acceptance fee is set lower, the journal will "under-publish." In this simple model, a journal that "under-publishes" 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 $n_r^* c + c_a$.

Further remarks are in order concerning mechanisms to enhance a journal's ability to commit to an editorial policy besides fine tuning the fee structure as proposed in Proposition 5. In a dynamic model in which editorial talent/journal quality, t, is private information, journals would be concerned with signaling their quality and maintaining a reputation for high quality, either because reputation is explicitly in the journal's objective function, as might be the case for a non-profit journal, or because a profit-maximizing journal cares indirectly about reputation through its effect on the stream of future profits. Principal-agent frictions between the owners of a profit-maximizing 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, founder of the Public Library of Science open-access journals, 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).

In the model, the subscription fee was assumed to be fixed, independent of the number of articles. If subscription fees are increasing in the number of articles, a different form of an "over-publishing" problem arises with subscriber-pays journals. As the House of Commons Science and Technology Committee writes,

> It should be noted that subscriber-pays publishers also have an incentive to publish ever greater numbers of research articles, because, as is shown in paragraph 52 of this Report, increases in the volume of articles are used to justify price increases. For the reasons outlined above, we believe that the publishing process needs to have inbuilt checks and balances that would mitigate against the acceptance of an increasing volume of substandard articles. (House of Commons Science and Technology Committee 2004, p. 80)

This problem could also be solved by setting subscription fees equal to the marginal cost generated by an additional reader. With Internet distribution, this marginal cost is at or near zero, suggesting a subscription fee at or near zero, i.e., open access, would solve the implied commitment problem in the absence of other commitment devices.

The normative lesson from Proposition 5 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 referred to 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 "over-publishing" 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 5. 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.

5 Conclusion

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.

We investigated the optimal fee schedule for profit-maximizing and non-profit journals, paying particular attention to the conditions under which open access emerged in equilibrium. For profit-maximizing journals, we found that low-quality journals are more likely to adopt open access than high-quality journals, all else equal. Compared to a high-quality journal, a lower-quality journal provides readers with less surplus since they have to pay the effort cost of reading more bad articles which provide no value. To maintain a reasonable readership, a lower-quality journal must provide a relative subsidy to readers. Authors do not need to receive as much of a relative subsidy since they obtain some benefit from the increased chance of being published and care only indirectly about journal quality through its affect on the number of readers. This result does not imply that a high-quality, profit-maximizing journal would never adopt open access, but rather that the set of parameters for which it would adopt open access is smaller than for a low-quality journal. The effect of parameters other than quality on a journal's propensity to adopt open access are straightforward: a profit-maximizing journal will charge lower prices, and thus be more likely to adopt open access, the lower are costs of serving readers (fixed costs, c_r, and costs that vary with the number of articles delivered to readers, c) and the higher are author benefits.

We proved that the relationship between journal quality and the propensity to adopt open access is ambiguous for a non-profit journal. Offsetting the effects mentioned above for profit-maximizing journals, there are new effects associated with the break-even constraint for a non-profit journal. One new effect is that, the lower the quality of a journal, the fewer readers it has; and the fewer readers, the less revenue it makes. A non-profit journal must make up for this revenue shortfall in order to break even by charging a higher subscription fee than a higher-quality journal. Another effect in this same direction is that lower-quality journals publish more articles, implying some processing and distribution costs may be higher than for a higher-quality journal, in turn implying that subscription fees may have to be relatively higher for a non-profit journal to break even. We demonstrated numerical examples in which a low-quality journal adopts open access but not a high-quality journal, and examples in which the reverse is true.

The last part of the paper examined the claim that open access, because it involves author fees, may result in the degradation of quality as journals publish more, lower-quality articles to boost revenue. We showed that even in a stark model with no exogenous ability to commit to an editorial policy, including no long-run reputational concerns, journals can obtain the commitment outcome with judicious division of author fees into submission and acceptance fees. In particular, setting the acceptance fee equal to the marginal cost of accepting an additional paper removes any concern about maintaining editorial standards.

In future work, we are interested in extending the model to include authors' private information about the quality of their articles. Extending the model in this way would allow us to analyze signaling strategies involved in the decision to submit to journals of varying quality. It would also allow us to prove new results on the optimal division of author fees into submission and acceptance fees. We are also interested in introducing journal competition in this model as we did in our earlier analysis of a model without quality (McCabe and Snyder 2004).

Appendix

Proof of Proposition 1: Suppose $b_a > \rho + c$. We will show the unconstrained optimal p_r is weakly increasing in t. It will then be immediate that the constrained optimum is also weakly increasing in t. Therefore, ignore the constraint $p_r \geq 0$ for the moment. The first-order condition from the maximization of $\Pi(p_r)$ in (7) with respect to p_r is

$$1 - F - (\alpha b_a + p_r - c_r - \alpha c)\left(\frac{f}{\gamma}\right) = 0, \tag{A1}$$

where the argument $(p_r + \alpha\rho)/\gamma$ has been dropped on f and F for brevity. Differentiating expression (A1) again with respect to p_r and rearranging, we see that the second-order condition implies

$$-\left(\frac{\alpha b_a + p_r - c_r - \alpha c}{\gamma}\right) f' < 2f. \tag{A2}$$

Applying the implicit function rule to the first-order condition (A1), if the second-order condition holds, $dp_r^*/d\alpha$ has the same sign as

$$\begin{aligned}
& -\left[\frac{\rho(\alpha b_a + p_r - c_r - \alpha c)}{\gamma^2}\right] f' - \left(\frac{b_a - c}{\gamma}\right) f - \left(\frac{\rho}{\gamma}\right) f \\
< \; & \left(\frac{\rho}{\gamma}\right) 2f - \left(\frac{b_a - c}{\gamma}\right) f - \left(\frac{\rho}{\gamma}\right) f \\
= \; & \left(\frac{f}{\gamma}\right)(\rho + c - b_a) \\
< \; & 0.
\end{aligned}$$

The second line holds by substituting from (A2). The third line is simple algebra. The last line follows from $b_a > \rho + c$. Therefore,

$$\frac{dp_r^*}{dt} = \left(\frac{dp_r^*}{d\alpha}\right)\left(\frac{d\alpha}{dt}\right) \tag{A3}$$

$$= -(1-\gamma)\frac{dp_r^*}{d\alpha} \tag{A4}$$

$$\geq 0. \tag{A5}$$

Summarizing, for the unconstrained optimum, $dp_r^*/dt \geq 0$. The constrained optimum is thus also weakly increasing in t. $\square$

Proof of Proposition 2: Let F be the uniform distribution on $[0, 1]$. Substituting this functional form into equation (7) yields the following expression for the journal's objective function:

$$\Pi(p_r) = (\alpha b_a + p_r - c_r - \alpha c)\left(\frac{\gamma - p_r - \alpha\gamma}{\gamma}\right) - c_s - \alpha c_a. \tag{A6}$$

The optimal submission price can be found by solving the first-order condition from (A6), which yields:

$$p_r^* = \max\left\{0, \frac{1}{2}[\gamma + c_r - \alpha(b_a + \rho - c)]\right\}. \quad \text{(A7)}$$

The max operator in equation (A7) reflects the fact that the submission price is constrained to be non-negative. Substituting $\alpha = \gamma + (1-\gamma)(1-t)$ into equation (A7) and rearranging implies that $p_r^* = 0$ if and only if condition (8) holds. □

Proof of Proposition 3: In the text, it was argued that, without loss of generality, author prices can be set as $p_s = 0$ and $p_a = n_r b_a$ in the second best. Given these prices, social welfare can be shown to be

$$\int_{(p_r+\alpha\rho)/\gamma}^{\infty} (b_{rk} + b_a - \alpha\rho - c_r - \alpha c) f(b_{rk}) db_{rk} - c_s - \alpha c_a. \quad \text{(A8)}$$

The derivative of the expression in (A8) with respect to p_r is

$$-\frac{f}{\gamma}\left(\frac{p_r + \alpha\rho}{\gamma} + b_a - \alpha\rho - c_r - \alpha c\right), \quad \text{(A9)}$$

where the argument on f has been dropped for brevity. The expression in (A9) is non-positive since the factor in parentheses is non-negative. To see this, note that

$$\begin{aligned} & \frac{p_r + \alpha\rho}{\gamma} + b_a - \alpha\rho - c_r - \alpha c & \text{(A10)} \\ \geq\ & p_r + b_a - c_r - \alpha c & \text{(A11)} \end{aligned}$$

since $p_r/\gamma \geq p_r$ and $\alpha\rho/\gamma \geq \alpha\rho$ for $\gamma \in [0,1]$. The expression in (A11) equals the margin between the submission price and the average variable reader cost in (7). This must be non-negative for the firm to at least break even. Hence social welfare is weakly decreasing in p_r. Without loss of generality, therefore, the second-best submission fee is the lowest p_r satisfying the journal's zero-profit constraint. □

Proof of Proposition 4: We have

$$\begin{aligned} \frac{\partial \Pi(p_r)}{\partial t} &= \left(\frac{\partial \Pi(p_r)}{\partial \alpha}\right)\left(\frac{\partial \alpha}{\partial t}\right) \\ &= -(1-\gamma)\left(\frac{\partial \Pi(p_r)}{\partial \alpha}\right). \end{aligned}$$

It follows that $\partial \Pi(p_r)/\partial t$ has the same sign as expression (10). We will abuse notation slightly and add an argument to $\Pi(p_r)$ and p_r^{**}, i.e., $\Pi(p_r, t)$ and $p_r^{**}(t)$, to stress their dependence on the additional parameter. Let $t' < t''$.

Suppose expression (10) is positive. Then $\partial \Pi(p_r, t)/\partial t > 0$, implying $\Pi(p_r, t') < \Pi(p_r, t'')$.

Hence $0 \leq \Pi(p_r, t')$ implies $0 \leq \Pi(p_r, t'')$. Therefore,

$$\{p_r \geq 0 | \Pi(p_r, t') \geq 0\} \subseteq \{p_r \geq 0 | \Pi(p_r, t'') \geq 0\},$$

implying

$$\begin{aligned} p_r^{**}(t') &= \min\{p_r \geq 0 | \Pi(p_r, t') \geq 0\} \\ &\leq \min\{p_r \geq 0 | \Pi(p_r, t'') \geq 0\} \\ &= p_r^{**}(t''). \end{aligned}$$

We have shown that if expression (10) is positive, p_r^{**} is weakly increasing in t. Similar arguments establish that if expression (10) is negative, p_r^{**} is weakly decreasing in t. □

Proof of Proposition 5: Suppose the profit-maximizing journal cannot commit to an editorial policy. In view of the expression for journal profit (1), ex post the journal will choose $\alpha \in [0, 1]$ as a free parameter to maximize

$$p_s n_a + \alpha p_a n_a + p_r n_r - n_a c_s - \alpha n_a c_a - n_r c_r - \alpha n_a n_r c, \tag{A12}$$

where p_s, p_a, p_r, n_a, and n_r are regarded as fixed ex post. The derivative of (A12) with respect to α is

$$p_a n_a - n_a c_a - n_a n_r c. \tag{A13}$$

If expression (A13) is positive, the journal would publish all articles, those known to be bad as well as those believed to be good. If (A13) is negative, the journal would publish no articles, rejecting even articles known to be good. If (A13) equals zero, the journal would be indifferent among editorial policies and in equilibrium would implement the same editorial policy as in the commitment case, accepting only papers believed to be good. □

References

Aumann, Robert. (1959) "Acceptable Points in General Cooperative n-Person Games," in A. W. Tucker and R. D. Luce, eds., *Contributions to the Theory of Games* vol. 4. Princeton, New Jersey: Princeton University Press.

Bernheim, B. Douglas, Bezalel Peleg, and Michael D. Whinston. (1987) "Coalition-Proof Nash Equilibria I. Concepts," *Journal of Economic Theory* 42: 1–12.

House of Commons Science and Technology Committee. (2004) *Scientific Publications: Free for All? Tenth Report of Session 2003-04.* London: The Stationery Office Limited.

Jeon, Doh-Shin, and Domenico Menicucci. (2003) "Bundling Electronic Journals and Competition among Publishers," Universitat Pompeu Fabra working paper.

Lerner, Josh, and Jean Tirole. (2004) "A Model of Forum Shopping, with Special Reference to Standard Setting Organizations," Harvard Business School Negotiations, Organizations and Markets Research Paper no. 04–31.

McCabe, Mark J. (2002) "Journal Pricing and Mergers: A Portfolio Approach," *American Economic Review* 92: 259–269.

McCabe, Mark J. (2004) "Information Goods and Endogenous Pricing Strategies: The Case of Academic Journals," *Economics Bulletin* 12(10): 1–11.

McCabe, Mark J., and Christopher M. Snyder. (2004) "The Economics of Open-Access Journals," Georgia Institute of Technology and George Washington University working paper.

Milgrom, Paul and John Roberts. (1994) "Comparing Equilibria," *American Economic Review* 84: 441–459.

Morrison, Alan D., and Lucy White. (2004) "Financial Liberalisation and Capital Regulation in Open Economies," University of Oxford and Harvard Business School working paper.

Rochet, Jean-Charles, and Jean Tirole. (2004) "Two-Sided Markets: An Overview," Institut d'Economie Industrielle working paper.

Wellcome Trust. (2003) *Economic Analysis of Scientific Research Publishing*. Histon, Cambridgeshire: SQW Limited.