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The Economics of Open-Access Journals

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Abstract: A new business model for scholarly journals, open access, has gained wide attention recently. An open-access journal's articles are available over the Internet free of charge to all readers; revenue to cover publication costs comes from authors' fees. In this paper, we present a model of the journals market. Drawing upon the emerging literature on two-sided markets, we highlight the features distinguishing journals from examples economists have previously studied (telephony, credit cards, video game consoles, etc.). We analyze the efficiency of equilibrium author and reader fee schedules for various industry structures and for various assumptions about journals' objective functions. We ask whether open-access journals are viable in these various economic environments.

Keywords: Open access, scholarly journal, two-sided market, competition

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

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1 Introduction

The typical scholarly journal earns most of its revenue from subscriber fees—fees charged to libraries and individual subscribers. In economics, yearly library subscription fees, constituting most of journal revenue, especially for journals published by commercial (for-profit) firms, ranged from an average of $190 for the ten top-cited journals published by non-profit publishers to $1,370 for the ten top-cited journals published by commercial firms in 2001 (Bergstrom 2001). Across science and technology journals more generally, the average yearly library subscription fee, measured by the Blackwell Periodical Price Index, was $1,210 in 2000 (Wellcome Trust 2003).[1]

Recent developments in the market for journals have led to dissatification among some scholars and librarians with this business model.[2] The advent of the Internet offers the prospect of nearly zero marginal cost distribution of journals in electronic form, potentially much lower than the traditional method of mailing print copies. Yet while technological advances might be expected to result in lower journal prices, real journal prices in fact have risen substantially over the past decade. In his sample of biomedical journals published by commercial firms, McCabe (2002) found average library subscription fees more than doubled from the 1988–1994 period to the 1995–2001 period. The Blackwell Periodical Price Index for science and technology journals rose by a factor of 1.8 between 1990 and 2000 (Wellcome Trust 2003). The recent wave of mergers among commercial publishers has dramatically increased concentration in many fields: the market share of the dominant firm, Elsevier, exceeded 50 percent in biomedical journals according to some measures (McCabe 2002). McCabe (2002) provides evidence that this consolidation has directly contributed to the price increases.

This dissatisfaction with the traditional business model for journals has led to the proposal of a new business model, the open-access model. An open-access journal's articles are available

[1] The figure of £671 was converted to U.S. dollars using an exchange rate of 1.81$/£.

[2] For a newspaper account, see Weiss (2003).

over the Internet free of charge to all readers. Revenue to cover publication costs (and generate a profit for commercial publishers) come from fees charged to submitting authors. In March 2004, the Directory of Open Access Journals (www.doaj.org) listed over 800 open access titles across all fields. The most widely publicized open-access initiative is the Public Library of Science (PLoS), publishing the *PLoS Biology* and *PLoS Medicine* journals, founded by Nobel-prize-winning biologist Harold Varmus with a $9 million grant from the Moore Foundation, with the stated goal of competing with the top-tier journals in biomedicine. The PLoS journals charge $1,500 to authors of accepted papers. This appears to be on the upper end of author fees: other notable open-access journals, for example, the BioMed Central journals, charge lower author fees, $500 per accepted paper in the case of BioMed Central journals. In economics and business, open access has so far been limited to largely to niche publications. The exhaustive list in Table 1 of refereed journals in economics and business all charge no author fees, so the journals operate on donated labor and computer facilities.

The fee structure of journals has potentially important consequences for social welfare. Subscription prices have risen to the point where libraries have begun to cancel significant titles (Weiss 2003). This in turn harms both readers and authors: readers because their access to past research is limited, and authors because fewer readers will reduce their impact and citations at the margin.[3]

Many questions surround the economics of open-access journals. First, it is not obvious that profit-maximizing journals would ever voluntarily choose to have open access. If such examples exist, they may depend on special conditions on market structure, demand, and costs. Second,

[3] The possibility that open access will offer more citations to authors is suggested by Lawrence's (2001) study of 1,500 computer conference "venues" that publish some of their content as open-access articles and some only in print. For 90 percent of the venues, the open-access articles were more highly cited. Within venues, open-access articles generated over three times the citations of print articles. The study does not fully account for the possible bias due to the selection of articles for open-access versus print publication. Walker (2001) discusses the example of an entomology journal that has a hybrid model, allowing authors to choose open access for a fee. In 2001, about a year after introducing this model, over half of the authors paid for open access at a cost of $90 for a seven page article.

it is not obvious that an open-access journal would be competitively viable. If open access only leads to a slight increase in readership and impact, authors may choose to stay with traditional journals and avoid the open-access journal's higher author fees. Third, it is not obvious that social welfare is enhanced by open access. True, it reduces any deadweight loss on the reader side. But if author fees need to be raised to pay for publication costs and to provide a profit margin, it may increase deadweight loss on the author side, leading to the publication of less research.

In order to address these and other related questions, in this paper we seek to construct an elementary model of open access. Even though we seek to make the model as simple as possible, there is one complication relative to the rest of the emerging theoretical research on academic journals (McCabe 2003, Jeon and Menicucci 2003) that cannot be avoided. The rest of the literature only considers one side of the market, focusing on library subscription fees alone. To study open access we need to model two sides of the market, author fees in addition to subscriber fees. There are bilateral benefits exerted by readers on authors and vice versa. Since authors typically cannot pay readers directly and vice versa, these bilateral benefits are externalities. The existence of these bilateral externalities prevents the full pass through of fees charged on one side of the market to the other. Thus the structure of individual fees charged to authors and readers will matter in equilibrium. The sources of these bilateral externalities are clear: on one side of the market, authors benefit from greater impact and citations and thus prefer a journal which has more readers; on the other side of the market, readers benefit from content and thus prefer journals with more articles (or, in another dimension, higher quality articles).

Our paper is part of a growing theoretical literature on two-sided markets, studying telecommunications, payment-card systems, and or the general problem.[4] The closest paper in this literature is Rochet and Tirole's (2003) general treatment of platform competition. Our paper

[4] This literature includes among many other papers, Baye and Morgan (2001); Caillaud and Jullien (2003); Evans (2003); Hermalin and Katz (2004); Jeon, Laffont, and Tirole (2004); Laffont, *et al.* 2001; Rochet and Tirole (2002, 2003); Schmalensee (2002); and Wright (2003).

differs on several formal dimensions from Rochet and Tirole (2003). In Rochet and Tirole (2003), both sides of the market can "multihome", that is, can simultaneously operate on two or more platforms. In our application, one side of the market, readers, can multihome since they can subscribe to multiple journals. The other side of the market, authors, cannot multihome. Authors cannot have the same paper published in multiple journals. Another unique feature of the journals market is that journals offer a bundle of articles/authors to readers. In Rochet and Tirole (2003), the platform mediates a single transaction between buyer and seller. These differences require new formal analysis in our paper.

Aside from the complication of two-sided markets, in other dimensions we seek to make the model as simple as possible. The model is static. Authors produce a single article of equal quality. Journals publish only one issue. The readers' benefit from additional articles is heterogeneous across readers but is linear in the number of articles. A journal's quality is endogenously determined solely by the number of articles it publishes. Analogous to the readers' benefit from additional authors, the authors' benefit from additional readers is heterogeneous across authors but is linear in the number of readers. Costs have a simple affine structure. We leave aside the role of other market participants such as libraries, funding agencies, and editors. Still, the analysis is sufficiently complicated that we have to devote a number of sections to the general analysis of journal pricing before focusing on the questions about open-access journals of central interest. Section 2 lays out the model. Sections 3, 4, and 5 analyze the case of a monopoly journal, competing journals, and the social optimum as a benchmark. We derive a number of general propositions in these sections, but the presence of discontinuities in even simple numerical examples prevents us from placing too much stock in results that require the existence of well-behaved interior solutions. In Section 6, we gain further insight by studying numerical examples. We step back in Section 7 and take stock of what our results imply for the questions about open access posed in this Introduction. Section 8 concludes.

2 Model

The model has three types of economic agents: journals, authors, and readers. Journals are intermediaries between authors and readers. Journals acquire articles from authors, bundle them into a journal issue, and distribute them to subscribing readers. Each article costs the journal c^A to process, including the costs of refereeing, copyediting, typesetting, etc. 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.

Each author produces a single article.[5] Author i obtains a benefit $b_i^A \in \mathbb{R}$ 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 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_i^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. Assume b_i^A is a random variable with continuous cumulative distribution function F^A. Normalize the mass of authors to unity.

Reader k obtains benefit $b_k^R \in \mathbb{R}$ per article read. This term embodies the benefit the reader obtains from the information contained in the article. The reader can read as many articles as he likes from the journals to which he subscribes. Assume b_i^R is a random variable with cumulative distribution function F^R. Normalize the mass of readers to unity.

[5] 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.

Note we have assumed a fair degree of homogeneity. There are no exogeneous differences among journals. They have identical costs. They may differ in quality but only to the extent they publish different numbers of articles, not in the quality of the articles published nor in the value added in selecting or editing them. Authors differ in the benefits they gain from publishing their articles, but their articles provide identical benefits to readers. That is, articles are of a similar quality. Readers differ in the benefits they gain from reading a given article, but having the article read provides the same benefit to an author regardless of who is doing the reading. If the author benefits from the readers' citations, for example, the implicit assumption is that all readers are equally likely to cite a given author's work. In particular, it might be realistic in some settings to assume high-b_i^R readers produce more citations, but for simplicity we do not pursue this extension here. We have also assumed a fair degree of linearity. An author's benefit from having his article read is linear in the number of readers. A reader's benefit is linear in the number of articles he reads.

The benefits reader 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 (2002) 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.

Journal j charges each author a submission fee p_j^A and each reader a subscription fee p_j^R. Note that, following industry practice, these fees are taken to be fixed in the sense that p_j^A is independent of the number of journal j's readers and p_j^R is independent of the number of articles in journal j. Since all articles are of equal quality, it makes no difference whether p_j^A is taken to be a submission fee or a fee paid conditional on acceptance since all submitted articles will be published in equilibrium. We will constrain prices p_j^A and p_j^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.

A reader can read as many articles as he wants from a journal to which he subscribes. If $b_k^R > 0$, indeed he will read all of the articles since there is a positive marginal benefit but no marginal fee to do so. Following industry practice, an author is assumed to be able to publish his article in only one journal, i.e., journals sign exclusive contracts with authors. On the other hand, readers may subscribe to multiple journals.

Next we will compute the surplus of the economic agents. Suppose journal j has n_j^A authors and n_j^R readers. Its profit is

$$p_j^A n_j^A + p_j^R n_j^R - TC(n_j^A, n_j^R) \tag{1}$$

where $TC(n_j^A, n_j^R)$ is the total cost function

$$TC(n_j^A, n_j^R) = c^A n_j^A + c^R n_j^R + c n_j^A n_j^R. \tag{2}$$

If author i submits his article to journal j, he obtains net surplus

$$n_j^R b_i^A - p_j^A. \tag{3}$$

If reader k subscribes to journal j, he obtains net surplus

$$n_j^A b_k^R - p_j^R. \tag{4}$$

The existence of the infinitesimal players (authors and readers) generates a multiplicity of subgame-perfect, rational-expectations equilibria supported in many cases by “bizarre” coordination behavior. For example, with a monopoly journal there can exist a 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 (a reader) to deviate unilaterally if the journal charges higher prices since it obtains no surplus from dealing with a journal with no readers (authors). Similarly, with competing journals, there are rational-expectations equilibria in which all submitters and subscribers deal with a journal even though it has higher submission and subscription prices. Again, there is no incentive for an author or a reader to deviate unilaterally since the other journal has no customers and thus provides no surplus. We say that such equilibria are supported by “bizarre” coordination behavior because the infinitesimal players are coordinating on an outcome that is Pareto dominated by another. We thus will strenthen our subgame-perfect, rational-expectations equilibrium concept to require the infinitesimal players to pursue strategies leading to Pareto-undominated outcomes for the coalition of all infinitesimal players on any proper subgame and to require journals’ strategies to be immune to deviations that would be profitable for some Pareto-undominated response by the infinitestimal players.

3 Monopoly Journal

In this section, we will analyze the case of a single, monopoly journal. We will drop subscript j on journals for now. Author i will submit his article to the journal if his surplus given in expression (3) is positive, or, upon rewriting, if $b_i^A > p^A/n^R$. Recalling the mass of authors has been normalized to one, the structural equation for authors' demand is

$$n^A = 1 - F^A(p^A/n^R). \tag{5}$$

Reader k will subscribe to the journal if his surplus in (4) is positive, or, upon rewriting, if $b_k^R > p^R/n^A$. Recalling the mass of authors has been normalized to one, the structural equation for readers' demand is

$$n^R = 1 - F^R(p^R/n^A). \tag{6}$$

Solving equations (5) and (6) simultaneously yields reduced-form solutions for author demand, $\hat{n}^A(p^A, p^R)$, and for reader demand, $\hat{n}^R(p^A, p^R)$. In particular,

$$\hat{n}^A(p^A, p^R) = \sup\{n | G^A(n, p^A, p^R) = 0\} \tag{7}$$

where

$$G^A(n, p^A, p^R) = 1 - F^A\left(\frac{p^A}{1 - F^R(p^R/n)}\right) - n \tag{8}$$

and

$$\hat{n}^R(p^A, p^R) = \sup\{n | G^R(n, p^A, p^R) = 0\} \tag{9}$$

where

$$G^R(n, p^A, p^R) = 1 - F^R\left(\frac{p^R}{1 - F^A(p^A/n)}\right) - n. \tag{10}$$

The reduced-form demands have straightforward comparative static properties. Authors' demand $\hat{n}^A(p^A, p^R)$ is of course weakly decreasing in submission fees p^A. Authors' demand and also weakly decreasing in subscription fees p^R. This is because authors anticipate that high subscription fees reduce the number of readers and thus the benefit authors obtain from publishing in the journal. Deriving these comparative statics results is complicated by the fact that the problems $G^A(n, p^A, p^R) = 0$ and $G^R(n, p^A, p^R) = 0$ may have multiple solutions for n, and these solutions may vary discontinuously with p^A and p^R.

The possibility of discontinuous demands is demonstrated in Figure 1, which graphs author demand in a numerical example in which F^A and F^R, the distributions of author and reader benefits, are taken to be uniform $[0, 1]$. Increasing p^A above a certain threshold causes author demand to jump down to zero as the feeback between reductions in submitters and subscribers causes the market to unravel.

Comparative statics results can still be obtained in this setting using the results of Milgrom and Roberts (1994). The proof of Proposition 1 and all subsequent propositions are provided in the Appendix.

Proposition 1. *Monopoly demands $\hat{n}^A(p^A, p^R)$ and $\hat{n}^R(p^A, p^R)$ are weakly decreasing in p^A and p^R.*

The monopoly journal maximizes profit given by expression (1), substituting $\hat{n}^x(p^A, p^R)$, $x \in \{A, R\}$, for demands. Call this profit $\Pi^m(p^A, p^R)$. As mentioned above, demands $\hat{n}^x(p^A, p^R)$ may not be continuous. To build intuition, however, for now suppose demands are continuous, indeed are differentiable, and the monopoly optimum is given by an interior solution. Supress the arguments of the demand functions for brevity. Let MC^A be the effective marginal cost of adding an author, $MC^A = c^A + c\hat{n}^R$; and let MC^R be the effective marginal cost of adding a reader, $MC^R = c^R + c\hat{n}^A$. The first-order conditions for the optimum are

$$\hat{n}^x + (p^A - MC^A)\frac{\partial \hat{n}^A}{\partial p^x} + (p^R - MC^R)\frac{\partial \hat{n}^R}{\partial p^x} = 0 \tag{11}$$

for $x \in \{A, R\}$. The first-order conditions in (11) resemble the usual ones for a multiproduct monopolist with interdependent demands. They can be rewritten in the form of a Lerner index building on Tirole (1988, p. 70). Define the Lerner index $L^x = (p^x - MC^x)/p^x$ and demand elasticity $\epsilon^{xy} = (\partial \hat{n}^x / \partial p^y)/(\hat{n}^x / p^y)$ for $x, y \in \{A, R\}$. One can show

$$L^x = \frac{1}{|\epsilon^{xx}|}\left[1 + L^y \epsilon^{yx}\left(\frac{p^y \hat{n}^y}{p^x \hat{n}^x}\right)\right] \tag{12}$$

for $x, y \in \{A, R\}$. Proposition 1 implies $\epsilon^{yx} \leq 0$ for $x, y \in \{A, R\}$. This in turn implies our monopoly journal prices as would a multiproduct monopolist producing complementary goods, here, authors and readers. The journal shades the submission fee p^A down somewhat from the single-product Lerner index formula to take account of the effect that increasing the number of articles increases the number of readers. Similar reasoning holds for the subscription fee p^R.[6]

Equation (12) indicates that a monopoly journal will typically charge prices strictly above marginal cost for both authors and readers. The monopolist typically seeks to extract rent from both sides of the market. The exception are cases in which the demand on one side of the market, say readers, has a negative cross-price elasticity with respect to author fees, and the revenue from readers' fees is much less than from authors (note the revenue-ratio term in equation (12)). The monopolist would then subsidize readers in order to extract more rent from the "important" side of the market, authors.

[6]The equilibrium price for the multiproduct monopolist may be higher than for the single-product monopolist because the existence of the complementary good may raise a product's demand. Here we are comparing structural Lerner index formulae rather than equilibrium prices.

4 Social Optimum

As a benchmark, we will analyze the second-best problem for a social planner. The second best maximizes the sum of consumer and producer surplus subject to a break-even constraint for the firm. Continue to suppose that demands $\hat{n}^x(p^A, p^R)$ are differentiable and the social planner's problem has an interior optimum. The Lagrangian associated with this constrained optimization problem is

$$\int_{p^A/\hat{n}^R}^{\infty} \hat{n}^R b \, dF^A(b) + \int_{p^R/\hat{n}^A}^{\infty} \hat{n}^A b \, dF^R(b) - TC(\hat{n}^A, \hat{n}^R) + \lambda \Pi^m(p^A, p^R) \tag{13}$$

where $\lambda \in \mathbb{R}^+$ is the Lagrange multiplier, and where we have continued to supress the arguments of the demand functions for brevity. Let $V^A(p^A, p^R)$ be the benefit from adding an author averaged across the population of readers:

$$V^A(p^A, p^R) = \int_{p^R/\hat{n}^A}^{\infty} b \, dF^R(b). \tag{14}$$

Similarly, let $V^R(p^A, p^R)$ be the benefit from adding a reader averaged across the population of authors:

$$V^R(p^A, p^R) = \int_{p^A/\hat{n}^R}^{\infty} b \, dF^A(b). \tag{15}$$

Then the first-order conditions associated with Lagrangian (13) are

$$\lambda \hat{n}^x + \left[(1+\lambda)(p^A - MC^A) + V^A\right] \frac{\partial \hat{n}^A}{\partial p^x} + \left[(1+\lambda)(p^R - MC^R) + V^R\right] \frac{\partial \hat{n}^R}{\partial p^x} = 0 \tag{16}$$

for $x \in \{A, R\}$. Equation (16) can be rearranged into a Lerner index formula:

$$L^x = \frac{1}{|\epsilon^{xx}|}\left\{\frac{\lambda}{1+\lambda} + \epsilon^{yx}\left[L^y + \frac{V^y}{(1+\lambda)p^y}\right]\left(\frac{p^y \hat{n}^y}{p^x \hat{n}^x}\right)\right\} - \frac{V^x}{(1+\lambda)p^x} \tag{17}$$

for $x \in \{A, R\}$. Equation (17) nests both the first best, as can be seen by letting $\lambda \to 0$, and the monopoly problem, as can be seen by letting $\lambda \to \infty$. Equation (17) is readily interpretable. If one were to ignore the terms V^A and V^R, one would have the usual Ramsey pricing formula. The inclusion of V^A and V^R reflects the positive externalities exterted by each side of the market on the other. The higher is V^A, for example, the greater the externality exerted by authors on readers, and thus the higher the markup on subscription fees to pay for a reduced markup on submission fees.

5 Competing Journals

In this section, suppose there are two identical journals $j = 1, 2$ which choose prices P_j^A and P_j^R simultaneously prior to the submission and subscription decisions of authors and readers. Recall our equilibrium concept involves the refinement that the coalition of infinitesimal players (authors and readers) cannot coordinate on a Pareto-dominated outcome given journal prices. We will also focus for the moment on symmetric equilibria. By symmetry we mean equal journal prices. The next proposition, proved in the appendix, shows that our refinement is inconsistent with full symmetry in the sense of equal journal prices and equal quantities. The reason is that rather than dividing themselves (in particular the authors) across two journals, the coalition can benefit by coordinating on one of the two. Our refinement thus requires that all submitters and subscribers coordinate on a single journal ex post.

Proposition 2. *In the symmetric-price equilibrium of the duopoly journal game under the refinement we consider, submitters and subscribers coordinate on a single journal ex post, though* *they can randomize between the journals ex ante.*

Our game resembles the standard Bertrand game in that we have two firms choosing prices simultaneously for homogeneous products. The difference is that here firms are intermediaries between two markets rather than serving a single one. Still, the usual undercutting arguments used to prove firms earn zero profits in the standard Bertrand game apply here, with one slight wrinkle involving demand discontinuities.

Proposition 3. *In the symmetric-price equilibrium of the duopoly journal game under the refinement we consider, equilibrium prices* (p^{A*}, p^{R*}) *satisfy*

$$\Pi^M(p^{A*}, p^{R*}) = 0 \tag{18}$$

if monopoly demands $\hat{n}^x(p^A, p^R)$*,* $x \in \{A, R\}$*, are continuous at* (p^{A*}, p^{R*})*. That is, equilibrium prices are such that a single journal serving market demand at those prices would earn zero profit. Ex post, one of the two journals serves all submitters and subscribers and both journals earn zero profit. If monopoly demands are discontinuous at* (p^{A*}, p^{R*})*, journals may earn positive expected profit in equilibrium.*

We expect that in applications, it will be rare for there to be a demand discontinuity precisely at the prices solving equation (18), so that Proposition 3 implies that zero journal profit characterizes equilibrium for the typical application.

In the standard Bertrand game, there is only one equilibrium outcome, marginal-cost pricing for the single good, yielding zero profit. With two prices here, there may be a continuum of prices satisfying the zero-profit condition (18). Unlike the standard Bertrand game, therefore, here we potentially have a continuum of equilibria.

Let Z be the set of prices satisfying the zero-profit condition (18):

$$Z = \big\{(p^A, p^R) \in \mathbb{R} \big| \Pi^m(p^A, p^R) = 0\big\}.$$

Let $\underline{Z}$ be the lower boundary of the set Z:

$$\underline{Z} = \left\{(p^A, p^R) \in Z \middle| \nexists\, (p^{A'}, p^{R'}) \in Z \text{ such that } (p^{A'}, p^{R'}) < (p^A, p^R)\right\}$$

where the inequality $(p^{A'}, p^{R'}) < (p^A, p^R)$ implies $p^{A'} \leq p^A$ and $p^{B'} \leq p^B$ with at least one of the inequalities strict. Let (p^{AA}, p^{RA}) be the point in $\underline{Z}$ maximizing author demand and $(p^{AR}, p^{RR}$ the point in $\underline{Z}$ maximizing reader demand:

$$(p^{Ax}, p^{Rx}) = \text{argmax}\left\{n^x(p^A, p^R) \middle| (p^A, p^R) \in \underline{Z}\right\}, \quad x \in \{A, R\}.$$

The next proposition states that any point in $\underline{Z}$ between the ones maximizing author demand and the one maximizing reader demand are equilibria.

Proposition 4. *For all $(p^A, p^R) \in \underline{Z}$ such that $p^A \leq p^{AR}$ and $p^R \leq p^{RA}$, there exists an equilibrium of the duopoly journal game under the refinement we consider in which both journals charge (p^A, p^R).*

Since the second best is a point in $\underline{Z}$ between the ones maximizing author and reader demands, it is an equilibrium with competing journals.

Proposition 5. *There exists an equilibrium of the duopoly journal game under the refinement we consider in which both firms charge the prices observed in the second-best social optimum.*

6 Numerical Examples

As demonstrated by the demand curves in Figure 1, there may be demand-curve discontinuities even in the simplest examples with uniformly-distributed benefits, rendering our Lerner index formulae (12) and (17) invalid. In this section we analyze simple numerical examples in which we can account for any discontinuities to verify the previous results and derive additional intuition that may lead to further general propositions.

Assume the distributions of author and reader benefits, F^x, $x \in \{A, R\}$, are uniform distributions on $[0, 1]$. Table 2 presents results from three different cost configurations for this uniform example. We chose the configuration in Example 1 ($c^A = 0.1$, $c^R = 0.1$, $c = 0$) to make authors and readers completely symmetric in terms of benefits and costs. This is for pedagogical purposes, but may capture the print-journal case in which there is a fixed cost of producing an issue of a journal and of shipping it to a reader that does not depend much on the number of articles/pages it contains. Example 2 ($c^A = 0.1$, $c^R = 0.0$, $c = 0.1$) is meant to capture cost conditions in a print-journal environment where the cost of producing and shipping an issue to a reader depends linearly on the number of articles/pages. Example 3 ($c^A = 0.1$, $c^R = 0.0$, $c = 0.0$) is meant to capture cost conditions in an online-journal environment. Most costs in this environment have to do with processing the articles and posting them on the Internet. There are nearly zero marginal costs of serving readers. It is Example 3 that will be most useful in addressing the question of open access. In all examples, we have assumed the same author cost $c^A = 0.1$.

We see in all examples that the monopoly journal prices significantly above marginal cost. Social welfare is only about half that in the first best.

There are a range of equilibria in the case of competing journals. The table exhibits the two endpoints of the set. Figure 2 graphs the entire set for each of the three examples. The equilibrium maximizing the number of authors puts all the fees on the reader side and vice versa for the equilibrium maximizing the number of readers. Recall that we have exogenously limited prices to be positive; it is conceivable that if we did not add this constraint, there would be additional equilibria in which yet larger reader fees went toward positive payments for authors and vice versa. The equilibrium maximizing the number of readers is an open-access regime in all three examples. It tends to give higher social welfare than the equilibrium maximizing the number of authors and yields surplus close to that in the second best. Indeed, the equilibrium maximizing the number of readers coincides with the second best in Example 3, the example capturing the online journals case.

7 Open Access Journals

In this section, we will review what the results of our previous general analysis of journal pricing have to say about the questions surrounding open access posed in the Introduction.

First, the theoretical results from Section 3, in particular the Lerner index formula (12), suggest that profit-maximizing monopoly journals will not voluntarily choose open access except in a rare case where the elasticities line up in just the right way and author revenues are much more important than reader revenues. In the numerical examples of Section 6, we saw open access never emerged with a profit-maxmizing monopoly journal. There were substantial markups to readers as the monopolist tried to extract revenue from all possible sources.

In cases where journals are competitive (in essense perfectly competitive in our model), open access may emerge in equilibrium with profit-maximizing firms. In all three numerical examples of Section 6, open access emerged in the equilibrium maximizing the number of readers.

In sum, if journals have a substantial degree of market power, there will be little inclination for profit-maximizing journals to move to open access. Competition appears necessary to make open access a likely outcome with profit-maximizing journals.

The next question regards whether journals with the objective of introducing open access can be viable in competition with profit-maximizing journals. If the journal is competitive, the answer is yes. There exists a stable equilibrium in which both firms choose open access. We did not discuss asymmetric equilibria, but it is clear that there exist asymmetric equilibria in which an open-access journal competes alongside another journal that charges a different configuration of prices, involving possible positive reader prices, as long as this configuration of prices yields the firm zero profit if it serves all demand.

Of course if the journal dedicated to open access has market power, in the extreme being a monopolist, it will have an easier time instituting open access since it will have greater rents from its captive set of authors to use to subsidize readers.

The final question regards the efficiency of open access. The examples indicate that open access is not universally efficient. If there are substantial costs of serving readers, then the second best involves positive reader fees. However, if the cost configuration is as in Example 3, open access is efficient. But the cost configuration in Example 3 corresponds to online journals, precisely the environment in which open access has been advocated (open-access was not a policy issue in the print-journal era). Our results indicate that open access tends to be efficient in an environment with online journals.

8 Conclusion

To be added.

Appendix

Proof of Proposition 1: It is evident that $G^A(n, p^A, p^R)$ in expression (8) is weakly decreasing in p^A. Thus, by Lemma 1 of Milgrom and Roberts (1994),

$$\sup\{n|G^A(n, p^A, p^R) = 0\} \geq \sup\{n|G^A(n, p^A + \delta, p^R)\}$$

for all $\delta \geq 0$. Therefore $\hat{n}^A(p^A, p^R) \geq \hat{n}^A(p^A+\delta, p^R)$. That is, $\hat{n}^A(p^A, p^R)$ is weakly decreasing in p^A. The proofs that $\hat{n}^A(p^A, p^R)$ is weakly decreasing in p^R and $\hat{n}^R(p^A, p^R)$ is weakly decreasing in p^A and p^R are similar. □

Proof of Proposition 2: Consider a first outcome in which journals charge equal prices and both make some positive sales. Consider a move to a second outcome in which journals maintain the same prices as in the first outcome, the active submitters and subscribers from the first outcome coordinate on one of the two journals, say journal 1, and the inactive authors and readers remain out of the market. Inactive consumers are no worse off in the second outcome. Active consumers are no worse off since they pay the same prices but have at least as many consumers on the other side of the market from which to benefit. Indeed, since journal 2 made some positive sales in the first outcome, at least one side of the market will have strictly more consumers on the other side from which to benefit, and will strictly benefit from the move from the first to the second outcome. □

Proof of Proposition 3: Consider the symmetric-price outcome (p^{A*}, p^{R*}). Suppose demands $\hat{n}^x(p^A, p^R)$, $x \in \{A, R\}$, are continuous at (p^{A*}, p^{R*}). By Proposition 2, one of the two journals makes all the sales ex post at these prices. Thus, ex ante, there is some positive probability, $\alpha > 0$, at least one of the journals, say journal 1, makes all the sales at these prices. Journal 2's profit is thus at most $(1 - \alpha)\Pi^m(p^{A*}, p^{R*})$ from an ex-ante perspective.

If $\Pi^m(p^{A*}, p^{R*}) < 0$, journal 1 can avoid the negative profit by deviating to higher prices, effectively exiting the market. Hence (p^{A*}, p^{R*}) would not be an equilibrium.

If $\Pi^m(p^{A*}, p^{R*}) > 0$, journal 1 must earn positive margins on at least one side of the market (authors or readers). Journal 2 can deviate by slightly undercutting the price on the side of the market on which journal 1 makes positive margins by $\epsilon > 0$. The Pareto-optimal outcome for the coalition of authors and readers would be to all coordinate on journal 2. For small enough ϵ, since monopoly demands and thus monopoly profit are continuous at (p^{A*}, p^{R*}), journal 2 can guarantee itself a profit arbitrarily close to $\Pi^m(p^{A*}, p^{R*})$, and can guarantee it earns this with probability one from an ex ante perspective. Its profit would be strictly higher than $(1 - \alpha)\Pi^m(p^{A*}, p^{R*})$, an upper bound on what it could earn in the outcome considered initially. Hence the proposed outcome is not an equilibrium. $\square$

Proof of Proposition 4: To be added. $\square$

Proof of Proposition 5: To be added. $\square$

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Table 1: Refereed Open-Access Journals in Business and Economics

Economics Journals
Brazilian Electronic Journal of Economics
Economics Bulletin
Electronic Journal of Evolutionary Modeling and Economic Dynamics
Finnish Economic Papers
Industrial Geographer
Nova Economia
Review of Network Economics
Industrial Geographer
Business Journals
Academy of Marketing Science Review
B Quest
Electronic Journal of Business Ethics and Organization Studies
Journal of Empirical Generalisations in Marketing Science
M@n@gement
Public Administration and Management

Source: March 28, 2004 download of economics or business journals from Directory of Open Access Journals (www.doaj.org). From this initial set of 19 journals, the subset in this table stated positively on their websites that journal was referreed.

Table 2: Numerical Examples with Uniformly Distributed Benefits

		Competitive Equilibria		Social Optimum	
	Monopoly	Maximizing Authors	Maximizing Readers	Second Best	First Best
Example 1 (Symmetry between authors and readers): $c^A = 0.1$, $c^R = 0.1$, $c = 0.0$					
Submission Fee	0.237	0.000	0.230	0.100	0.000
Subscription Fee	0.237	0.230	0.000	0.100	0.000
Number Authors	0.612	1.000	0.770	0.887	1.000
Number Readers	0.612	0.770	1.000	0.887	1.000
Industry Profit	0.168	0.000	0.000	0.000	−0.200
Consumer Surplus	0.229	0.682	0.682	0.699	1.000
Social Welfare	0.398	0.682	0.682	0.699	0.800
Example 2 (Print journals case): $c^A = 0.1$, $c^R = 0.0$, $c = 0.1$					
Submission Fee	0.317	0.000	0.200	0.172	0.000
Subscription Fee	0.170	0.230	0.000	0.022	0.000
Number Authors	0.536	1.000	0.800	0.824	1.000
Number Readers	0.682	0.770	1.000	0.974	1.000
Industry Profit	0.196	0.000	0.000	0.000	−0.200
Consumer Surplus	0.222	0.682	0.720	0.721	1.000
Social Welfare	0.418	0.682	0.720	0.721	0.800
Example 3 (Online journals case): $c^A = 0.1$, $c^R = 0.0$, $c = 0.0$					
Submission Fee	0.304	0.000	0.100	0.100	0.000
Subscription Fee	0.164	0.113	0.000	0.000	0.000
Number Authors	0.573	1.000	0.900	0.900	1.000
Number Readers	0.713	0.887	1.000	1.000	1.000
Industry Profit	0.234	0.000	0.000	0.000	−0.100
Consumer Surplus	0.263	0.837	0.885	0.855	1.000
Social Welfare	0.497	0.837	0.885	0.855	0.900

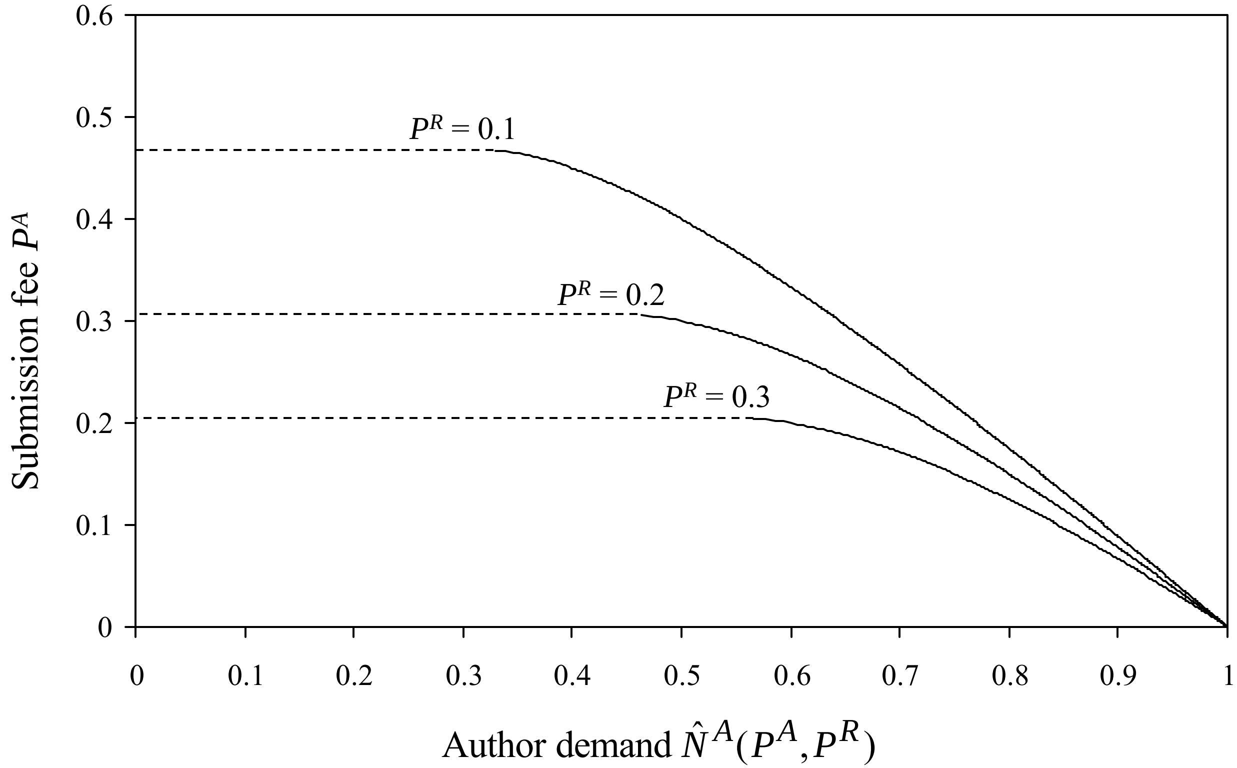

Figure 1. Discontinuities exhibited by reduced-form author demand in numerical example with uniformly-distributed benefits.

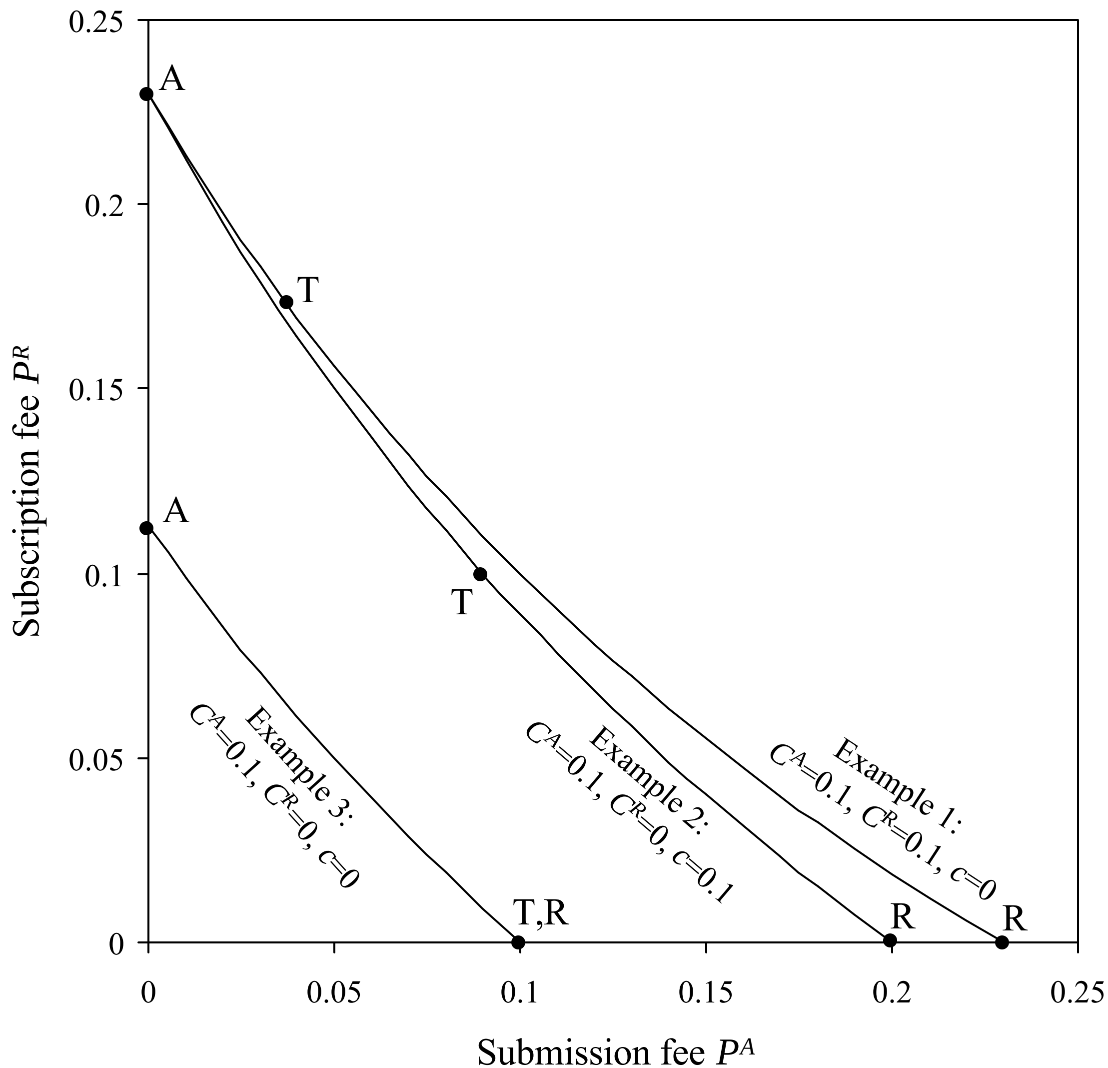

Figure 2. Continuum of competitive equilibria in three numerical examples with uniformly-distributed benefits. In each example, A is the equilibrium maximizing authors' demand, R is the equilibrium maximizing readers' demand, and T is the equilibrium maximizing consumer (i.e., author plus reader) surplus.